Lars F. Reeker

Cognition Enhanced Business Processes

Designing a Conceptual Design Process for
the Enhancement of Business Processes
Leveraging Artificial Intelligence Technologies

Master Thesis – Delft University of Technology

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Cognition Enhanced Business Processes

Designing a Conceptual Design Process for the Enhancement of Business
Processes Leveraging Artificial Intelligence Technologies

by

Lars F. Reeker

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Preface

The document in front of you is my MSc thesis report, describing the research I conducted for seven months in order to complete the programme Systems Engineering, Policy Analysis and Management – Information Architecture at the Faculty of Technology, Policy and Management of the Delft University of Technology. By finishing this master thesis project, so will my time as a student of this fantastic faculty and great university. During my life as a student, I sometimes had the feeling of the faculty to be my second home in Delft.

The precision of which scientific inquiry has to the performed fascinates me. Attempts to tackle complex problems give me lots of energy. Although this research was quite a challenge for me, I deeply enjoyed it. This research would never have finished without the help of a number of people who I want to thank here.

Many of my thanks goes to the committee that assisted me in performing my first real scientific research. First, I owe many thanks to Huib, for meeting with me on a regular basis through the whole period I conducted this research. Our shared interest in the concepts of cognition, systems design and artificial intelligence of the research got us through some challenging moments in the overall process. Thank you for your all the time and energy you put in as my mentor to help me achieve this very final result of which I am proud of. Next, I want to say thank you to my second supervisor Pieter. Your advice is been always of great value to me, most importantly on conducting my research through design. I heavily enjoyed our bi-weekly meetings on the Friday morning, in which we had highly substantive and fun discussions. Usually I did not leave your office before two hours had past by – I even think that sometimes a scheduled meeting with me was the only reason for you to come and travel to Delft. It was fantastic to have you as supervisor. Furthermore, I want to thank Frances for overseeing and guiding my research efforts. Your suggestions for scoping my research proved to be very valuable. Your interest in my research and accompanying article have pushed me to go the extra mile – I have a good feeling about the possible acceptance of the article on Research to Design to the RtD2017 Conference that has resulted from this master thesis project. From the Faculty of Electrical Engineering, Mathematics and Computer Science I want to thank Koen for his advice on the more technical parts of my research. I have found our monthly meeting always very helpful and pleasant.

As a graduate intern of Jibes Data Analytics B.V. during the period of this research, I was able to execute this research in co-operation with experts in field, something that I was looking for before starting this research project. Furthermore, Jibes had provided me the opportunity to experience real-life projects, which also resulted in the case studies I have used in this research. For making this

possible, I want to greatly thank Paul for providing me with this opportunity. I further want to thank to the people of Jibes for sharing their knowledge and their interest in my research.

At last, and to me most important, I want to show my gratitude to my family and close friends, who make me happy every day such that I can always enjoy the things I want to do. Especially, I want to thank my mum and dad for providing me the chance to develop myself the best way possible, my housemates and former housemates for providing such a warm home, Rick for supporting me so greatly during this research with his continuous valuable feedback and comic utterances and last, but certainly not least, Stephanie for always believing in myself, supporting me in all I do and her love.

On to a new adventure!

Lars Reeker

Executive Summary

For several years software companies promise to provide businesses with systems which use cognitive principles such as humans have, to support decision making based on large amounts of data. The scientific field of Artificial Intelligence (AI) is a major driver behind these software technologies.

AI-driven software systems are considered to have a lot of potential when applied to knowledge-intensive business processes of organisations (Power, 2015). However, organisations initiating transformation projects to apply AI techniques to their systems experience this as challenging (The Economist, 2015b). This has two main causes. First of all there is no shared understanding present amongst stakeholders to communicate effectively and efficiently about how these new business-AI concepts can be utilised in favour of the business (van der Hulst, 2015). Second of all, companies find it hard to develop AI technologies into business solutions, especially with the technology moving so fast (Power, 2015).

Concluding from above, there appears to be little knowledge about the design, development and implementation of AI software within business processes. Furthermore, it seems that no consistent language and definitions of the concepts exists to properly communicate about these transformational projects. AI is concerned with the design and development of intelligent systems, which on its turn is coupled to cognition. When AI software is designed, developed and implemented in an organisation for the purpose of improving the operation of a business process, it thereby addresses the cognition utilised in this business process.

The statements above led to the formulation of the objective of this research, *to strengthen the scientific understanding of knowledge-intensive business processes of which their cognition is enhanced by integrating Artificial Intelligence software, and support their development*. With *cognition enhanced* is meant here the utilisation of AI methods and techniques (software), delivered by computerised machines, to improve the cognition which is utilised to perform the business process.

Preliminary research shows that the design of AI systems for business processes is often done free-wheeling, without properly conceptualising the design. Thereby, steps such as the formulation of requirements, concept generation and evaluation of concepts are skipped in the design process. How to properly construct a conceptual design seems a gap in scientific literature. The research described in this thesis therefore constructed a *conceptual design process (CDP)* to support the design of cognition enhanced business processes, worded in the following main research question:

> **Can a conceptual design process of knowledge-intensive business processes be created, such that the cognition utilised in the process can be enhanced by integrating Artificial Intelligence software?**

The research approach *Research through Design (RtD)* is used to provide an answer to this research question. This approach provides a exploitative way to gain the insights needed to answer the research question above by performing a design exercise. Here, the conceptual design phase from the field of Design Science is leveraged, providing a sequence of steps a conceptual systems design sub-phase consists of (Dym and Little, 2010). In order to study the cognition utilised in business processes, this research took an integrated systems perspective on cognition, found in the scientific field of Cognitive Systems (Langley, 2011; Heylighen, 2011).

In essence, the CDP generates possible ways for AI software to enhance the cognition expressed in a business process by matching the cognitive capabilities of the software to the cognitive requirements of the business process. Next, these so called cognitive possibilities are combined into design alternatives, which can be assessed by applying metrics. Based on this selection, the most appropriate design alternative for the business process at hand can be chosen.

The CDP created in this research consists of six components. Four of the components comprise of design steps to be executed, therefore called here sub-design processes. The first sub-design process of the CDP elicits the cognitive requirements of the business process under review and is called the *Cognitive Requirement Design Process (CRDP)*. The CRDP can be conducted by performing the following five steps:

1A. Decomposing the business process to tasks and roles and formulating stakeholders' requirements
1B. Collecting preliminary domain knowledge
1C. Identifying sub-tasks and types of knowledge that are required to perform the tasks under review
1D. Extracting the cognitive activities from the tasks at hand
1E. Formulating cognitive requirements based on the cognitive activities extracted

The second sub-design process of the CDP elicits the cognitive capabilities of the AI software under review and is called the *Cognitive Capabilities Design Process (CCDP)*. The CCDP can be conducted by performing the following four steps:

2A. Decomposing the selected AI software to its services
2B. Identifying the corresponding methods and techniques for each service
2C. Establishing the cognitive functionalities of each service of the software
2D. Formulating cognitive capabilities based on the cognitive functionalities established

The third sub-design process of the CDP generates the design possibilities for AI software in the business process under review and is called the *Cognitive Possibilities Design Process (CPDP)*. The CPDP can be conducted by performing the following three steps:

3A. Categorising the cognitive requirements and cognitive capabilities by cognitive function
3B. Structurally matching the cognitive capabilities to the cognitive requirements
3C. Analysing each potential match and formulating the rationale for each match

The fourth sub-design process of the CDP comprises the generation and selection of design alternatives and is called the *Design Alternative Generation & Selection Process (DAGSP)*. This design process state uses the design possibilities generated in the CPDP as input. The DAGSP is not specifically addressed in this research, but introduced for the purpose of completeness.

This research found that the four components presented above are often not solely performed in a sequential way. Therefore, a fifth components of the CDP is responsible for the co-ordination of the whole design process, providing a design process strategy and allocates resources such as time and information amongst the design processes. This component is called *Design Process Co-ordination (DPC)*, named after the theory that describes such design process component.

AI technology cannot be leveraged without data that fuels these technologies. Therefore, when design AI-driven solutions using the CDP, the design has to fit to the data available. The sixth and last component of the CDP created in this research comprises a *Data Availability & Quality Assessment (DAQA)* that ensures fitness of the design to data.

The six components described above form together the final conceptual design process as envisioned in this research. After validation, the CDP indicates that conceptually designing cognition enhanced business processes can be done by considering the cognitive requirements of the business process and cognitive capabilities of AI software. This answers the main question of this research. Figure 1 shows the created conceptual design process in a schematic way.
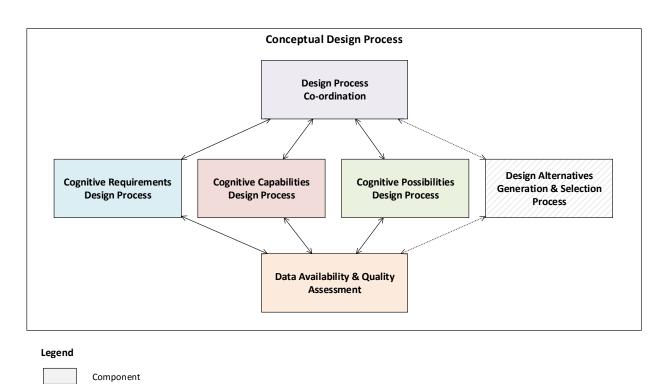

FIGURE 1: The conceptual design process created in this research, indicating in light grey striped the component not addressed in this research

Due to the exploratory character of this research, a number of other insights are generated while creating the CDP. These insights are:

1. A human-centric perspective can be valuable for the design of AI-driven solutions, to construct intelligent business systems
2. Examining the cognition utilised in a business process can support the identification of the potential to smarten its operation
3. An integrated systems perspective on cognition (i.e. cybernetics) can be a valuable perspective for the design of AI solutions in business processes
4. A integrated systems perspective on cognition can provide potential lean improvements in an organisation
5. More focus on the conceptual design of AI solutions for business processes can lead to better designs and thus better solutions
6. Considering the current state of practice, optimising the current operations through cognition enhancement by integrating AI software should be preferred over a complete re-design of the business process itself
7. At this moment in time, no single commercial AI software package can deliver all possibilities for AI-driven systems for organisations
8. Data availability and data quality are essential for the proper design of AI-driven intelligent systems
9. The health-insurance domain is, to some extent, a suitable environment for the application of AI software systems
10. Besides knowledge, products, such as dictionaries of and visual models, relating to AI-driven systems in organisations can support their design and development

These insights presented above contribute to the scientific knowledge base of business processes enhanced by AI-driven systems and support their development. These insights should be considered when designing AI-driven systems for business processes to improve their operation.

Validating the conceptual design process resulted in the knowledge that certain factors and/or elements of the business process under review can change when designing business processes that leverage AI technologies. To further strengthen the knowledge base, research can be conducted to identify these factors and/or elements of a business process that change when designing, developing and/or integrating such systems, such that future development of AI-driven business processes can be performed more robustly.

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Abbreviations

Abbreviations of theoretical concepts

CS   Cognitive System

AI   Artificial Intelligence

BPM   Business Process Modelling

BPMN   Business Process Modelling Notation

CTA   Cognitive Task Analysis

ACTA   Applied Cognitive Task Analysis

DPC   Design Process Co-ordination

RtD   Research through Design

Research specific abbreviations

CR   Cognitive Requirements

CC   Cognitive Capabilities

CADP   Cognitive Requirement Design Process

CCDP   Cognitive Capability Design Process

CPDP   Cognitive Possibilities Design Process

DAGSP   Design Alternative Generation and Selection Process

DAQA   Data Availability & Quality Assessment

CDP   Conceptual Design Process

"We do not learn from experience –
we learn from reflecting on experience"

John Dewey
Philosopher, psychologist and educational reformer

1 | Introduction

For several years software companies have promised to develop systems that use cognitive principles like humans have. An example is IBM, that commercialises Artificial Intelligence technologies in its 'cognitive computing' platform called Watson, that can be used by organisations to leverage the promised power of these technologies (IBM Corporation, 2016; Olavsrud, 2014). This and other commercial 'intelligent' software claim to provide businesses with the ability to ingest and analyse (large amounts of) data, and support intelligent decision-making. The scientific field of Artificial Intelligence (AI), formally studying the creation of machines that express intelligent behaviour (Russell and Norvig, 2003), is a major driver behind these software technologies. AI has given birth to technologies such as machine learning, natural language processing, speech recognition and computer vision (Schatsky et al., 2014).

Applications of AI software can be distinguished in three main categories: product, process, and/or general insights (Schatsky et al., 2015). Product applications of AI software provide benefits to the product and/or service, and thus in the end the end-customer. Process applications of AI technologies on the other hand, deliver value to a work-flow of an organisation, automating or improving business operations. Finally, AI technologies could be exploited to generate more general insight for a business: knowledge that can inform those, e.g. managers, to help them in operational and strategic decision making across an organisation.

Of these three applications of AI driven software systems, their application to business processes is considered to have a lot of potential (Power, 2015). For example, business processes can perform more efficient and/or more accurate when they leverage AI in a proper way, reshaping workforce needs and reducing costs (KPMG International, 2015). As a result, the quality of its output can increase significantly. Therefore, this research particularly focuses on business processes within organisations. According to Schatsky et al. (2015); Verhoeff (2016); Goel and Davies (2011), business processes that have to deal with a lot of information and knowledge seem to be most viable as a subject for application for AI technologies, since these technologies are driven by (a lot of) data. When the performance of a business process is strongly related to its ability to properly handle a large amount of data, computer machines are considered to be of great value when their (AI) computing power is leveraged properly, thereby creating a competitive edge (Microsoft Corporation, 2012).

1.1 Challenges of Artificial Intelligence for Organisations

Some organisations have initiated projects to discover the possibilities of AI for their organisation.

However, these organisations have experienced these (transformational) projects as very challenging (van der Hulst, 2015; The Economist, 2015b). A survey among people working with AI software such as IBM Watson shows for example that no shared understanding is present amongst stakeholders – system designers, end-users, process managers, et cetera – to communicate effectively and efficiently about how these new business-AI technology concepts can be utilised in favour of the business (van der Hulst, 2015). Furthermore, companies often find Artificial Intelligence and its derived technologies difficult to integrate into business solutions, especially with the technology moving so rapidly (Power, 2015).

AI software services like IBM Watson's 'cognitive computing' thus raise some issues. At this moment, AI is gaining momentum in the business world by attracting the attention of CIO's, CTO's and IT specialists in organisations. AI does not remain a topic only related to the field of business. Because of its developments and (media) attention past years, some people do have concerns that these technologies will affect people's life drastically in the future. For example, Silicon Valley entrepreneur Elon Musk is investing in AI "to keep an eye on it" – has said it is potentially "more dangerous than nukes" (Schatsky et al., 2014; Hern, 2015). Scholars at the University of Oxford published a study estimating that 47 percent of total US employment is "at risk" due to the automation of human-cognitive tasks (Schatsky et al., 2015).

The attention for AI in the business context is clearly visible in recent investment decisions made by companies. For example, on November 6st, 2015, the Japanese car manufacturer Toyota announced an one billion dollar investment over five years in the research and development of artificial intelligence applications in its business (Markoff, 2015). Google recently open sourced its Artificial Intelligence engine for anyone to use, to stimulate and foster the development of Artificial Intelligence and its applications (Lewis, 2015). IBM has committed $1 billion to commercialise AI such that businesses will be able to leverage these technologies. These snippets indicate a lot of movement in the field of AI business applications in the past year, and more will probably follow. As a result, the list of business application examples of AI is continuously becoming larger. However, with all these applications available, many businesses ask themselves where they should start, what they need to do in advance, and how to execute a (transformational) project to start leveraging AI technologies in their business (van der Hulst, 2015).

Although this attention to AI and its development of intelligent systems by the business world is quite recent, scholars have been studying how to design and develop such systems already for decades (Ashby, 1962; Russell and Norvig, 2003). *Intelligence* is the capability to analyse, interpret and understand data to generate relevant and valuable information and to learn from it. Human beings are the example of entities that strongly exhibit intelligence. Intelligent behaviour of human beings is studied in literature extensively. This intelligent behaviour arises from the mental processes of humans, such as perception, reasoning, decision-making and learning. These mental processes are designated as cognition. Put differently, a more general component of cognitive competence, in the sense that it does not require specific knowledge, is what is conventionally known as intelligence, i.e. the general ability to solve problems (Heylighen, 2011).

Recent experiments show that computer intelligence has become more powerful in the past years (MIT Technology Review, 2015). Very recently, in March 2016, a computer system powered by AI technology achieved another milestone in Computer Science history, by being victorious in the game Go over the world champion. Because the ruleset of this game is very small, the rules give rise to a lot of complexity – the reason why this game is considered to be "*one of the great intellectual mind sports of the world*" (Byford, 2016). With these technologies improving so fast, the opportunities for organisations increase.

Human cognition has the ability to analyse and interpret data fairly well, but there are limitations, such as in our capabilities to analyse huge amounts of data (The Economist, 2015a). In contrast to humans, computers are able to process a vast amount of data, but are still not able to structurally translate these data from observation to understanding and ultimately decision-making autonomously. Furthermore, AI's ability to learn from behaviour and subsequent consequences (internal learning), and especially from outside its context (external learning) is not near human performance (Chang, 2016). In other words, computers have not yet the "*fluid ability to infer, judge and decide that is associated with intelligence in the conventional human sense*" (The Economist, 2015b). Many authorities in the field of AI therefore do not think that AI will replace humans in organisations in the foreseeing future (The Economist, 2015b; Gordon, 2016).

1.2   Development of Cognition Enhanced Business Processes

Summarising and analysing the above, it seems that little is known about the design, development and implementation of AI software within business processes. Furthermore, it seems that no consistent language and definitions of the concepts exists to communicate about these transformational projects. As stated before, AI is concerned with the design and development of intelligence, which is coupled to cognition. *Cognition*, as used in this thesis, is the ability to execute processes of thought including perception, recognition, memory, learning, knowledge, language, comprehension, goal generation, decision-making, judgement, reasoning and problem solving (further elaborated in Chapter 3). When AI software is designed, developed and implemented in an organisation for the purpose of improving the operation of a business process, it thereby addresses the cognition utilised in this business process. More specifically, it aims to improve the overall cognition leveraged in the business process. As mentioned above, knowledge-intensive processes are considered to be most viable as a subject for application for AI technologies. From now on, when referring to business processes in this thesis, knowledge-intensive business processes are meant.

Thus, little is known about the design, development and implementation of cognition enhanced business processes. *Cognition enhanced* in this context is the utilisation of AI methods and techniques (software), delivered by computerised machines, to improve the cognition utilised to perform the business process. That is, to increase the ability to perform the necessary cognitive activities by the business process. The objective of this research therefore reads as follows:

> **To strengthen the scientific understanding of knowledge-intensive business processes of which their cognition is enhanced by integrating Artificial Intelligence software, and support their development.**

In this research, the (grand) goal of the research object above is the starting point to further analyse this problem. Figure 1.1 visually represents the transformation of a business process to its cognition enhanced state. As addressed before, the transformation of a business process is of interest of this research. This transformation comprises the use of AI technology within the business process.

FIGURE 1.1: Transformation of a business process to its enhanced state

From now, let us take a systems thinking principle perspective: a business process can be viewed as a system, processing some kind of input to a desired output. For example, a marketing department of an organisation is responsible for all marketing activities of the business. It is thereby concerned with the business process that transforms (processes) business goals and business resources related to marketing (inputs) into operational marketing campaigns (outputs). Because a business process is here considered as a system, a decomposition of the transformation of a business process to its enhanced state can be generated using the Systems Development Life Cycle (SDLC) (The US Department of Justice, 2003). Figure 1.2 shows the transformation of a business process as in Figure 1.1 and extends that figure by denoting the first five stages of the Systems Development Life Cycle (SDLC): Preliminary Analysis, System Analysis, System Design, Development and Implementation.
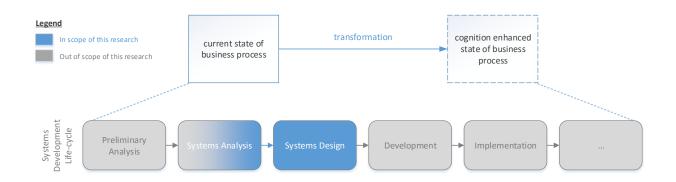
FIGURE 1.2: Transformation of a business process to its enhanced state and related SDLC phases

Through preliminary research, I discovered that businesses are interested in enhancing their business processes by means of utilising AI software, and experimenting with it in (small) projects to proof the usefulness of AI in businesses. However, only a few businesses are actually running such projects full scale, really transforming their business processes (van der Hulst, 2015). Although projects are live that are focusing on the development of such business processes, many business are still reluctant to perform these transformational projects.

A quick literature study resulted in the observation that currently no guidelines for the development of such a cognition enhanced business process exist. However, these are not considered as the major barrier in these transformations, since also little is known about proper design of such enhanced business processes. Because the latter is a prerequisite for the development phase of a system (recall Figure 1.2), this design phase is the most relevant and logical subject of study, considering the current state of the research field. When the systems design phase is researched and fathomed, its subsequent phases can be studied properly. Hence, the focus of this research is only on the system design phase of the SDLC (indicated in blue in Figure 1.2); as the input of the system design phase comes from the system analysis phase, the latter is taken into account in this research too.

Regarding business processes, AI software systems can support work performed by humans in two main ways: by supporting humans to improve their performance or by (partially) replacing their execution of tasks. For example, AI systems can support a worker to do his job better and/or faster – it can help the worker with sub-tasks and by providing valuable information such that the worker can focus more on the activities in which human intelligence excels. Work executed by humans is believed to become more strategic than it is now (KPMG International, 2015).

As mentioned earlier, computer intelligence is not near the level of intelligence shown by humans. Therefore, system development that reasons from the collaboration between human- and computer intelligence is to date considered to be more realistic than development of fully automated intelligent computer systems. Hence, this research presupposes that in the end an improvement to a business process by computers always affects people in the process, which urges a human-centered focus. This is explained in more detail in Chapter 2.

1.3   Conceptual Design of Cognition Enhanced Business Processes

Because a business process is here viewed as a system, one can argue that a business process consists of more than one component that interact with each other (Sage and Armstrong, 2000). For clarification, the cognition that these components embody is the cognition that is referred to when talking about cognition enhancement. These components can be present at multiple levels of abstraction in the business process, which is further elaborated in Chapter 2 and 3.

Reasoning about this transformation according to the decomposition of the different phases of the SDLC, the weaknesses (and thus opportunities) currently present in both the scientific domain as practical domain can be revealed. As stated above, the systems design phase is found as most promising to research. The systems design phase of the SDLC consist of a couple of sub-phases, as presented in Figure 1.3: Problem Definition, Conceptual Design, Preliminary Design, Detailed Design and Design Communication.

The existing opportunities for research on cognition enhanced business processes are gained by analysing backwards from the design communication sub-phase to the problem definition sub-phase (see Figure 1.3). Through observations of current projects constructing AI software for business processes (system), it has been noticed that, to some extent, detailed design specifications are often present. Furthermore, overall system configurations are mostly defined in schematics, diagrams, and other layouts. Hence, the Detailed Design sub-phase and Preliminary Design sub-phase are generally addressed well.
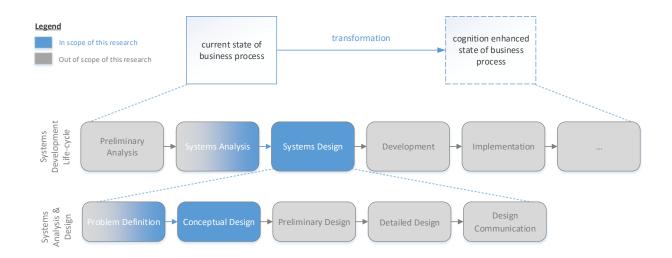
FIGURE 1.3: Transformation of a business process to its enhanced state, related SDLC phases and sub-phases of systems analysis and -design phases

However, preliminary analysis of running projects show that the design of such systems are not always conceptualised before preliminary designs are drafted. Projects are often freewheeling and rushing to solutions, skipping steps such as the formulation of requirements, concept generation (also known as ideation) and evaluations of these concepts. That is, they do not give much attention to the conceptualisation of those solutions. Therefore, sound detailed solution design based on (existing) sound conceptual principles is rather the exception than the rule. Thus, the conceptual design phase seems often not to be addressed explicitly enough in such a design exercise. The opportunities for research come down to this gap in knowledge, which is about the conceptual design of cognition enhanced business processes. Hence, this research only focuses on this conceptual design phase of the transformation of business processes to their cognition enhanced state (indicated in blue in Figure 1.3).

More specifically, this research thus addresses how the conceptualisation process of designing such cognition enhanced business process looks like, which is input for detailed design, development and implementation of such a enhanced business process. Thus, delineating to this even smaller grained description of the problem at hand, the 'how to get there' seems a big but very important challenge to come to proper designed cognition enhanced business processes. This is exactly the unknown this research is tackling, by developing and proposing a conceptual design process that supports the (conceptual) design of cognition enhanced business processes. This research will therefore answer the following main research question:

Can a conceptual design process of knowledge-intensive business processes be created, such that the cognition utilised in the process can be enhanced by integrating Artificial Intelligence software?

To answer this main research question, two projects are analysed which consists of the design, development and implementation of business processes that leverage the technology of commercial AI. In

these projects – used as case studies in this research and explained later on in this thesis – the design of the business process enhanced by AI software is the main topic. Such enhanced business process is the envisaged state which is created by means of an enhancement process or transformation. Both projects consider the commercial available IBM Watson as the AI software to be leveraged in their business process under review.

This research is thus interested in analysing, i.e. obtaining information about, the transformation of the current state of a business process towards this enhanced state of a business process by leveraging AI software, a future state that is not known on forehand. According to the SDLC (recall Figure 1.3), the transition of a business process to its enhanced version entails several phases. Through a design phase, a formal design of the enhanced business process that is envisioned, is specified. This results in a designed enhanced business process. As described above, this phase is of particular interest to this research, since it includes the conceptual design phase of a system, e.g. a cognition enhanced business process. Therefore, and also explained earlier, the development phase, the implementation phase and their subsequent states are outside the scope of this research.

As has been argued before, no general rules exist that support the conceptual design of business processes that utilise Artificial Intelligence software. More specifically, no literature exists that describes or prescribes a process for the conceptual design of enhanced business processes, that could serve as a point of reference for similar future projects. Such a process is called a conceptual design process. A conceptual design process provides valuable information on how to approach a conceptual design of a system and how to execute such a conceptual design phase. A conceptual design process of cognition enhanced business processes can thus deliver the information this research is looking for in order to answer the main research question.

To answer the main research question, the conceptual design phase of systems in general is investigated. Within the scientific field of Design Science, design theory provides us with a sequence of steps a conceptual systems design sub-phase consists of (Dym and Little, 2010):

1. Establish functions
2. Establish requirements (function specs)
3. Establish means for functions
4. Generate design alternatives
5. Refine and apply metrics to design alternatives
6. Choose a design

Leveraging these steps of the conceptual systems design phase, Figure 1.3 can further be specified as in Figure 1.4 indicating the to be constructed design process in this research. Stage 1 of the conceptual design process is to establish the functional requirements of business process. Stage 2 entails the specifications of the capabilities of AI software under review. Since both case study projects use the IBM Watson software suite, this research builds upon the set of AI capabilities of IBM Watson. Both steps are input for Stage 3, in which the requirements from Stage 1 and the capabilities of Stage 2 are

matched to each other, ultimately generating a set of possible designs in Stage 4. This set of so called design alternatives can then be refined and assessed based on predefined metrics in Stage 5, which can be used to finally choose a design in Stage 6, thereby completing the conceptual design phase.
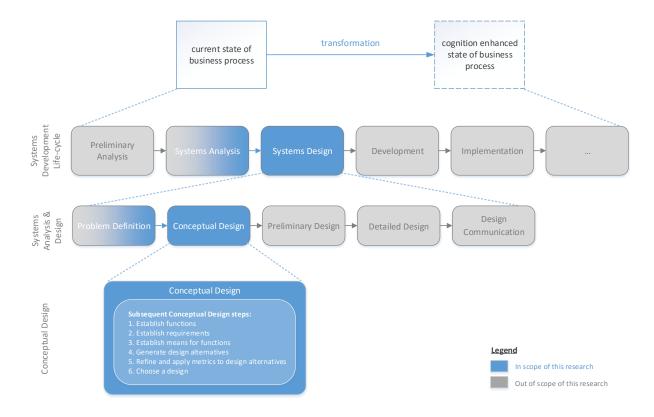
FIGURE 1.4: Transformation of a business process to its enhanced state, highlighting the relevant SDLC phases and sub-phases of this research

Regarding these steps of of this conceptual design phase, this research focuses only on the first three steps, since those steps form the essential part to generate design alternatives, which is the ultimate rationale underlying this research. Due to time constraints the latter steps are not addressed in this research and are thus out of scope. Formulating these steps according to the main question and objective of this research, provides five research issues which are solved and covered further in this thesis. Figure 1.5 denotes these research issues; to establish requirements and establish functions, such that they together can construct possibilities for AI software to enhance the cognition of a business process.

A project focusing on enhancing the cognition present in a business process can reason along two main ways of thinking or basic principles for the design and development of cognition enhanced business processes. Firstly, a business process can be *optimised* by making changes to its current state. This way of thinking inherits the current existing business process, its as-is situation, as the starting point of the development of the cognition enhanced business process. It transforms the current state of the business process into the to-be state by reasoning about the elements of the current state, improving the existing elements of the process. Secondly, a business process can be *designed from scratch*, abandoning the
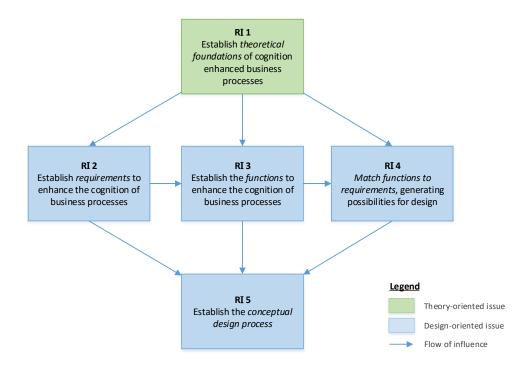
FIGURE 1.5: Research issues covered in this research, their solutions together form the envisioned conceptual design process

as-is situation entirely, reasoning solely from the to-be state. This way of thinking lacks constraints imposed by the currently present business process and is, in other words, a greenfield project. It questions the existing elements of the process in the first place, improving the business process from ground up.

Preliminary analysis shows that current projects pursuing AI for business processes are projects that address the transformation as an improvement of the current process; optimising a business process by enhancing its cognition. These projects are set-up to identify the opportunities for the current state of the business process (projects described in Chapter 3); businesses are reluctant to complete transformations of their processes, since they find it too risky due to the newness and rapid development of the technology and the solution to be too ill-defined, which is in line with literature about technological projects (de Bruijn and Heuvelhof, 2012). The conceptual design process to be created here therefore embraces the way of thinking to optimise the business process, rather than opting for a design from scratch.

Enhancing the cognition utilised in business processes by leveraging the support offered by a conceptual design process can be part of more comprehensive change projects within an organisation. Process improvement projects embracing Lean management (eliminating waste and ensuring swift) and/or Six Sigma (eliminating defects and reducing variability) focus on optimising the current business process. These concepts are driven by methods such as the Deming Cycle (Plan-Do-Check-Act), DMAIC improvement cycle (an acronym for Define, Measure, Analyse, Improve and Control), et cetera. Enhancing the cognition of a business process can contribute to these types of improvement, by processing

data in a smart way such that waste and variability are minimised. A conceptual design process for enhancing the cognition of a business process can offer a hand in this improvement projects, supporting the improvement of a business process by introducing AI technologies that enhance the cognition utilised. How a conceptual design process can fit in such a general process improvement project is however out-of-scope of this research and subject for future research (see Chapter 8).

AI technology cannot be leveraged without data that fuels these technologies. Therefore, data are assumed to be important for the development of cognition enhanced business processes. Here, the concept of 'Garbage-in, Garbage-out' applies; the AI system will not produce any desirable outcomes when its is provided unintended data (Babbage, 1864). For example, input data can be incomplete, inconsistent, not accurate and/or not precise, resulting in low data quality (Dravis, 2004). AI systems that process data of low quality will deliver undesirable outcomes to the business process, which will on its turn lead to faulty operation. Hence, one can expect higher level of cognition in the business process when the quality of the data is improved for automation. Section 2.2 further elaborates on the concept of data in the conceptual design process.

1.4   In Pursue of Insights

The question that now raises is how business processes are scrutinised to gather the desired information to ultimately answer the main research question stated above and comply to the research objective. Fuelled by the decomposition of a general cognition enhanced business process in Figure 1.4 and Figure 1.5, this research is interested in analysing and obtaining information about the formulation of requirements of a business process, formulation of functions of (AI) software i.e. and the process of generating means for functions.

To come to answers to the main research question, I use a design-method itself to come up with a design process that can be used by business process architects and developers. The approach that I used for this analysis is the *Research through Design* (RtD) approach. This approach is well suitable for this research, because it entails the systematic act for acquiring information taking advantage of the insights gained through a conducted design practice. Hereby, it provides an understanding of complex and future-oriented issues regarding the design of the system under review. This approach has an iterative character, testing acquired information continuously by comparing it to available literature and by reflecting on the design in practice, thereby acquiring relevant insights. This research gained its insights by designing cognition enhanced claim-assessment processes of two different health insurance companies as case studies. A further elaboration and explanation why the Research through Design approach is useful and its application to this research can be found in Chapter 2, which addresses the research methodology.

1.5   Outline of Thesis

Tying together the statements above to the main interest of this research provides us a clear understanding of the subject of this research: business processes' cognition enhanced by AI software. This research does an attempt to couple knowledge from the Artificial Intelligence research community to

the operational business community using concepts such as intelligence and cognition. Figure 1.6 visually describes the stages of this research and how they are linked, as well as the structure of this thesis.
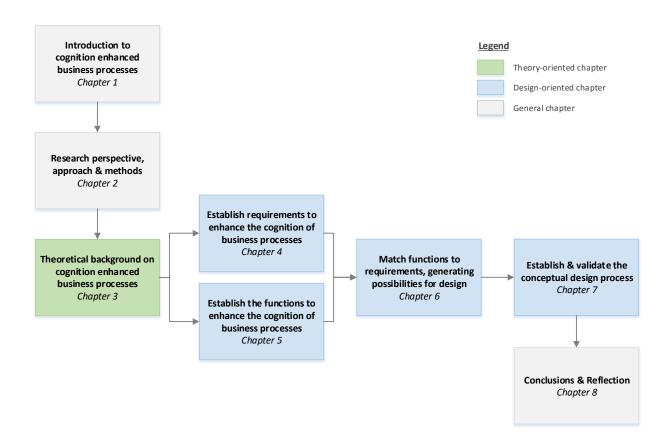
FIGURE 1.6: Visual outline of this research

Firstly, Chapter 2 further elaborates on the problem at hand by indicating the need for proper understanding of theoretical concepts such as Business Processes, Cognition, Artificial Intelligence and Systems. Furthermore, it introduces the perspective of this research on these concepts and their coupledness to each other. Besides, it argues more in detail about the research approach that is just touched upon, which guides this research such that it will come to an answer to the main research question. This chapter concludes with a draft overview of the design process constructed in this research. A more solid theoretical background on the concepts just mentioned is discussed in Chapter 3, resulting in a framework for the categorisation of requirements of business processes and capabilities of AI software. Chapter 4 then starts of with presenting the first stage of the design process, to identify and formulate the requirements of business processes. How to identify and specify the capabilities of AI software is addressed in Chapter 5, which forms the second stage of the design process. By matching these 'cognitive' requirements and -capabilities from the first two stages of this conceptual design process to each other, the opportunities of AI software in the business process under review can be identified, which can be combined into design alternatives. This matching is underpinned by the theoretical framework derived in Chapter 3, resulting in the third stage of the design process that is

discussed in Chapter 6. The three stages elaborated in Chapter 4, 5 and 6 are illustrated by means of a case study, a business process that is enhanced by AI software. These three stages of the design process form together the whole conceptual design process that this research delivers to the scientific and business community. The integration of these three stages is described in Chapter 7. It furthermore introduces and elaborates on the second case study and expert round table discussion used in this research used for validation of this research. The conclusion that can be derived from this design exercise is presented in Chapter 8, as well as reflecting notions on this research. Furthermore, this chapter presents the insights generated while performing this research, thereby contributing to achieve the research objective. The chapter ends with stating recommendations to the business community regarding the design of AI systems solutions, and suggestions for further research.

2 | Research Methodology & Setup

This chapter further elaborates on the topic of using AI software in business processes, and more specifically how it is studied in this research. Section 2.1 starts where Chapter 1 left of: defining this master thesis research, describing the research's theoretical perspective on the concepts of interest. Next, Section 2.2 elaborates on the specific setup of this research, which results in the outlines of the conceptual design process constructed. This section delivers the pointers for Section 2.3, which describes the research approach *Research through Design* more in detail, as well as the methods that are applied. Furthermore, a set of criteria is presented to which the conceptual design process should comply. A brief summary of this chapter is provided in Section 2.4.

2.1 Theoretical Perspective on Cognition Enhanced Businesses Processes

Before elaborating further on the methodology used in this research, some general notions should be made on the perspective of this research regarding the important concept it makes use of: Artificial Intelligence, in the light of business processes. From experience obtained throughout this research, it is noted that multiple viewpoints can be taken to analyse the topic of this research: purely from a Business perspective, purely Information Technology perspective, purely Computer Science perspective, or a more integrated perspective. This indicates that a clear explanation of the perspective taken in this research is of value, and even necessary to describe this research and its results. This section therefore elaborates on its topic and how it adds to the perspective taken this research.

Artificial Intelligence studies the design and development of intelligent systems, systems that express some form and degree of intelligence. AI methods and techniques have the potential to create a software system that expresses (some form and degree of) intelligence (Russell and Norvig, 2003). As formulated by (Langley, 2012), AI research were, in its early days, guided by the common vision of *"understanding and reproducing, in computational, i.e. machine systems, the full range of intelligent behaviour observed in humans"*. The same perspective is initially used for this research.

However, some scholars in the field state that, for a couple of decades, the field of AI emerged in a way in which it somewhat abandoned these initial and grand goals (Langley, 2012; Heylighen, 2011; Brachman and Lemnios, 2002). Langley (2012) states a couple of factors that caused this change of focus of AI research:

- Increased computer speed and storage has aided simple-minded CPU-intensive and memory-based approaches;
- Emphasis on quantitative performance metrics has encouraged incremental progress on standardised problems;
- Influence of mathematics has led to "theorem envy" and to an optimality obsession, encouraging a focus on simple tasks;
- Commercial success on narrowly defined problems has fostered research on similarly limited tasks.

According to Langley (2012), these trends together have transformed AI in to the research field as it is to date, adopted more restricted goals than its initial vision, for example focusing more on specific algorithmic challenges in sub-fields such as Machine Learning.

This research studies the enhancement of this cognition of business processes by leveraging the (intelligent) computational capabilities of machines (AI). Humans play a very important role in organisations and their (business) processes: they are the entities that exhibit intelligence and cognition, using it in favour of the business. This is the intelligence and cognition utilised by business processes to achieve their goals. Therefore, this research also largely takes into account human intelligence, and thus not solely built on machine intelligence. Hence, a purely Computer Science perspective does not suit the intentions of this research.

As a result, the modern approach of the field of AI is not used in this research, since a more comprehensive perspective is desired. However, it identifies itself for a bigger part with the initial broad vision of the field of AI, as mentioned above. Its view on the design of intelligence thus calls for a perspective that integrates this human- and machine intelligence, addressing integrated intelligent systems, opposed to fragmented algorithmic components of intelligence.

A field of study addressing the design of these integrated intelligent systems is found in the paradigm of *Cognitive Systems*, a term championed by Brachman and Lemnios (2002). This field of study refers to the discipline that designs, constructs, and studies computational artifacts that exhibit the full range of human intelligence. According to Langley (2012), this field is not, at heart, a new movement, but rather a continuation of the old, initial vision of the field of Artificial Intelligence. To make clear, this research does not oppose itself to AI research, but identifies its way of thinking to the Cognitive Systems paradigm – a paradigm that also not opposes the field of AI, but, besides its similarities to AI, also has some fundamental differences. Put differently, the Cognitive Systems paradigm broadens the thinking of the field of Artificial Intelligence towards the design of human-level intelligent systems.

In his article on Artificial Intelligence and Cognitive Systems, Langley (2012) characterises the Cognitive Systems paradigm by means of several assumptions that it adopts, in which it differs from the characteristics of the field of AI. To describe and clarify the perspective of this research on the design of intelligent systems, these characterising features as formulated by Langley (2012) is here briefly adopted and elaborated. They provide understanding of the concept of Cognitive Systems and set the

scene for further deliberation on cognition enhanced business processes.

High-level cognition The Cognitive Systems paradigm takes into account high-level cognition, a feature that can be clearly distinguished from current researched AI capabilities to recognise concepts, perceive objects, or execute complex motorised skills. These abilities are clearly important for agents that operate in physical environments, but they are not real distinguishing features of intelligent systems. Rather, this intelligence here entails the capacity to engage in abstract thought that goes beyond immediate perceptions and actions, having the capacity to engage in multi-step reasoning, to understand the meaning of natural language, to design innovative artifacts, to generate novel plans that achieve goals, and even to reason about their own reasoning as humans are able to do.

Structured representations Early AI researchers also assumed that structured representations play a central role in intelligence, which in turn depend on the ability to represent, create, and interpret content encoded in such representations. This position is closely related to the fundamental insight – arguably the foundation of the 1956 AI revolution – that computers are not simply numeric calculators but rather general symbol manipulators. This emphasis runs counter to recent trends in many branches of AI, which, over the past few decades, have retreated from this position. Some sub-fields, such as Machine Learning, have abandoned almost entirely the use of interpretable symbolic formalisms, caring only about performance (such as improving even more the prediction accuracy of Machine Learning models).

System-Level Research A third feature that characterised much early AI work was an emphasis on system-level accounts of intelligence. Because researchers envisioned comprehensive theories of the mind, they naturally recognised the need for their programs to comprise a number of interacting components. The argument for this approach was compelling: because intelligence is clearly such a complex and multifaceted phenomenon, even partial accounts should incorporate multiple capabilities and aim to explain how these different processes can work together to support high-level mental activities of the sort observed in humans. Despite these promising beginnings, by the 1990s many researchers had come to focus on component algorithms rather than integrated systems.

Heuristics and Satisficing Another central assumption of initial AI research was that intelligence involves heuristic search. Using heuristics clearly differentiated AI from mainstream computer science, which emphasised 'algorithms' that provided formal guarantees. The resulting systems often satisfied by finding acceptable rather than optimal solutions, and even these were not guaranteed. However, in practice, heuristic methods could often solve problems that the more constrained approaches could not. AI today turns away from this practical attitude and adopt other fields' obsession with formal guarantees.

Links to Human Cognition The design and construction of intelligent systems has much to learn from the study of human cognition. Many central ideas in knowledge representation, planning, natural language, and learning were originally motivated by insights from cognitive psychology and linguistics. The field also looked to human activities for likely problems that would challenge existing capabilities, and design intelligent systems that could offer support. However, attention

moved instead to problems on which computers can excel using simple techniques combined with rapid computing and large memories, like data mining and information retrieval. Langley (2012) claims that they reveal little about the nature of intelligence in either humans or machines, and there still remains a need to research this.

Exploratory Research Because in the early days of AI few examples of intelligent artifacts existed, a common strategy was to identify some intellectual ability of humans, design and implement a system that exhibited it, and demonstrate its behaviour on a set of convincing examples: exploratory research. However, when people began to develop new approaches to established problems, it became natural to compare the behaviours of different methods. Performance on metrics became increasingly important, however, the broad coverage of intelligence was not yet achieved. As a result, there remains a need for exploratory research on cognitive systems that demonstrate a wider range of capabilities, even if they are not as efficient or accurate as current techniques.

This research embraces the paradigm of Cognitive Systems to study the enhancement of cognition of business processes by AI software. It is thus a more integrated perspective, combining a human-centric approach to the design of intelligent systems and a machine-centric approach. Furthermore, it uses systems thinking principles to structurally analyse and design such systems (see Figure 2.1).
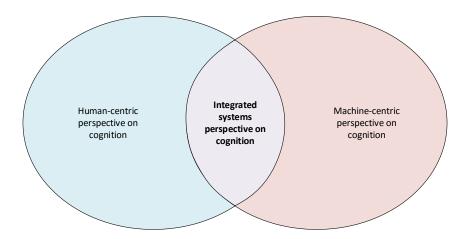
FIGURE 2.1: Visualisation of the perspective taken in this research, formatted in bold

The context of this study involves organisations, and more specifically the business processes that structure their expressed business efforts. Each process existing in an organisation contributes to this overall organisation goal in its own way. Utilising AI in a business process is pursued to better achieve the objective of the business process. Goal-directedness is therefore important in the design of cognition enhanced business processes; the cognition enhancement should contribute towards achieving this goal. In the two case studies analysed in this research, the cognition enhancement takes into consideration the pursue of the business process to achieve its highest goal. In addition, the goal of the business for the transformation of a business process to its cognition enhanced state is therefore also important in

order to be able create a proper design, since it forms the input, i.e., rationale for the actual design exercise.

Furthermore, because the conceptual design process does not necessarily focus on the enhancement of cognition of human beings, it focuses more generally of cognition utilised in the process (systems perspective) and higher this level of cognition. The word *enhancement* covers this description in a correct way. If it would specifically focus on the cognition of people in the business process, it would be called augmentation – a concept also studied in scientific literature.

So far, this chapter intended to clarify the topic of this research by discussing Artificial Intelligence (software), human- and machine intelligence, their role in business processes, and the overarching integrated perspective on intelligent systems of the theory on Cognitive Systems. How to leverage these AI software in a business process context such that it increases the cognition that is utilised in the process, is a complex question, but a question this research aims to tackle. To answer this question, one has to research cognition in the context of business processes, which is done in the next chapter (Chapter 3) of this thesis. This thesis first introduces and explain the approach and methods applied by this research to in the end deliver insightful and useful results.

2.2 Conceptual Design Process for Cognition Enhanced Business Processes

The main question of this research that should be answered is how the conceptual design process of knowledge-intensive business processes, enhanced by integrating Artificial Intelligence software, looks like. Utilising the theoretical perspective as explained in Section 2.1, this enhancement can be seen as cognitive enhancement. Chapter 1 already provided a description of a cognitive enhancement, as it is the transformation of the current state to the desired state of a business process in which it possesses increased cognitive capabilities (see Figure 1.1). The conceptual design process supports the future design steps of cognition enhanced business processes, and thereby addresses the transformation of the current state of the process into its enhanced state. The ultimate goal of such a cognition enhancement, i.e. transformation, is to create actual business value, e.g. more efficiency and/or more consistency of its operations.

Recall Figure 1.4 in Chapter 1, schematically representing the decomposition of a enhanced business process into different phases, based on the Systems Development Life-Cycle (The US Department of Justice, 2003) and Design theory from Dym and Little (2010). They presents some general steps to construct a conceptual design of a system through the design phase and design process. However, they are therefore not very specific for a cognitive enhancement of a business process. Regarding the context of this research, this specification is highly needed, since commercial AI software is just seeing light to commercial application and therefore very little knowledge about the concepts in this practical domain exists. Besides, no experience is present which can be built on. Furthermore, even no shared vocabulary is used by professionals initiating the design of these new technology driven process within their organisations.

These factors demand a more sophisticated design process that is tailored to cognition enhanced business processes. First, this envisioned design process should grasp the (human-) cognitive aspects of the business process and deal with them, since this research also utilises a human-centric focus next to a machine-centric focus, as explained earlier. Second, the design process should deal with commercial AI software, since this research is studying how actual implementable business software can be of value to the business. Third, its use should at least be understandable for relevant stakeholders, such as process architects, software system developers, end-users, process managers and innovation officers.

Reformulating the steps of Dym and Little (2010) to suit the theoretical perspective on Cognitive Systems provides an overview of the stages of the conceptual design phase that suits this research:

1. Establish the requirements of a business process which indicate the opportunities for AI software (opportunities to enhance its cognition). From now on, these are called **cognitive requirements (CR)**.
2. Establish the capabilities of AI software to fulfil the opportunities in the business process and thereby providing the cognition enhancement that is demanded. From now on, these are called **cognitive capabilities (CC)**.
3. Establish a way to match the cognitive requirements of business processes and cognitive capabilities of AI software. This can be seen as the way to establish means to enhance the cognition of business processes.
4. The fourth and last stage is the integration of these three stages, i.e. design sub-processes into the final conceptual design process, by including the fourth, fifth and sixth step of the conceptual design phase of Dym and Little (2010).

With this knowledge, Figure 1.4 can be contextualised for this research, which results in Figure 2.2. For clarity, note that only the stages addressed in this research are visualised. The steps *Generate design alternatives*, *Refine and apply metrics to design alternatives* and *Choose a design* are not displayed.

Regarding the application of the envisioned conceptual design process, this research assumes that a business process as object for the enhancement is already chosen on forehand. This also applies to the software suite that is selected to perform the enhancement. Thus a selection process is likely to be executed, before starting with the cognition enhancement process as described in this research. Such selection will probably be based on a business assessment, considering largely the financial aspects of such a project. To be clear, this selection process based on business/financial assessments are out of scope of this research: it only considers the potential possibilities of cognition enhanced business process by AI software.

The three stages presented above together form the envisioned **Conceptual Design Process (CDP)**, besides the process for generating and selecting design alternatives. This research however argues that the context specific issues for the conceptual design phase of cognition enhanced business processes are mainly present in the first three steps of the conceptual design phase (see Section 1.4). That is, because in these first steps the possibilities for AI technologies in business processes are actually
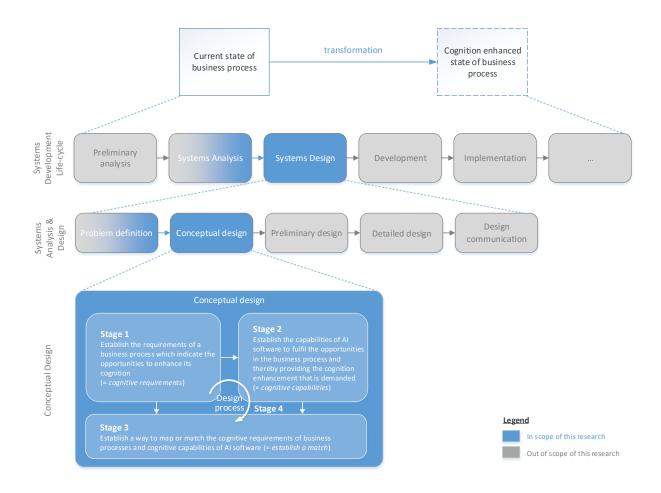
FIGURE 2.2: Transformation of a business process to its enhanced state, highlighting the conceptual design phase as made applicable for this research

investigated. The generation of design alternatives and subsequent design steps can be executed similar to other design exercises. However, for a complete picture, these latter steps are jointly represented in a separate process and included in the CDP. As of now, the following sub-design processes can be formulated:

1. **Cognitive Requirements Design Process (CRDP)**: establishing the cognitive requirements (CR) of a business process

2. **Cognitive Capabilities Design Process (CCDP)**: establish the cognitive capabilities (CC) of AI software

3. **Cognitive Possibilities Design Process (CPDP)**: establish means to enhance the cognition of business processes by *matching* the CC's to CR's.

4. **Design Alternatives Generation & Selection Process (DAGSP)**: construct design alternatives from the results of the CPDP, select based on pre-defined metrics.

Based on the above, the structure of the CDP can be visualised as in Figure 2.3. It indicates the different components the CDP can consists of. This breakdown is used in this research to construct the CDP as envisioned.
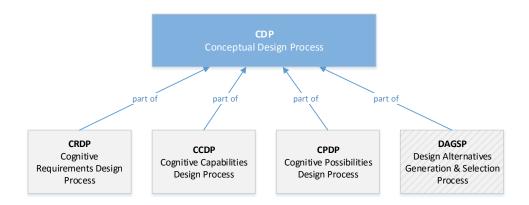
FIGURE 2.3: A schematic visual of the envisioned conceptual design process and its components –
the striped component is outside the scope of this research

The above described the distinct components of an envisioned CDP. These components together form the basis to draft designs for cognition enhanced business processes, the main purpose of the CDP. It is preferable to know on which aspects a CDP can be assessed, next to its content. These important aspects are here called criteria, and indicate why and to what extent a conceptual design process is suitable for use if met. From informal interviews with designers and developers of AI systems in business processes in the preliminary analysis of this research, a set of four criteria is drafted and listed below. Throughout this thesis, the criteria relevant to each part of the CDP constructed in this research are mentioned and argued for. In this way, more substantiated argumentation can be provided to answer the main research question raised in Chapter 1.

Universally applicable The CDP is ought to be applicable to different business processes within the domain it is constructed for, as well as different AI software packages. The subject and scope of this research limits the CDP to be made for knowledge-intensive (claim-) assessment business processes, thereby, all business processes matching this characteristic should be suitable for cognition enhancement by the CDP. The same holds for the AI software packages used in a cognition enhancement project. The CDP thus should not exclude certain business processes or software packages by its structure, content or otherwise. Hence, universal applicability is pursued.

Methodical in essence For the CDP to be useful in projects that strive for cognition enhancement, the CDP is ought to be usable for designers and developers of AI systems in business processes in general. Furthermore, the CDP is ought to support their practice by providing rigid to the design process on the one hand, but also room to manoeuvre in the design and design process on the other hand. Hence, the CDP can steer the design process to an extent while remaining variety in the designs it produces. This asks for the CDP to be methodical in its essence and its different components should accommodate a systematic or established procedure.

Flexible but robust As mentioned in the introduction of this thesis, the AI technology is evolving. The CDP should be flexible to changes in the state-of-the-art, such that it is still useful when technology capabilities change during a design process. That is, it is ought to embrace the

changes in a software package and adjust its design to. The same holds for business processes, which in reality not always follow the same work flow according to procedures. The CDP should be able to deal with these changes to produce a suitable design. On the contrary to its flexibility to changes the design should adapt to, the CDP should be robust to external disruptions. For example, a design produced by the CDP should resilient to the disappearance of a member of the design team, and not to jam when this occurs. The degree of flexibility and robustness at the same time is a balancing act, considered in the construction of the CDP.

Context-aware At last but still important is the fact that the CDP should be constructed in such a way that it accommodates the design (cognition enhanced business process) to the context it is exists in. That is, it is ought to perform and work is such a way that its design is suitable to its environment. Here, the people performing activities in the business process, information that they use and the data that underlies this information are considered as the environment. For example, it should not rush certain design steps when stakeholders do generally speaking not agree on their outcomes. In this case it is considered to be better if more effort and time is put in these steps.

Furthermore, the influence of *data* to the design process and thus design is assumed to be of importance in Chapter 1. Data powers AI technology, and is therefore relevant for investigation what role data plays in the context-awareness of the CDP. The CDP is therefore ought to indicate the designer when and how to take into account data during the design process. For example, if data is not available or considered to be of insufficient quality, the number of possible designs can decrease. Thus, data can be of importance when designing cognition enhanced business processes. If the data is of too bad quality, projects can be initiated in the organisation to create (new) data needed for possible solutions. The latter is not further discussed in this thesis.

With the more specific conceptual design phase as showed in Figure 2.2 and structure of a CDP in Figure 2.3, a related design process can be inferred. However, this is not a straightforward assignment, due to the lack of knowledge, experience and shared vocabulary that qualify the design of cognition enhanced business processes. Partly due to these unknowns, a hand full of examples of such designed enhanced processes only exist in both the business community and/or scientific literature. This results in even more unknowns on forehand such as how such a enhanced process actually will look like and what exactly is making the design of these enhanced processes so difficult. Furthermore, the problem overarches more than one field of study (Artificial Intelligence, Cognitive Systems, Business Process Engineering, et cetera) and is therefore interacting with an evolving set of interlocking issues and constraints.

This characterisation of the problem, the design of a cognition enhanced business process, indicates that it can be denoted as a so called *wicked problem* (Rittel and Webber, 1973). Another noticeable characteristic of wicked problems is that they do not have a defined goal. In case of a wicked problem, if you cannot define the problem, how can you tell when it's resolved? Therefore, wicked problems do not have a perfect solution (Rittel and Webber, 1973), the solution is rather good or bad. When solving a wicked problem, the designer keeps iterating and refining the solution – or goes back and considers other solutions. The research and design process does not have an ending, since a better

solution is always possible. However, the problem solving process ends when you run out of research resources, such as time, information sources or money (Rittel and Webber, 1973). These statements suggest a scientific research approach is needed that is able to deal with these kinds of unknowns and uncertainties. The research approach *Research through Design* is known for exactly these purposes, and is described in the next section.

2.3 Research Approach and Methods

Research through Design (RtD) is described in literature as an approach to structurally and continuously design and refine an envisioned artifact (Godin and Zahedi, 2014). It is a conceptualising research done by means of the skillful practice of design activity, revealing research insights (Krogh et al., 2015). More specifically, this knowledge is gained by conducting a design exercise and continuously extracting information by means of direct and indirect observations, beliefs and experiences (van Langen, 2015a). The approach has a highly iterative character, switching frequently between a theoretical and a practical application perspective (van Langen, 2015b).

Research through Design lends itself for addressing wicked problems through its holistic approach of integrating knowledge and theories from across many disciplines, and its iterative approach to re-framing the problematic situation and the preferred state as the desired outcome of the research (Zimmerman et al., 2010). The resulting artifact can be seen as a proposition for a preferred state or as a placeholder that opens a new space for design, allowing other designers to make artifacts that then better define the relevant phenomena in the new space (Zimmerman et al., 2010). Furthermore, design researchers have claimed that RtD can result in conceptual frameworks and guiding philosophies as well as community discourse on preferred states, identification of gaps in current theories from other disciplines, and indications of new materials (technology) that would be especially valuable to invent. Finally, literature describes how RtD leads to new artifacts (products, environments, services, and systems) where the artifact is itself is a type of implicit, theoretical contribution. The power of these artifacts was described in how they codify the designers' understanding of the current state. This includes the relationships between the various phenomena present, and furthermore the description of the preferred state as an outcome of the artifact's construction (Zimmerman et al., 2010).

Based on the description above, Research through Design is considered to be a suitable approach to use in this research. By means of iteratively conducting a design exercise and frequent use of relevant theories (which is done in both case studies), insights are extracted for designing a cognition enhanced business process. This can result in valuable input for the construction of the conceptual design process this research is pursuing. To provide the definition of a design process as used this research, the terminology of van Langen (2002) is used: a design process is in this thesis defined as "*a sequence of design activities, such as civil engineering or software design*". A design activity is defined as "*an act of designing, such as the refinement or structuring of a design problem, or the generation of a design solution*" (the final version of the design). Leveraging this definition, the sub-design processes as pointed out in Figure 2.2 will thus consist of a sequence of design activities. By utilising the Research through Design approach, these design activities of the envisioned design process of cognition enhanced business processes are therefore revealed through the design exercise this approach entails. Appendix A further

elaborates on Research through Design as a scientific research approach and describe the Research through Design-process this research went through.

To show that the cognition of business processes can be enhanced, this research illustrates and validates this design process to an actual case: a claim-assessment process within the health insurance business. Currently Jibes Data Analytics, a small sized IT advisory organisation in the Netherlands, runs projects at two health insurance companies to design, build, implement and test AI software in their current claim-handling processes. The goal of these two projects is to enhance the processes, for two main reasons: to be more efficient (less time per claim assessment, at least maintaining the same assessment quality) and to assess the claims more consistent (assessing claims with similar characteristics the same way) (van der Hulst, 2015). These two projects are used in this research as case studies; one for illustrative purposes, one for validation purposes.

In this process, subject matter experts (SME's) assess health insurance claims from patients and health providers and decide if these claims will be granted or not. These SME's have extensive knowledge of and experience with medical treatments, which they use to assess the claims. However, to assess these insurance claims they also use a lot of information from several external sources: law books, internal protocols, state-of-the-art literature, and so forth. To search for and collect all the right and relevant information for a particular case, and make a right and well-founded decision, is a complex and time consuming activity. Altogether, this makes the process very knowledge-intensive. The next chapter further elaborates on these two case studies.

2.4   Chapter Summary

First and foremost, this chapter introduces and argues the perspective take in this research (Section 2.1). This perspective comprises a systems perspective on cognition, found in literature under the name of Cognitive Systems. Furthermore, the research's both human-centric focus and machine-centric focus denote the integrated nature of its perspective. Next, this chapter further describes the envisioned conceptual design process where Chapter 1 left of, identifying the sub-design processes it consist of. These sub-design processes are design processes on themselves: a Cognitive Requirement Design Process (CRDP), a Cognitive Capabilities Design Process (CCDP), a Cognitive Possibilities Design Process (CPDP) and a Design Alternative Generation & Selection Process (DAGSP) (Section 2.2). This chapter concludes with an introduction to the approach utilised by this research, called Research through Design (Section 2.3). It provides a more detailed description of this approach, which has an exploratory nature.

Besides this, this second chapter also served as the introduction to the 'way of thinking' this research embraces and presumes when reading this thesis. This research is proposed and conducted with constant thoughts of experimenting in a (new) field which is not trusted by all people. This research thrived based on creativity and bold ideas, not only focusing on precision, but also on hunches and intuitions.

3 | Theoretical Notions on Cognitive Systems in Business Processes

This chapter presents the research that is conducted on the first research issue (RI1) raised Chapter 1 in Figure 1.4: *Establish theoretical foundations of cognition enhanced business processes.* That is, it describes a way to describe and analyse cognition in business processes from an integrated systems perspective (see Section 2.1). Thereby, it pursues to deliver a theoretical foundation for the design of the envisioned conceptual design process of cognition enhanced business processes.

First, this chapter introduces the first of the two case studies used in this research in Section 3.1. Throughout this and following chapters, this case is used to provide examples of the theoretical concepts and methods explained. Next, Section 3.2 elaborates on Cognitive Systems, the concept of cognition analysed from a cybernetics perspective. It defines the important concepts that are used in this thesis, such as system, agent, intelligence, their properties and their components. Thereafter, these theoretical concepts are linked to the main object under study in this research, business processes, in Section 3.3. Section 3.4 concludes this chapter by summarising the takeaways on the concepts addressed.

3.1 Introduction to the Claim-Assessment Process

As explained in Chapter 2, two cases are studied to execute this research. One case for illustrative purposes throughout the first three sub-design processes (CRDP, CCDP and CPDP), one for validation purposes of the final design process. Both case studies entail the claim-assessment process of a health insurance company.

Health insurance companies offer insurances to clients. They reimburse claims they receive from their clients to compensate for medical related treatments they receive from health suppliers. Stakeholders that play a role in such a health insurance market are clients (the insured), the health practitioner, the health specialist, the health supplier, the insurance company and the government.

Part of their business consists of checking whether a particular client should be compensated for a health treatment or not. That is, assessing if the claim should be approved for reimbursement or not. This business process of a health insurer is called the claim-assessment process. Within this claim-assessment process in this case study, two sub-processes can be identified, which both have the same goal: assessing whether the claim should be approved or not. However, the first sub-process is executed by a claim handler that uses standardised tools (such as a decision-tree tool or other protocols)

to assess the claim. The second sub-process is executed by a subject matter expert (SME), which assess the claim utilising its own expertise. Expertise is here described as both knowledge and experience.

This claim-assessment process is a relatively straight forward process, as is argued in Section 4.1. However, it its a rather difficult process because substantive knowledge and experience is necessary to perform the process properly. The latter makes it a valuable object to analyse in this research, as Chapter 1 signified the potential of Artificial Intelligence applications to knowledge-intensive business processes.

Within the assessment process different forms and degrees of expertise are experienced. SME's are required to do training before starting their work, and the claim handler employees develop expertise handling claims and their assessment using the tools available to them.

These claim-assessment processes are quite representative for other assessment processes, such as the assessment process of a bank which provides or refuses a loan to a client (mortgage to house owner, loan to company to innovate, etc.). Both have similar characteristics: contextualised information (all information that is relevant to a specific case) is gathered, identified and analysed in such a way that it forms the basis for a particular decision. This decision is always made by a person accountable for making this decision.

The goal of this research is to deliver a conceptual design process that supports the design of cognition enhanced business processes. This implies that there is a rationale behind this enhancement, or transformation as stated in the introduction chapter of this research. This rationale is considered to be established by the business and related to financial aspects. Determining the rationale for this transformation is outside the scope of this research. In this illustrative case, the business goal for this transformation is determined by means of an interview with relevant stakeholders. The rationals in this illustrative case study are to (1) lower throughput time and increase of quality (2a. less errors, 2b. more consistency) (van der Hulst, 2015).

3.2 From Business Processes and Intelligence to Cognitive Systems

As briefly touched upon in the previous chapters, AI software is considered to provides business processes with clever automation solutions. In order to study these 'intelligent' functionalities of AI software and what they can bring to business processes, this chapter further introduces and describe the perspective this research takes regarding business processes and Artificial Intelligence. To do this, a deep dive into intelligence and even more into cognition within business processes is needed in the first place. This research is searching for a way to analyse this cognition within business processes and thus a detailed specification of how one can scrutinise the cognition that is utilised. Namely, if there is a way to describe cognition in a process, this can be leveraged to reason about how one can enhance this cognition. As stated before, this research investigates how AI software can play a role in this.

This section first elaborates on business processes and the entities that express intelligence in a process, called agents, in Subsection 3.2.1. Subsection 3.2.2 presents the definition of cognition as used in this research. Next, the systems perspective is introduced more in detail in Subsection 3.2.3 which is the foundation of the perspective taken in this research. Finally, Subsection 3.2.4 links the concepts

of Subsection 3.2.2 and Subsection 3.2.3 to each other, elaborating on the cognitive functions that a system in a business process could posses.

3.2.1   Agents and Business Processes

A business process is defined as a set of business activities that represent the steps required to achieve a particular business objective (Object Management Group, 2011). A business process consists of sub-processes (distinct parts of the process that can perform independently) and tasks (the work in the process that is not broken down to a finer level of process model detail). The execution of tasks is performed by entities in the business (process), functioning according to a certain role. Such role can be fulfilled by a human being, a software service or a combination of the two (Object Management Group, 2011).

Using the vocabulary of Artificial Intelligence field of study, these entities can be called agents. In the preliminary research conducted in the field of Artificial Intelligence, I noticed that a broad range of definitions and descriptions exists of agents. As described by Wooldridge (1999), there is no agreement in literature about what an agent exactly is and no universally accepted definition of the term agent exists. *"There is a good deal of ongoing debate and controversy on this very subject"* (Wooldridge, 1999).

One definition of an agent, created by Russell and Norvig (2003), is that an agent is *"anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors"*. An example of another definition provided by Wooldridge (1999), is that *"an agent is a [...] system that is situated in some environment, and that is capable of autonomous action in this environment in order to meet its design objectives"*.

Humans can be defined as intelligent agents (Russell and Norvig, 2003), but according to their definition of an intelligent agent (*"an autonomous entity which observes through sensors and acts upon an environment using actuators and directs its activity towards achieving goals and may also learn or use knowledge to achieve their goals"*), a thermostat is also considered an intelligent agent (complex versus simple agents). According to Wooldridge (1999), a distinction between agent and intelligent agents should be made. Wooldridge (1999) states that *"an intelligent agent is [an agent] that is capable of flexible [(reactivity, pro-activeness, social-ability)] autonomous action in order to meet its design objectives"*.

Besides their definition of an agent, Russell and Norvig (2003) state that there are agents in different forms such as human agents, robotic agents and software agents. This research is, however, not interested in these agents solely human or machine-like, but particular interested in agents as in an entity representing a combination of a human and machine (robotic or software service), where the machine is facilitating the human in its activities. This is because in a business process, such as the claim-assessment process, humans are executing tasks within the process, leveraging machines to support, i.e. facilitate them in the activities to perform these tasks.

I am fully aware that this field of agents within Artificial Intelligence is very broad. Furthermore, I recognise that I hereby only touch upon a small part of agent theory, which studies the design of (intelligent) agents. However, agents and their intelligent behaviour as described in the field of Artificial Intelligence inspired me to conduct this research, and is of interest to the development of this research. Besides, it is a logical starting point for this research, since we are here studying AI applications within business processes.

Before presenting the definition of an agent as used in this research, first some notions on intelligence and cognition ought to be made, considered from a human point of view. This is regarded as a legitimate choice, since we are studying humans that are performing tasks within a particular organisation (structured by business processes), facilitated by the machines they can utilise.

3.2.2 Intelligence and Cognition

Human beings are seen as entities that possess intelligence, i.e. behave intelligently. *Intelligence* is a term describing one or more capacities of the (human) mind. Human intelligence is studied widely in literature, all together covered by the umbrella term cognitive science. Cognitive Science consists of multiple research disciplines, including psychology, artificial intelligence, philosophy, neuroscience, linguistics, and anthropology (Thagard, 2014). Probably this is the reason that no uniform definition of intelligence exists.

To some extent, machines also can carry out intelligent behaviour, but very little relative to humans (Power, 2015). Recall the system that can play Go as introduced in Chapter 1. This system is considered to be capable in playing this one game. However, it cannot play other games, not to mention other capabilities that humans consider as very normal. This human intelligence is closely related to *cognition*. Intelligence can be seen as a subset of cognition, and popularly described as the set of conscious mental processes of a human being (Hendriks et al., 1997). Cognition is the collection of mental process and activities used in perceiving, remembering, thinking, and understanding, as well as the act of using those processes (Ashcraft, 2006). This is one of the many definitions of cognition; such as the concepts of agents and intelligence, multiple fields of study hold multiple definitions of cognition.

Nevertheless, some sort of definition of cognition is important for this research. The definition of cognition used in this research is composed out of several books on cognition, such as Ashcraft (2006), Anderson (2013) and Hendriks et al. (1997) by extracting the main concepts they address, and is worded as follows:

> **Cognition** – The ability to execute processes of thought including perception, recognition, memory, learning, knowledge, language, comprehension, goal generation, decision-making, judgement, reasoning and problem solving

To research cognition enhanced business processes, the following gap of knowledge to tackle is how this cognition is considered in business processes. Systems thinking on cognition, as studied in cybernetics, provides a perspective to research this knowledge gap.

3.2.3 System Perspective on Agents and Cognition

Above, I briefly touched upon agents, described from an Artificial Intelligence point of view. This research is however particularly interested in entities representing an entity that is a combination of a human and machine (robotic or software service), where the human is facilitated by the machine to execute its assigned tasks. Therefore, this particular entity is in this research related to what has been said before about agents, by leveraging a definition of an agent from systems (cybernetic) theory. The definition of an agent that is used in this research is obtained from Heylighen (2011): an agent is a goal-directed system that tries to achieve its goals by acting on its environment. *"Agents are typically organisms, such as animals or people. However, they can also be artificial systems, such as robots or software agents, with pre-programmed goals. They can even be organisations or other social systems, such as a firm, a football team, or a country, that consist of coordinated individual agents with a shared set of goals (e.g. making profit for a firm, winning for a football team)"* (Heylighen, 2011). To depict this description, think about an agent as a coherent and collaborating whole of a human and machine within a business environment.

The systems philosophy can be summarised by the well-known saying that *"the whole is more than the sum of the parts"*. A whole possesses **emergent** properties, i.e. properties that are not properties of its parts. For example, an organism has the property of being alive; the same cannot be said of the atoms and molecules that constitute it. A song has the properties of melody, harmony and rhythm, unlike the notes out of which it is composed.

A **system** can be defined as a number of parts connected by relations or interactions. The connections are what turn a collection of parts into a coherent whole. What thus counts are the relations between the elements, not the elements themselves (its emergent character). The essence here is **organisation**, that is, the pattern of connections and the information that is passed on along them, which give the system its coherence. An systems is always considered to be embodied in its environment, thereby interacting with this environment by inputs and outputs: they exchange matter, energy and/or information, and thus mutually affect each other. This leads us to define two other basic systems concepts:

- **Input**: what enters the system from the environment
- **Output**: what leaves the system to end up in the environment

Because we know that humans express cognition, i.e. execute cognitive activities, we can say that their abstraction in systems also hold cognition and the corresponding (cognitive) activities. Next to that, human beings live and only because they are alive, they are able to express their cognition. Therefore, a systems abstraction of a human can be denoted as (living) cognitive system.

Ideally, a system exists if its purpose is of value to the world it is embodied in. For example, within a company, a particular business process only exists if it adds value to the business, that is, it contributes to the general goal of the business. If it is not of any value, there is no need for the business to exist, because the burden of its existence (use of business's resources such as time, people, money, etc.) is higher that the gain it delivers to the business (which is then zero). This is the principle of a 'business

case'. However, there should be noted that in practice, organisations deal with legacy systems that do not entail value to the business.

This results in the principle that systems are **goal-directed** (Heylighen, 2011). Besides, all living systems are intrinsically goal-directed: *"they try to maintain and (re)produce themselves, in spite of perturbations from the environment"* (Heylighen, 2011). A system is pursuing a particular goal, whereby achieving this goal it creates value. In the example of a business process, the process has a particular goal. By achieving this goal, it adds certain value to the business by which it is coming closer to achieve its (overall) business goal.

In a business organisation however, humans are also working towards a certain goal: getting their work done (individual goal), such that the overarching goal of the organisation (business goal) is achieved. With that, a systems implicit goal or value is *fitness*. Fitness is defined as the quality of being suitable to fulfil a particular role or task. Thus, in the example of a business, a business process' fitness describes the quality of the process being suitable to fulfil the task it is assigned to by the overall business. If the fitness of a business process rises by the cognitive enhancement, the business process could perform better because of the cognitive enhancement. Futhermore, the fitness of a human-machine system to the business process describes the quality of the system of being suitable to fulfil the task in the business process it its responsible for. When such a system performs better due to a cognition enhancement, its fitness in the business process will improve.

From the literature on cybernetics, goal-directedness is achieved via **control** (Ashby, 1962; Heylighen and Joslyn, 2001). Control is the successful reduction of deviations from the goal by appropriate counteractions. For example, *hunger* is a deviation from the state of sufficient energy. Its counteraction is to find and eat food. The agent is in control if it manages to eat sufficient food not to stay hungry. A deviation thus triggers an action (finding and eating food), which produces a reduced deviation (less hungry), which in turn produces a further action (eat more), and so on, until all deviations have been eliminated (not hungry anymore). Thus, control is characterised by a negative feedback loop. A **feedback loop** is a circular coupling of a system with itself via the environment. The feedback is called negative when it reduces deviations, positive when it increases deviations.

Thus, agents are control systems, pursuing a goal and able to act to achieve this goal. Generally, such a system consists out of the following elements, also see Figure 3.1:

- **perception (P)**: information enters the agent from the environment, representing the situation as experienced by the agent.
- **goal (G)**: internal representation of the ideal or preferred situation for the agent.
- **action (A)**: the agent affects the environment in order to bring the perception closer to the goal.
- **diversions (Di)**: changes in the environment that affect the situation independently of the agent (i.e. that are not under control of the agent), making it deviate from its present course of action. Can be diversions that help the agent achieve its goal, i.e. positive diversions (affordances) or just the opposite, counteract the agent to achieve its goal, i.e. negative diversions (disturbances).

When an agent experiences a (current) situation (perception) which is not the same as its desired situation (goal), a difference (deviation) in situation is experienced/noticed by the agent. This difference
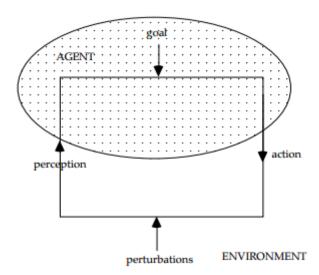
FIGURE 3.1: Schematic illustration of a Agent and its Environment (Heylighen and Joslyn, 2001)

in situation is called a **problem**. If there would be no difference, the agent would be perfectly satisfied and would have no reason to act. Two notions on problems here:

- A problem in this sense is not necessarily negative or unpleasant: it is sufficient that the agent can conceive of some way to improve its situation and is motivated to seek such a improvement. For example, if I feel like drawing, then my "problem" is defined as the difference between an empty page and a page with an esthetically pleasing sketch on it.

- A problem should also not be seen as something purely intellectual: if the cup I am holding tilts a little bit too much to the left, so that coffee may leak out, this defines a problem that I must resolve by restoring the balance.

Referring to state-determined systems, any problem is characterised by:

- an initial state, i.e. the situation you start from which is unsatisfactory (such as a car that does not start, or an unsolved puzzle).

- a goal state, i.e. a conceivable situation that would satisfy your criteria for a problem solution (such as a car that drives, or a puzzle where all the pieces have fallen into place).

With perceiving its current situation (initial state) and its willingness to reach its goal (goal/desired state), the agent's task is to bridge this gap between these to situations, i.e. solve the problem. To solve its problem, the agent has to select and perform one or more actions that together eliminate (or at least minimise) that difference (using the presumptions created by negative feedback loop).

For example, the claim-assessment process tries to minimise the number of claims in the cue that (still) need assessment. To achieve this, it executes tasks to perform this assessment of the claims. This is a sequential process: claims are assessed in sequence.

3.2.4   Systems and Cognitive Functions

As stated earlier, to execute certain tasks an agent in a company needs some form and degree of cognition. Thus, from a systems (cybernetic) perspective, when a system encounters a problem that

it wants to solve, cognition is required. If this system is capable of executing tasks (associated with a particular business process), it is capable of successfully expressing the right cognitive functions to get closer to its intended goal(s).

Recall the definition of cognition as used in this research: cognition is *"the ability to execute processes of though such as/including perception, recognition, memory, learning, knowledge, language, comprehension, decisions, judgements, reasoning and problem solving"*. From the definition of cognition, a decomposition of the cognitive functions that exist, i.e. that a cognitive system holds (and needs to solve a problem) can be made. This decomposition is largely based on (adapted from) Heylighen (2011).

Perception (P) The agent needs to sense as precisely as possible what deviations there may exist, and in how far previous actions have affected these.

Representation (R) Perception produces an internal representation of the outside situation, such as a pattern of activation across neurons. Note that this representation is not an objective reflection of external reality as it is, but a subjective experience of how the agent's personal situation may deviate from the preferred situation. There is also no reason to assume that a representation consists of discrete units (symbols) that represent separate objects or aspects of the situation. Fundamentally, the agent's cognition does not represent objective phenomena, but subjective sensations that depend on the agent's goals.

Information processing (IP) The agent needs to process or interpret the information in the representation, and in particular determine precisely in what way it differs (or may start to differ) from the goals, and which actions could be used to reduce those differences. This requires some process of inference.

Decision making (De) The agent needs to select an action to perform. In general, only one action can be performed at a time; if several actions seem appropriate, the best one needs to be determined.

Knowledge (K) To make adequate decisions, the agent has to know which action is most appropriate to reduce which deviation. Otherwise the agent would have to try out an action at random, with little chance of success, and thus a high chance of losing the competition with more knowledgeable agents.

Intelligence (I) If the problem is complex-so that solving it requires more than one interpretation and/or action-the agent may need to look ahead at likely future situations by making inferences, exploring their consequences, and developing a plan to deal with them, i.e. by designing a sequence of well-chosen, coordinated actions that as much as possible take into account the intricacies of the situation.

Note that these *distinct functions do not necessarily correspond to distinct components* in the cognitive system: the same component (e.g. a nerve connecting a sensor to an effector) may perform more than one function (e.g. perception, representation, knowledge, etc). Let us follow through the control process outside the agent, noting how the environment too participates in solving (or worsening) the problem:

Action (A) The agent should be able to perform a sufficiently broad repertoire of actions to affect the environment in the needed way: the more variety there is in the diversions, the more variety there must be in the actions to deal with them. This requires sufficiently powerful and flexible effectors.

Affected variables (AV) Only certain aspects of the environment are affected by the agent's actions: for example, the agent cannot change the weather, but may be able to find or make a shelter against the rain.

Dynamics (Dy) Changes in the environment, whether produced by the agent or by diversions (i.e. all events not produced by the agent), generally lead to further changes, according to the causal laws or dynamics governing the environment. For example, a stone pushed over a cliff by the agent will fall down to the bottom, where it may break into pieces. This dynamics may help or hinder the agent in achieving its goals. It may even perform some of the required information processing, like when the agent adds stones together to perform calculations (calculus = Latin for "small stone").

Observed variables (OV) The agent cannot sense all changes in the environment, whether caused by its own actions, diversions or dynamics; the variables it can perceive should ideally give as much information as possible relevant for reaching the goal; irrelevant variables are better ignored since they merely burden the cognitive system.

In cybernetic literature, systems that are considered to hold and can express (some form of) cognition are called cognitive systems. A **cognitive system** can be defined as a goal-directed system that tries to achieve its goals by acting on its environment (Heylighen, 2011).

When we put the different internal and external components of the control process together, we end up with the following more detailed scheme as presented in Figure 3.2 and obtained from Heylighen and Joslyn (2001).

In general, the cognitive system cannot be certain which action is appropriate (Heylighen and Joslyn, 2001). This is because the environment is infinitely complex: every phenomenon in the universe has potentially some influence on what can happen here and now. Moreover, every situation is unique: even seemingly identical situations can produce different outcomes.

Furthermore, the cognitive system cannot have perfect knowledge of what to do for each possible situation. This implies that some of the actions the cognitive system performs will not be optimal, or not even adequate (Heylighen and Joslyn, 2001). However, this is not grave because errors can generally be corrected by subsequent actions. The only real requirement is that actions must be more likely to improve than to worsen the situation. If that condition is met, a long enough sequence of actions will eventually bring the cognitive system close to its goal.

Cognitive Systems are studied in scientific literature. The Elsevier journal of *Cognitive Systems Research* published its first volume in 1999 (Honavar et al., 2015), thus is fairly new to the scientific body. The journal *Advances in Cognitive Systems* publishes research articles, review papers, and essays on the computational study of human-level intelligence, integrated intelligent systems, cognitive architectures, and related topics since 2012.
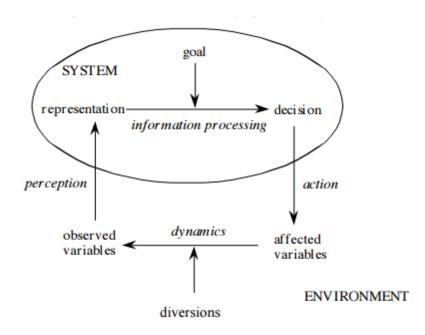
FIGURE 3.2: Schematic illustration of a System embodied in its Environment, denoting the Cognitive and Physical aspects of control of these two concepts (Heylighen and Joslyn, 2001)

3.3 Cognitive Systems as Used in this Research

In this research, the concepts and Figure 3.2 from Heylighen and Joslyn (2001) and the earlier presented definition of cognition is used to study cognition enhanced business process by AI system more in detail. To emphasise, a cognitive systems is thus considered here as an entity that consists of a human agent and a machine agent, and thereby purely a conceptual notion.

From a cybernetics perspective, such a cognitive system can thus be seen as a system where a human and a machine interact with each other (Heylighen, 2011). In other words, a human which is being facilitated by a machine. This machine may have to have some form and to some degree have artificial intelligence, of which its design is studied in the Artificial Intelligence and Computer Science.

In an organisation, humans interact with each other and the organisation depends on the interaction of these people. Often multiple roles are present in a business process, and thus multiple cognitive systems. Each cognitive system behaves individually, trying to achieve its own goal(s). However, in an organisation consisting of multiple cognitive systems, the cognitive systems are collectively working together to achieve the organisation's goal (Dignum, 2013). One studying business processes is therefore obliged to say something about these interactions between the people and the machines they are using (could be collective use: shared computer services, e.g. same data processing environment) in the organisation. Leveraging concepts from systems theory, one can denote that these '(cognitive) systems' or agents are coupled and interact with each other and form as a group a system on itself, a so called multi-agent system (Dignum, 2013).

Cognitive systems can furthermore be identified on different organisational levels. Furthermore, systems can be systems that consists of other systems, called sub-systems, allocated in a hierarchical

order. Therefore, a group of cognitive systems performing the tasks of a business process can, from a holonic perspective, be seen as one cognitive system itself. That is, a system – consisting of a collective of cognitive systems – executing the business process with a certain performance. Thereby, this system is also capable of conducting cognitive performances, i.e. inheriting the (collective) cognition of the cognitive systems it consists of, and thus indeed can be (also) called a cognitive system. Such systems are called holonic systems in literature (Clegg, 2007).

However, this research however only focuses on the *lowest organisational level* where *individual* humans (workers) are **performing individual tasks** by **executing a set of activities**. That is, it does not take into account the interactions between systems on the same hierarchical level (multiagent systems) nor systems on other hierarchical levels (holonic systems).

According to Russell and Norvig (2003) and thus stated from an Artificial Intelligence point of view, *"intelligent agents need knowledge about the world in order to reach good decisions"*. Furthermore, according to the cybernetician Ashby (1962), this **appropriate selection of sequential actions** (i.e. making the right decisions) is the essence of intelligence. These statements corresponds what has been stated about a business process executed by human beings such as the claim-assessment process mentioned earlier; humans (and certainly subject matter experts) utilise their knowledge to be able to make decisions when presented a complex and difficult tasks. This research therefore identifies its view on intelligence in business processes with this statement on intelligence as appropriate selection of sequential actions by Ashby (1962).

The relation between cognitive systems, roles, tasks and business processes as considered in this research are schematically visualised in Figure 3.3, utilising the Business Process Modelling Notation (Object Management Group, 2011) to draft the Organisation worldview in this figure. One can see in this figure that a cognitive system fulfils a certain role, thereby executing certain tasks within the business process. The cognitive systems that fulfil a role in a business process are performing tasks all together to execute the business process.

To execute tasks, a (cognitive) system needs to utilise its cognition to execute the necessary activities to perform a certain task at hand, thereby expressing cognition. Thus, a cognitive system performs tasks within the business process, using the capabilities it possesses, included in these are its cognitive capabilities. From a task-point of view, to perform a certain task, certain cognitive capabilities are required to perform the tasks in (at least) a sufficient way.

3.3.1 Cognition Enhanced Business Processes

When the cognitive capability of a cognitive system is enhanced, the cognitive system is more capable of performing the task, i.e. the performance with which the tasks is executed will be raised – bluntly, the task will be 'better' executed. This performance raise depends on the goal of the (cognition) enhancement of the business process (efficiency, quality, et cetera). Thus, to make clear, it is *not* the business process itself that is being enhanced as meant in this research. What is being enhanced is the cognitive system that performs activities in the business process, as a conceptual entity.
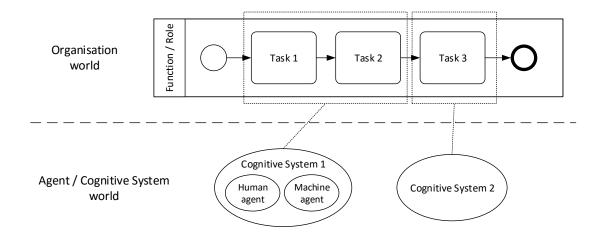
FIGURE 3.3: The relation between the Organisation world and Agent / Cognitive Systems world

Recalling Figure 3.2, the interaction between the components through their connecting processes form the 'cognitive activities' the agent/cognitive system can express. Thus, if one increases the performance of these cognitive processes (perception, information processing, action, etc.), one thereby increases (enhances) the quality of the cognitive activities executed by the cognitive system, and thus its overall cognitive performance. These cognitive processes can thereby be leveraged as categories or types of cognitive enhancements.

Based on all above, one could characterise cognitive requirements and capabilities through the cognitive functions as identified and argued in this chapter. The Cognitive Requirements of a business process can be seen as the (form and level of) cognition that the tasks in the business process require in order to be performed such that it creates value for the business process (and thereby for the whole business). The Cognitive Capabilities of AI software as introduced in Chapter 2 are thus the capabilities of the software to 'boost' the cognitive functions of the cognitive system (human), thereby boosting the performance of the tasks performed by humans. Finally, a cognitive enhancement can now be defined as the increase of the 'level' of cognition, i.e. the difference between the current state and the desired (enhanced) state.

To summarise, the link between the behaviour of elements of business processes and cognition is presented, which is found in theories on cognitive systems. Now this understanding is created, one can denote what is meant by enhancing this cognition and what it entails. Recalling Figure 3.2, representing the components and processes of a cognitive system. The interaction between these components through their connecting processes form the 'cognitive' activities the agent/cognitive system can express. Thus, if one increases the performance of these cognitive processes (perception, information processing, action), one thereby increases (or: enhances) the quality of the cognitive activities executed of the agent/cognitive system, and thus its (overall cognitive) performance. These cognitive processes can be used as categories or types of cognitive enhancements.

Now recall the conceptual design phase from Chapter 1 to conceptually design a system (Figure 2.2), which is the focus of this research. This conceptualisation phase forms the underlying setup of this research, and the question is now how this design process of cognition enhanced business processes looks like.

3.3.2   Cognitive Systems Applied in Illustrative Case

Recall the description of the claim-assessment process in Section 3.1. With the concepts such as business processes, intelligence and cognitive systems introduced and described in Section 3.2 and Section 3.3, the claim-assessment process is analysed here for illustration purposes.

Consider the claim handler and the machines that he or she uses to process the claims as a cognitive system. This system starts by observing the claim and its corresponding record it receives (*perception*) and determining that an assessment is needed if the claim should be reimbursed or not (*goal*). The claim handler will then make an internal *representation* of all the information available on the record, which is processed in order to infer an assessment of the claim (*information processing / reasoning*). Based on this reasoning, the claim handler decides if the assessment and his or her recommendation is complete and correct (enough) (*decision*), the claim handler sends the record including the drafted assessment and recommendation back to the person who sent the claim. If not, the claim handler takes an action such that it is better able to draft a complete and correct assessment. Examples of possible actions are gathering more information, consulting with colleagues (*language*), et cetera (*problem solving loop*). These actions cause changes to the variables of the claim record (*affected and observed variables*), which are again perceived by the claim handler.

A claim handler in this case study has a lot of *knowledge* on different kinds of domains: the health insurance domain, biology domain, knowledge on internal protocols and guidelines set by the health insurance company, and more. All relevant knowledge from its *memory* is used to reason about the information at hand and draft an assessment and recommendation. The expertise of the claim handler is here considered as the ability to use its cognitive capabilities properly, such that the claim handler will produce better outcomes.

To process the information such that this information is actually digested by the claim handler, he of she needs to *comprehend* the information at hand, which can then be used to reason and to be used to come to *judgement*. The final most correct judgement, according to the claim handler, will most likely be transformed into the final decision if the claim should be reimbursed or not. Otherwise, it will be a judgement that says that more information is needed to come to such a decision. When a claim-handler has assessed multiple claims, it generates experience, by reasoning about each individual assessment and all assessments overall to infer certain patterns (*learning*).

The enhancement of the cognition of the cognitive system here focuses on what is considered to be the most difficult cognitive processes when handling claims as described above. An interview with stakeholders from a health insurance company, responsible for the handling of claims, resulted in the observations that the most difficult activities are related to deducing the correct conclusion from the

right information. The question that remains to be answered is thus what possibilities exist to enhance the cognitive functions expressed in the business process by AI software, i.e. cognitive system such as formally conceptualised in this research. Chapter 4 presents the first step of the envisioned conceptual design process that contributes to the answer to this question.

3.4   Chapter Summary

This chapter provides insights in the concepts that are used throughout this thesis. The main insight that it generates is that a human facilitated by machines, performing certain activities which are associated with a particular business process, can be viewed as a cognitive system. In this research, these cognitive systems are studied individually and only those systems that are on the level of performing tasks. Next, it gives a description of such a cognitive system, emphasising its cognitive function, which is primarily used further in this research. Furthermore, the notion how a cognition of a business process can be enhanced is described. It states that this can be achieved by enhancing the performances of the cognitive functions of a cognitive system within the business process, by designing these cognitive systems utilising the cognitive capabilities that can be leveraged by (AI) software. Finally, this chapter illustrated how the concept of cognitive systems and its related notions can be used by applying them to a case. This case on the claim-assessment process of a health insurance company is further studied in the next chapters of this thesis.

4 | Cognitive Requirements of Business Processes

This chapter presents the research that is conducted on the second research issue (RI2) raised Chapter 1 in Figure 1.4: *Establish requirements to enhance the cognition of business processes.* As explained in the Chapter 2, this research is interested to know how to match the properties of business processes that are (in some form and degree) related to cognition to the AI software and the technologies they utilise (e.g. machine learning). Therefore, one needs first to examine business processes in such a way that these cognitive properties can be identified and analysed, and formulated in such a way that they represent the **cognitive requirements (CR)** of the business process; the cognitive activities that are required to properly execute the tasks in the business process and thus the process as a whole. These cognitive requirements can be used to match suitable AI software and corresponding technologies to the business process at hand. Thereby, this chapter creates the first part of the conceptual design process, the **Cognitive Requirements Design Process (CRDP)** (see Section 2.2). The chapter shows a way to elicit the cognitive requirements of a business process, by sequentially describing the theoretical underpinnings of this design process, focused on eliciting these cognitive requirements and its use in the illustrative case introduced in Section 3.1.

Section 4.1 kicks off by describing and explaining what is exactly needed for the formulation of cognitive requirements of business processes. More specifically, it describes how a business process is analysed and decomposed in sub-processes and tasks and how these can be specified utilising Business Processes Modelling theory and notation. Section 4.2 elaborates on Cognitive Task Analysis and how this theory and its methods can help to identify the cognitive elements within a (knowledge-intensive) task. When the cognitive elements are identified, they can be formalised as cognitive requirements such that their specification is consistent in terms of granularity. Section 4.3 therefore addresses Requirement Engineering as a scientific concept and business standard, describing how it can be leveraged to formulate these cognitive requirements from the cognitive elements identified in Section 4.3. By combining Business Process Modelling, Cognitive Task Analysis and Requirement Engineering from respectively Section 4.1, Section 4.2 and Section 4.3, a description of the first part of the engineered design process on how to formulate (i.e. design) cognitive requirements of a business process is given in Section 4.4. This last section furthermore assesses and discusses the constructed CRDP on the criteria stated in Chapter 2, which thereby concludes this fourth chapter.

4.1   From Business Processes to Tasks and Roles

The goal at hand is to formulate the cognitive requirements of a business process. We can thereby identify the starting point of our quest by analysing business processes of organisations. To date, it is common to describe organisations as sets of business processes (Pidd and Melao, 2000). More specifically, we are interested in what happens in a business process or, put differently, what the execution of such a business process entails. The Object Management Group (2011), an organisation describing and maintaining definitions of technological standards worldwide, defines a business process as *"[...] a defined set of business activities that represent the steps required to achieve a business objective. It includes the flow and use of information and resources"*.

4.1.1   Business Process Modelling

According to the above mentioned definition of a business process, business activities are those activities that have to be executed such that the goal of the business process is achieved. For this research, these business activities are of interest; when an overview of these business activities would be available, we would be a step closer to identify the cognitive properties that are needed to execute these business activities, and thereby the business process as a whole. Such overview of the activities of a business process can be drafted by employing approaches that identify and analyse business processes and their activities. Such an approach is Business Process Modelling and is well known in both the business world as the scientific world, abbreviated to BPM (Pidd and Melao, 2000).

Using Business Process Modelling one is thus able to decompose and formulate the distinct tasks in the process (Object Management Group, 2011). Although many notations for business process models exist, a well known BPM notation is the Business Process Modelling Notation (BPMN) standard (Object Management Group, 2011). BPMN is a formal notation standard of business process modelling, and commonly used in and adopted in practice by organisations. In this modelling notation business processes are decomposed in sub-processes, which on their turn consist out of tasks (in increasing order of granularity). A sub-process is a process that is included in another process, thereby lower in hierarchy and can entirely be executed stand alone (Object Management Group, 2011). Next, a tasks is denoted as *'the work in the process [that] is not broken down to a finer level of process model detail'* (Object Management Group, 2011).

4.1.2   Application to this Research

Within an organisation, tasks can be executed by a person, an application, or both. In the light of this research, such an application could thus be an AI technology driven piece of software, i.e. AI software service. BPM visually denotes these participants in a business process. It can be a specific organisational entity (e.g. department) or a role (e.g. assistant manager, doctor, student, vendor). In BPMN the rectangular boxes represent these specific organisational entities or roles. One or more tasks present in a business process are in BPMN visually differentiated by the specific organisational entity or role played by an organisational entity executing these tasks.

Recapitulating, these specific organisational entities and roles described in a business process model indicate the entities that execute the tasks in a business process. In the light of the theoretical notions

on cognitive systems in Chapter 3, such an entity (a human worker, facilitated by a machine) is viewed as a cognitive system. These cognitive systems are, conceptually speaking, thus the entities executing these tasks. Because these tasks are considered to be executed utilising some form and degree of cognition, these entities (cognitive systems) are expressing cognition when executing these tasks. Section 3.3 furthermore showed that it is possible to analyse cognitive systems to identify the cognitive functions of such a system. The line of reasoning corresponds to insights from the field of psychology on humans working in businesses, which state that the activities performed by humans in an organisation involve 'some form and some degree' of cognition, and these humans are thus expressing cognitive process (Klein et al., 1989).

Based on the insights above, one can infer that the tasks in a Business Process Model (specified according to the BPMN standard) are the objects that can entail cognitive properties when executed. Furthermore, the entities executing these tasks (in Chapter 2 referred to as cognitive systems) are considered to possess the cognition needed and utilise their cognitive functions to execute these tasks. As a result, the tasks of a business process are considered to be very valuable to look at to succeed in our quest to the cognitive properties of business processes. A business process modelling exercise is thereby considered to be a valuable approach in this research, as it will result in a clear set of tasks a particular business process consists of (Object Management Group, 2011).

This set of tasks can be filtered to extract the tasks that are valuable for further investigation. As mentioned before in Chapter 2, this research is interested in enhancing the cognition utilised in business processes. The tasks performed in the business process model that entail a relatively high degree of cognition are most interesting here, since that indicates that when this cognition is enhanced, the corresponding tasks could be performed in a better way.

Next to the decomposition of the business process, the current viewpoint lends itself to investigate the requirements of the stakeholders of the business process under review. It is important to identify their needs and define them specifically into stakeholder requirements, such that the design will also reflect their needs. These defined stakeholder requirements can be taken into account in the design process.

4.1.3 Example by Means of Illustrative Case

To illustrate the conceptual notions and BPM exercise as described above, the business process model as visualised in Figure 4.1 describes the claim-assessment process of this case study. The case study only considers claim assessments where a human being is needed in the assessment process for to perform the actual assessment, thereby neglecting assessments that are performed automatically by (computer) systems.
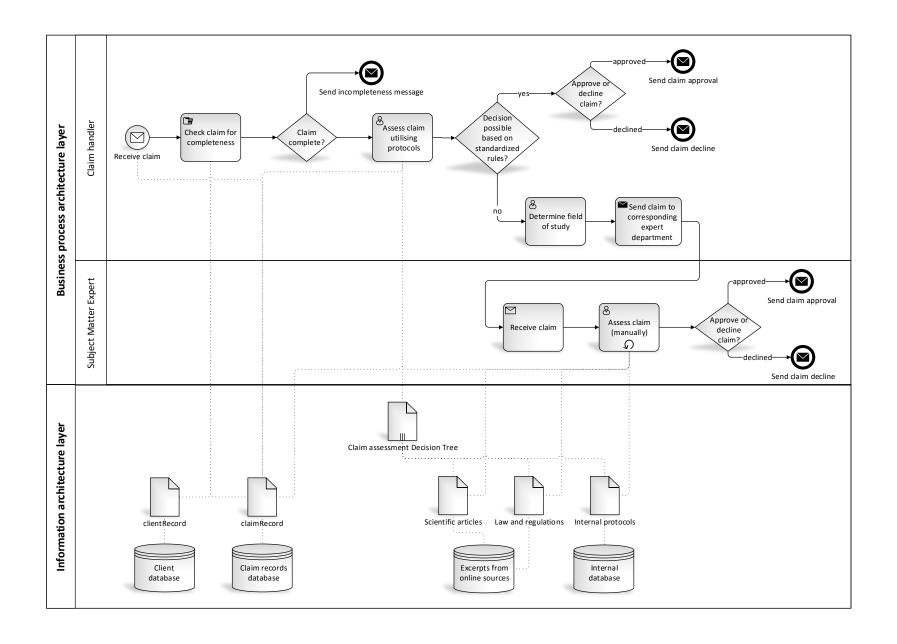
FIGURE 4.1: Business Process Model of case study 1

In this business process model, two architecture layers are presented. These layers are considered to be of most value here, since we are interested in the different process tasks within the process and, because we are dealing with knowledge-intensive business processes, the information that is involved in these tasks.

Figure 4.1 shows that two different sub-processes exist within this organisation that are both responsible for the assessment of claims. The first sub-process, executed by a claim handler, assesses if the claim is complete. If not, the claim is send back to the applicant. If the claim is complete, the claim handler tries to assess the claim based on standardised protocols (such as decision-trees). If the claim handler succeeds, the claim handler can approve or decline the claim properly. If, for a certain reason, the claim handler is not able to assess the claim in a proper way, the claim is send to a subject matter expert (SME). The subject matter expert advises, amongst other things, on more complex medical claims (second sub-process). All the information on the claim is send to the SME, who conducts a second assessment. With his or her in depth knowledge on medical concepts and experience assessing many different claims, the SME is able to come to a legitimate assessment and decision of the claim.

From the business process model, the tasks relevant to the assessment of claims can be extracted. The following tasks can thus be extracted from Figure 4.1:

- Check claim for completeness
- *Assess claim utilising protocols*
- Determine field of study
- Send claim to corresponding expert department
- Receive claim
- *Assess claim (manually)*

Reviewing the list above, the tasks *Assess claim utilising protocols* and *Assess claim (manually)* seem play an important role in the whole business process, since they comprise the essential activity of the process: assessing if a claim should be approved for reimbursement or not. Furthermore, a significant portion of cognition is needed to execute these tasks: both knowledge about medical concepts and claim insurance is needed to adequately perform such a claim assessment, utilising thought to perceive, process and judge the information in the claim. This also borne witness of the fact that one needs a sufficient amount of training before one can actually assess claims in a proper way. At the insurance company this case study is conducted, claim handlers are being trained for half a year. The two highlighted tasks are essentially the same – both entail the assessment of a claim, however executed by different roles in the process (claim handler and subject matter expert). Based on these reasons the tasks *Assess claim utilising protocols* and *Assess claim (manually)* are further investigated in this first sub-design process of the conceptual design process. Therefore, the focus on the rest of this chapter is on these two tasks.

4.1.4 Intermediate Conclusion

To conclude the story so far, Business Process Modelling (here shown according to the BPMN standard)

can aid one in eliciting the cognitive properties of a business process, namely the cognitive aspects of its tasks. Therefore, it can be utilised to perform the first step of the cognitive requirements design process – the construction of an overview of the elements of a process – from here referred to as the design step *A. Business Process to Tasks*. For this research, the identification of sub-processes, tasks and roles is especially valuable, although the BPMN standard notion is much more comprehensive than only this selection. As already stated in this section, the tasks are executed by entities (viewed from a systems/cybernetic perspective) that entail some form and degree of cognition. Performing this business process modelling exercise will result in a list of tasks. Thus, the cognitive aspects of these tasks are of particular interest for this research to analyse. The question that raises is how to reveal these cognitive aspects of the tasks of interest.

4.2 From Tasks and Roles to Cognitive Activities

With the overview of the tasks in a business process formed in Section 4.1, the designer is able to take a closer look at these sub-processes and tasks. To be able to formulate the cognitive requirements of a business process, the cognitive aspects of the tasks need to be identified and extracted in some way. A method that can be utilised to guide this identification and extraction process is desirable.

From psychological and management literature, theories under the scientific umbrella term Task Analysis are found. Task Analysis consists of a variety of techniques for identifying and understanding the structure, the flow, and the attributes of tasks, required for a user to complete a task or achieve a particular goal (Jonassen et al., 1999). Task Analysis is studied in the System Engineering field as well. According to Jonassen et al. (1999) in the light of designing a new system, *"task analysis makes it possible to design and allocate tasks appropriately within the new system. The functions to be included within the system [...] can then be accurately specified"*. A branch of Task Analysis is Cognitive Task Analysis, focusing more on the cognitive aspects of the task under study. Cognitive Task Analysis seems promising for achieving the objective presented above. Therefore, this section further elaborates on Cognitive Task Analysis and how it is used in this research.

4.2.1 Cognitive Task Analysis

Cognitive Task Analysis (CTA) is a category of Task Analysis, focusing on the cognitive aspects of executing tasks, i.e. describing and representing the cognitive activities that underlie goal generation, decision making, judgements, etc., not on evaluating the outcomes of task executions (Hoffman, 2005; Schraagen et al., 2000). One can recognise (a part of) the definition of cognition as presented in Section 3.2.

Cognitive Task Analysis analyses and represents the cognitive activities users utilise to perform certain tasks. CTA describes approaches to the understanding of cognitive activities required for man-machine systems (Hollnagel, 2003). Some of the steps of a cognitive task analysis are: the mapping of the task, identifying the critical decision points, clustering, linking, and prioritising them, and characterising the strategies used (Klein et al., 1989). There is a collection of methods available for conducting a cognitive task analysis. Applied Cognitive Task Analysis (ACTA), the Critical Decision Method (CDM), Skill-Based CTA Framework, Task-Knowledge Structures (TKS) and the Cognitive Function Model (CFM) are a few examples. Cognitive task analysis has been used to examine for

example the decision-making process of experts, the development and evolution of mental models and the information requirements for command and control systems (Klein et al., 1989).

Although there are many varieties of CTA methods, most methods follow a five-stage process (Schraagen et al., 2000; Clark et al., 2006; Coffey and Hoffman, 2003; Cooke, 1994; Hoffman et al., 1995; Jonassen et al., 1999):

1. Collect preliminary knowledge: getting familiar with the content, systems and procedures being analysed;

2. Identify knowledge representations: examining each task to identify its underlying activities and types of knowledge required to perform it;

3. Apply focused knowledge elicitation methods: collect the knowledge identified in the prior stage, using methods that are appropriate to the targeted knowledge type;

4. Analyse and verify data acquired: sometimes the knowledge elicitation techniques are less formal and require that the analyst code and format the results for verification, validation, and applicability for use in their intended application;

5. Format results for the intended application: for less formal CTA methods, such as those described here, the results must be translated into models that are appropriate to aid the design and development of the system under review.

The first two stages will be referred to as respectively the design step *B. Preliminary knowledge collection* and *C. Knowledge representation identification*. These design steps mainly resulted in the information of the claim-assessment process as noted in Section 3.1. From here, the third to fifth stage of the CTA will be combined and referred to as one design step for the purpose of clarity: *D. Tasks to Cognitive activities*. This stage is actually responsible for the extraction and formulation of the cognitive activities from the tasks under review. This design step is scrutinised and constructed in the next subsection.

4.2.2 Application to this Research

CTA is focused mainly on the design of training systems, but also other systems where cognitive skills are valuable input for the design of that system. CTA focuses, more specifically, on expertise. Expertise can be described as knowledge on how to execute a particular skill set in the best way. The characteristics of CTA match with the intention of eliciting the cognitive requirements within the design process, since it focuses on the design of cognitive systems in a business process. Furthermore, the business processes that are considered in this research are delineated to processes that are knowledge-intensive. Hence, CTA is considered as relevant to this research.

To elicit the cognitive activities expressed (by a cognitive system) when executing particular tasks, Cognitive Tasks Analysis seems thus to be a method that is able to achieve this, making it a valuable method in the process of identifying the cognitive properties of business processes and thus valuable for formulating the Cognitive Requirements of business processes.

As stated earlier, many variants of CTA methods exist. The challenge is to choose the method that delivers the outcomes that suit the design of a systems as intended by the designer. To choose wisely, for this research a couple of criteria are formulated to which the method should comply to:

1. The method should be relatively easy to conduct for people that are no experts in psychology, because this research constructs a design process intended for business system designers and AI software experts.

2. The method should not be very time consuming, since it will be used in a business context where time is costly.

3. The method should deliver a high probability of high quality outcomes, otherwise the design process will not be very valuable.

Based on a literature search and brief assessment, Applied Cognitive Task Analysis (ACTA) is considered most appropriate in view of these three criteria (Clark et al., 2006; Militello and Hutton, 1998) and therefore utilised in this part of the design process. ACTA is an approach where you sequentially conduct three structured interviews: an interview for constructing a Task Diagram, an interview where you audit the knowledge available and an interview where you extract additional knowledge through a simulation.

Task Diagram Through the first interview, you develop a Task Diagram that gives a broad representation of task and that specifically allows you to hone in on complex cognitive processes that merit further consideration. This interview is intended to elicit a very broad overview of the tasks, thereby ensuring that one will not try to extract detailed knowledge from the interviewee (Rouse and Morris, 1986). Therefore, the delineation of each tasks should be limited to six steps (Militello and Hutton, 1998), thereby complying to criteria 2.

Knowledge Audit The second interview yields a Knowledge Audit, which probes the expert on the skills and knowledge applied to the tackle specific component tasks or decision points in the overarching task process. It draws directly from the extensive research literature on expert-novice differences and critical decision method studies (Hoffman et al., 1995; Klein et al., 1989; Militello and Hutton, 1998). The knowledge audit is organised around knowledge categories that have been found to characterise expertise: diagnosing and predicting, situation awareness, perceptual skills, developing and knowing when to apply tricks of the trade, improvising, meta-cognition, recognising anomalies, compensating for equipment limitations. It is a relatively non labour-intensive method (thereby complying to criteria 1), focusing not on the extensive detail and sense of dynamics such as the critical decision method (Klein et al., 1989). However, they do provide enough detail to retain the appropriate context of the task (Militello and Hutton, 1998), thereby complying to criteria 3.

Simulation Interview The third and last interview involves presenting the expert with a specific and relevant scenario designed to elicit insight into the cognitive processes used by the expert in the scenario context, i.e. conducting a simulation interview. Klein et al. (1989) and Howell, W. C. and Cooke (1989) have asserted that identification and exploration of information surrounding high consequence, difficult decisions can provide a sound basis for generation of effective training and systems design. Simulation- and incident-based interviews have been used successfully in many domains (Klein et al., 1989; Flanagan, 1954), all in all complying to criteria 3.

Furthermore, each of these interviews, i.e. steps generate a separate easy formatted and structured outcome (Clark et al., 2006; Militello and Hutton, 1998). Also, ACTA is developed as a streamlined

CTA method intended for use by instructional designers and systems designers rather than knowledge engineers, cognitive psychologists, and human factors/ergonomics professionals (Clark et al., 2006), thereby complying both to criteria 1.

To leverage the process steps of both Cognitive Task Analysis and Applied Cognitive Task Analysis, the third process step of CTA is replaced by the three process steps of ACTA, resulting in a seven step process which is suited to the goal of this part of this research. These seven steps are described and elaborated in Appendix B.

4.2.3   Example by Means of Illustrative Case

To illustrate the conceptual notions and the CTA exercise described above, the CTA is performed on case study one. First, preliminary knowledge is gathered about the tasks in the claim-assessment process by means of conducting informal interviews and reading relevant documents. The following insights are extracted in this step:

- A claim-assessor is asked to give advice on whether or not a claim should be reimbursed. Such advice is always written down in text. An advice is furthermore always structured in three parts: a general sentence indicating what is asked ('a request for reimbursement for a patient of age X, suffering from disease Y and treatment Z'), factual information about the patient, from literature and regulatory frameworks, and the actual assessment of the claim in the form of a line of reasoning supported by all relevant information. A proper advice can only be given if the request is properly formulated.
- A request for reimbursement is mostly textual in form, sometimes supplemented with pictures, casts, etc. In a request a proper formulated question must be present explicitly, in order to be assessed.

Next, more in depth knowledge about what kind of information is dealt with during the execution of the tasks, and which knowledge is required to perform the tasks, are examined. This step resulted in a terminology to use for proper communication about the concepts and insights what type of knowledge is required in order to be able to assess a claim: internal assessment frameworks, laws and regulations regarding health care, professional groups standard protocols, communication with colleagues, medical institutions, etc.

Third, an ACTA-interview is conducted with a claim-assessment expert of the company this case study is performed at. This step created the most valuable insights for this research, since it addresses the cognitive elements that are involved in performing a claim assessment. Note that only the tasks *Assess claim utilising protocols* and *Assess claim (manually)* in the business process model in Figure 4.1 are considered, as explained in Section 4.1.

- As stated in Section 4.2.2, first a Task Diagram is constructed together with the claim-assessment expert. This resulted in the Task Diagram as visualised in Figure 4.2. For each step in the task, the expert is asked to describe the step in detail, which information is needed to perform this step and, most importantly, which cognitive functions he/she needs to perform this step properly (a list of cognitive functions plus description is provided in advance of the interview). This first part

of the ACTA resulted in a table with extracted cognitive steps performed by the claim-assessment expert, which can be seen in Appendix B.

FIGURE 4.2: Task Diagram from the Cognitive Task Analysis conducted in case study 1

- In the second part of the ACTA-interview, the expert is asked to reflect on a couple of probes presented by the interviewer, the Knowledge Audit, to extract the cognitive functions that are employed by people having experience assessing claims. For different aspects of expertise, the expert was asked to formulate the cues and strategies used to perform the assessment of a claim and what is difficult about it. The main results of this step include the extension of the insights generated by the Task Diagram and the identification of three abstraction levels of a claim assessment, denoted by the interviewee: micro (one claim specific), meso (claims that belong to the same case) and macro (assessment of general treatments on national level). On meso level, more than one claim assessment is considered and ultimately judged if these claims can be dealt with similarly. All results of this second part of the ACTA-interview resulted in Appendix B.
- The third part of the ACTA-interview is the Simulation interview, resulting in more understanding how the experts thinks when assessing a claim. For all events occurring in the simulation, the expert is asked for each event which actions he/she performs, how he/she assesses the situation at the time of the event, the critical cues that the experts uses when performing the action and the potential errors a novice would be likely to make when he/she has to deal with this particular event. The results of this third part of the ACTA-interview resulted in Appendix B.

The results of this interview are analysed, processed and formatted such that they are of value in the next step of the CRDP of the conceptual design process. Due to the fact that all the results together are a big amount of information, only an excerpt is visualised in Figure 4.3 but nevertheless illustrates its purpose and value to this research. In this figure, in literature called a Cognitive Demand Table (Militello and Hutton, 1998), the steps *Extract relevant and valuable facts* and *Compose a sound line of argumentation (meso level)* are elaborated by describing their relevant difficult cognitive activities, necessary cognitive skills, why these are difficult to perform, what the common errors are and finally what cues and strategies are used by the claim handler.

Step	Difficult Cognitive activity	Cognitive skills	Why difficult?	Common errors	Cues and strategies used
The extraction and listing of relevant and valuable facts	Indicate the facts within the information	Perception: percept the facts in the information Recognition: recognize the facts contained in the information	To recognise the facts in the claim information, one needs a proper understanding of a wide variety of medical concepts, master the corresponding vocabulary (knowledge) and how such claim dossier is constructed (knowledge)	Not all facts are recognised in the first shot, which can have several reasons	Scanning through all information, paying attention to medical terms and words describing the context of the claim.
	Indicate which facts are relevant for the line of reasoning	Reasoning: reason which facts are relevant for the judgement of the claim Reasoning: reason which facts are valuable for the judgement of the claim Judgement: determine which facts are relevant to come to a legit judgement of the claim Judgement: determine which facts are valuable to come to a legit judgement of the claim	Reasoning and judging about the relevance and value of all facts in the claim information is difficult, mainly because these processes are performed very iteratively. The relevance and value of a fact can constantly change when a new fact is considered, resulting in a (mental) list of facts sorted on their relevance and value.	The value of the facts are not assessed properly, leading to miss-judgements. The relevance of the facts are not assessed properly, leading to miss-judgements. Wrong judgement, although based on the correct facts.	Consideration of each fact. Looking out for 'key' facts; facts that often are important for the assessment of the claim.
	Indicate which facts relevant for the line of reasoning are missing Find the necessary extra facts	Reasoning: reason which facts are missing	To reason what relevant and valuable facts are missing, proper knowledge about medical concepts and claim assessment is needed	Neglect relevant facts that should be included. Include irrelevant facts that should not be included	Words and terms present in the information, and reason which words and/or terms are likely to be relevant
The judgement of a claim by establishing a line of reasoning (Meso)	Know that a similar claim already has been treated	Reasoning: reason which of the characteristics of the claim are comparable to a existing case Recognition: recognise that this claim has come up before Meta-cognition - Reasoning: reason if the similar claim has been treated already → pattern recognition Reasoning: reason which historic claim has comparable characteristics (= similar case) Recognition: recognise the line of reasoning of a claim	Do to this, lot of experience is needed with the assessment of claims, since only then patterns could be noticed. One should be able to relate the words/concepts that are present in the information are similar to a previous claim.	Misinterpretation of the facts. Incorrect match to a previous claim.	Words and terms present in the information. Search through previous claims to find a similar one.
	Determine that a case can be treated in the same way as a similar claim	Judgement: determine that standardisation is possible without loss of quality	Checking if the claims are indeed the same	Misjudgement of the equality of claims	Word and terms present in the information. Appeal to knowledge and experience on medical concepts and claim assessment.
	Know that a claim can be treated in the same way as a similar claim	Learning: learn when a case can be treated in the same way as a similar claim	Checking if the current claim is indeed the same as a previous one		

FIGURE 4.3: Excerpt of the Cognitive Demand Table from the Cognitive Task Analysis performed in case study 1

For the task *Extract relevant and valuable facts*, Figure 4.3 indicates that a difficult cognitive activity is to report all facts in the information. This is due to the fact that a claim dossier often consists of multiple documents, each with multiple pages, and these facts are 'hidden' in the information, spread throughout the dossier. This difficult cognitive activity can be performed by the cognitive skills *Perception* and *Recognition*; one should perceive (the facts in) the information and recognise the facts contained in the information. A Cognitive Demand Table such as in Figure 4.3 thus provides information which cognitive skills are executed in the task under review, indicated by the cognitive functions listed.

In the case of the claim assessment process, different forms and degrees of expertise are noticed (see Section 3.1). Both Claim handlers and SME's are required to do training before starting their work, and develop expertise handling claims and their assessment. However, the SME's have a lot more in-depth medical knowledge, whereas Claim handlers are experts themselves in assessing claims efficiently and effectively. The detailed description of the illustrative case (based on case study 1) can be found in Appendix B.

4.2.4 Intermediate conclusion

To summarise this section, Cognitive Task Analysis and Applied Cognitive Task Analysis can be utilised to drill down the tasks in a business process to the cognitive activities expressed when these tasks are executed. Thus, from a systems perspective, the cognitive activities that are executed to perform the tasks in a business process, can be considered the lowest level of detail for describing the cognitive properties of a business process.

Now the cognitive activities of tasks within a business process are identified and described, we are looking for a way to formulate these cognitive activities more specific and formal, such that they can be used more sophisticatedly in the matching process to the cognitive capabilities of AI software later on in this research (see Chapter 6). Thus, the question that now raises is how could one formalise and specify the cognitive activities as elicited in this section such that their level of granularity is lowered.

4.3 From Cognitive Activities to Cognitive Requirements

The previous section resulted in a (long) list of cognitive activities demanded for proper execution of the tasks in a business process. In a later sub-design process of the conceptual design process, these demanded cognitive activities should be matched to the capabilities that AI software can deliver. For proper matching, these demanded cognitive activities and software capabilities should syntactically and semantically be on the same level. One is therefore looking for a formal specification of these cognitive activities, since their specificity will influence the likelihood of a complete and correct match to one or more AI software capabilities.

4.3.1 Requirement Formulation

To overcome this hurdle, Requirement Engineering (RE) theory and its practical standard in ISO 15288 are considered valuable to use. Requirement Engineering is a systematic approach to come to system requirements and software requirements. The latter is not in the scope of this research, since we are exploring the conceptual design phase, not the systems development phase (see section Section 2.3).

The system requirements consist of functional requirements that have to be met in order to complete the task and process at hand (ISO/IEC/IEEE-42010, 2015).

Requirements are statements of what the system must do, how it must behave, the properties it must exhibit, the qualities it must possess, and the constraints that the system and its development must satisfy. The Institute of Electrical and Electronics Engineers (IEEE) defines a requirement as *"a condition or capability needed by a user to solve a problem or achieve an objective, a condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document"* (Institute of Electrical and Electronics Engineers (IEEE), 2011).

According to ISO 15288 standard of the field of Systems Engineering, the process of Requirement Engineering consists of 5 process steps: a Stakeholder Requirement Definition Process (1), a Requirement Analysis Process (2), an Architectural Design Process (3), a Verification Process (4) and a Validation Process (5).

The purpose of the Requirements Analysis Process is to transform the stakeholder, requirement-driven view of desired services into a technical view of a required product that could deliver those services. This process builds a representation of a future system that will meet stakeholder requirements and that, as far as constraints permit, does not imply any specific implementation. It results in measurable system requirements that specify, from the supplier's perspective, what characteristics it is to possess and with what magnitude in order to satisfy stakeholder requirements.

Characteristics of good requirements according to the (Institute of Electrical and Electronics Engineers (IEEE), 1998) are:

1. **Unitary (Cohesive)** The requirement addresses one and only one thing.
2. **Complete** The requirement is fully stated in one place with no missing information.
3. **Consistent** The requirement does not contradict any other requirements and is fully consistent with all authoritative external documentation.
4. **Non-Conjugated (Atomic)** The requirement is atomic, i.e., it does not contain conjunctions. E.g., 'The postal code field must validate American and Canadian postal codes' should be written as two separate requirements: (1) 'The postal code field must validate American postal codes' and (2) 'The postal code field must validate Canadian postal codes'.
5. **Traceable** The requirement meets all or part of a business need as stated by stakeholders and authoritatively documented.
6. **Current** The requirement has not been made obsolete by the passage of time.
7. **Unambiguous** The requirement is concisely stated without recourse to technical jargon, acronyms (unless defined elsewhere in the Requirements document), or other esoteric verbiage. It expresses objective facts, not subjective opinions. It is subject to one and only one interpretation. Vague subjects, adjectives, prepositions, verbs and subjective phrases are avoided. Negative statements and compound statements are avoided.
8. **Specify Importance** Many requirements represent a stakeholder-defined characteristic the absence of which will result in a major or even fatal deficiency. Others represent features that may

be implemented if time and budget permits. The requirement must specify a level of importance.

9. **Verifiable** The implementation of the requirement can be determined through basic possible methods: inspection, demonstration, test (instrumented) or analysis (to include validated modelling & simulation).

4.3.2 Application to this Research

Specifically, the Requirement Analysis Process of RE is found useful to formulate the cognitive activities identified above into the cognitive requirements we are looking for, since that activity in Requirement Engineering deals with the formulation of requirements. More specifically, the these requirements can be seen as a refinement of the cognition skills, contextualised to the corresponding task and difficult cognitive activity. Notice that the elicitation of the requirements is already taken into account in the previous section by eliciting the cognitive activities of tasks in a business process.

The syntax and guidelines provided by the ISO 15288 is used here. Figure 4.4 shows the general syntax formats of a syntactically sound requirement. These formats will be used for the formulation of requirements, is illustrated by means of the case study previously used.

[Condition] [Subject] [Action] [Object] [Constraint]

EXAMPLE: When signal x is received **[Condition]**, the system **[Subject]** shall set **[Action]** the signal x received bit **[Object]** within 2 seconds **[Constraint].**

Or

[Condition] [Action or Constraint] [Value]

EXAMPLE: At sea state 1 **[Condition]**, the Radar System shall detect targets at ranges out to **[Action or Constraint]** 100 nautical miles **[Value]**.

Or

[Subject] [Action] [Value]

EXAMPLE: The Invoice System **[Subject]**, shall display pending customer invoices **[Action]** in ascending order **[Value]** in which invoices are to be paid.

FIGURE 4.4: Types of syntax of requirements, adopted from Institute of Electrical and Electronics Engineers (IEEE) (2011)

4.3.3 Example by Means of Illustrative Case

For each cognitive skill identified and presented in the Cognitive Demand Table as drafted in Section 4.2, a corresponding requirement is formulated according to (one of) the syntax formats of Figure 4.4. These Cognitive Requirements are displayed in Figure 4.5.

Step	Difficult Cognitive activity	Cognitive skills	Cognitive Requirement	Syntax used
Extract and list relevant and valuable facts	Indicate the facts within the information	Perception: percept the facts in the information	When the claim information is received, all claim related facts in the claim information shall be identified	[Condition] [Subject] [Action] [Object]
		Recognition: recognize the facts contained in the information	When the claim information is received, all claim related facts in the claim information shall be categorised	[Condition] [Subject] [Action] [Object]
	Indicate which facts are relevant for the line of reasoning	Reasoning: reason which facts are relevant for the judgement of the claim	When the facts in the claim information are categorised, the relevance of every fact individual to the assessment of the claim shall be noted	[Condition] [Subject] [Action] [Object]
		Reasoning: reason which facts are valuable for the judgement of the claim	When the claim information has been annotated, the cognitive system shall state the value of every fact individual to the assessment of the claim	[Condition] [Subject] [Action] [Object]
		Judgement: determine which facts are relevant to come to a legit judgement of the claim	When the facts in the claim information are annotated, the relevance of each fact shall be noted if it is high enough for a legitimate assessment, in descending order	[Condition] [Subject] [Action] [Object] [Constraint]
		Judgement: determine which facts are valuable to come to a legit judgement of the claim	When the facts in the claim information are annotated, the value of each fact shall be noted if it is high enough for a legitimate assessment, in descending order	[Condition] [Subject] [Action] [Object] [Constraint]
	Indicate which facts relevant for the line of reasoning are missing	Reasoning: reason which facts are missing	When the facts in the claim information are annotated, the relevant facts that are not present in the claim information shall be suggested, considering the claim assessment	[Condition] [Subject] [Action] [Object]
	Find the necessary extra facts			
The judgement of a claim by establishing a line of reasoning (Meso)	Know that a similar claim already has been treated	Reasoning: reason which of the characteristics of the claim are comparable to a existing case	When the facts are extracted from the claim information, the facts of the claim that appear in previous assessed claims shall be noted	[Condition] [Subject] [Action] [Object]
		Recognition: recognise that this claim has come up before	When the facts are extracted from the claim information, the previous assessed claim(s) which are similar to this claim shall be noted	[Condition] [Subject] [Action] [Object]
		Meta-cognition - Reasoning: reason if the similar claim has been treated already → pattern recognition	A claim that is already assess before shall be presented if it comprises similar characteristics	[Subject] [Action] [Value]
		Reasoning: reason which historic claim has comparable characteristics (= similar case)	When the facts in the claim information are related to previous claims, which previous claims have the same properties as the current claim shall be determined	[Condition] [Subject] [Action] [Object]
		Recognition: recognise the line of reasoning of a claim	When the facts in the claim information are annoteted, which previously assessed claims have a similar line of argumentation shall be indicated	[Condition] [Subject] [Action] [Object]
	Determine that a case can be treated in the same way as a similar claim	Judgement: determine that standardisation is possible without loss of quality	When this is possible, a standardised protocol to assess future claims, maintaining assessment quality levels shall be suggested	[Condition] [Subject] [Action] [Object]
	Know that a claim can be treated in the same way as a similar claim	Learning: learn when a case can be treated in the same way as a similar claim	When this is possible, the current claim shall be assessed using the line of argumentation of a previous claim	[Subject] [Action] [Value]

FIGURE 4.5: Formulation of Cognitive Requirements for the cognitive activities found in Section 4.2

Every requirement is constructed using the general notion of the cognitive skill, the cognitive activity it is expressed in and the step of the task. The cognitive requirement is a refinement of the cognitive skill, contextualised in its corresponding cognitive activity and step.

For example, the step *Extract and list relevant and valuable facts*, the cognitive activity *Report the facts in the information* and the cognitive skill *Perception: perception of the facts in the information* result in the cognitive requirement *When the claim information is received, all claim related facts in the claim information shall be identified*. For constructing this requirement, one should formulate the cognitive skill as it is expressed in the cognitive activity and corresponding step. This contextualises the cognitive requirement. Furthermore, one should phrase the cognitive requirement as a condition that something or someone can fulfil by providing the right functionality. This makes the requirement sound like an obligation that is achieved or not.

4.3.4 Intermediate Conclusion

Briefly summarising, this section provided the means to refine and formulate the cognitive activities from the Cognitive Task Analysis into cognitive requirements. This process is from here referred to as the design step *E. Cognitive activities to Cognitive requirements*. These cognitive requirements denote the cognitive skills in a particular activity that are needed for proper execution of the task. This is done in such a way that they are ready to be matched with the capabilities of AI software.

4.4 Stage 1 of Conceptual Design Process

Concluding, the steps described in this section can be merged in the first part of the design process, addressing the cognitive requirements of a business process. Figure 4.6 present the five design steps of the CRDP. This chapter described the part of the design process that is related to the first and second step in the conceptual design phase of Dym and Little (2010), and entailed the extraction of functions (cognitive activities that have to be performed for executing a task) and specification of the cognitive requirements of the tasks present in a business process. Hence, it delivers the CRDP of the conceptual design process as envisioned in this Chapter 1 and 2. This chapter concludes by providing a description of the CRDP and assess it on the criteria stated in Chapter 2.

4.4.1 Description of the Cognitive Requirements Design Process

The first design step of the CRDP comprises the decomposition of a business process to its tasks and roles (in Figure 4.6 as A). This step involves the use of Business Process Modelling and the formulation of stakeholder requirements, as elaborated in Section 4.1. After a qualitative assessment of the identified tasks, the tasks that seem to be essential for the business process and are driven by cognition are selected for further examination in the conceptual design process. In the second design step of the CRDP, preliminary domain knowledge used in the selected tasks is collected (B). This step involves the identification of experts, the analysis of documents and conduction of interviews, all relevant to the tasks under review. The next design step of the CRDP comprises the identification of knowledge representations (C). This step involves the decomposition to sub-tasks and identification of all relevant knowledge and information that is needed for the execution of the task. This information is a prelude to the fourth design step in the CRDP, which comprises the extraction of cognitive activities from the tasks under review (D). This step involves the three subsequent interviews described by the

A. Business Process to Tasks

1. Create an **overview of the business process** under review:
- **Decompose** the process in sub-processes and tasks and construct a process model (BPMN)
- **Identify** roles and stakeholders
2. Formulate the **requirements of stakeholders** fulfilling a role in the business process:
- **Elicit** stakeholder requirements
- **Define** stakeholder requirement
- **Analyse and maintain** stakeholder requirements throughout the design process

B. Preliminary knowledge collection

For the business process under review, **collect preliminary domain knowledge**:
- Identify experts to participate in the knowledge elicitation process.
- Execute Document Analysis
- Observe the process while being executed
- Conduct Unstructured interviews

C. Knowledge representa-tions identification

For each task, identify the sub-tasks and **types of knowledge required** to perform it:
- **Identify sub-tasks** of each task
- Construct flow charts to capture **procedural knowledge**
- Construct a concept map to capture **declarative knowledge**
- Execute a **Learning hierarchy analysis**

D. Task to Cognitive activities

1. Apply the Applied Cognitive Tasks Analysis (ACTA) to **elucidate required knowledge** for executing the tasks:
- Construct a Task Diagram to elicit the cognitive steps of each sub-task
- Execute a Knowledge Audit to identify the most important cognitive elements of the task
- Conduct a Simulation Interview to understand the cognitive processes.
2. **Analyse and verify** data acquired
3. Format results in a **Cognitive Demands Table (CDT)**

E. Cognitive activities to Cognitive requirements

Utilise the **Requirements Analysis Process** of Requirement Engineering to refine the cognitive demands of the tasks and formulate them as requirements one by one:
- Select an appropriate **requirement syntax** considering the level of depth available in the CDT
- **Refine and formulate** a cognitive requirement for every cognitive skill in the CDT

Section 4.1

Section 4.2

Section 4.3

FIGURE 4.6: Schematic representation of the design process to formulate cognitive requirements, using the concepts from Chapter 4

Applied Cognitive Task Analysis, presenting its results in a Cognitive Demands Table. Design process steps B, C and D are elaborated in Section 4.2 of this chapter. Finally, the cognitive activities identified in D are refined and reformulated to cognitive requirements in the fifth and last design step of the CRDP (E). This design step entails the use of the rules for the formulation of system requirements from Requirement Engineering, which is elaborated in Section 4.3.

4.4.2 Assessment of the Cognitive Requirements Design Process

To assess the suitability of the CRDP constructed and described in this chapter, the criteria stated in Section 2.2 are elaborated below regarding the CRDP.

Universally applicable Both Business Process Modelling and Cognitive Task Analysis as concepts used in he CRDP (step A respectively D) have the characteristic to be object independent. That is, they can both be used to analyse respectively all business processes and all tasks. Requirement Engineering (step E), the third concept used in the CRDP, is a general design concept that can be used in every design exercise, domain or object independent. Hence, the CRDP is considered to be universally applicable to business processes.

Methodical in essence The CRDP entails a number of steps to be followed by the designer. They are constructed such that they together form a systematic, methodical procedure to formulate cognitive requirements of the business process under review. These steps are ought to be formulated in such a way that it is understandable, providing a clear procedure for the designer to follow. This is the very reason why in the CRDP is chosen for the Applied Cognitive Task Analysis-method (as argued before in Section 4.2).

However, the CRDP produces to some extent different outcomes, i.e. designs, when executed by different people. That is, the resulting design will change if the CRDP is not executed by the same person. One can expect changes in the part of the CRDP where the Cognitive Task Analysis is performed (step D), since this concept has a relatively strong personal bias. It depends on the questions the designer asks, the perspective that the designer has towards the tasks and cognitive activities, the persons to be interviewed, et cetera, that influence the outcome of the ACTA. Efforts to reduce this variability in the design caused by the personal bias of the ACTA are therefore advisable, such as conducting the ACTA with more than one designer. Formulating the cognitive requirements has less possible bias when executed by different people, due to the syntax that is provided with the method itself (step E). However, still some variability can be present in the quality of the formulated requirements, which is for a part due to the knowledge level of AI technology. Designers with more AI knowledge can formulate the requirements in such a way that they match the cognitive capabilities later on in the design exercise more easily than designers with less knowledge about AI. The variation that here can occur is thus in essence more about fitness of the cognitive requirements to future cognitive capabilities, and not experienced until the matching sub-design process of the CDP (see Chapter 6). The Business Process Modelling is, in contrast to the other two concepts used in the CRDP, considered to deliver relative similar results when conducted by different persons. This is because of its formalised

language and due to the fact that its outcomes are used in the CRDP not in a very detailed way, in contrast to the ACTA and RE.

Flexible but robust In reality, experienced in the case study used to construct the CRDP, a business process does not always operate in the way it is thought of. The CRDP accounts for this variation on the work flow, since the ACTA provides room to manoeuvre to extract the cognitive activities from a business process (step D), if the outcomes of the Business Process Modelling exercise would be of less quality (step A). This is due to the designer's gut feeling to indicate what is most important.

On the other hand, all steps (A to E) can still be executed when disruptions in the design process occur, and not jam. One can think of that a member of the design team can be replaced by someone else, without damaging the design process or design. Knowledge gained can be passed on due to the fact that the steps produce proper documentation (written text, figures and schematics, tables, et cetera). The CRDP is therefore considered to be robust to external effects.

Context-aware In general, executing projects within organisations that demand change and affect people have to deal with resistance towards this change (de Bruijn and Heuvelhof, 2012). Furthermore, as mentioned in Chapter 1, people are hesitant about the rapid development of AI technology. A CDP that is accommodated to these phenomena is considered to be less affected by their negative effects. For example, if people are resisting themselves to the project automating parts of their work flow by implementing AI, they will not contribute to the design process in a productive way. This can lead to designs of. Thus, regarding the context-awareness of the CDP, the CRDP is ought to be constructed such that it accommodated to this context. The design steps A, B, C and D of the CRDP is the part that satisfies to this criteria, since these steps actively pursue collaboration with stakeholders in the business process and let them be part of the design process. For example, in step A, the designer interviews stakeholders to elicit their 'stakeholder requirements', where in step D the ACTA is grafted on extracting the cognitive activities executed in the tasks in the process thought the people that actually perform them, interviewing them personally. Instead, the CRDP could have also consists of methods that are less stakeholder-oriented. Hence, the CRDP is considered to be context-aware in a process management or expectation management way.

Next to this, the availability of data is in executing the CRDP is considered as an important issue in the case study. Namely, the CRDP is part of the CDP that provides the first pointers how the eventual design is going to look like. Thereby, it is thus also indicates what data can be used in this (conceptual) design. Especially the fact if relevant data is available in the business process or organisation is important, and to what extent it is complete. If this data is not present and/or incomplete to large extent, the designer(s) are ought to be hindered in the the design process in moving towards that particular design. Thus, data – and especially data availability – are in the case study performed here considered as a constraint in the CRDP.

This chapter provides an answer to the second research issue (RI2) raised Chapter 1 in Figure 1.4: *Establish requirements to enhance the cognition of business processes.* The Cognitive Requirement Design Process (CRDP) created is thereby the first component of the conceptual design process as

envisioned in Section 2.2. It provides a way to formulate cognitive requirements from a given business process. As described above, the CRDP thereby recognises the values (specified in criteria) elaborated in Section 2.2 to a certain extent. To what extent precisely is not researched here, and therefore subject for further research (see Chapter 8).

5 | Cognitive Capabilities of Artificial Intelligence Software

This chapter presents the research that is conducted on the third research issue (RI3) raised Chapter 1 in Figure 1.4: *Establish the functions to enhance the cognition of business processes.* That is, it describes how the **cognitive capabilities (CC)** of AI software can be formulated. Thereby, it creates the second part of the conceptual design process, the **Cognitive Capabilities Design Process (CCDP)** (see Section 2.2). This chapter shows a way to elicit the cognitive capabilities of AI software, by sequentially describing how to elicit these cognitive capabilities, illustrating the procedure by applying it to the case study introduced in Section 3.1.

Firstly, Section 5.1 posts some general notions on these Cognitive Capabilities of software, and especially on the role of AI software in this story. Next, Section 5.2 elaborates on how these Cognitive Capabilities can be extracted and formulated from AI software and illustrates this by means of the case study. This chapter then presents and describes the second part of the conceptual design process in Section 5.3. This last section furthermore assesses and discusses the constructed CCDP on the criteria stated in Chapter 2, which thereby concludes this fifth chapter.

5.1 Extracting Cognitive Capabilities of AI software

The conceptual design process that is drafted in this research is meant for the design of computerised software systems. As argued in Chapter 2 and Chapter 3, this research takes a more human-centric perspective on the design of 'intelligent' computer systems by embracing the cognitive systems theory. Therefore, when talking about this software, it does not consider the capabilities of software systems right away, since the human cognitive capabilities are taken into account also. This research focuses on the enhancement of human cognition by automation, delivered by computer systems. The question that rises is what software can deliver to this enhancement.

Currently, AI software has gained great attention by the media and business and is developing rapidly. Artificial Intelligence is considered to be the field of study that today delivers the most sophisticated intelligent systems. Therefore, AI software holds strong ties to this research. AI software rises from a (purely) machine-intelligence perspective. Hence, AI software does not fully match with the perspective taken by this research. However, this research recognises that AI software comes closest to the suppositions regarding the design of cognitive software systems. This is mainly because no other clear field of study developing intelligent software is currently present, i.e. insisting its applicability to

research and practice.

This chapter tries to bridge the gap between the cognitive requirements of business processes and what is currently possible designing and developing automated cognition, in the existence of AI software. This type of software is able to power automation, which is recognised and appreciated by this research. On the other hand, the software is not able to deliver high-level cognitive functionalities, as referred to in Chapter 2. It mainly focuses on algorithmic problems.

This is considered as a big limitation to the design of cognitive enhanced business processes as studied here. However, in the light of this research, it is not perceived as a problem, since its structured approach provides the possibility to pin point these mismatches between the cognitive requirements of business processes and the cognitive capabilities of AI software. It is thus possible that certain cognitive requirements cannot be met by the cognitive capabilities delivered by AI software today. Although, if technology develops over time, the conceptual design process will be able to deal with this change. That is, it can still be used unconcerned about such possible changes in technology, since the process is not adjusted to a level of technology, i.e. the process is technology independent.

Above is explained why AI software is of interest for this research. In the remaining of this chapter, the process of extracting and formulating the cognitive capabilities of AI software are examined and elaborated.

5.2 Analysis of IBM Watson

To extract the capabilities of software to achieve a particular goal, one first needs to select the software that will be focused on. Such a software package often consists of multiple services, which on their turn deliver multiple functionalities. Each of these functionalities can be employed to contribute to achieve a particular (business) objective. A description of services and the functionalities is therefore desirable. The first step of the CCDP thus entails the selection of software, and the identification and description of its services. From here, this design step is referred to as *A. Selection of AI software.*

When talking about AI software, these functionalities are considered to result in intelligent behaviour of the software system. However, this research aims to leverage the functionalities of AI software to support, i.e. enhance the cognitive capabilities of a human being, thereby relying on the (composition) of a cognitive system. Hence, the cognitive capabilities of AI software can be identified according to the cognitive systems functions as described in Chapter 3. That is, the functionalities of an AI software package can be translated into cognitive capabilities by typifying each functionality according to the cognitive functions of a cognitive system.

From the process of designing these cognitive capabilities of AI software, the research found that by first determining a specific related field of study of each functionality of the software, the translation into cognitive capabilities is more easy and also more logical. Furthermore, to make sure the cognitive capabilities can be properly matched against the cognitive requirements extracted in Chapter 4, it

Entity Extraction The identification and classification of entities within a text. Examples of entities are people, places and companies: US President Barack Obama*[person]*, Google*[company]*, The Netherlands*[country]*.

Keyword Extraction The extraction of topic keywords within a text. Examples of keywords are US President Barack Obama, Google, The Netherlands.

Concept Tagging The classification of concepts / topics relating to the overall text, which do not necessarily have to be mentioned. An example is a text mentioning BMW and Audi is about 'the automotive industry'.

Taxonomy Classification The identification of one or more taxonomic categories related to the overall text. An example here is 'automotive/brands/german/...'.

Relationship Extraction The identification of Subject-Action-Object relations within a text. An example of relationship extraction is 'Lars*[subject]* is a student*[action]* of Delft University*[object]*'.

Speech to Text The recognition and conversion of spoken language into text.

Visual Recognition The identification of objects in a visual image.

Trade-off Analytics The ability to visually balance multiple objectives such that it can support decision making.

Knowledge Studio The ability to train a machine learning model, such that it can be used in a particular setting.

FIGURE 5.1: Selection of IBM Watson's services and a description of their functionality

is desirable to formulate the cognitive capabilities similarly to these cognitive requirements. Consequently, Requirement Engineering seems again valuable in this design exercise.

In the claim-assessment process case, the goal is to develop a software system that is able to support or enhance the cognitive functions performed to execute the task in the process. In this case study, the AI software IBM Watson is selected to deliver these capabilities and is therefore examined in this section. Besides that this software package is actually used in a development project at a health insurance company, IBM's software Watson is considered to be the leading AI business software service at this moment (Hof, 2016). Therefore, executing this design exercise with IBM Watson as subject is a logical choice.

First, the software is decomposed in the different modules or software services it consists of. IBM Watson provides twenty unique services companies can utilise. These services are divided in five categories: Language, Speech, Vision, Data Insights and Knowledge Studio. Each service is briefly described in Appendix C. Figure 5.1 presents a list of a couple of these services and a description of their functionality.

The functionalities as illustrated above can be categorised into distinct sub-fields of study within the Artificial Intelligence field of study. The following list in Figure 5.2 expands the list above, by indicating these categories. This is the second step of the CCDP, further referred to as *B. Identification of Methods and Techniques*.

AI commercial software (IBM Watson)	Functions (according to IBM)	Example	Formal concept(s)	..is a sub-field of..	..is a sub-field of..	..is a sub-field of..	Underlying techniques
Language							
Entity Extraction	Identifying people, companies, cities, geographic features and other typed entities from your HTML, text or web-based content	Lars Reeker = Person	Entity linking	Information Retrieval	Information Extraction	Natural Language Processing	Classification, Conditional random fields (CRFs), Rigid designator
Keyword Extraction	Extracting keywords from text that can be used to index content, generate tag clouds, and more	Lars, student, Delft, University of Technology	Keyword Extraction	Information Retrieval	Information Extraction	Natural Language Processing	Count
Concept Tagging	Abstraction, understanding how concepts relate and tagging accordingly	Education, Technology, Profession	Latent-semantic indexing	Information Retrieval	Information Extraction	Natural Language Processing	Latent-semantic indexing (SA), singular value decomposition (SVD), Clustering
Taxonomy Classification	Assigning the most likely topic category (baseball, mobile phones, etc.) to a text	this article corresponses to the taxonomy *education/academic/university*	Classification	Multivariate statistics	-	Natural Language Processing	Classification
Relationship Extraction	Linguistic analysis of input text	Lars [is a] student of Delft University of Technology	Relationship extraction	Information Retrieval	Information Extraction	Natural Language Processing	Classification
Speech							
Speech to Text	Convert speech in multiple languages into text	Lars is a student (speech) to Lars is a student (text)	Machine translation	Computational linguistics	-	Natural Language Processing	Multiple approaches: rule-based, statistical, etc.
Vision							
Visual Recognition	Provides scores for relevant classifiers representing things such as objects, events and settings of an image	A picture of a tiger with 99% confidence	Image processing Pattern recognition Statistical Inference	Signal processing	-	-	Wide variaty of techniques: Statistical signal processing, Functional Analysis, etc.
Data Insights							
Tradeoff Analytics	Helps people make decisions when balancing multiple objectives	Visual tradeoff support tool, multi-critera, filtering and selection	Visual analytics	Information visualisation	-	-	Multiple: Argument map, software visualisation
Watson Knowledge Studio	Supervised learning environment	[Lars Reeker]*person_1/student_at_uni_1* studies at [TU [Delft]*loc/uni_1*. [He]*person_1* is working on its graduation thesis.	Entity linking Keyword extraction Relationship extraction	Information Retrieval	Information Extraction	Natural Language Processing	Machine learning

FIGURE 5.2: IBM Watson's services, annotated with their related field of study

With these categories and the description of their meaning, the services within IBM Watson can be scrutinised to ascertain the set of 'cognitive' functionalities they can provide when leveraged properly when applied. Utilising the cognitive processes that can be performed by a cognitive system as presented in Chapter 3, these 'cognitive' functionalities of IBM Watson can be tagged to indicate their potential support to cognition within a business process. Recall the schematic visualisation of a cognitive system form Chapter 3 and presented again in Figure 5.3 for convenience. This figure indicates the different cognitive function of a cognitive system.
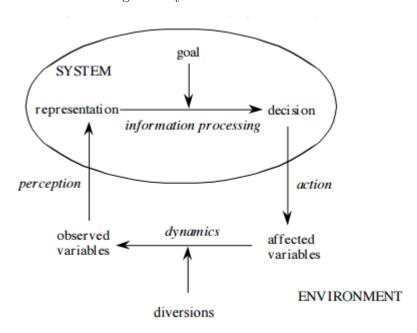
FIGURE 5.3: Schematic illustration of a System embodied in its Environment, denoting the Cognitive and Physical aspects of control of these two concepts – from Heylighen and Joslyn (2001)

With the knowledge from Chapter 3 about cognitive systems and the cognitive processes such a system can express, the list in Figure 5.2 can be expended by adding the corresponding cognitive processes from Figure 5.3 to each of the functionalities identified. The result of this exercise is presented in Figure 5.4. This is the third step of the CCDP, further referred to as *C. Establish Cognitive Functionalities of Services.*

To illustrate this process, the service *Entity Extraction* is used as an example. This service comprises the classification of all entities which are mentioned in the text. It identifies and classifies these entities, and finally extracts them. Thus, this service can be used to identify the entities that are in the text in an automated way. Thereby it serves as a step to get insight what the text is about, for example which persons or organisations play a role in the text. This information can thereby be used to analyse the text even further. Relating this functionality to the cognitive functions identified in Chapter 3, this services can be categorised as *Perception.* To perform this identification process, the system has to have a knowledge base which consists of entities and their corresponding entity type, for example *IBM: Company.* Since the service needs a knowledge base to perform its functionality, this services can be categorised as *Knowledge* as well. It thus *recognises* entities in the text using its knowledge base and scanning through the text at hand.

AI commercial software (IBM Watson)	Functions (according to IBM)	Example	Formal concept(s)	..is a sub-field of..	Underlying techniques	Cognitive functionality
Language						
Entity Extraction	Identifying people, companies, cities, geographic features and other typed entities from your HTML, text or web-based content	Lars Reeker = Person	Entity linking	Information Retrieval	Classification, Conditional random fields (CRFs), Rigid designator	Perception, Recognition, Knowledge
Keyword Extraction	Extracting keywords from text that can be used to index content, generate tag clouds, and more	Lars, student, Delft, University of Technology	Keyword Extraction	Information Retrieval	Count	Perception
Concept Tagging	Abstraction, understanding how concepts relate and tagging accordingly	Education, Technology, Profession	Latent-semantic indexing	Information Retrieval	Latent-semantic indexing (SA), singular value decomposition (SVD), Clustering	Recognition, Knowledge, Comprehension
Taxonomy Classification	Assigning the most likely topic category (baseball, mobile phones, etc.) to a text	this article corresponses to the taxonomy *education /academic/university*	Classification	Multivariate statistics	Classification	Reasoning, Knowledge
Relationship Extraction	Linguistic analysis of input text	Lars [is a] student of Delft University of Technology	Relationship extraction	Information Retrieval	Classification	Recognition, Comprehension
Speech						
Speech to Text	Convert speech in multiple languages into text	Lars is a student (speech) to Lars is a student (text)	Machine translation	Computational linguistics	Multiple approaches: rule-based, statistical, etc.	Language, knowledge
Vision						
Visual Recognition	Provides scores for relevant classifiers representing things such as objects, events and settings of an image	A picture of a tiger with 99% confidence	Image processing Pattern recognition Statistical Inference	Signal processing	Wide variaty of techniques: Statistical signal processing, Functional Analysis, etc.	Perception, Recognition
Data Insights						
Tradeoff Analytics	Helps people make decisions when balancing multiple objectives	Visual tradeoff support tool, multi-critera, filtering and selection	Visual analytics	Information visualisation	Multiple: Argument map, software visualisation	Goal generation, Judgement
Watson Knowledge Studio	Supervised learning environment	[Lars Reeker]*person_1/student_at_uni_1* studies at [TU [Delft]*loc/uni_1*. [He]*person_1* is working on its graduation thesis.	Entity linking Keyword extraction Relationship extraction	Information Retrieval	Machine learning	Learning

FIGURE 5.4: IBM Watson's services, annotated with related cognitive functions from cognitive systems theory

Figure 5.4 provides an overview of the services from IBM Watson and the corresponding cognitive functionalities. That remains this sub-design process with the step to reformulate these cognitive functionalities into cognitive capabilities. This is done based on the same principles as the cognitive activities of a business process are reformulated into cognitive requirements, argued and illustrated in Chapter 2. The same syntax is used here, therefore recall Figure 4.4 which is adopted form Institute of Electrical and Electronics Engineers (IEEE) (2011). In contrast to Chapter 4, the subject is here the selected AI software package. The result of the reformulation of cognitive functionalities into cognitive capabilities is illustrated in Figure 5.5. Thus, the last step of this design exercise to identify and formulate the cognitive capabilities of IBM Watson software is hereby executed, referred to as the design step *D. Cognitive Functionalities to Cognitive Capabilities*.

To illustrate this process, again the service *Entity Extraction* is used as an example. As mentioned before, this service entails the identification and classification of entities in a textual document. Its functionalities are categorised with the cognitive functions *Perception* and *Knowledge*. Formulating the cognitive capability per service is done by taking into account both cognitive functions. Together with its brief description, these cognitive functions are formalised in such a way that a system that uses this service, is able to perform its functionality. In this example, the system will have the functionality to *perceive* and *recognise* the entities in a textual document, using a knowledge base or dictionary to denote the known entities. Formulating this functionality in one sentence delivers its cognitive capability, which is worded as '*The system can denote (all) entities within a textual document*'.

AI commercial software (IBM Watson)	Functions (according to IBM)	Example	Formal concept(s)	Underlying techniques	Cognitive functionality	Cognitive capability (The system…)
Language						
Entity Extraction	Identifying people, companies, cities, geographic features and other typed entities from your HTML, text or web-based content	Lars Reeker = Person	Entity linking	Classification, Conditional random fields (CRFs), Rigid designator	Perception, Recognition, Knowledge	…can denote (all) entities within a textual document
Keyword Extraction	Extracting keywords from text that can be used to index content, generate tag clouds, and more	Lars, student, Delft, University of Technology	Keyword Extraction	Count	Perception	…can identify all keywords within a textual document
Concept Tagging	Abstraction, understanding how concepts relate and tagging accordingly	Education, Technology, Profession	Latent-semantic indexing	Latent-semantic indexing (SA), singular value decomposition (SVD), Clustering	Recognition, Knowledge, Comprehension	…can denote relevant concepts from a textual document
Taxonomy Classification	Assigning the most likely topic category (baseball, mobile phones, etc.) to a text	this article corresponses to the taxonomy *education /academic/university*	Classification	Classification	Reasoning, Knowledge	…can denote the taxonomy classes a textual document corresponds to
Relationship Extraction	Linguistic analysis of input text	Lars [is a] student of Delft University of Technology	Relationship extraction	Classification	Recognition, Comprehension	…can recognise relationships between enitities mentioned in a textual document
Speech						
Speech to Text	Convert speech in multiple languages into text	Lars is a student (speech) to Lars is a student (text)	Machine translation	Multiple approaches: rule-based, statistical, etc.	Language, knowledge	…can translate a textual document into another language
Vision						
Visual Recognition	Provides scores for relevant classifiers representing things such as objects, events and settings of an image	A picture of a tiger with 99% confidence	Image processing Pattern recognition Statistical Inference	Wide variaty of techniques: Statistical signal processing, Functional Analysis, etc.	Perception, Recognition	…can recognise objects in a static image
Data Insights						
Tradeoff Analytics	Helps people make decisions when balancing multiple objectives	Visual tradeoff support tool, multi-critera, filtering and selection	Visual analytics	Multiple: Argument map, software visualisation	Goal generation, Judgement	…can support decision making through visual mathematical representation decision criteria
Watson Knowledge Studio	Supervised learning environment	[Lars Reeker]*person_1/student_at_uni_1* studies at [TU [Delft]*loc/uni_1*. [He]*person_1* is working on its graduation thesis.	Entity linking Keyword extraction Relationship extraction	Machine learning	Learning	…can learn from previous textual documents to improve its linguistic functionalities

FIGURE 5.5: IBM Watson's services and their corresponding cognitive capabilities

5.3 Stage 2 of Conceptual Design Process

Summarising the steps illustrated in the previous section, the second part of the envisioned conceptual design process can be drafted. This part is visualised in Figure 5.6 and thus entails the identification and specification of the cognitive capabilities of selected AI software, referred to as the CCDP sub-design process. This chapter concludes by providing a description of the CCDP and assess it on the criteria stated in Chapter 2.

5.3.1 Description of the Cognitive Capabilities Design Process

The first design step of the CCDP comprises the selection of AI software package for further study, and its decomposition to all services it offers to the user, i.e. developer of the AI driven system (A in Figure 5.6). For every service in the software package, the methods and techniques are identified in the second step (B). This is done to get an idea how the service actually works and to which field of study its part of. That provides the designer with information what functionality the service can deliver when implemented. This knowledge is needed in the third design step of the CCDP (C), which comprises the formulation of the cognitive functionality of the service. This is done based on the principles of cognitive systems theory elaborated in Chapter 3. The last step of this sub-design process entails the refinement and formulation of these cognitive functionalities to cognitive capabilities (D). This is done via a design exercise itself, leveraging the rules for the formulation of requirements in Requirement Engineering.

A. Selection of AI Software

1. Through a business focussed assessment, **select the AI software** to consider in this stage.
2. For the selected AI software:
- **Identify** the distinct services of the software.
- **Describe** the distinct services of the software.

B. Identification of Methods and Techniques

1. For each software service identified under *A*:
- **Identify** the methods (formal concepts) it utilises
- **Describe** the application of these methods in the service
2. For each method utilised in the software services:
- **Identify** the techniques it utilises
- **Describe** the application of these techniques

C. Establish Cognitive Functionalities of Services

Formulate the distinct functionalities that comprise some form and degree of cognition of the services identified under *A* using the information from *B* and cognitive systems theory:
- For every service, **analyse** the underlying techniques it utilises
- **Categorise** each service with at least one cognitive function

D. Cognitive Functionalities to Cognitive Capabilities

Utilise the Requirements Analysis Process of Requirement Engineering to **refine the cognitive functionalities** found in *C* of each service and **formulate them as capabilities** one by one:
- **Analyse** the cognitive functionalities and formal concept of each service
- **Formulate** a cognitive capability for every cognitive functionality

FIGURE 5.6: Schematic representation of the design process to formulate cognitive capabilities, using the concepts from Chapter 5

5.3.2 Assessment of the Cognitive Capabilities Design Process

To assess the suitability of the CCDP constructed and described in this chapter, the criteria stated in Section 2.2 are elaborated below regarding the CCDP.

Universally applicable The CCDP extracts the cognitive capabilities of a given AI software package. In the case study used in this research to construct the CCDP, IBM Watson is the software considered to deliver AI technologies. In step A, the CCDP specifically focuses on selecting and identifying AI software to be considered in the design process. In the subsequent steps, the CCDP formulates cognitive capabilities of this chosen AI software packages by analysing the methods and techniques it comprises, and thus independently of any other software. Hence, the CCDP is considered to be universally applicable to AI software suites.

Methodical in essence The CCDP steps are formulated in such a way that a designer can produce cognitive capabilities of an AI software suite in a systematic way: from the services of the software, to methods used in the services to the techniques that power these methods, selecting cognitive functions and formulate cognitive capabilities. Hence, the CCDP is considered to be methodological in essence.

However, the CRDP produces to some extent different outcomes, i.e. designs, when executed by different people. That is, the resulting design will change if the CCDP is not executed by the same person. Step A en B are considered to result in similar outcomes, due to the factuality of identifying and describing the software's services, methods and techniques. Knowledge of AI technology does play a role here, as it will decrease the time needed by the designer to go through steps A and B. On the contrary, step C is more driven by the designer's way of thinking and perspective on cognition. Therefore, this step is considered to be affected by personal bias of the designer. Formulating the cognitive capabilities in step D has less possible bias when executed by different people, due to the syntax that is provided with the Requirement Engineering method that is used here. However, still some variability can be present in the quality of the formulated requirements, which is for a part due to the knowledge level of AI technology.

Flexible but robust The CCDP is the part of the CDP that elicits the cognitive capabilities of the AI software selected. Due to the systematic procedure to formulate these cognitive capabilities, the CCDP allows for changes in the software under review during the design process. Although the steps in the CCDP are subsequent to each other, the designer can execute the CCDP in an iterative way. Therefore, the CCDP is considered to be able to embrace the changes in a software package and adjust its design to.

However, if the software suite will change in such a way that it is not functioning anymore, the design process will jam. When this happens, the CCDP can be re-executed from start using a different software package. The progress made using the old software suite can not be re-used. The CCDP is not robust to such a disturbance.

Context-aware The CCDP is focused on the AI technology that is leveraged to enhance the cognition of a business process under review. Thereby, the context of the CCDP can be seen as the people that are related to this software and the resources the software uses to perform. As experienced in the case study executed to create the CCDP described in this chapter, some people in the

organisation often have preliminary knowledge about a software suite already available before a project is initiated to start leveraging AI technology in a business process. These people often drive the initiation of the project in the organisation. As AI software companies have big promises for organisation that use their software, it is important that organisations have a realistic view of what software can do for them. The CCDP provides insights in the functionalities of the software under review, by analysing the techniques underlying the services. These insights provide the organisation knowledge what functionalities the current state-of-the-art can offer.

Next to this, the context in which the CCDP is executed, data is of importance. Where in the first part of the CDP, the CRDP, data availability is considered to be a constraint for that design process in the case study, the type of data is in the CCDP is considered to constrain the further design process. This is because the type of data prevails the choice for particular AI techniques. The CCDP allowed for the first 'back-of-the-envelop' analysis to indicate which AI technologies in any case can be excluded from further analysis, since they cannot be used for the type of data at hand. Thus, data – and especially the type of data – is in the case study performed here considered as a constraint in the CCDP.

This chapter provides an answer to the third research issue (RI3) raised Chapter 1 in Figure 1.4: *Establish the functions to enhance the cognition of business processes.* The Cognitive Capability Design Process (CCDP) created is thereby the second component of the conceptual design process as envisioned in Section 2.2. It provides a way to formulate cognitive capabilities from a given AI software suite. As described above, the CRDP thereby recognises the values (specified in criteria) elaborated in Section 2.2 to a certain extent. To what extent precisely is not researched here, and therefore subject for further research (see Chapter 8).

6 | Generating Possibilities for Cognition Enhancement

In the previous two chapters, 4 and 5, the processes of acquiring the cognitive requirements of business processes and the cognitive capabilities of software are elaborated and argued. Both chapters account for a step in the conceptual design phase of Dym and Little (2010). The next step in this conceptual design phase is to *establish means for functions*, i.e. to construct means by matching the generated capabilities to the requirements, such that it results in an overview of all possibilities to leverage software capabilities in the business process. In this research they are called **Cognitive Possibilities (CP)**. This chapter describes how the design possibilities for cognition enhancement of business processes can be formulated, illustrating the procedure by applying it to the case study introduced in Section 3.1. The steps described in this chapter result in the third part of the conceptual design process, the **Cognitive Possibilities Design Process (CPDP)** (see Section 2.2). It thereby presents the research that is conducted on the fourth research issue (RI4) raised Chapter 1 in Figure 1.4: *Match functions to requirements, generating possibilities for design.*

First Section 6.1 kicks off this chapter by synthesising the cognitive requirements from Chapter 4 and the cognitive capabilities from Chapter 5, and describes and argue the theoretical underpinning of the matching exercise, based on the concepts and theories introduced in Chapter 3. Section 6.2 continues by elaborating on how the matching process can be structured. This matching process is illustrated in Section 6.3, using the case study used before. The matching exercise is formalised and presented as the third component of the conceptual design process in Section 6.4. This last section furthermore assesses and discusses the constructed CPDP on the criteria stated in Chapter 2, which thereby concludes this chapter.

6.1 Theoretical Underpinning of Matching Capabilities to Requirements

Chapter 4 and 5 studied the cognitive elements of respectively business processes and AI software. This section provides several notions on these cognitive requirements and cognitive capabilities, focused on the envisioned matching process which is presented in the next section. Furthermore, the Cognitive Systems theory studied in Chapter 3 is leveraged to provide a framework to support this matching process.

Chapter 3 explained the concept of a Cognitive System. In this research, such a Cognitive System is regarded as the systemic abstraction of a human being performing tasks supported by computing

technologies. The envisioned conceptual design process is meant for the design of software systems that embody these computing technologies. The decomposition of a Cognitive System by Heylighen (2011) provides the elements of a 'system' that is able to express cognition in different forms and degrees. These elements corresponds to the majority of concepts of the definition of cognition used in this research. Recall Figure 3.2 in Figure 6.1 from Chapter 3. However, the value of the schematic visualisation of a Cognitive System in Figure 6.1 goes beyond its textual and visual definition. This is because this concept is constructed from a cybernetic perspective. It denotes the relations between the concepts. That is, it indicates how its different elements (i.e. different elements of cognition) form together a system that is able to utilise cognition to solve problems, that is within a business process, to execute allocated tasks. Each of these elements influences how such Cognitive System performs its problem solving exercises, i.e. executes its assigned tasks, and to which level of quality.
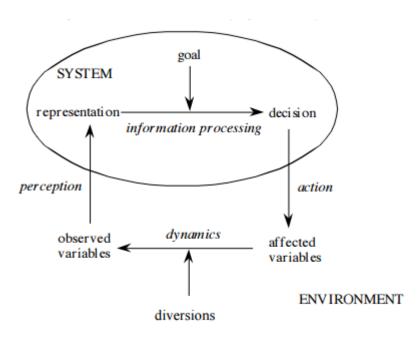
FIGURE 6.1: Schematic illustration of a System embodied in its Environment, denoting the Cognitive and Physical aspects of control of these two concepts – from Heylighen and Joslyn (2001)

As stated in Chapter 1 and 2, it is interesting to know how to raise the cognition of a Cognitive System, since it can increase the performance of such a system. The control feedback loop of the Cognitive System is thereby of importance. For example, when the information processing skills of the Cognitive System are improved, the system will be able to analyse information more efficient and/or effective. The result of this improvement can be twofold: the Cognitive System is able to come faster to the decision-making part of the problem-solving cycle (1) and/or the system processes information in a qualitative better way, which can results in a higher quality of decision-making or following cognitive functions. Thus, improving a cognitive element of a Cognitive System can lead to an increase in performance (quantitative and/or qualitative).

In this research, this improvement is caused by the support by computing technologies, enhancing the cognitive expressions of human beings. Not their own real cognition (one would talk about human-computer symbiosis), rather the abstraction of cognition used to execute tasks in a business

process. Thus, considering what is said above, the cognitive capabilities of software pick up on the cognitive functions of the Cognitive System to enhance these functions. Hence, the cognition level of the particular cognitive function of the Cognitive System will be improved. How much the level of cognition is improved, is not in the scope of this research, as stated in Chapter 1.

Chapter 4 elicited a way to extract and formulate the cognitive requirements of business processes. These cognitive requirements denote the cognition that is being asked for proper execution of the task within the business process. This research assumes that, especially in knowledge-intensive business processes, the cognitive skills that are utilised to execute tasks are not providing the maximum level of cognition which can be deployed to execute those tasks. That is, there is a difference between the level of cognition currently used and what level of cognition ultimately can be used (such that it still results in a performance increase). This is where the cognitive capabilities of software systems kick in. These cognitive capabilities are namely considered to be able to increase this level of cognition. In other words, these capabilities are able to change the level of cognition used to execute tasks in the direction of the ultimate level of cognition, increasing the performance of a system.

It might sound evident that a cognitive capability concerning the (cognitive) perception function will not increase the cognition level of the system when applied to, for example, the (cognitive) information processing function. However, this insight is important for the matching of cognitive capabilities to cognitive requirements. Hence, cognitive capabilities that are not of the same cognitive function category as cognitive requirements will probably not be applicable, since they are addressing a fundamentally different part of cognition. Furthermore, more than one cognitive capability (of the same category) can positively influence a cognitive requirement (of the same category), also in synchroneity. These insights form the groundwork of the matching framework, which is described in the next section.

6.2 Application to this Research

The previous section elaborates on (theoretical) insights how to use the cognitive capabilities of software systems to improve the level of cognition leveraged in business processes. This section presents a framework how to match cognitive capabilities to cognitive requirements. From Systems Engineering theory, ideas from rigorous engineering methods are borrowed how to perform this matching process. An example of such method is the House of Quality for defining the relationship between customer desires and the enterprise capabilities (Sage and Armstrong, 2000). To match cognitive capabilities to cognitive requirements in a complete and structured way, one would try to match each capability to every requirement. This would however be a very time-consuming exercise.

Based on the insights of Section 6.1, only the capabilities and requirements that belong to a particular cognitive function category are needed to be tried to match to each other. This results in the first design step of the CPDP, comprising the categorisation of the cognitive requirements and cognitive capabilities by cognitive function. This first design step is referred to as design step *A. Categorisation by Cognitive Functions*. Furthermore, the to be constructed framework needs to support the matching of multiple capabilities to one requirements. A similar form of matrix-based framework as the House of Quality can be generated to support the systematic matching process of cognitive capabilities to cognitive requirements. Table 6.1 shows a version of this framework. This matching activity can be

considered as the second step of the CPDP, referred to as design step *B. Structural Matching.*

		Cognitive Capabilities			
		Cap 1	Cap 2	...	Cap n
Cognitive Requirements	Req 1				
	Req 2				
	...				
	Req n				

TABLE 6.1: Matching capabilities to requirements, an engineering approach

Subsequent to this table, a second table can be generated that provides an overview of all matches of cognitive capabilities to cognitive requirements. Furthermore, an extra column in the table serves as a placeholder to describe the rationale of each match. This serves both validation purposes (objectivity of the matching process) and for communication about the matching process to all parties involved in the project. An example of this table is shown in Table 6.2. The analysis of the matched pairs, and the formulation of the rationales for each pair together form the third and last design step of this sub-design process. This design step is referred to as *C. Analysis of matched pairs.* The next section illustrates how to go through these three design steps and how both frameworks can be used by means of the claim-assessment process case study.

Match number	Cognitive Requirement	Cognitive Capability	Rationale for match
1			
2			
3			
...			
n			

TABLE 6.2: Suggested structure for listing the matches and their rationale

6.3 Example by Means of Illustrative Case

Recall the Cognitive Requirements of the case study from Chapter 4 and the cognitive capabilities of the case study found in Chapter 5. In this section, the capabilities will be matched onto the requirements by means of the framework as visualised in Table 6.1. However, first a synthesis step needs to be conducted since the cognitive requirements and -capabilities are not yet sorted per cognitive function category. Furthermore, this step entails the realisation of requirements and capabilities that can be matched onto each other. Since their formulation is conducted independently, it may be that they are not specified on the same abstraction level. This could result into a difficult matching process. Therefore, this two steps support some tweaking that may be needed before the actual matching of the two.

Another important step in the synthesis process is the filtering of categories and their corresponding capabilities and requirements. Through experience, not every cognitive function is found equally valuable for the claim-assessment process. Hence, not every category is considered to be necessary to

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Cognitive Requirements belonging to the category *Reasoning*

R1 When the facts in the claim information are categorised, the cognitive system shall state the relevance of every fact individual to the assessment of the claim

R2 When the claim information has been annotated, the cognitive system shall state the value of every fact individual to the assessment of the claim

R3 When the facts in the claim information are annotated, the cognitive system shall suggest which relevant facts are not present in the claim information, considering the claim assessment

R4 When the facts are extracted from the claim information, the cognitive system shall assess if and which facts of the claim appear in previous assessed claims / a known case

R5 When the facts are extracted from the claim information, the cognitive system shall indicate if and which previous assessed claim is similar to this claim

R6 The cognitive system shall be able to present if a similar claim is already assess before, based on recognition of patterns

R7 When the facts in the claim information are related to previous claims, the cognitive system shall determine which previous claims have the same properties as the current claim

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FIGURE 6.2: A selection of cognitive requirements belonging to the category *reasoning* from the illustrative case, as formulated in Section 4.3.2

Cognitive Capabilities belonging to the category *Reasoning*

The system can...

C1 ...deduce the taxonomy classes a textual document corresponds to.

C2 ...identify the author of a text.

C3 ...find specific information within a set of documents.

C4 ...the emotional tones of the text.

C5 ...provide similar images of a given picture.

C6 ...deduce the category of a picture.

C7 ...recognise objects in a static image.

C8 ...support decision making through visual mathematical representation of decision criteria.

C9 ...learn from previous textual documents to improve its linguistic functionalities.

FIGURE 6.3: A selection of cognitive capabilities belonging to the category *reasoning* from the illustrative case, as formulated in Section 5.3

analyse in the matching process. Through deliberation, the cognitive functions *perception, recognition, reasoning/information processing, learning, judgement* and *comprehension* are identified as relevant cognitive functions for the claim-assessment process, since they cover the essence of an assessment to process information, analyse it and formulate a decision based on that information. Hence, these categories are taken into account in the matching process of this case study. The cognitive requirements formulated in Section 4.3.2, belonging to the cognitive systems category *reasoning*, are presented for illustrative purposes in Figure 6.2. From Section 5.3, the cognitive capabilities of the IBM Watson software package, belonging to the same category (reasoning), are listed in Figure 6.3.

The following step is to fill in all the cognitive requirements and cognitive capabilities into the framework as presented in Section 6.2. This is done per category. Table 6.3 shows the framework filled in

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with the requirements and capabilities belonging to the category *reasoning* of this case study.

Next, the actual matching process takes place. This is done by analysing each cell in the framework in sequence, indicating all possible matches between the requirements on the one hand, and capabilities on the other hand. One by one the designer has to consider if a capability has the potential to fulfil, i.e. meet a requirement. If so, the designer places an 'x' in the corresponding cell. If not, an '-' (dash) is placed. Then, the designer goes on to the next cell and so on and so forth. The matching process ends when all cells have been subject to consideration.

Category *Reasoning*		Cognitive Capabilities								
		C1	C2	C3	C4	C5	C6	C7	C8	C9
Cognitive Requirements	R1	-	-	x	-	-	-	-	-	x
	R2	-	-	x	-	-	-	-	-	x
	R3	-	-	x	-	-	-	-	-	x
	R4	-	-	x	-	-	-	-	-	-
	R5	-	-	x	-	-	-	-	-	x
	R6	-	-	x	-	-	-	-	-	x
	R7	-	-	-	-	-	-	-	-	x

TABLE 6.3: Matching the cognitive capabilities to the cognitive requirements of the illustrative case

A few insights can be gathered from Table 6.3. First, one can see that C3 and C9 are capabilities that can be used often. The other capabilities of IBM Watson software are not applicable in this case. Secondly, one should keep in mind that the capabilities matched to certain requirements are *not the only* capabilities that are needed in order to fully realise the corresponding requirement. That is, other capabilities will be needed to meet the requirements. These capabilities can be cognitive capabilities as well as non-cognitive capabilities. The latter type of capabilities are not addressed in this research.

After the actual matching process, a new table can be generated by extracting all pairs of cognitive requirements and -capabilities which are in the framework indicated with an '*x*', indicating a potential software cognitive capability that could improve the cognition in a business process. For every pair of capability-requirement, the software service can be denoted that delivers that particular capability by looking back into the results of the CCDP. Finally, a table that provides an overview of all matches and their rationale can be constructed, as elaborated earlier in Section 6.2.

The last steps of the third part of the conceptual design process comprise the generation of design alternatives, refinement and application of metrics to design alternatives and ultimately choosing a design. These three steps are not addressed in this case study, since they do not differ from other design exercises: the main focus and scientific potential is in the first three steps of the conceptual design process. This ends the illustration of the third step of the conceptual design phase. Next, the insights generated from theory and this case study deliver the third component of the envisioned conceptual design process, which is presented in the next section.

6.4 Stage 3 of Conceptual Design Process

Summarising the steps illustrated in this chapter, the third part of the envisioned conceptual design

process can be drafted: the Cognitive Possibilities Design Process. This part is visualised in Figure 6.4 and thus entails the matching of the cognitive capabilities of selected AI software to the cognitive requirements of the tasks within a particular business process. This chapter concludes by providing a description of the CPDP and assess it on the criteria stated in Chapter 2.

6.4.1   Description of the Cognitive Possibilities Design Process

The CPDP consists of three steps. First, the cognitive requirements from the CRDP and the cognitive capabilities from the CCDP are synthesised and categorised according to the cognitive function they relate to (A). In the second design step, the cognitive requirements and cognitive capabilities are put opposite to each other in a table (Table 6.1). For every cognitive function, such a table will be created. This table structures the matching process, as each cell corresponds to a potential match, indicating a pair. The designer should go through each of the cells, assessing if the selected capability can potentially comply to the selected requirement. Each cell will be marked with an 'x' if this is the case (B). When this matching process is completed, the third and last design step of the CPDP will extract all pairs of capabilities and requirements matched to each other and put them in a new table (Table 6.2). A more thorough analysis will be conducted to reason if the capability can meet the requirement when implemented. For each matched pair of capability and requirement, the designer writes down the rationale behind this match for communication purposes (C). These three design steps together form the CPDP of the CDP.

A. Categorisation by Cognitive Functions

Synthesise the outcomes of Stage 1 and Stage 2 and **categorise** these results according to cognitive functions:
- **Categorise** the *cognitive requirements* from Stage 1
- **Categorise** the *cognitive capabilities* from Stage 2

B. Structural Matching

To **match** the Cognitive Capabilities to the Cognitive Requirements:
1. **Fill in** the template table structure per category for both Requirements and Capabilities
2. Based on the description of both requirements and capabilities:
- **Go through each cell** of the table and assess if the selected capability can potentially meet to the selected requirement.
- If so, **mark** this cell. If not, go to the next cell

C. Analysis of Matched Pairs

After going through the whole table:
1. For each marked cell in the table, execute a more **thorough analysis** whether the capability can actually cause the effect that the Requirement can be met:
- **Analyse** the methods and techniques of the service
- **Write** for every pair one or two lines argumentation explaining the rationale of the match
2. Check if a combination of capabilities can have a positive effect such that a requirement can be met

FIGURE 6.4: Schematic representation of the design process to match the cognitive requirements to the cognitive capabilities, using the concepts from Chapter 6

6.4.2 Assessment of the Cognitive Possibilities Design Process

To assess the suitability of the CPDP constructed and described in this chapter, the criteria stated in Section 2.2 are elaborated below regarding the CPDP.

Universally applicable The CPDP as described above provides a way to match the cognitive capabilities to the cognitive requirements as formulated in the previous sub-design processes of the CDP. The steps in the CPDP are formulated in such a way that they can be performed to each set of cognitive capabilities and/or cognitive requirements; the steps are not bounded to certain specific formulated cognitive capabilities and/or cognitive requirements. Thereby, the CPDP can be run through irrespective of how its input is formulated, although this input should conform to the syntax of a requirement. The CPDP is therefore universally applicable to the outcomes of the CRDP and CCDP.

Methodical in essence The steps of the CPDP together form a systematic way to create cognitive possibilities from the cognitive requirements of the business process and the cognitive capabilities from the AI software under review; each step contributes in its own way to formulate these possibilities for AI technology to power the cognition of a business process. The CPDP is therefore considered methodical in essence.

The CPDP is considered rigid, since its procedure to generate the cognitive possibilities is strict and self-explaining, offering one structural way to generate these possibilities. This strictness is considered the main strength of the CPDP, ensuring that this sub-design process of the CDP where the design space is created is executed in an uniform way when performed by different people. However, the matching step (B) itself comprises room for manoeuvre for the designer. Different sets of input (cognitive capabilities versus cognitive requirements) therefore result in a different set of cognitive possibilities, i.e. design space. On the other hand, the CPDP ensures that the same sets of input in principle result in the same set of cognitive possibilities when executed by different designers, thanks to its strictness. Step A is considered to have little variation in its outcome if performed by different people. This is also considered for step C, despite variations in the rationales of the matches; people can have different ideas why a cognitive capability meets a certain cognitive requirement, and/or formulate the rationale of a match in a different way but still meaning the same.

Flexible but robust If the set of cognitive requirements and/or cognitive capabilities changes entirely during the execution of the CPDP, the CPDP can be re-executed using the new set of capabilities and/or requirements. This will require the designer to start from the first step (A) of the CPDP, categorising this new set. The progress it already made is however no longer useful, since it is generated for a different set of input. If the set changes only a bit, for example only a few cognitive requirements and/or cognitive capabilities are added to or removed from the set, the matching table created and used in step B can be changed by the designer, and thereby offers the possibility to extend or limit the design space. This characteristic of the CPDP denotes the flexibility of the CPDP.

On the other hand, all steps of the CPDP ensure robustness to the CPDP to external disruptions, such as the removal of a designer (in a design team). Each step in the CPDP requires

documentation of the outcomes of the step; a list of cognitive requirements and -capabilities per cognition function, a completely filled matching table and a textual description of the matching rationales. This documentation maintains the progress made in the design process, and gives the CPDP robustness to unexpected disruptions in the design process.

Context-aware The documentation generated in the CPDP serves furthermore one other purpose, which is related to the context in with the CPDP is executed. The documentation, and especially the written description of the matching rationales, provide explicit argumentation why a particular match is made. When a capability is considered not to fulfil a requirement, this is also indicated by the matching table. This allows stakeholders in the project to understand why certain design choices are made in the design process. This contributes to more realistic expectations by the stakeholder regarding possible design alternatives created in the next sub-design process of the conceptual design phase. With that, the CPDP is aware of its environment when questions are raised regarding its outcomes.

Just as the CRDP and CCDP, data is considered to be of importance when executing the CPDP. The CPDP is meant to generate design possibilities. These design possibilities indicate which AI software service can meet the cognitive requirements of the business process with its cognitive capability(-ies). Since these AI technologies are driven by data, the data to power these cognitive capabilities need to be of sufficient quality. If the data is of bad quality, the AI software cannot provide the cognitive capabilities it is developed for. Where data availability, completeness and type are important for the CRDP and CCDP, the other data quality aspects are important for the CPDP: consistency, timeliness, accuracy and precision. Therefore, these data quality aspects are ought to be analysed in step C of the CPDP where a thorough analysis is performed whether the cognitive capability can actually cause the effect such that the cognitive requirements can be met. Thus, data available in organisation partly determines the possibilities for design. The CPDP is thereby aware of the context it is used in, i.e. the environment it generates design possibilities in.

This chapter provides an answer to the fourth research issue (RI4) raised Chapter 1 in Figure 1.4: *Match functions to requirements, generating possibilities for design.* The Cognitive Possibilities Design Process (CPDP) created is thereby the third component of the conceptual design process as envisioned in Section 2.2. It provides a way to formulate cognitive possibilities from the cognitive requirements and capabilities from previous sub-design processes of the CDP. As described above, the CPDP thereby recognises the values (specified in criteria) elaborated in Section 2.2 to a certain extent. Again, to what extent precisely is not researched here, and therefore subject for further research (see Chapter 8).

7 | Constructing & Validating the Conceptual Design Process

This chapter presents the research that is conducted on the fifth and last research issue (RI5) raised Chapter 1 in Figure 1.4: *Establish a conceptual design process of cognition enhanced business processes*. That is, it describes how the three design processes created in Chapter 3 to 6 can be combined to form a coherent whole. This chapter delivers the overall **Conceptual Design Process (CDP)** as envisioned in this research.

Section 7.1 describes the effort of constructing the CDP from the CRDP, CCDP and CPDP. Furthermore, it argues that besides these components two other components are necessary for the sake of completeness. Section 7.2 and Section 7.3 elaborate on these two other components of the CDP. Section 7.2 presents and elaborates on the theoretical concept of Design Process Co-ordination, which coordinates the other components of the design process such that its goal are met. It furthermore discusses how this concept of Design Process Co-ordination can be used in the conceptual design process envisioned in this research. Next, Section 7.3 introduces and describes the way in which data is present and formalised in the overall conceptual design process. Adding these two last components of the conceptual design process results in the last part of this research creating a CDP for cognition enhanced business processes. Section 7.4 therefore presents the final conceptual design process, which is validated in Section 7.5 by a round table discussion with experts and assessment on the criteria introduced in Chapter 2, and by applying the conceptual design process to the second case study in this research. Section 7.6 presents the conclusion of this chapter.

7.1 Constructing the Conceptual Design Process

So far, Chapter 4 presented the CRDP which extracts and formulates the required cognitive activities of a business process, by decomposing a business process to tasks and elicit the cognitive activities that are performed when executing each task. Next, Chapter 5 presented the CCDP, which formulates the cognitive capabilities of AI software, by defining the different services provided by the software and by specifying its functionalities in the context of the business process under review. This part of the design process is also driven by a design exercise. The previous chapter, Chapter 6, described how the outcomes of the CRDP and CCDP can be matched to each other supported by a categorisation leveraging the concepts addressed in Chapter 3. This matching process generates insights in the possibilities of utilising AI software in the business process under review (such that ultimately design alternatives can be constructed), referred to as the CPDP.

These three design processes are viewed as components of the overall CPD how to enhance the cognition of (the tasks in) a business process. As formulated by (Dym and Little, 2010), the conceptual design phase consists of six steps, of which three are covered by the CRDP, CCDP and CPDP. However, the last three steps of the conceptual design phase – *Generate design alternatives*, *Refine and apply metrics to design alternatives* and *Choose a design* – are not covered yet. These steps together are referred to as the **Design Alternatives Generation & Selection Process (DAGSP)**. However, as already mentioned and argued in the introduction of this thesis, the DAGSP is not studied in this research.

To form the overall conceptual design process, the question is how the components are connected to each other. Are they used purely sequentially? Do these components transfer information or other resources to each other? If so, what information do these components transfer to each other? The answer to this question is rather difficult. Expert opinions from design scientists state that, because every design exercise is different (Rittel and Webber, 1973), their design strategy used in the project is never the same (van Langen, 2015b). Therefore, it is not worthwhile to formulate a fixed sequence for the execution of the four components of the design process. Furthermore, the transfer of information between the four components will be different in each design project. Thus, within the design process, another component is needed that is responsible for the the strategy that guides the design process towards its goal: to design a cognition enhanced business process.

The CDP is, in all its essence, ought to support the conceptual design exercise as mentioned above. Thereby, the CDP has to cover the important design activities that are related to this design exercise. The CRDP, CCDP and CPDP are the components responsible for this. However, next to the important design activities, other relevant and important concepts and/or factors are ought to be covered by the CDP, since they would play an significant role in the design process or affect this design process.

As noticed while exploring the possible ways to form the final conceptual design process, the CDP components (CRDP, CCDP and CPDP) all are affected by *data* related factors. As already mentioned in the introduction of this thesis, AI technology cannot be leveraged without data that fuels these technologies. If data is not available or considered to be of insufficient quality, the number of possible designs decreases. Data quality aspects of importance to the CRDP, CCDP and CPDP are discussed in Chapter 4 to 6. Thus, data quality aspects are important during the whole CDP as investigated in this research. Hence, the concept of data, and especially data quality, has to be included in the CDP in a certain way.

Figure 7.1 schematically denotes the two envisioned components that have to be found, in order for the design process to be useful and sound. The dark grey blocks indicate the still missing components of the CDP. The striped grey block represents the DAGSP component of the CPD, which is not further addressed in this research. This chapter presents the last two components of the design process, and integrates them in the CDP together with the CRDP, CCDP and CPDP from respectively Chapter 4, 5 and 6.
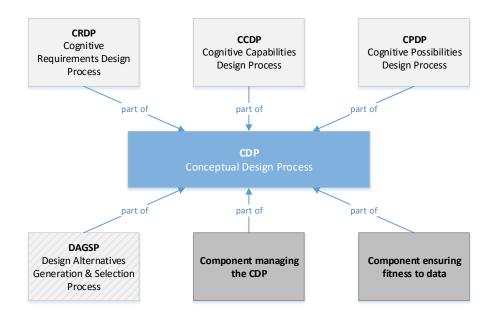
FIGURE 7.1: The components of the conceptual design process so far, highlighting in dark grey the components still unknown

7.2 Strategy in the Design Process

A designer who is responsible for the design of a (new) cognition enhanced business process can leverage the three design processes to receive the guidance that these processes provide for conducting the design task at hand. The question is how to utilise these three processes in such a design exercise? More specifically, the following unknowns are present regarding the use of these three design processes (i.e. interaction between these design processes):

- The order of use (task control): with which design process do you start? Do you use it purely subsequently? Or do you switch between the design processes (iterative character)? How often do you then switch?
- The information exchange between the design processes: does information flow from one design process to the other? How often? And what information precisely?

Two objects in the design process that are of relevance to these two unknowns are the specification of the system under design, and the (design) requirements to which the system's design should comply (van Langen, 2002). The changes by the designer to the specification of the design and the design requirements influence the order in which design activities are performed and what information between which design activities is exchanged. The process of these manipulations is driven by the objectives of the design process, which manifest themselves in the form of a strategy that provides the design process with a course of action.

7.2.1 Design Process Co-ordination

As firstly coined by van Langen (2002), **Design Process Co-ordination (DPC)** is the concept that controls a design process in accordance with given design process objectives. Hence, it is responsible

for the overall design strategy of the design exercise. Design Process Co-ordination is furthermore concerned with the use of requirements, working towards a certain (design) solution. Besides indicating which design activity should be performed at a given moment, it suggests how to properly allocate resources such as information, time and stakeholders in the design process.

DPC is thus situated on a more strategical level of a design process, where the other components of a design process have a more tactical nature within the design process. Just as other components in the design process, the context of the design is taken into account in DPC. Because DPC can be considered as the 'glue' between all components in a design process, it embodies the learning character of the design process, which the other components do not deliver on themselves.

Figure 7.2 schematically visualises the input and output of Design Process Co-ordination. The input of DPC are the objectives of the design process. An example of a design process objective is the goal to finish the design exercise within three months. The output of DPC are evaluations of the Design Process. These evaluations are for example statements if and to what extent the design process objectives are met, throughout the design process and at the end of the design exercise. The connection of DPC with other components of the design process is twofold. First, it entails the communication of the strategy formulated by DPC to the other components. An example of this is when and which steps should be executed by that part of the design process. The second part is the evaluation of this first part, which are evaluation statements how well that part of the design process is controlled. Every other part of the design process still has its own inputs and outputs. These components mutually communicate and transfer information when necessary to perform their design activities.
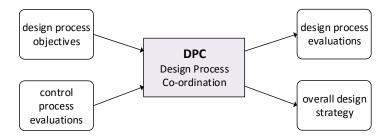
FIGURE 7.2: Input and Output of Design Process Co-ordination

7.2.2 Application to this Research

Interpreting the notions above in the light of this research, DPC is considered to be of value in the envisioned conceptual design process since it delivers the strategy throughout the design process that is needed to steer the process towards its objectives. The Design Process Co-ordination process should not be considered to be similar to the three design processes constructed in this research, since it serves a different purpose in the conceptual design process. Namely, where the three components can be typified as tactical deciding *how* the design activities should be performed, DPC can be considered here as strategical, since it decides on *when* certain design activities should be performed in the overall design process. Figure 7.3 illustrates the structure and relationships between the DPC and the three design processes. For the sake of clarity and simplicity, the DAGSP is not visualised in Figure 7.3 since

it is not specifically addressed in this research. As described above, DAGSP is part of the total CDP and thus has a link to DPC as well. Its place in the CDP is illustrated in the overview of the total CDP.
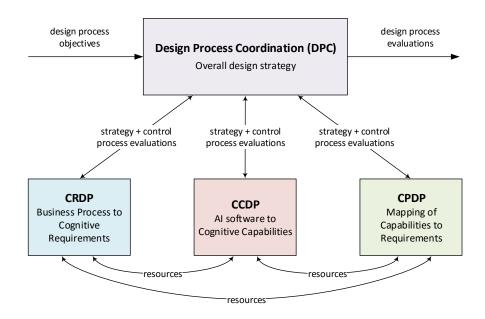
FIGURE 7.3: Design Process Coordination applied to the CRDP, CCDP and CPDP of the CDP

In the process of designing a software system that enhances the cognition used in a business process, DPC is thus the responsible component that determines the strategy of the design exercise. It executes this strategy by determining which design activities should be performed of which part of the design process (CRDP, CCDP, CPDP) at a given moment in time. For example, when entering the CPDP, it could be that some requirements (or capabilities) are not formulated detailed enough in order to be properly used in the matching process. DPC then determines to go back to the CRDP (or CCDP) to re-execute the design activity that is responsible for this formulation. DPC is thus a guiding component of the conceptual design process.

When utilising the conceptual design process, first the design process objectives have to be specified. These objectives form the input for the DPC, and are used for the formulation of the design strategy. Each time a design activity is performed, for example in a design step of the CRDP, the strategy is evaluated if it still meets the predefined design process objectives. Furthermore, throughout the design processes CRDP, CCDP and CPDP, the DPC gathers information about the need for resources from the sub-design processes and facilitates this. DPC fulfils thereby an essential role in the CDP.

Figure 7.4 shows the components of the conceptual design process, adding the Design Process Coordination component to the four other known components. This leaves a component ensuring the design to fit to the data still unknown. The following section elaborates on this last unknown component of the CDP.
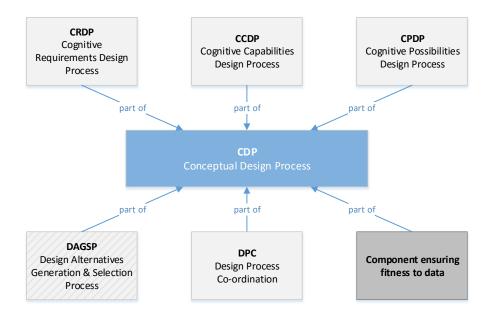
FIGURE 7.4: Visual of the components of the conceptual design process, indicating in dark grey the component still missing

7.3 Ensuring Fitness to Data

As assumed in Chapter 1, data is of importance when using AI technology in a particular system. As turned out in the assessments of the design processes applied to the case study regarding the criteria drafted in Chapter 2, the CRDP, CCDP and CPDP can indeed be affected by data. More specifically, the quality of the data is considered to be especially relevant for the design of AI powered systems to create cognition enhanced business processes.

Data quality is thus of significant importance to the whole CDP. If the conceptual design under creation does not fit to the data (quality) available, the conceptual design will in the end not suit the environment in which the design exists in, i.e., the solution will not suit the problem. Thus, data can then be considered as a constraining factor in the design process. Therefore, in each sub-design process of the CDP, an assessment if data quality is considered as a issue or not should be performed frequently. Hence, a sixth component of the CDP is proposed, that is responsible to make sure that the system under design will in the end be accommodated to the relevant available data.

7.3.1 Assessment of Data Availability & Quality

To what extent data fits to a particular design is considered to be determined by the availability of the data and the quality of the data. As fitness of the system under design to data is important to keep track of, **Data Availability & Quality Assessments (DAQA)** have to be executed in the conceptual design process. In essence, an assessment of the data availability & data quality entails the determination of whether the data – of the quality required by a particular design – can be available, such that it can be used when the design is going to be developed after the design phase of the system. If the required data is not available, data quality is non-existing; if the required data is to some extent available, data quality is of importance.

Literature on data quality identifies multiple attributes of data quality, although no consensus seems to exist on this topic. An example of a set of data quality aspects is found in Wang and Strong (1996), which analysed multiple studies on data quality. They drafted a conceptual framework of data quality differentiating fifteen data quality dimensions into four categories. These four categories are Intrinsic Data Quality (1), Contextual Data Quality (2), Representational Data Quality (3) and Accessibility Data Quality (4). Figure 7.5 shows these four categories and the data quality dimensions they consists of.
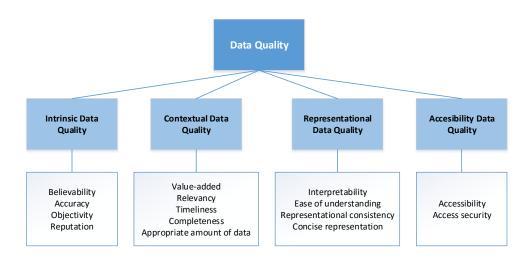
FIGURE 7.5: A conceptual framework of data quality, from Wang and Strong (1996)

The data quality dimensions provided by the framework visualised in Figure 7.5 are an example of a set of data quality aspects that can be used to identify data issues along the way of designing. Based on such a set of data quality dimensions, a data quality assessment can be executed.

7.3.2 Application to this Research

Interpreting the notions above in the light of this research, DAQA is considered to be of value in the envisioned conceptual design process, since it provides a way to frequently check if the solution under design will fit to the data. If data is not taken into account in the conceptual design process, a implication is that the resulting (conceptual) design will not fit to its purpose, due to the applicability of the 'Garbage-in, Garbage-out' principle. With fitness of a design to its purpose is meant the extent the design is similar to its most desired state. The same holds when the quality of the data is not taken into account; low data quality results in low fitness of the design to its purpose. Featuring data availability and data quality in the conceptual design ensures a more appropriate design. By frequently assessing the data availability and data quality in the CDP, the designer can minimise the risk that the design does not fit to the data.

As described in Section 4.4.2, data availability and data completeness are considered important to the formulation of the cognitive requirements in the case study used. They determine if a certain direction of the design process is in the first place considerable. The type of data available is of importance to

the cognitive capabilities of an AI software suite, indicating if the AI techniques available are suitable to deal with the data that is present (see Section 5.3.2). Besides, the appropriate amount of data is considered to be important for the services of the AI software to be used in the case study. The matching of the cognitive capabilities to the cognitive requirements in the case study can be affected by data quality factors such as the accuracy, consistency and timeliness of the data available to the design process (see Section 6.4.2).

Although the important data quality dimensions are found for the case study used in this research, these are not necessarily the (most) important data quality dimensions for each part of the CDP or the CDP as a whole. No guidelines are considered to exist which tell when which data quality dimension is important during each sub-design process of the CDP. A designer can choose to use a conceptual framework such as the one presented in Figure 7.5 or other reference material on data quality dimensions to supports the data assessment. Next to ensuring fitness to data, this component can be used to indicate to what extent an increase in data quality can change the possibilities in design. When the designer or other stakeholders of the design process finds a design possibility particular interesting, but the data quality is not sufficient enough for this, a data quality project can be initiated to increase the quality of the data available.

The DAQA comes to play when certain design activities are performed and their outcomes can be assessed. The DAQA provides information to the design processes in the form of an assessment to what extent a particular design fits the data. Figure 7.6 indicates the relationship of the DAQA with the CRDP, CCDP and CPDP, which is in essence an exchange of information on whether the data quality aspects are relevant to the conceptual design process component (assessment). The CRDP, CCDP and CPDP share this information between themselves to support the execution of their design activities, which is then typified as a resource.
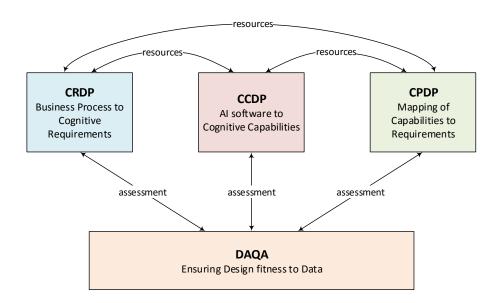
FIGURE 7.6: The Data Availability & Quality Assessment-component applied to the CRDP, CCDP and CPDP of the CDP

In contrast to the other components in the CDP, the DAQA is not considered to be situated on the more strategic level of the CDP such as the DPC (steering the design process to meet its objectives), neither the more tactical level where the of the CRDP, CCDP and CPDP (specify which design activities should be executed). However, since the the DAQA comprises the verification if certain design elements and -possibilities can exist or not, the DAQA is considered to be on a different, more operational level, in the CDP. It thus supports the CRDP, CCDP and CPDP in executing the design activities they propose.

To illustrate the DAQA component in a conceptual design process, let us take an example in the CCDP where the AI software under review only consists of capabilities to extract entities of an input text and translate a text into another language. If the data available to the design process relevant to its objective are mainly databases and other data sources that are not suitable to these AI capabilities, the DAQA will indicate this mismatch. It thereby indicates that or an other AI software suite should be used with different capabilities, or that suitable data should be gathered in the organisation, which often comprises in a data collection project internally in the organisation.

Another example to illustrate the DAQA in the CDP is the following. In matching the cognitive capabilities of the AI software to the cognitive requirements of the business process, data availability can be important. If for a particular design possibility (a match of a cognitive capability to a cognitive requirement) the specific required data is not available, the design possibility will never come to development. The DAQA provides this information to the CPDP by assessing which data is specifically needed by the AI software from the CCDP and which data is available in the business process or organisation from the CRDP.

7.4 Final Conceptual Design Process

Summarising the steps illustrated in this chapter, the envisioned conceptual design process can be created. This part is visualised in Figure 7.7 and thus entails the CRDP, CCDP, CPDP and DAGSP, connected to each other by the DPC and supported by the DAQA as explained in this chapter. For simplicity, only the interactions from and to the Design Process Co-ordination-component and Data Quality Assessment-component are visualised.

Figure 7.7 thus provides the overview of the final CDP as studied and constructed is this research. It provides sub-design process and corresponding design steps to develop in the end a conceptual design of a cognition enhanced business process. Furthermore, it specifies what the design activities within these design steps are, and how they should be performed and paid attention to.

The conceptual design process can serve as a structural approach to identify the possibilities for AI software in business processes, but also the problems currently present regarding the use of cognition. It forces to describe these opportunities and problems in an explicit way, instead of talking about it in a general way. Its scope does not entail what software should be doing in a business process (software engineering view), but where it can fit in, and be of value to the business process (systems engineering view). The conceptual design it addresses adds value to the design of AI systems within business
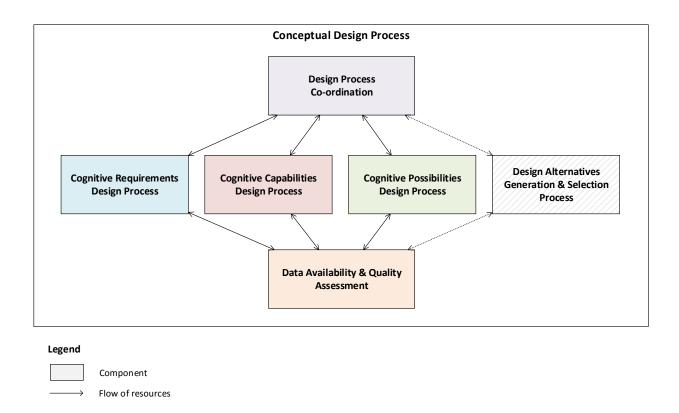
FIGURE 7.7: Schematic of the elements of the conceptual design process constructed in this research, indicating in light grey striped the component not addressed in this research

processes, by making explicit why particular AI services and corresponding techniques should be used. The design process is built upon the theory of Cognitive Systems theory as elaborated in Chapter 3, using the concept of cognition to enhance a business process, thereby contributing to the overall goal set by the organisation. By going through the CDP, answers can be provided to questions such as: what is our objective regarding the use of AI in the business process? And what needs to be improved exactly? And which feasible AI solutions can therefore be used?

To make sure that this CDP can be used in design projects, the validity of the CDP is assessed in two ways: validating the conceptual design process and a conceptual design it produces. The next section describes this validation exercise. The assessment of the final CDP on the criteria stated in Chapter 2 is a part of the validation and is addressed in Section 7.5.1.4.

7.5 Validation of Research

The validation of the conceptual design process is performed in twofold. Process-wise, the CDP is validated with Jibes Data Analytics B.V. who employs experienced AI system developers which belong to the target group of the CDP, since they design, develop and implement these types of systems. This validation shows how usable the conceptual design process is for them, and how they think about its value for the to be designed systems in the end. To assess the validity of the CDP, a full blown empirical validation study is desirable. However, due to time constraints and due to the fact that this research uses a RtD approach, such a validation study is not performed. Instead, a round table discussion was

organised and conducted with three AI-solution experts of Jibes, which also serves the purpose of this research in a proper way. Content-wise, the CDP was validated by applying the conceptual design process onto a new case study. This shows whether if the CPD actually generates meaningful and useful design solutions in another case study. Respectively Section 7.5.1 and Section 7.5.2 present and elaborate on these two validations performed in this research.

7.5.1 Validating the Conceptual Design Process

For the validation of the Conceptual Design Process, I hosted a round table discussion at Jibes Data Analytics B.V with three of its AI-business solutions experts. In this round table session, I first briefly presented the goal of this validation step, setup of the meeting and the background of my research. The latter explained why I developed a CDP and what perspective I took to scrutinise the opportunities of AI in business processes. The main part of the meeting comprised of a discussion about the five components studied in this research of the CDP to challenge their existence and content. Here, I asked the participants to speak out their thoughts and beliefs about the usability and usefulness of the CDP. Furthermore, the discussion entailed also the broader topic of AI solutions for business processes, not limiting to the conceptual design phase of such solutions. Therefore, together with the actual design process of the CDP, these validation steps can be seen as results of this research, and therefore as a prelude to the conclusions of this research.

To describe the main points from this round table validation discussion, the notions are presented per sub-design process of the CDP. At last, this section assesses the final CDP on the criteria stated in Section 2.2.
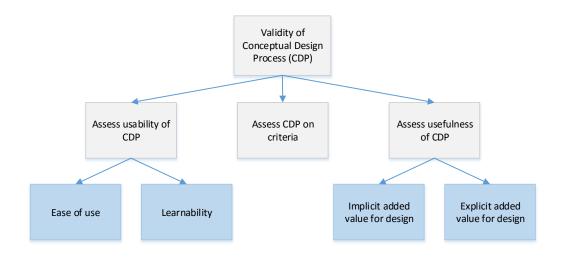
FIGURE 7.8: Schematic outline of validation of the conceptual design process

7.5.1.1 Validation of CRDP

The discussion about the CRDP touched upon each step of this design sub-process (recall Figure 4.6) in Chapter 4. Overall, the participants of the round table stated that it is desirable to *think about the requirements of the solution independently from the technological possibilities*. Not until the CCDP in the CDP, the CCDP, the technology is considered for the possibilities it can deliver. Because of this,

a designer is able to analyse the possibilities for the business process under review as objectively as possible regarding the goals it wants to achieve. The participants agreed on the fact that the CRDP allows for this objective review.

Secondly, the experts indicated that *human-centric view* of the CRDP is a strength of the design process. They described that, to date, projects concerning AI solutions in business processes are often viewed from a purely machine-centric perspective, mainly due to the hype regarding automation by AI. The human-centric approach of the CRDP forces stakeholders to think about the environment the solutions is going to play a role in, namely the business process, in which human beings are not neglectable. In the end, the AI solutions have to function and perform well in the business process such that it is *accepted* in the whole organisation.

Furthermore, they have expressed that the detailed analysis of the business process is another strong point of the CDP, and even necessary for a proper design of a solution. They refer here to the decomposition of the business process, by specifying the boundaries of the business process (system) under review, its break-down to sub-processes and tasks.

Next to that, the Cognitive Task Analysis is found to be interesting by the experts and useful for the *extraction and analysis of both explicit and implicit knowledge* used within the business process, as well as other *cognitive skills expressed and utilised* in the business process. They indicated that the new glance, the *cognitive systems perspective* on the business process, and especially on its tasks to be refreshing and to some extent valuable. However, they also expressed some concerns regarding the (still) *general character* of the Applied Cognitive Task Analysis for its use in projects developing AI solutions in business processes. To use this CDP, the Cognitive Task Analysis step is suggested to be researched more in detail, resulting in a more specific, more rigorous and less elaborate version of this analysis.

Furthermore, they indicated that the ACTA has to *deal with a bias* in its analysis process, due to the fact that information is extracted from other persons. These interviewees could be biased in certain ways, resulting in less usable and objective results. For example, they can be uncooperative, provide false information, lack a necessary degree of self-reflection, and/or are not able to pronounce their thoughts well enough. When executing the ACTA in this CRDP, the designer has to *acknowledge this potential bias* and take into account that the raw results of the analysis have to be carefully examined and reflected on.

At last, the experts reported their slight concern of the approach of the CRDP of the CDP, since it seems that the CDP focuses only on *optimising a business process within the established frameworks*, i.e. the boundaries of the current state of the business process. Therefore, potential solutions will not be designed outside these boundaries, or question those boundaries, which could result in ignoring even more valuable solutions. Indeed, the CDP does not cover this, since it formulates the requirements for the cognition in the business process, in its current situation / state. The cognitive perspective taken in the design of this CDP is thus the reason for this approach.

7.5.1.2 Validation of CCDP

In the discussion about the CCDP, all steps were touched upon as presented in Figure 5.6 in Chapter 5.

The participants of the round table discussion expressed that they value the result of the CCDP, a table which describes the AI software under review on several criteria, as useful for themselves and colleagues as a reference for the design exercises they perform. Furthermore, it can serve also as a communication vehicle to clients and other stakeholders, describing relevant and valuable information about the AI software services such as their functionalities, examples of their use, and relation to technical fields of study. It thereby fosters the design process of the solution. It could be helpful for the selection process of the right software service, from for example a financial perspective and/or functionality perspective.

Furthermore, an expert indicated the usefulness of the CCDP to extract information about which data is needed for proper use of a particular software service. One could think about which business data is necessary, but also which dictionaries should be available for proper use of natural language processing services.

The experts also indicated that the CCDP of the CDP forces the designer to formulate and specify the functionalities of the software package under review in a clear way, which they think is a good thing and valuable for a solid and rigour design process. It can then improve communication about the software with both colleagues, clients as well as other relevant stakeholders (think about the financial department which has to agree on the software investment). Once created, updating the overview is less work and also desirable, since functionalities of software packages change over time (during the period of this research, one service of IBM Watson is taken offline and not available anymore for use). For a consulting company as Jibes, it is also desirable that its consultants have this knowledge about the software availability, to be able to quickly identify possible solutions for AI in a business process.

Just as the critique on the CRDP, the experts question the approach of the CCDP, since it extracts and formulates the capabilities of the software first. Instead, one can also reason more freely about the functionalities the to-be designed systems should have. Then, the designer can search for means that fulfil these functions. This is indeed a good point and a weakness of the CDP. Again, the cognitive systems perspective taken in the design of this CDP seems to be the reason that the CDP is constructed as it is now. It forced the design process of the CDP to identify and examine the cognition that is currently used in the business process.

7.5.1.3   Validation of CPDP

After the CRDP and CCDP, the design activities of the CPDP in Figure 6.4 in Chapter 6 are discussed in this round table meeting. Just as the CCDP, this sub-design process of the CDP is found useful as a communication vehicle to colleagues, as well as clients and/or other relevant stakeholders for the same main reason: it fosters the process of properly designing the (AI) solution. Furthermore, the extensive character of this design sub-process makes sure that no solutions possibilities are forgotten. This is also indicated as a strength of the CPDP by experts. The categorisation that is applied to the potential matches in the form of the cognitive skills from theory, is considered as logical and valuable for the matching process.

In addition to that, some experts expressed some critique on this extensiveness and rigorous character of the matching process. They question if this formal way of examination of each possibility is necessary

in practice, since the designer's gut feeling and creativity will focus on the possibilities that he or she thinks are viable. This research does not contradict this concern regarding this matching process. When the designer is experienced, he or she will indeed be able to recognise the potential solutions for design faster than going through all possible matches in the CPDP. In other words, when conducting the CDP in all its detail, it could take away some of the creativity of the designer to develop out-of-the-box solutions.

At last, the experts identified a limitation of the matching process, comprising the performance (quality and robustness) of a software service. The matching process as presented in Section 7.3 only identifies whether a particular capability is usable to fulfil a particular requirement. That is, it only takes into account the usefulness of the software service, but not how well this service is actually capable of meeting that requirement. The matching process can thus be improved by adding a scale of performance of the capability, being able to fulfil the requirement. The experts stated that the software services that they used (of IBM Watson) are not all of the same quality or robustness. The maturity levels of these software services can thus differ.

7.5.1.4 Assessment of the Conceptual Design Process

Besides these notions of the experts on the distinct components of the CDP, the round table discussion also resulted in some general remarks about the CDP as a whole (see Figure 7.7 for the total structure of the CDP). The experts agreed on the fact that the CDP provides end-to-end insights in the possibilities of AI software in a business process. The CDP supports this exercise with its structural character, identifying the potential of AI objectively. For developers of AI solutions in business processes, it decreases the freewheeling behaviour which is present in the design process without explicitly formulated guidelines. In addition, according to the experts, the CDP in the end contributes to help client organisations to identify the potential added value of AI for their business processes, in a methodological structured way, before investing (heavily) in software and/or projects that are not feasible. Furthermore, the methodical character of the CDP ensures that the conceptual design is made explicit. The documentation of the executed conceptual design process thereby serves as justification of the design choices made during the design process to the client.

The explicit details and structural character of the CDP is being praised by the experts, although it is also recognised as a potential fallback. This is due to the fact that in practice, it is an extensive process to go through. The question that is asked is if this much detail significantly increases the added value of the CDP for use in real projects. The experts therefore recommend to assess in further research if a light version of the CDP as presented here is of about the same value. If so, a light version of the CDP can be constructed from the detailed version of the CDP as presented here. At least, and backed by the participants of the round table meeting, the structure and level of detail of the CDP makes sure that a designer will not be able to miss a step in the design process. Although the designer can choose to skip a design step or design activity, the CDP compels the designer to at least think about it.

According to the experts, the CDP components together form a logical and consistent whole. To their knowledge, the design activities in each sub-design process seem to be clear and usable in different cases. This accounts for the *universal applicability* of the CDP. They found it particularly useful that

the CDP indicates how much design activities exist and have to be conducted. It thereby provides also knowledge about when a particular sub-design process is completed, as well as the final conceptual design of a solution. Hereby, the CDP is considered to be *methodical in its essence.*

Another strong point of the CDP acknowledged by the experts is the fact that the CDP is able to grasp and explicitly formulate the implicit and explicit knowledge about how to perform tasks and processes, present in a business process and particular tasks in the business process. Until know, the experts found it hard to identify and specify the implicit knowledge that is present in an organisation, embodied by its people. This also counts for the implicit knowledge about potential solutions, which is in the CDP covered by the DPC. This denotes the *context-awareness* of the CDP.

As stated earlier in the validation of the CRDP, the experts state the human-centric perspective taken by the CDP as valuable, next to its focus on cognition from a systems perspective. However, due to this view on the design of a solution, the CDP constructs solutions from within certain solution boundaries, set by the situation of the business process as it is in know. It does not take a to-be perspective, and from there reasons back to the means that are available to fulfil the requirements set by the envisioned state of the solution. This is considered by some experts as a fallback of the constructed CDP.

As encountered in executing the case study, people working in the claim process interviewed for the design process did not feel threatened by the content and form of the analysis of the cognitive activities they performed. Thereby the CDP is on this point considered to be aware of the context it is performed in. Besides, data is a factor in the design process that is considered by the experts to 'make or break' possible design possibilities and thereby final (conceptual) designs along the way of designing cognition enhanced business processes. They acknowledge the importance of a component of the DAQA in the design process. This also accounts for the context-awareness of the CDP.

As explained in Chapter 3 to 6, changes in the design do occur when the CRDP, CCDP and CPDP are executed by different designers. Besides this, variety in the result of CDP can also be caused by the DPC and/or DAQA. For example, different designers interpret design objective and control process evaluations in a different way, resulting in different design strategies. The DPC provides the designer space to executes the CDP in the way that he or she thinks is best, shaping the solution in a particular way. This also holds for the DAQA, where different designers can focus on different data quality aspects that he or she thinks is of importance. In these ways, the *flexibility* of the CDP is also covered in the DPC and DAQA components.

7.5.2 Validation of Conceptual Design

To validate the (first steps of the) conceptual design such as it results from the CDP, a second case study is used. This second case study also entails a claim assessment process of a health insurance company. In this case study, the three design sub-processes CRDP, CCDP and CPDP have been completed, resulting in a list of cognitive possibilities for that particular business process. This validation therefore presents its findings according to these three sub-design processes, concluding with some general notions on the validity of the process. As mentioned before, the DAGSP is not in scope in this

research, and therefore also not addressed in this validation.
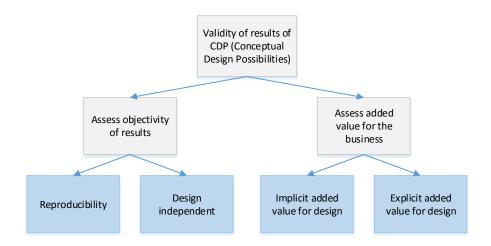
FIGURE 7.9: Schematic outline of the validation of the conceptual design

Before continuing to the results of the validation, a short description of the case study is provided here. In general, this case study is similar to the characteristics of case study 1 in that it also is a claim-assessment process, assessing health insurance claims if they should be reimbursed or not. However, the two case studies are different in the way that they exist in two different health insurance companies, and therefore comprise different people, systems and processes. Hence, this case study can be used to validate the CDP if it indeed results in valuable outcomes for the business.

The validation is conducted with three persons of the insurance company and one business-AI analyst of the consultancy company Jibes. Of the insurance company, two interviewees hold positions in the Medical Assessment department of the organisation, responsible for claims that comprise health support tools: a claim assessor and an advanced assessor. The claim assessor (CP) is part of the processing team, actually assessing claims from start to finish. The advanced assessor (AP) advises the processing team with medical substantive matters, and is responsible for the periodical checks of claims, maintaining and updating protocols, e.g. work instructions, and the higher level assessment of cases (claims that belong to the same case). The third person that is been interviewed to assess the validity of the conceptual design is an internal adviser (IA) on strategy and development of the business, currently participating in (internal) projects to determine the value of Artificial Intelligence for the business. From the consultancy company, a business-AI analyst (BA) that participated in a project to build an AI solution for the insurance company is also used as a source of information regarding the validity of the Conceptual Design deliverables.

7.5.2.1 Validation of CRDP

In Appendix D, the three deliverables of the Cognitive Requirements Design Process are documented: the Business Process Model of the claim assessment process, the Cognitive Demands Table of the Cognitive Task Analysis, and the Cognitive Requirements table as the end result of the CRDP. The main question here is to assess the validity of these deliverables of the CRDP executed in this case

study. That is, are these deliverables established objectively, and do they result in added value to the business and the CDP as a whole in the end.

The Business Process Model is constructed based on an interview with the IA and validated afterwards with the BA of the consultancy company. Since Business Process Modelling is a mainstream practice in the business community as well as the scientific community, this deliverable is regarded as relatively straight forward in the CRDP. This step is furthermore not of high importance for the resulting Cognitive Requirements of the CRDP, it mainly provides the designer with a sound overview and decomposition of the business process at hand, providing relevant general information about the process and indicate about which concepts substantive knowledge is required such that the next steps of the CRDP can be executed properly. The final version of this deliverable is checked by the IA and BA and judged to be objective. Furthermore, they stated that it is a valuable step to execute, because it provides an overview of the possible tasks for further study in the CDP.

The Cognitive Task Analysis is conducted with the CP and the AP. Relative to the previous addressed Business Process Model, the Cognitive Task Analysis is a less straightforward method to perform. Some prior study on how such an analysis should be conducted is necessary. There should be mentioned that this analysis inherently comprises subjective judgement of the designer. However, after validation with the IA of the insurance company, the Cognitive Task Analysis is considered to result in interesting insights in the cognition that is required for executing the task(s) of the business process at hand. Furthermore, the BA stated that this analysis does result in insights that are objectively satisfying.

The last step of the CRDP entails the refinement of the outcomes of the Cognitive Task Analysis into the cognitive requirements. This step is meant to more precisely formulate these requirements of the cognition necessary to perform the task(s) in the business process. Therefore, this step actually helps to improve the degree of objectivity of the cognitive requirements. The BA recognises the value of this step to refine the results of the Cognitive Task Analysis, mainly because it will serve their purpose in a better way: the matching of the cognitive requirements to the cognitive capabilities, formed in the next design sub-process.

Overall, the CP, AP and IA acknowledged the correctness of the content of the deliverables, which serves a quick verification. Furthermore, the IA stated the value to the business of the whole CRDP, since it provides insights in the cognitive aspects of the business process under study. However, the IA indicated that the Cognitive Task Analysis would result in more valuable insights if the analysis would be refined and adjusted more specifically to the type of process it is conducted on. This adjustment exercise of the Cognitive Task Analysis is not performed in this research, but seems as a valuable thing to do regarding the goals of the CDP. It is therefore discussed in the further research section of this thesis (see Chapter 8).

7.5.2.2 Validation of CCDP

In this case study, IBM Watson software is selected on forehand in the project to construct a proper AI system for the claim assessment process. This case study is therefore the same as the case study used

in this research for illustrative purposes. For the elaborate description of the extraction of cognitive functions from IBM Watson software services, the same information is therefore used. This information can be found in Appendix C. The main question here is to assess the validity of the decomposition of IBM Watson services to its cognitive capabilities as is performed in the Cognitive Capability Design Process. That is, if this decomposition is performed objectively, and resulted in added value to the business and the CDP as a whole.

For this part of the validation, the BA is questioned about his thoughts concerning the results of this exercise. The decomposition of the AI software is experienced as a valuable exercise, since it provides information about the functional capabilities of the software services, examples how it will function, identifies the formal (scientific) fields of which the services, and the cognitive aspects that each individual service can deliver, i.e. its cognitive capabilities. These insights are not yet found in other sources of information as specific as the CCDP for business processes. It is therefore considered to be valuable for the business. Because the CCDP holds a crucial position in the CDP, namely the supply of the capabilities of the to be designed (software) system, it is found also valuable for the CDP as a whole.

7.5.2.3   Validation of CPDP

The Cognitive Possibilities Design Process entails the matching of the cognitive capabilities, the outcomes of the CCDP, to the cognitive requirements, which are the outcomes of the CRDP. The CPDP is important to the overall CDP, since the CPDP delivers the (final) outcomes of the whole Conceptual Design Process as addressed in this research. The CPDP provides the outcomes of the first three steps of the conceptual design phase which are addressed in this research, and thereby the final outcomes of the CDP as constructed in this research. However, they are thus not the final outcome of the formal conceptual design phase. The main question here is to assess the validity of this matching process of the CPDP by indicating its objectivity and value to the business.

The objectivity of the results of the CPDP is to assess by means of questioning the BA. This person stated that the results of the CPDP are to some extent objective, although the character of this matching exercise is rather subjective. Proper documentation and discussion of the (intermediate) results with peers support the objectivity of the CPDP. To be clear, the CPDP as presented in this research is not foolproof, since it does not provide a detailed road map that fully voids improvisation, creativity, etc., i.e. the design skill(s) that a designer is expected to have.

The value to the business of the CPDP is to assess through questioning the BA. The BA stated that the cognitive possibilities resulting from the CPDP are of value, if the matching of the cognitive requirements to the cognitive capabilities is properly done. More specifically, the results are of value for the business, in that they comprise the possibilities of AI software to possibly and ultimately increase the efficiency and consistency of the claim assessment and decrease the number of errors made in this assessment. However, the assessment if these possibilities indeed result in these envisioned business goals is outside the scope of this study.

7.5.2.4   General Remarks

Besides the validation of the three components of the resulting Conceptual Design from the CDP, some general remarks are presented here. The BA of the health insurance company characterised the focus of the CDP as human-centric, since it specifically addresses the cognition used in the business process by people. Therefore, he recognises the potential supportive role of designed, developed and implemented (cognitive) systems to people executing tasks in the process at the moments where it is really needed. Furthermore, the BA acknowledged that the support or (partial) automation of activities within a task has the potential to decrease the number of moments where cognitive skills are performed while being unnecessary. In both ways, the BA thus states that utilising the CDP generates an overview of the possibilities for an enhancement of the cognition of the business process as a whole by means of integrating AI software to a (still) unknown extent. Recall that the level of cognition enhancement of a business process is outside the scope of this research.

However, the BA also states some criticising notions. Namely, AI is not always the solution to opportunities to improve the business process. For example, in many ways the business process benefits more from very strict rule-based solutions, which have the advantage above more fuzzy solutions such as machine learning models. The criteria of reproducibility and traceability play an important role here. Furthermore, he questions the as-is oriented analysis performed in the CRDP, since it describes the current situation of the business process. However, in the first place, it could be that the process itself can be improved by optimisation projects, resulting in a different kind of process. Extending on this, the to be designed, developed and implemented system as envisioned, will also require a different business process. That is because the way of working (due to this new system) will change. These two points are however outside the scope of this research and thus not addressed.

7.6   Chapter Summary

To conclude, the CRDP, CCDP, CPDP and DAGSP can be merged such that they form the conceptual design process envisioned in Chapter 1. The first design process addresses the whole process of analysing a Business Process and formulating its Cognitive Requirements. The CCDP addresses the analysis of the (chosen) AI software and formulating its Cognitive Capabilities. The outcomes of these first two design processes can be matched to each other, such that the opportunities for AI software in the considered Business Process can be identified and described. The last design process, DAGSP, finally generates and selects a feasible design alternative, but is not covered by this research.

These four design processes are overseen and managed by a fifth of the Conceptual Design Process, which is Design Process Co-ordination. DPC determines and controls the strategy of the design process, making sure that the design objectives will be met by managing the design activities of the conceptual design sub-processes. At last, the sixth component of the CDP is the Data Availability & Quality Assessment component. The DAQA ensures that, during the design process, the design fits to the data available and its quality.

When this final design is developed and implemented in a proper way, the cognition utilised in the business process will (partly and to some degree) be enhanced. However, the development and implementation phases are not part of this research and thus not addressed. The value of the CDP

and its usefulness for system designers are assessed by means of a case study and expert workshop. Based on these validations, the conceptual design process is found to be effective, useful and usable to a large extent.

8 | Conclusion & Reflection

In this chapter, the conclusion of this research is presented in Section 8.1 by providing an answer to the main research question. The answer to the main research question is formed by tackling the research issues presented in Chapter 1 in Figure 1.5, which is done in the previous chapters of this research. Next, a critical reflection on these conclusions is presented in the rest of this chapter. Section 8.2 discusses the limitations of this research and the possibilities for improvement. Next, a number of key insights generated by this research are formulated and described in Section 8.3. Together with the conceptual design process, theses insights form the outcomes of this research. The insights thereby contribute to achieve the objective pursued in this research, as presented in Chapter 1. Thereafter, the possibilities for future research of cognition enhanced business processes are briefly described in Section 8.4. Section 8.5 concludes this chapter and thesis by presenting recommendations to the business community regarding the design and development of Artificial Intelligence-driven systems in business processes.

8.1 Conclusions
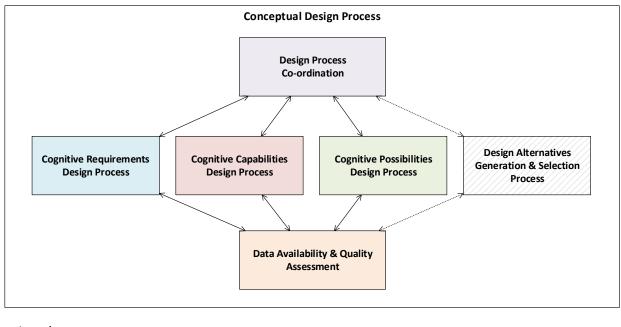
After an exploratory phase of formulating a valuable and feasible problem to tackle, the main research question of this research raised in Chapter 1 is worded as follows:

> **Can a conceptual design process of knowledge-intensive business processes be created, such that the cognition utilised in the process can be enhanced by integrating Artificial Intelligence software?**

The answer to this main research question is that such a conceptual design process can be created, where the research described in this thesis acts as proof. The conducted research delivers a conceptual design process that consists of six components, displayed in Figure 8.1.

Four of the components of the conceptual design process comprise design steps to construct a conceptual design of cognition enhanced business processes. First, the *Cognitive Requirement Design Process (CRDP)* entails the extraction of the cognitive needs of a business process in the current situation. These needs are formulated into functional requirements for the cognition utilised in the business process to ensure proper business operation, so called cognitive requirements. The CRDP can be conducted by performing the following five steps:

1A. Decomposing the business process to tasks and roles and formulating stakeholders' requirements

1B. Collecting preliminary domain knowledge

1C. Identifying sub-tasks and types of knowledge that are required to perform the tasks under review

FIGURE 8.1: The conceptual design process constructed in this research, of which the light grey striped component is not studied

1D. Extracting the cognitive activities from the tasks at hand

1E. Formulating cognitive requirements based on the cognitive activities extracted

Second, the *Cognitive Capabilities Design Process (CCDP)* of the conceptual design process establishes the functionalities of an AI software package under review that express a cognitive skill. These functionalities are formulated into so called cognitive capabilities. The CCDP can be conducted by performing the following four steps:

2A. Decomposing the selected AI software to its services

2B. Identifying the corresponding methods and techniques for each service

2C. Establishing the cognitive functionalities of each service of the software

2D. Formulating cognitive capabilities based on the cognitive functionalities established

These two design processes are input for a third component, the *Cognitive Possibilities Design Process (CPDP)*, in which the requirements from the CRDP and the capabilities of the CCDP are mapped to each other, possibly resulting in match. These matches lead to a set of possibilities for AI software to fulfil the cognitive requirements of the business process. The CPDP can be conducted by performing the following three steps:

3A. Categorising the cognitive requirements and cognitive capabilities by cognitive function

3B. Structurally matching the cognitive capabilities to the cognitive requirements

3C. Analysing each potential match and formulating the rationale for each match

The outcomes from the CPDP can be used to draft a set of design alternatives of AI-driven business processes, which can then be refined and assessed based on pre-defined metrics. On these metrics the best scoring design alternative can be selected to draft a subsequent preliminary design. These design steps form together the *Design Alternative Generation & Selection Process (DAGSP)* of the conceptual design process. Due to time constraints, the DAGSP fourth design process is left out of the research scope and therefore not unravelled in this research.

To construct a coherent conceptual design process next to these four sub-design processes, this research found that two other components should be included in the conceptual design process. First, a component responsible for the co-ordination of the design exercise when utilising the conceptual design process is considered essential and therefore created, called *Design Process Co-ordination (DPC)*. This component is present on a more strategic level than the components mentioned before, executing the strategy of the overall design process by allocating resources (such as time and information) amongst the sub-design processes. Second, the component *Data Availability & Quality Assessment (DAQA)* completes the conceptual design process created in this research, covering the specific need to ensure that the design being created fits the data present in the business process and thus its context. The DAQA thereby finds itself on a more operational level than the sub-design process components of the conceptual design process.

The six components identified, studied and specified in this research form together the final conceptual design process and thereby the main deliverable of this research. The conceptual design process indicates that conceptually designing cognition enhanced business processes can be done by identifying and matching the requirements of the business process and capabilities of AI software scrutinised from an integrated systems perspective on cognition, to generate design possibilities. A project aiming to draft a conceptual design of a business process that leverages an AI driven software system can utilise this conceptual design process and/or the components it consists of.

The conceptual design process is created based on two case studies comprising a claim-assessment process of health-insurance companies. After validation, the conceptual design process is viewed to be applicable to assessment business processes, which indicates its universal applicability to processes with the same characteristics. Furthermore, attributable to its methodical nature, the conceptual design process is considered to provide to some extent rigour to a conceptual design exercise, limiting the design process to freewheel to improper preliminary designs.

8.2 Limitations

This research assumes that, when enhancing the cognition of a business process, the business process will be improved. In what way the business process is improved depends on the objective of the cognition enhancement project (see Section 2.2). However, this assumption on which the CDP is built on is a first noteworthy limitation of this research. In essence, the CDP considers the possibilities for AI software to transfer the performance of cognition in the business process from humans to machines. However, one-on-one replacement of humans to machines is technically not (yet) possible. Therefore, when transferring cognitive activities in a business process from a human to a machine, additional

changes have to be made to the business process in order to realise such an improvement. One cannot consider cognition solely to realise such an improvement in the operation of a business process, sliding the level of cognition between a human and AI system. There are more aspects that, intentionally or unintentionally, will change when such an improvement is designed. This is considered as a fallback of the CDP created in this research.

A second important limitation of the perspective taken by the conceptual design process, is that it approaches the conceptual design of a system from an 'as-is' perspective or current state viewpoint. In other words, the point of departure of the conceptual design process towards a new system is within the boundaries of the current business process, considering the objectives of this existing business process. More specifically, the conceptual design process studies first the cognition that is present in a business process, thereby considering the current state of the business process. Thereafter, the resulting cognitive requirements (established from this 'as-is' perspective) are taken into account in the process that matches these requirements to the capabilities of AI software.

However, one can also approach the design of a new system from a 'to-be' perspective or future state viewpoint. This perspective questions the framework of the current situation in which systems can be developed. More specifically, it does not take into account the current cognitive needs of the business process; it designs a systems with the cognitive capabilities that are needed in the future state of the system. It thus could be that different cognitive capabilities are needed for this future state compared to the cognitive capabilities that are needed in the current state. In addition, such a new designed business process could even totally abandon all tasks and activities it comprised of, bringing into play a more extensive or even radical change of operations within the whole organisation. The conceptual design process created here is not accommodated to this 'to-be' perspective, which is mainly due to time constraints and the fact that the very concept of AI-driven solutions for business processes is not yet widely studied in literature.

Talking about these two different perspective on the transformation of a business processes to its enhanced state, it results in a noteworthy distinction of (business) objectives for such a transformation. When taking an 'as-is' perspective, one approaches this transformation of a business process as an improvement of the current process (by enhancing the cognition in the process). That is, views the business process as it is now and pursues to find possibilities to optimise the business process. Taking a 'to-be' perspective can lead to a design from scratch of the business process, designing a new version of the business process from the ground up. This approach does not remain true to the current structure of the process. Instead, it questions the structure and existing frameworks (see Chapter 1).

This research focuses on the cognitive aspects of an existing business process, which is an as-is situation. Although, I argue that these cognitive aspects are very different in the to-be state than in the as-is state, because the same cognitive skills have to be performed to achieve the goal of the business process. For example, in the claim-assessment process, also in the to-be situation still a form of *perception* of information is needed, as well as *information processing*, *goal generation*, *knowledge*, *judgement* and *decision-making*. It may be to another extent, but it will be there in some way. The cognitive systems perspective taken to design of the conceptual design process is considered to be the reason why this as-is approach is chosen, to search for solutions within the existing frameworks, instead

of looking beyond its boundaries.

Another important limitation of this research that has to be mentioned concerns the perspective of the conceptual design process towards the establishment of the system under design. As embodied in the different design components, the conceptual design process comprises, it does not consistently use one perspective from begin to end. The first sub-design process (CRDP), described in Chapter 1, entails the extraction and formulation of the cognitive requirements of the business process under review. Here, it takes an integrated (human- and machine centric) perspective as raised in Section 2.1 and the integrated systems perspective on cognition as elaborated in Section 3.2 and applied in Section 3.3.

However, the second sub-design process (CCDP) abandons this integrated perspective, only contemplating AI software as a possible source of cognitive functionalities. The perspective taken in the CCDP is constructed from a solely machine-centric perspective. Further in the conceptual design process, these machine cognitive capabilities are matched onto the cognitive requirements that are established from an integrated perspective, as mentioned earlier. Therefore, this matching principle actually only concerns if machine functionalities can be mapped onto the requirements of the cognitive systems-level. It thus neglects any possibilities for humans to fulfil these requirements. Hence, the conceptual design process only delivers a way to study which cognition in the business process can be automated by (AI) software, only partially taking an integrated perspective on the conceptual design of cognition enhanced business processes.

Another limitation of the approach taken to construct the conceptual design process at hand is that it solely took a bottom-up approach, reasoning from the tasks in a business process about the possibilities of the role AI software could play. Hence, this conceptual design process does not take into account the grand business objectives. This would be found in a top-down approach. Although the conceptual design process takes into account the stakeholders requirements in the first design step of the CRDP (Section 4.1), they only comprise the needs regarding the conceptual design.

However, the design sub-phases prior to the conceptual design phase and also prior to the system design phase cover more of the organisational objectives, which should not be neglected. Proper understanding of these grand objectives can be used as input for a feasibility study to select the right design alternative in the DAGSP of the conceptual design process.

This reflection also has to call into question the use of Cognitive Systems theory in this research, the field that designs, constructs, and studies computational artifacts that exhibit the full range of human intelligence (Langley, 2011). Firstly, because the Cognitive Systems paradigm it describes is not (yet) widely supported in scientific literature. Some prominent scholars argue that this paradigm is able to tackle more sophisticated challenges currently present in the interdisciplinary fields of intelligence and cognition (Psychology, Computer Science, Systems Engineering, et cetera) (Langley, 2012; Heylighen, 2011). However, it also has to deal with resistance, opposing Cognitive Systems theory due to its abstract, conceptual and incomplete nature.

This research used the Cognitive Systems theory for the categorisation of the cognitive requirements of business processes and the cognitive capabilities of AI-driven software by cognitive function,

such that they can be matched. However, its use in and value to this research does not end here, and is not just practical. More particularly, the Cognitive Systems theory is used as 'a pair of glasses' to take a new perspective on business processes and intelligence present in these business processes. The underlying thought thereby is that the theory can be utilised to identify and reason about the cognitive aspects of business processes, which can contribute to the understanding of designing of more intelligent business processes. On the other hand, one could also call this part of the theory's contribution to this research somewhat superficial, since it is not very tangible. This reasoning should indeed not be ignored, and scientific discussions on this topic is therefore necessary. Although, as postulated by Maslow (1966), "*[...] [researchers should] not [be] afraid of hunches, intuitions, or improbable ideas. All of this is exemplified in the greater versatility of the great scientist, of the creative, courageous, and bold scientists*".

The conceptual design process can be utilised to generate possibilities that indicate a potential fit of the functionalities of an AI software package to the cognitive requirements of a business process. It has drafted this conceptual design process under the assumption that when the cognition of a business process is enhanced, it would likely result in a more efficient and/or effective way. However, this is questionable, since the conceptual design process is not tested and assessed this particular effect. Therefore, a desired improvement to the conceptual design process as delivered in this research would be to study, elaborate and describe the DAGSP in detail. The conceptual design process would then take into account to what extent the software will fit the particular requirement(s), while generating design alternatives. Furthermore, it would indicate the performance of that possible solution. With that information, a feasibility study of a design alternative can then assess how valuable the design alternative would be to the business, what investment decisions would be needed to develop, implement and maintain the new systems, et cetera. Based on such a feasibility study, a design alternative can be selected for further design. Due to the time constraints of this research, this should still be studied.

Besides the choice for Business Process Modelling, the use of the Applied Cognitive Task Analysis (ACTA) is argued in Chapter 4. An experimental study to select the most appropriate Cognitive Tasks Analysis (CTA) method and technique(s) for the constructed conceptual design process is not conducted in this research. Partly for this reason the choice for ACTA can be criticised. Furthermore because literature on CTA and ACTA states that results of such techniques are influenced by the interviewee(s), since they are probably biased towards the goal of the new system. Besides this, they can have problems articulating their thoughts (on which ACTA heavily relies) due to the fact that people often cannot describe everything they know (Clark et al., 2006). This makes completing a valuable Cognitive Task Analysis challenging. Because one cannot design a system well if you do not know its aspects and environment, the ACTA used in this research forms a limitation of the conceptual design process. To cope with this limitation, literature suggests to aid expert performers in communicating their cognitive processes by using techniques such as card sorting, process tracing or concept mapping (Clark et al., 2006).

To conclude this section, some notions on the approach Research trough Design (RtD) are presented. The RtD approach steered the process of constructing (designing) the conceptual design process. It

provides a way of researching that has an exploratory character, resulting in insights that go beyond the main subject of interest. This somewhat freewheeling character is at the same time a downside of the approach, since it does not provide rigorous guidance during the research process. Documentation of the research process that provides insight in major design and research decisions is therefore essential for the scientific reproducibility of the research. However, no guidelines for conducting and documenting the research process of a RtD are present in literature. In this research, an attempt was made to keep track of the research process to the best of the researcher's ability to cope with this limitation. How the RtD process developed in this research is described in Appendix A. Note that the constructing the conceptual design process was not as straightforward as it is described in this thesis.

8.3   Insights Generated by this Research

This research utilised the RtD approach to generate research insights by performing a design exercise. This research created the conceptual design process presented in Section 8.1, which is considered as the main deliverable of this research. However, characteristic for RtD, this research has produced more insights than only the presented CDP. The insights are generated by reflecting on the design process of the conceptual design process, and this design artefact itself.

This section presents and describes these generated insights. This set of insights is another main contribution and deliverable of this research. The insights contribute to achieve the objective pursued in this research **to strengthen the scientific understanding of knowledge-intensive business processes of which their cognition is enhanced by integrating Artificial Intelligence software, and support their development**. In addition, these insights are a prelude to the suggestions for further scientific research in Section 8.4 and the recommendations to professionals designing, developing and implementing AI systems within business processes in Section 8.5.

A human-centric perspective can be valuable for the design of AI-driven solutions, to construct intelligent business systems

Because computer technology is not near autonomous intelligent systems by itself at this point in time, no commercial software package brings of-the-shelf intelligence that businesses can leverage. Therefore, a human-centric perspective is still crucial for proper design of intelligent systems that businesses can use. With such a perspective, problems regarding intelligence in organisations can be identified and challenged, because one takes into account the problems human beings encounter during their operations. The conceptual design process starts of with a decomposition of a business process to identify problems in the operation that could potentially be solved with an AI-driven system. Via this way, AI technology can provide value to the business.

Examining the cognition utilised in a business process can support the identification of the potential to smarten its operation

If one aims to increase the level of intelligence leveraged in a business process to better achieve its goals, cognition expressed in a business process can be examined. Scientific literature states that intelligence is a subset of cognition. This research shows that investigating cognition utilised in an organisation is valuable for the design of an enhanced claim-assessment process. Cognitive functions are still mostly

expressed by human beings, which play important roles in business processes. Investigating the cognition a business process utilises can result in valuable insights where improvements can be made to improve its operation.

An integrated systems perspective on cognition (i.e. cybernetics) can be a valuable perspective for the design of AI solutions in business processes

Combining a human-centric perspective and the already considered machine-centric perspective brings an integrated perspective, as argued by scholars described in Chapter 2. Since a business process can be viewed as a system, an integrated systems perspective on cognition provides a way to examine the cognition utilised in a business process. This research uses this perspective, and considers the perspective as insightful, providing a new way to scrutinise where in the organisation automation is of value. Literature about this perspective and design of such systems is found in Cognitive Systems theory (Langley, 2011; Heylighen and Joslyn, 2001; Brachman and Lemnios, 2002). Furthermore, it provides a way to identify the entities, playing a role in the business process, that express cognition. It also provides a way to identify the particular cognitive skills that can be enhanced in the business process.

An integrated systems perspective on cognition can provide potential lean improvements in an organisation

Continuing on these insights on cognition enhancement, an integrated systems perspective on the cognition utilised by business processes can potentially identify room for improvement for lean optimisation. For example, it can identify that current operations are using 'Optical Character Recognition'; techniques to scan images, rather than making sure that that same information is provided to the process in a digital textual way (in the cognition systems theory classified as *perception*). Another example would be a machine learning model that assesses all claims in a few seconds and extracts the claims that have a high confidence to be approved. Removing these type of claims from the general assessment operation creates more time for the assessment of claims that deserve more time by the human expert (in the cognition systems theory classified as *reasoning* or *information processing*). Such improvements concern the reduction of 'cognitive waste' (which is a lean improvement), thereby decreasing the cognition expressed in the operation that is in essence is not a contribution to to the business process's objective.

More focus on the conceptual design of AI solutions for business processes can lead to better designs and thus better solutions

This research found that the conceptual design of AI driven software system in a business process seems to be skipped often in the design process. The conceptual design phase is very important for the design of a solution/system, since it gives birth to ideation, the generation of concepts that could achieve the preset objectives. It identifies the major functional requirements and the means for achieving them (Dym and Little, 2010). The conceptual design provides insights what the possibilities are for the business process to leverage AI technology.

Considering the current state of practice, optimising the current operations through

cognition enhancement by integrating AI software should be preferred over a complete re-design of the business process itself

During this research, I noticed that a complete re-design of businesses regarding their cognition would likely be too radical for organisations that are just exploring the possibilities of AI for its business. Optimising the current operations is accepted by the organisation, since people generally do not like change and have conflicting interests (de Bruijn and Heuvelhof, 2012). With little steps one can re-design the business process to embrace a cognitive system, but this takes time. This is also observed in the business community at this moment in time: projects that are running now are mostly Proof-of-Concepts types of projects. These are short projects that quickly deliver, to some extent, functional prototypes by going through the design phases very quickly. Solutions that support people can serve as a prelude to more radical solutions, for example by going from white-box solutions to more black-box solutions. Stakeholders have to cooperate, but likely may be reluctant due to newness of AI and its accompanying possible unknown consequences to their trusted environment.

At this moment in time, no single *commercial* AI software package can deliver all possibilities for AI-driven systems for organisations

AI software package IBM Watson software is considered by experts to be one of the most promising commercial AI tools. In this research, I noticed that IBM Watson mainly comprises textual processing capabilities. It seems thereby not (yet) as a sophisticated toolkit for the design of intelligent business systems. Besides, the design of such systems should not instantly focus on the functionalities of such AI software packages, since it limits the design space for valuable solutions for an organisation. Multiple toolkits should be considered and assessed regarding the selection of the most valuable and feasible solution for the business.

Data availability and data quality are essential for the proper design of AI-driven intelligent systems

High data quality and data availability are considered to be important for the proper design of AI-driven intelligent systems, since those system rely on this data/information in almost all of their essence and it thus plays a crucial role. One can design and develop the best quality systems, but if the data are not there or of the desired quality, they are useless. The conceptual design process supports the identification which data (implicit and explicit knowledge and information) are needed for a particular solution. Based on this identification, a concurrent study can be conducted to assess to what extent this information is (already) available in the organisation. Experts state that many organisations did not store relevant and valuable information in the past years. This is considered to be the effect of an information problem, since in the past organisations did not know what data in present time would be of value and thus did not know what data to collect.

The health-insurance domain is, to some extent, a suitable environment for the application of AI software systems

Continuing on the topic of information and data, the domain of health and more specifically health-insurance is considered to suitable for the design and development of AI software systems. This is

because the domain comprises a lot of both implicit and explicit knowledge, i.e. information, i.e. (unstructured) data. However, almost all of this unstructured data are structured according to codes, rules, categories, etc. That leads to a relative low granularity of the data available, which makes the design and development of intelligent systems a challenge. Application domains that as well operate using a lot of implicit and explicit knowledge, information and data are considered to be viable domains to apply AI software to.

Besides knowledge, products such as dictionaries and visual models relating to AI-driven systems in organisations, can support their design and development
Concepts relevant to the design of AI systems for business process are studied and described in this thesis. This information can be used for the creation of a dictionary specifying terms and concepts of this topic, which can foster the shared understanding amongst stakeholders. Besides, while actively contributing to projects aimed to design AI solutions for business processes, a schematic model describing different levels of AI systems solutions for organisations is drafted. This model is meant for and used by AI system solution professionals to better communicate with their clients and other stakeholders in corresponding projects. It can be found in Appendix E of this thesis. Both products of this research thus support the design and development of AI system solutions in business processes.

8.4 Suggestions for Future Research

Although this research has generated insights and created knowledge regarding the design of cognition enhanced business processes by utilising AI technologies, it also has raised many new questions regarding this topic. Future research can aim to tackle these questions to further strengthen the understanding of knowledge-intensive business processes of which their cognition is enhanced by integrating Artificial Intelligence software. Most suggestions for further research stem from reflecting on the conceptual design process created in this research and from the insights generated through this process of creation. A number of suggestions for further research are presented and described below.

- Extending on what has been said about the difference between an 'as-is' and 'to-be' approach in Section 8.2, the conceptual design process created in this research is not constructed to design a complete new business process from the ground up. However, creating a conceptual design process that is able to support the design of these types of designs would be valuable, since such a design of AI software systems in business processes is considered by the experts, that partook in the validation process of this research, to have the largest impact. Future research can explore how this 'to-be' state should be determined and how a conceptual design process can look like.

- As mentioned in the reflection in Section 8.2 on the concept of cognition enhanced business processes, further research should be conducted to study the aspects and/or elements in a business process that change with a cognition enhancement of that business process. This research can be conducted by performing the conceptual design process created in this research and investigate which aspects and/or elements of the business process under design change, identify what causes these changes and to what extent they are harmful for the design to fit its environment.

- As indicated throughout this thesis, the conceptual design process is roughly assessed on pre-defined criteria (see Section 2.2), which are considered to indicate proper conceptual design process. After each component was created, a brief assessment of this component is done. However, how the CDP meets these criteria when actually used is not researched. Future research can study the performance of the CDP constructed in this research in an empirical way, and come up with improvements.

- As stated in Section 8.3 as a research insight, RtD can be a valuable approach to conduct scientific research. However, as mentioned in the reflection in Section 8.2, it is an approach that has not a rigorous nature. Furthermore, no practical guidelines exist in literature for conducting a RtD-led approach. Future research can address this gap in knowledge by aiming to identify and formulate such guidelines. This can be done by studying the research process of research that used RtD as its approach.

- This research constructed a CDP by studying two claim-assessment process of health-insurance companies. This research did not study if and how the conceptual design process can be applied to other business process. Although the conceptual design process is formulated in such a general way that it can be applied to other business processes, it is up to further research to determine if it also leads to valuable results as it did here. Future research can thus investigate to what extent the conceptual design process as delivered by this research can be applied to other domains and subjects. Suggested is to start with a business process that has different characteristics as claim-assessment processes, and investigates if the CDP holds.

- This research addressed the design of cognition enhanced business processes by creating a conceptual design process. However, it does not say anything about the level of cognition that can be improved. Further research can try to answer the question how to measure the level of cognition of a business process. A follow-up question would be how much this level of cognition can be enhanced when implementing AI-driven systems solutions.

- In the case studies used in this research the capabilities of IBM Watson are identified, which can be used to fulfil requirements of, for example, a business process. However, reasoning backwards, the capabilities that are missing in a software suite can be identified by scrutinising which requirements it cannot fulfil. Further research can study for a given software suite which capabilities would be valuable to include.

- Section 7.4 elaborates on the need for assessment of data availability and data quality during the process of design. However, it does not state when which type of data quality dimensions or aspects are important, nor guidelines that one can follow to execute such an assessment in a proper way. Further research can pursue to study these data dimensions regarding the design of AI-driven solutions to create this knowledge.

- As stated in Chapter 1, enhancing the cognition utilised in business processes by leveraging the support offered by a conceptual design process can be part of more comprehensive change projects within an organisation. Process improvement projects embracing Lean management (eliminating waste and ensuring swift) and/or Six Sigma (eliminating defects and reducing variability) focus on optimising the current business process. The CDP created here is not designed and accommodated to such a co-operation with process improvement ways of thinking. This would be a

valuable improvement of the CDP in a practical sense. Further research can thus address and study the relationship of the CDP with process improvement approaches, such as Six Sigma and Lean optimisation, to identify improvements of the CDP and to identify practical guidelines to combine these approaches in a valuable way for the design of enhanced business processes.

The experience gained by conducting this research and an analysis of the process of this research by the researcher and peers resulted in an additional study next to this research. The study delivers three (practical) lessons learned how to conduct a RtD-led research. These lessons learned and argued in the scientific article accompanying this thesis (see Reeker et al. (2016)).

8.5   Recommendations to the Business Community

The second part of the objective of this research is to support the development of knowledge-intensive business process of which its cognition is enhanced by integrating Artificial Intelligence software. Insights generated in this research are therefore valuable for the business community, since organisations are exploring the possibilities of Artificial Intelligence for their business. More particularly, the conceptual design process delivered by this research is especially valuable to, for example, AI developers, business analysts, solution architects and innovation managers of organisations which working on such types of business process improvements.

Therefore, this thesis ends with presenting a number of recommendations to the business community to support their design efforts regarding these AI-driven business solutions. The recommendations are drafted based on the conclusion and generated insights of this research described in Section 8.1 respectively Section 8.3. These recommendations are presented and briefly described below.

- Focus during projects on developing AI-driven systems more on the (conceptual) design of possible solutions. Do not skip this phase by starting directly with the preliminary design phase or development phase. Try to convince the organisation that the conceptual phase provides more insights in the possibilities of AI for the business when used, which can result in better quality designs, actively involving stakeholders in the whole design and development process.
- To date, little shared understanding about cognitive system' concepts and technologies is present. Actively participate as a knowledge creator in the field to enlarge the general understanding of cognitive systems and what it means to design AI systems in business processes.
- The design alternatives that would result from the CDP are considered to be able to serve as input for the generation of use-cases of AI systems in business processes. In the business community, use-case development of AI technologies is regarded as difficult. Since organisations often value the exploration of possible valuable business opportunities through development of use-cases, these design alternatives generated by the CDP are a valuable starting point for discussion with organisations interested in leveraging AI technologies and the use of AI software. The CDP and/or its components are thus suggested to be used for exploring different use-cases of AI.
- Use and extent the decomposition of services of IBM Watson into methods, techniques and their functionalities (resulting from execution of case study in Section 5.2) to gain better insights in what this technology can bring to a business. Actively sharing this knowledge contributes to a

further shared understanding of the possibilities of AI software systems by organisations, and enlarges the group of organisations that consider this information sharer as a trusted partner for developing commercial AI systems.

- Extending on the previous, establish and maintain an internal knowledge base available for designers/developers, as well as an external knowledge base which is available to clients (subscription) to improve and extend the shared understanding regarding AI solutions for organisations.

- Focus on the design and development of AI-driven systems that *support* cognitive functions in business processes, not (yet) on farfetched automated solutions that *replace* these cognitive functions, since those are hard to implement. This is caused by the fact that organisations are still reluctant to full blown use of Artificially Intelligence, which results in hard to achieve organisational change (de Bruijn and Heuvelhof, 2012). Progress step by step from rather small projects/changes to the client's organisations to more comprehensive solutions/changes. This can be achieved by not only focusing on the design and development of solutions, but also, more broadly speaking, on awareness of the client, the management of changes caused by technology, and foster their knowledge on AI in organisations.

- In addition to the previous recommendation, prototyping is likely to be of great value in shorter and smaller projects, and should thus be embraced. Investigate more the science behind prototyping to leverage best practises and insights from the academic field, such as the categorisation of different ways and types of prototyping. For example, because prototype structures become less suitable to its purpose due to constant change of its environment, long-term evolution of a prototyped design to a mature implemented system is difficult. Therefore, after a prototype is delivered to the client, do not continue with the prototyped solution – instead, start over.

- Try to focus on tacit knowledge in an organisation as well as knowledge explicitly available. Tacit knowledge and corresponding intelligence, embodied in people in the organisation, is considered to be of great value in the CDP for the design and development AI solutions. Since organisations have a lot of tacit knowledge, special attention to this knowledge and corresponding intelligence is suggested.

- To communicate more effectively with clients, one could categorise different AI-driven solutions based on several criteria to enlarge the understanding of organisations what particular types of solutions encompass. Examples could be human-centric vs machine centric design, degree of acceptation of the organisation, degree of radical change, support of human beings vs autonomous operations, degree of optimisation, degree of automation, degree of data/information availability, degree of data/information quality, etc. Examples of solutions are a self-service portal, a Machine Learning predictive model, et cetera. An example of a model that pursued to deliver such a 'talking board' is created in addition of this research and can be found in Appendix E.

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A | Research through Design

This appendix elaborates further on Research through Design as present in scientific literature in Section A.1. Next, Section A.2 describes how Research through Design approach is used in this research and furthermore elaborates on how the research process progressed in time.

A.1 Additional Literature on Research through Design

Research through Design (RtD) is described in literature as an approach to structurally and continuously design and refine an envisioned artifact (Godin and Zahedi, 2014). It is a conceptualising research done by means of the skillful practice of design activity, revealing research insights (Krogh et al., 2015). More specifically, this knowledge is gained by conducting a design exercise and continuously extracting information by means of direct and indirect observations, beliefs and experiences (van Langen, 2015a). The approach has a highly iterative character, switching frequently between a theoretical and a practical application perspective (van Langen, 2015b).

In the current literature, two perspectives exist where Research through Design has its roots. One side says that the foundation of Research through Design are found in the area of design research, originating from already identified research traditions such as the natural sciences, social sciences and art (Krogh et al., 2015; Koskinen et al., 2011; Steffen, 2014). Others state that the foundation of the approach is more distinct to other fields, differentiating itself with its capability to deliver valuable outcomes (Gaver, 2012; Zimmerman et al., 2010).

The term Research through Design indicates studies in which knowledge is generated on a phenomenon by conducting a design action, drawing in support knowledge from different disciplines, and reflecting on both the design action and an evaluation of the design result in practice. Figure A.1 illustrates the position of the Research through Design approach as a type of research between basic research and the design practice (Honavar et al., 2015).

Findeli (2005) redefined three forms of design research as follows:

- *Research for design* aims at helping, guiding and developing design practice. Those researches document the processes and concerns of professional designers and treat designers and their practice as the object of their study.
- *Research into design* is mainly found in universities and research centres contributing to a scientific discipline studying design. It documents objects, phenomena and history of design.
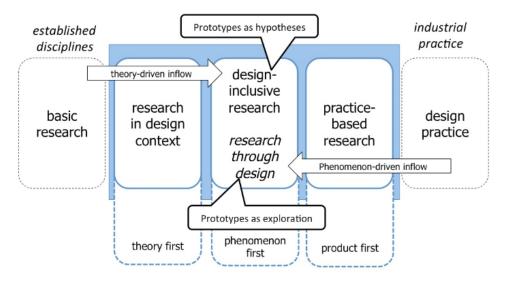
FIGURE A.1: Types of research, by Honavar et al. (2015)

- *Research through design* is the closest to the actual design practice, recasting the design aspect of creation as research. Designer/researchers who use RtD actually create new products, experimenting with new materials, processes, etc.

The idea of Research through Design is more focused on design than on research activities, contrary to other approaches using design to do research. Figure A.2 denotes the differences between Research through Design, Design through Research, Research-oriented Design and Design-oriented Research. A fine line distinguishes Research through Design from Design-oriented Research. In RtD, the design exercise is the core of the research, producing a design at the end. The core essence of Design-oriented Research is however the research into a defined problem, using a design exercise in a larger research process.

	Design ←	→ Research
Fallman (for HCI)	*Research-oriented design*	*Design-oriented Research*
	Design is driven by research within a larger design process, aiming at the real, by means of judgment and intuition, judged by the client	Research is driven by design within a larger research process, aiming at the true, by means of Analysis and logic, judged by academic peers.
Jonas (for design)	Research through design	Design through research
	Covering the whole situation/process, building design as an institution for human-centred innovation and supporting design as a discipline.	Focussing on isolated questions, producing knowledge for/about (?) design.

FIGURE A.2: Differences between Research through Design and similar approaches, from Jonas (2007)

A.2   Research through Design-process

This section elaborates on the Research through Design-process of this research. The process of this research can be distinguished in two parts: the first part pursued to make sense of the knowledge gap present regarding AI and business processes and what can be done to fill this gap, the second part aim to deliver the solution to fill this gap. The process this research went through was not a straightforward process, due to the characteristics of the problem at hand as explained in Chapter 2 and in Section A.1.

The first half of this research, the research focused on the identification and specification of the problem of integrating AI technologies in business processes. This was due to the fact that it was not yet clear what the research problem exactly was, and what this research could contribute to solve this problem. This preliminary research had an exploring character, searching for insights what could be done to support the design and development of business processes leveraging AI technologies.

This goal or objective was the starting point of this first part of the process. This preliminary research consisted of several (design) attempts to explain the complexity of integrating AI technologies in business processes. At first, the research to design a reference architecture of cognition enhanced business processes, by identifying and defining its critical and essential elements, relationships, interactions and functions and evaluate its feasibility and usability, aimed to support the design and development of this type of processes. Furthermore, the research focused on the technical domain of AI software, such as different data mining and machine learning techniques. However, after a brief investigation of projects to integrate AI in a business process available to the researcher, it appeared that non of these projects actually delivered a operational cognition enhanced business process. Therefore, creating a blueprint (architecture) of such cognition enhanced business processes seemed therefore not (yet) feasible for scientific research. Creating a reference architecture was thus too far fetched.

The research therefore drifted away from this reference architecture, searching for how cognitive capabilities of knowledge-intensive business processes can be enhanced by integrating AI technologies. Special attention was thereby given to the learning ability of business processes. The research aimed to establish a conceptual model of a cognition enhanced business process and a supplementary set of recommendations. Furthermore, the research found the theory of Cognitive Systems from a computer science or machine perspective to be helpful for the design, development and implementation of AI in business processes. However, this idea also seemed not yet applicable to current operational projects, such that it was too hard to establish such conceptual model of a cognition enhanced business process.

When also this chosen path seemed to fail, the focus of the research changed to find a way to describe the level of cognition enhancement possible by integrating AI software in a business process. The possibilities to categorise cognition enhanced business processes according to their cognition maturity was investigated, because with this the room for improvement of the business process can be determined. The degree of complexity of the process would determine the level of improvement. This line of reasoning and corresponding analysis is considered to be too general, however, it provided some pointers for the final set-up of the research: to analyse both the business process for its possibilities for the use of AI and the functionalities AI software can deliver.

The second half of the research comprised of creating the envisioned conceptual design process. This

conceptual design process is built from the ground up, making use of design theory for its structure and Cognitive Systems theory for the rationale behind its content. The design steps described in each design process' component are described in the chapters 4 to 7. The process of designing these components can be characterised by experimentation in the case study, analysis of theory and interviews with relevant stakeholders: people working in the business process, people working with AI software, people designing AI solutions for business processes, et cetera. As stated by Bang et al. (2012), experimentation is the cogwheel of a RtD-led research in dialogue with research activities such as hypothesising and theorising. In this research, new ideas got constructed by confronting technology, theory, and phenomenon (that what happens in the world), and many of these confrontations took place before the conceptual design process has matured into a testable thing. Stappers et al. (2015) state that a study usually is guided towards an unity. Within established disciplines, this unity is often achieved by working within a theory. According to Stappers et al. (2015), in design research, the unity can also be achieved by a commitment to achieving an improvement in the phenomenon under study, where either a designed prototype or a flexibly-defined framework provided the central focus of the work. This description of how design-based research ultimately produces valuable outcomes is considered applicable to this research. The CDP is the object that is considered to achieve an improvement of the design and development of AI solutions of business processes. Thereby it became the central object of study, i.e., the design artifact. Cognitive Systems theory was found as a steppingstone for the substance of the CDP.

In the experimental process of finding the right path to achieve the research objective, many topics are identified and analysed. To the best of knowledge of the researcher, a list of these topics is constructed for the purpose of documentation. This list of topics is presented below. One can see that certain topics have become a part of the research and thesis, but most topics did not. In the seventh month of the research process, no new concepts are studied.

Before starting this research project
- Intelligent Agent
- Natural Language Processing
- Data Mining
- Multi-Agent Systems
- Machine Learning

Month 1
- Artificial Intelligence in general
- Research through Design
- Focus on organisation: Product, Business Processes and Business Strategy
- Reference Architecture
- Systems perspective
- Case study 1: claim-assessment process

Month 2
- Self-adaptive systems, Self-organising systems, levels of automation, automation maturity

- Formulate guidelines
- Enterprise Architecture: Business Process Architecture, Information Architecture, Application Architecture
- Information Architecture: Modelling Information Architecture for the Organisation
- Domain Architecture: blueprint of change

Month 3

- Knowledge-based AI: Cognitive Systems (computer science perspective)
- Cognition (from a cybernetics perspective)
- Design thinking
- Wicked problem
- Enterprise Architecture together with Agent modelling notation

Month 4

- Requirement Engineering
- System Analysis and Design
- Perform a design exercise
- Commercially available AI (IBM Watson, Fluxicon, H2O, et cetera)
- Cognitive Task Analysis and Applied Cognitive Task Analysis
- System Design phase
- Level of Cognition versus Process Complexity

Month 5

- Conceptual Design Phase
- Case study 2
- Conceptual Design Process
- Cognitive Systems theory
- Design Process Co-ordination

Month 6

- Data Availability and Data Quality

This ultimately led to the set-up of the research as described in this thesis, with the idea to *support the design* of business processes that leverage AI software. The Cognitive Systems theory from a Cybernetic point of view is explored to create a conceptual design process from case studies that comprised of developing AI solutions for a business process. The perspective taken here is the integrated systems perspective on cognition, instead of solely a human-centric or machine-centric perspective. Together, this ultimately led to the research question as stated in Chapter 1: *Can a conceptual design process of knowledge-intensive business processes be created, such that the cognition utilised in the process can be enhanced by integrating Artificial Intelligence software?*

Figure A.3 shows the theoretical concepts studied and design experiments performed at what moment in the process of this research. Besides, it shows the development of the different artefacts considered in this research. This first phase of this research process as mentioned before is month 1 to 3, the second phase runs from month 4 to 7.

FIGURE A.3: Development of the process of this research

Furthermore, Figure A.4 visualises in a schematic way the construction of the conceptual design process. It indicates the development of the conceptual design process and the different design theoretical concepts and design exercises that have contributed to these developments. The green coloured ellipses indicate research activities that comprised of literature studies and contributed to the underlying theories the conceptual design process is built upon. The orange coloured ellipses indicate research activities that comprised of case study analyses. The blue coloured ellipses indicate research activities that comprised of literature studies, and contributed together with the orange coloured ellipses to the substance of the conceptual design process.
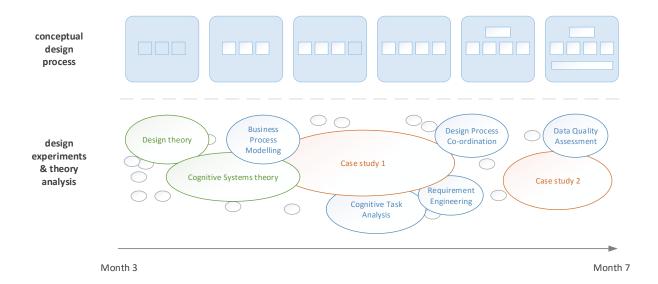
FIGURE A.4: Research through Design-sequence of this research

To describe the process this research went through more, the figures below present the different versions of the conceptual design process created in this research. They display the earlier versions of the CRDP, CCDP and CPDP, next to the final CDP. One can see that in these earlier versions, the flows between design steps have a label, denoting a particular transfer of information. The final version of the design processes, these specific flows are not present anymore, since the Design Process Co-ordination component now embodies these flows by managing the transfer of resources. Figure A.5 to Figure A.10 shows these earlier versions on page 128 to 133.

Granularity level of specification

Low level

High level

Level of abstraction

Process level

Tasks level

Cognitive activities level

Business Process + specification

Process to Tasks

Business Process Modelling

- Define delineation of the process of interest
- Identify all sub-processes and tasks in the process
- Define specifications of each task
- Select tasks interesting for further research

Tasks + specifications

Task to Cognitive activities

Cognitive Task Analysis

For each selected task:
- Collect preliminary knowledge
- Identify knowledge representations
- Apply applied cognitive tasks analysis (ACTA) to elucidate required knowledge
- Analyse and verify data acquired
- Format results in a Cognitive Demands Table

Cognitive activities + specifications

Cognitive activities to Cognitive requirements

Requirement Engineering

- asd

Cognitive requirements + specifications

FIGURE A.5: Earlier version of the CRDP (1)

Low level

High level

Level of abstraction

Process level

Tasks level

Cognitive activities level

Business Process + specification

Process to Tasks

Business Process Modelling

- Define delineation of the process of interest
- Identify all sub-processes and tasks in the process
- Define specifications of each task
- Select tasks interesting for further research

Tasks + specifications

Task to Cognitive activities

Cognitive Task Analysis

For each selected task:
- Collect preliminary knowledge
- Identify knowledge representations
- Apply applied cognitive tasks analysis (ACTA) to elucidate required knowledge
- Analyse and verify data acquired
- Format results in a Cognitive Demands Table

Cognitive activities + specifications

Process Model

Cognitive Tasks Model

Stakeholder requirements

Cognitive activities to Cognitive requirements

Requirement Engineering

Stakeholder Requirements Definition Process:
- Elicit stakeholder requirements
- Define stakeholder requirement
- Analyse and maintain stakeholder requirements

Requirements Analysis Process:
- Define system requirements
- Analyse and maintain system requirements

Architectural Design Process:
- Define the architecture
- Analyse and evaluate the architecture

Cognitive requirements + specifications

Figure A.6: Earlier version of the CRDP (2)

Cognition Enhanced Business Processes

FIGURE A.7: Earlier version of the CRDP (3)

Software

A. Selection of AI Software

1. Through a business focussed
assessment, select the AI software to
consider in this stage (out of scope of
this research).
2. For the selected AI software:
• Identify the distinct services of the
software.
• Describe the distinct services of the
software.

List of software services

Methods & Techniques

**B. Identification of Methods
and Techniques**

1. For each software service identified
under A:
• Identify the methods it utilises
• Describe the application of these
methods in the service
2. For each method utilised in the
software services:
• Identify the techniques it utilises
• Describe the application of these
techniques in the methods

List of methods & techniques

Cognitive Functionalities

**C. Establish Cognitive
Functionalities of Services**

1. Based on the outcomes of B,
formulate the distinct functionalities
that comprise some form and degree
of Cognition of the services identified
under A:
• This set of functionalities is
realised through a practical
exercise (Research through
Design)
• Specifically, Case Study 1 is used
for this exercise.

Set of cognitive functionalities

**D. Cognitive Functionalities
to Cognitive Capabilities**

Requirements Analysis Process:
• Define system requirements
• Analyse and maintain system
requirements

Cognitive Capabilities

Cognition Enhanced Business Processes

FIGURE A.8: Earlier version of the CCDP

Synthesis

Design

A. Categorisation

Synthesise the outcomes of Stage 1 and Stage 2:
1. Categorise the *Cognitive Requirements* from Stage 1 according to the Agent framework *(Sense-Plan-Act versus Perception-Information Processing-Action)*
2. Categorise the *Cognitive Capabilities* from Stage 2 according to the Agent framework *(Sense-Plan-Act versus Perception-Information Processing-Action)*

Lists of Requirements and Capabilities per category

B. Structural Matching

To match the Cognitive Capabilities to the Cognitive Requirements:
1. Fill in the template table structure per category for both Requirements and Capabilities
2. Based on the description of both Requirements and Capabilities:
• Go through each cell of the table and assess if the selected Capability can potentially meet/ comply to the selected Requirement.
• If so, mark this cell. If not, go to the next cell

Table structure indicating matches

C. Analysis and Selection

1. For each marked cell in the table (indicating a match), execute a more thorough analysis whether the Capability can actually cause the effect that the requirement can be met:
• Do such analysis for each match
• (Also, check if a combination of Capabilities can have a positive effect such that a Requirement can be met.)
2. For each match, assess if the match is feasible for the business

List of Capabilities meeting which Requirements

D. Architectural Design Process

Architectural Design Process:
• Define the architecture
• Analyse and evaluate the architecture

FIGURE A.9: Earlier version of the CPDP

Conceptual Design Process of Cognition Enhanced Business Processes

Stage 1

1A. Business Process to Tasks

1. Create an **overview of the business process** under review:
- Decompose the process in sub-processes and tasks and construct a process model (BPMN)
- Identify roles and stakeholders

2. Formulate the **requirements of stakeholders** fulfilling a role in the business process:
- Elicit stakeholder requirements
- Define stakeholder requirement
- Analyse and maintain stakeholder requirements

1B. Preliminary knowledge collection

For the business process under review, collect preliminary domain knowledge:
- **Identify experts** to participate in the knowledge elicitation process.
- Execute **Document Analysis**
- **Observe** the process while being executed
- Conduct **Unstructured interviews**

1C. Knowledge representations identification

For each task, identify the sub-tasks and types of knowledge required to perform it:
- **Identify sub-tasks** of each task
- Construct flow charts to capture **procedural knowledge**
- Construct a concept map to capture **declarative knowledge**
- Execute a **Learning hierarchy analysis**

1D. Task to Cognitive activities

1. Apply applied cognitive tasks analysis (ACTA) to **elucidate required knowledge** for executing the tasks:
- Construct a Task Diagram to elicit the cognitive steps of each sub-task
- Execute a Knowledge Audit to identify the most important cognitive elements of the task
- Conduct a Simulation Interview to understand the cognitive processes.

2. **Analyse and verify** data acquired

3. Format results in a **Cognitive Demands Table**

1E. Cognitive activities to Cognitive requirements

Requirements Analysis Process of Requirement Engineering:
- Define system requirements
- Analyse and maintain system requirements

Stage 2

2A. Selection of AI Software

1. Through a business focussed assessment, **select the AI software** to consider in this stage.

2. For the selected AI software:
- *Identify* the distinct *services* of the software.
- *Describe* the distinct *services* of the software.

2B. Identification of Methods and Techniques

1. For each software service identified under A:
- *Identify* the *methods* it utilises
- *Describe* the *application* of these *methods* in the service

2. For each method utilised in the software services:
- Identify the techniques it utilises
- Describe the application of these techniques in the methods

2C. Establish Cognitive Functionalities of Services

1. Based on the outcomes of B, formulate the distinct functionalities that comprise some form and degree of Cognition of the services identified under A:
- This set of functionalities is realised through a practical exercise (Research through Design)
- Specifically, Case Study 1 is used for this exercise.

2D. Cognitive Functionalities to Cognitive Capabilities

Requirements Analysis Process:
- Define system requirements
- Analyse and maintain system requirements

Stage 3

3A. Categorisation

Synthesise the outcomes of Stage 1 and Stage 2:

1. Categorise the *Cognitive Requirements* from Stage 1 according to the Agent framework *(Sense-Plan-Act versus Perception-Information Processing-Action)*

2. Categorise the *Cognitive Capabilities* from Stage 2 according to the Agent framework *(Sense-Plan-Act versus Perception-Information Processing-Action)*

3B. Structural Matching

To match the Cognitive Capabilities to the Cognitive Requirements:

1. Fill in the template table structure per category for both Requirements and Capabilities

2. Based on the description of both Requirements and Capabilities:
- Go through each cell of the table and assess if the selected Capability can potentially meet/comply to the selected Requirement.
- If so, mark this cell. If not, go to the next cell

3C. Analysis and Selection

1. For each marked cell in the table (indicating a match), execute a more thorough analysis whether the Capability can actually cause the effect that the requirement can be met:
- Do such analysis for each match
- (Also, check if a combination of Capabilities can have a positive effect such that a Requirement can be met.)

2. For each match, assess if the match is feasible for the business

3D. Architectural Design Process

Architectural Design Process:
- Define the architecture
- Analyse and evaluate the architecture

FIGURE A.10: Earlier version of the CDP

B | Cognitive Task Analysis in the Conceptual Design Process

This appendix first describes the concept of Cognitive Task Analysis (CTA) used in the conceptual design process created in this research in Section B.1. The version of CTA presented here suits the purpose of the conceptual design process and consists of five steps. The steps are to a large extent adapted from Clark et al. (2006) and Militello and Hutton (1998). Section B.2 presents the results of the CTA performed in this research on the first case study.

B.1   Description of Cognitive Tasks Analysis

1. **Collect preliminary knowledge**

    The first step of CTA is to identify those cognitive tasks that merit detailed study through cognitive task analysis. One has to select the (a) tasks that are important, frequent and highly critical cognitive tasks within the job performance that you are studying, and (b) tasks or problems within the job performance that allow for discrimination between expert from novice performance (these tasks are referred to as 'representative tasks'). The goal of this step is to develop some general understanding of the domain area, identify experts who are good candidates for serving as subjects and to identify the knowledge structures associated with the task area. The latter can be done through review & analysis of documents used in the process/tasks, through observations and/or by conducting unstructured interviews (Clark et al., 2006).

2. **Identify knowledge representations**

    During the second step, using the results from the preliminary knowledge data collection, identify the sub tasks and 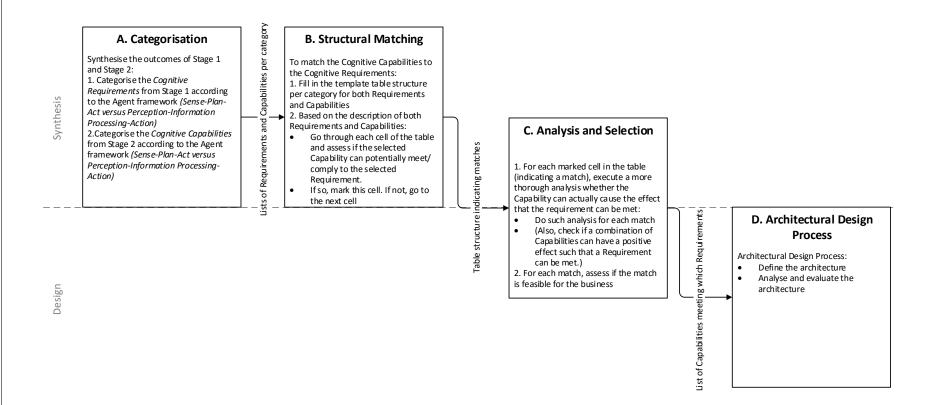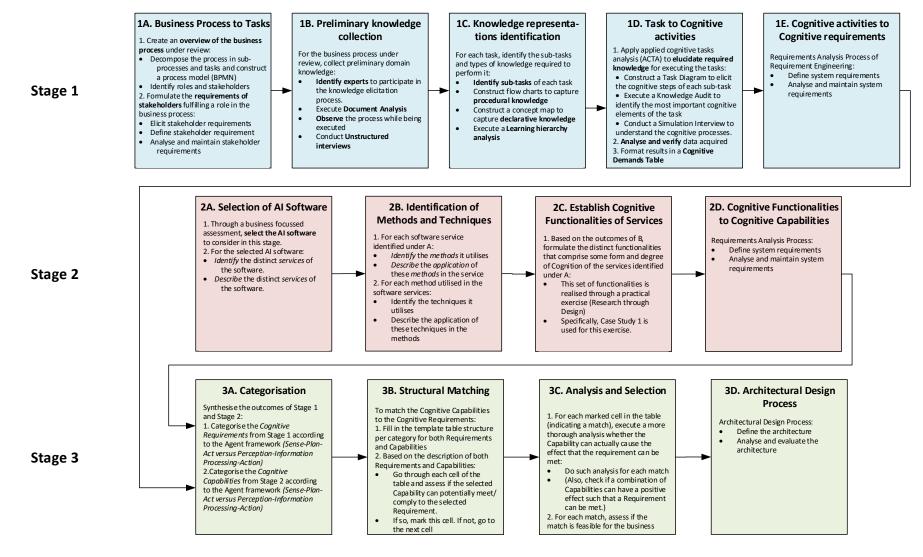knowledge that are associated with each of the tasks that you are interested in studying further. Generally, an effective approach for visually organising this information is by creating a visual representation of the relationship between the tasks, sub tasks and knowledge associated with the domain of interest. Concept maps can be an effective approach to visually representing the knowledge and task structures (Clark et al., 2006).

3. **Apply focused knowledge elicitation**

    The third step entails the identification, the clustering, linking, and prioritising the critical cognitive decisions that are routine in expert performance through a knowledge elicitation methods Clark et al. (2006). As explained before, this research will use applied cognitive tasks analysis (ACTA) as the knowledge elicitation method. Applied cognitive tasks analysis is an approach

where you conduct three structured interviews. Each interview generates as separate product. The compiled and analysed results from the applied cognitive tasks analysis can be formatted and represented in a Cognitive Demands Table (Militello and Hutton, 1998). Concept maps are graphical tools for organising and representing knowledge. They include concepts, usually enclosed in circles or boxes of some type, and relationships between concepts indicated by a connecting line linking two concepts. Words on the line, referred to as linking words or linking phrases, specify the relationship between the two concepts (Novak and Cañas, 2008).

3a. Create a Task Diagram

Through the first interview, you develop a Task Diagram that gives a broad representation of task and that specifically allows you to hone in on complex cognitive processes that merit further consideration.

Although this preliminary interview offers only a surface-level view of the cognitive elements of the task, it enables the interviewer to focus the more in-depth interviews (i.e. the knowledge audit and simulation interviews) so that time and resources can be spent unpacking the most difficult and relevant of those cognitive elements. The subject matter expert is asked to decompose the task into steps or sub tasks with a question such as, 'Think about what you do when you (task of interest). Can you break this task down into less than six, but more than three steps?' The goal is to get the expert to walk through the task in his/her mind, verbalising major steps. The interviewer limits the SME to between three and six steps, to ensure that time is not wasted delving into minute detail during the surface-level interview. After the steps of the task have been articulated, the SME is asked to identify which of the steps require cognitive skill, with a question such as, 'Of the steps you have just identified which require difficult cognitive skills? By cognitive skills I mean judgements, assessments, problem solving and other thinking skills'. The resulting diagram serves as a road map for future interviews, providing an overview of the major steps involved in the task and the sequence in which the steps are carried out, as well as which of the steps require the most cognitive skill (Militello and Hutton, 1998).

3b. Elicit knowledge

The second interview yields a Knowledge Audit, which probes the expert on the skills and knowledge applied to the tackle specific component tasks or decision points in the overarching task process.

The knowledge audit is organised around knowledge categories that have been found to characterise expertise. These include; diagnosing and predicting, situation awareness, perceptual skills, developing and knowing when to apply tricks of the trade, improvising, meta cognition, recognising anomalies, and compensating for equipment limitations. The knowledge audit employs a set of probes designed to describe types of domain knowledge or skill and elicit appropriate examples. The goal is not simply to and out whether each component is present in the task, but to find out the nature of these skills, specific events where they were required, strategies that have been used, and so forth. The list of probes is the starting point for conducting this interview. Then, the interviewer asks for specifics about the example in terms of critical cues and strategies of decision making. This is followed by a discussion of potential errors that a novice, less-experienced person might have made in this situation (Militello and Hutton, 1998).

3c. Conduct a Simulation Interview

The third and last interview involves presenting the expert with a specific and relevant scenario designed to elicit insight into the cognitive processes used by the expert in the scenario context, i.e. conducting a simulation interview.

The simulation interview is based on presentation of a challenging scenario to the SME. Surprisingly, in the authors' experience, the fidelity of the simulation is not an important issue. The key is that the simulation presents a challenging scenario. After exposure to the simulation, the SME is asked to identify major events, including judgements and decisions, with a question such as, 'As you experience this simulation, imagine you are the (job you are investigating) in the incident. Afterwards, I am going to ask you a series of questions about how you would think and act in this situation'. Each event is probed for situation assessment, actions, critical cues, and potential errors surrounding that event.

Information elicited is recorded in the simulation interview table. Using the same simulation for interviews with multiple SMEs can provide insight into situations in which more than one action would be acceptable, and alternative assessments of the same situation are plausible. This technique can be used to highlight differing SME perspectives, which is important information for developing training and system design recommendations. The technique can also be used to contrast expert and novice perspectives by conducting interviews with people of differing levels of expertise using the same simulation (Militello and Hutton, 1998).

4. Analyse and verify the data acquired

This step entails the analysis of the data that is gathered in the previous step, by further categorisation and synthesis of the transcripts of the conducted interviews by coding them. Pay special attention to diagnosing and characterising key decisions points based on the techniques used, cues signalling the decision points, and the inferences made. Verification is done by comparison of the formatted results of the multiple interviews conducted.

5. Format results in Cognitive Demands Table

The last step is all about using the formatted results from the expert knowledge elicitation sessions, create a single model task analysis, representing all the skills, knowledge and strategies used by the experts when functioning in the task area. Clearly, not every bit of information discussed in an interview will be relevant for the goals of a specific project. The compiled and analysed results from the ACTA are represented therefore in a so called Cognitive Demands Table, which is intended to provide a format for the practitioner to use in focusing the types of information that they might need to design and develop a new system (Militello and Hutton, 1998).

B.2   Results of Cognitive Tasks Analysis in Case Study

The following figures present the results of the Cognitive Task Analysis as described above in the first case study of this resesarch.

The information collection about the claim	The absorption of information to come to a judgement	The extraction of relevant information from the claim file and the listing of those facts	The judgement of a claim by establishing a line of reasoning (Micro) (1)	The judgement of a claim by establishing a line of reasoning (Micro) (2)	The judgement of a claim by establishing a line of reasoning (Meso)	The establishment of the advice
Perception: observe the documents in the claim file	Perception: percept the core elements of the claim file	Perception: percept the facts in the information	Comprehension: interpret the relevant facts	Judgement: judge which conclusion follows from the line of reasoning	Recognition: recognise that this claim has come up before	Reasoning: reason if the formed judgement is legit
Recognition: recognise the documents in the claim file	Recognition: recognise which core elements are present in the claim file	Recognition: recognize the facts contained in the information	Comprehension: interpret the meaning and use of the frameworks in an individual case	Judgement: ascertain that the information available cannot lead to a valid judgement	Recognition: recognise a type of claim based on the characteristics of the claim	
Reasoning: reason which documents are missing in the claim file	Reasoning: reason which core elements are not present in the claim file	Reasoning: reason which facts are relevant for the judgement of the claim	Comprehension: interpret the situation out of which the claim resulted (who, what, etc.)	Judgement: judge which facts need to be added	Recognition: recognise the line of reasoning of a claim	
	Perception: percept all submitted information (in different formats)	Reasoning: reason which facts are valuable for the judgement of the claim	Meta-cognition - Reasoning: reason that there is too much uncertainty about the judgement being of sufficient quality to come to an advice	Judgement: determine which presented facts are relevant, valuable and objective, and as such can be used in the judgement of the claim	Meta-cognition - Reasoning: reason if the similar claim has been treated already → pattern recognition	
	Recognition: recognise the essential facts within the information and who is communicating them	Judgement: determine which facts are relevant to come to a legit judgement of the claim	Reasoning: reason which fast are valuable are which are not valuable	Judgement: ascertain that the necessary knowledge is not available	Reasoning: reason which historic claim has comparable characteristics (= similar case)	
	Reasoning: reason the objectivity of the facts presented in the claim file	Judgement: determine which facts are valuable to come to a legit judgement of the claim	Reasoning: reason which facts are more important for the judgement then others	Judgement: ascertain that the method is not known	Reasoning: reason that the judgement structure of similar cases are not unambiguously enough	
		Reasoning: reason which relevant facts are missing	Reasoning: reason how the framework rules need to be translated to rules which are relevant for the claim	Judgement: determine is the information if reliable enough to be of use in the judgement of the claim	Judgement: determine that the line of reasoning of a similar case is applicable on this claim	
			Reasoning: reason if there are relevant protocols for this claim	Judgement: judge whether the judgement is logically derived from the line of reasoning	Judgement: determine that standardisation is possible without loss of quality	
			Reasoning: reason which facts are most important → form a judgement	Meta-cognition - Recognition: recognise that the available knowledge/skills are not sufficient to form a judgement	Judgement: determine that the deviation in content can be avoided in the future	
			Judgement: determine that a judgement of a colleague is necessary to form a valid judgement	Meta-cognition - Reasoning: be able to come to a line of reasoning for a new type of claim	Learning: learn when a case can be treated in the same way as a similar claim	
			Judgement: determine that the line of reasoning of the claim can be done (partially) by a relevant protocol	Meta-cognition - Recognition: recognise that certain knowledge / methods are not possessed / not know (consciousness about deviations in the judgement process)	Learning: learn that frequent arising claims of similar cases can easily be judged with the use of a new protocol	

FIGURE B.1: First iteration of the Cognitive Task Analysis performed in case study 1, listing all the identified cognitive functions corresponding to one of the tasks in the claim-assessment process

Situation	Cognitive skills	Difficult Cognitive activity
The information collection about the claim	Perception: observe the documents in the claim file	Collect information from the claim
	Recognition: recognise the documents in the claim file	
	Reasoning: reason which documents are missing in the claim file	
The absorption of information to come to a judgement	Perception: percept all submitted information (in different formats)	Find the essential facts within the information
	Perception: percept the core elements of the claim file	
	Recognition: recognise which core elements are present in the claim file	
	Recognition: recognise the essential facts within the information and who is communicating them	
	Reasoning: reason which core elements are not present in the claim file	Indicate if, and if yes which, facts are missing in the information
	Reasoning: reason the objectivity of the facts presented in the claim file	Determine the objectivity of the information
The extraction of relevant information from the claim file and the listing of those facts	Perception: percept the facts in the information	Indicate the facts within the information
	Recognition: recognize the facts contained in the information	
	Reasoning: reason which facts are relevant for the judgement of the claim	Indicate which facts are relevant for the line of reasoning
	Reasoning: reason which facts are valuable for the judgement of the claim	
	Judgement: determine which facts are relevant to come to a legit judgement of the claim	
	Judgement: determine which facts are valuable to come to a legit judgement of the claim	
	Reasoning: reason which facts are missing	Know which facts relevant for the line of reasoning are missing
		Find the necessary extra facts

Situation	Cognitive skills	Difficult Cognitive activity
The judgement of a claim by establishing a line of reasoning (Meso)	Recognition: recognise that this claim has come up before	Know that a similar case already has been treated
	Recognition: recognise a type of claim based on the characteristics of the claim	
	Meta-cognition - Reasoning: reason if the similar claim has been treated already → pattern recognition	
	Reasoning: reason which historic claim has comparable characteristics (= similar case)	
	Recognition: recognise the line of reasoning of a claim	
	Reasoning: reason that the judgement structure of similar cases are not unambiguously enough	Know that a claim is not treated in the same way
	Judgement: determine that the line of reasoning of a similar case is applicable on this claim	Know that the line of reasoning can be (partially) adopted by one of another claim
	Judgement: determine that standardisation is possible without loss of quality	Determine that a case can be treated in the same way as a similar claim
	Judgement: determine that the deviation in content can be avoided in the future	
	Learning: learn when a case can be treated in the same way as a similar claim	Know that a claim can be treated in the same way as a similar claim
	Learning: learn that frequent arising claims of similar cases can easily be judged with the use of a new protocol	Know that it is legit to treat a claim the same way as a similar claim
	Reasoning: reason how a new protocol to judge similar cases will look like	Establish a new protocol to judge similar claims in a legit way
The establishment of the advice	Know that the formed judgement is legit	Reasoning: reason if the formed judgement is legit

FIGURE B.2: Second iteration of the Cognitive Task Analysis performed in case study 1, listing all the identified cognitive functions corresponding to one of the tasks in the claim-assessment process

Situation	Cognitive skills	Difficult Cognitive activity
The judgement of a claim by establishing a line of reasoning (Micro)	Comprehension: interpret the relevant facts	Know which frameworks need to be used in an individual claim
	Comprehension: interpret the use of the frameworks in an individual case	Know how the frameworks need to be used in an individual claim
	Reasoning: reason how the framework rules need to be translated to rules which are relevant for the claim	
	Comprehension: interpret the situation out of which the claim resulted (who, what, etc.)	Know which situation caused the claim
	Reasoning: reason which fast are valuable are which are not valuable	Indicate how important a fact from the information is
	Reasoning: reason which facts are more important for the judgement then others	
	Reasoning: reason if there are relevant protocols for this claim	Know which facts correspond to which protocols
	Reasoning: reason which facts are most important → form a judgement	Select the most important facts from the information
	Meta-cognition - Reasoning: reason that there is too much uncertainty about the judgement being of sufficient quality to come to an advice	Indicate a judgement cannot be formed
	Judgement: ascertain that the information available cannot lead to a valid judgement	
	Judgement: ascertain that the necessary knowledge is not available	
	Judgement: ascertain that the method is not known	
	Meta-cognition - Recognition: recognise that the available knowledge/skills are not sufficient to form a judgement	
	Meta-cognition - Recognition: recognise that certain knowledge / methods are not possessed / not know (consciousness about deviations in the judgement process)	
	Judgement: determine that a judgement of a colleague is necessary to form a valid judgement	
	Judgement: determine that the line of reasoning of the claim can be done (partially) by a relevant protocol	Know that multiple protocols can be used in a judgement of an individual case
	Judgement: judge which conclusion follows from the line of reasoning	Indicate which conclusion is derived from the important facts
	Judgement: judge which facts need to be added	Indicate which important facts are missing to form a legit judgement
	Judgement: determine which presented facts are relevant, valuable and objective, and as such can be used in the judgement of the claim	Indicate if a fact can be used in the judgement of a claim
	Judgement: determine is the information if reliable enough to be of use in the judgement of the claim	
	Judgement: judge whether the judgement is logically derived from the line of reasoning	Know if the judgement is logically derived from the established line of reasoning
	Meta-cognition - Reasoning: be able to come to a line of reasoning for a new type of claim	Know how to establish a line of reasoning

FIGURE B.3: Second iteration (continued) of the Cognitive Task Analysis performed in case study 1, listing all the identified cognitive functions corresponding to one of the tasks in the claim-assessment process

Step	Difficult Cognitive activity	Cognitive skills	Why difficult?	Common errors	Cues and strategies used
Information collection about the claim	Collect information from the claim	Perception: observe the documents in the claim file			
		Recognition: recognise the documents in the claim file			
		Reasoning: reason which documents are missing in the claim file			
The absorption of information to come to a judgement	Find the essential facts within the information	Perception: percept all submitted information (in different formats)			
		Perception: percept the core elements of the claim file			
		Recognition: recognise which core elements are present in the claim file			
		Recognition: recognise the essential facts within the information and who is communicating them			
	Indicate if, and if yes which, facts are missing in the information	Reasoning: reason which core elements are not present in the claim file			
	Determine the objectivity of the information	Reasoning: reason the objectivity of the facts presented in the claim file			
The extraction of relevant information from the claim file and the listing of those facts	Indicate the facts within the information	Perception: percept the facts in the information	To recognise the facts in the claim information, one needs a proper understanding of a wide variety of medical concepts, master the corresponding vocabulary (knowledge) and how such claim dossier is constructed (knowledge)	Not all facts are recognised in the first shot, which can have several reasons	Scanning through all information, paying attention to medical terms and words describing the context of the claim.
		Recognition: recognize the facts contained in the information			
	Indicate which facts are relevant for the line of reasoning	Reasoning: reason which facts are relevant for the judgement of the claim	Reasoning and judging about the relevance and value of all facts in the claim information is difficult, mainly because these processes are performed very iteratively. The relevance and value of a fact can constantly change when a new fact is considered, resulting in a (mental) list of facts sorted on their relevance and value.	The value of the facts are not assessed properly, leading to miss-judgements. The relevance of the facts are not assessed properly, leading to miss-judgements. Wrong judgement, although based on the correct facts.	Consideration of each fact. Looking out for 'key' facts; facts that often are important for the assessment of the claim.
		Reasoning: reason which facts are valuable for the judgement of the claim			
		Judgement: determine which facts are relevant to come to a legit judgement of the claim			
		Judgement: determine which facts are valuable to come to a legit judgement of the claim			
	Know which facts relevant for the line of reasoning are missing	Reasoning: reason which relevant facts are missing	To reason what relevant and valuable facts are missing, proper knowledge about medical concepts and claim assessment is needed	Neglect relevant facts that should be included. Include irrelevant facts that should not be included	Words and terms present in the information, and reason which words and/or terms are likely to be relevant
	Find the necessary extra facts				
The judgement of a claim by establishing a line of reasoning (Micro)	Know which frameworks need to be used in an individual claim	Comprehension: interpret the relevant facts			
	Know how the frameworks need to be used in an individual claim	Comprehension: interpret the meaning and use of the frameworks in an individual case			
		Reasoning: reason how the framework rules need to be translated to rules which are relevant for the claim			
	Know which situation caused the claim	Comprehension: interpret the situation out of which the claim resulted (who, what, etc.)			
	Indicate how important a fact from the information is	Reasoning: reason which fast are valuable are which are not valuable			
		Reasoning: reason which facts are more important for the judgement then others			
	Know which facts correspond to which protocols	Reasoning: reason if there are relevant protocols for this claim			
	Select the most important facts from the information	Reasoning: reason which facts are most important → form a judgement			
	Indicate a judgement cannot be formed	Meta-cognition - Reasoning: reason that there is too much uncertainty about the judgement being of sufficient quality to come to an advice			
		Judgement: ascertain that the information available cannot lead to a valid judgement			
		Judgement: ascertain that the necessary knowledge is not available			
		Judgement: ascertain that the method is not known			
		Meta-cognition - Recognition: recognise that the available knowledge/skills are not sufficient to form a judgement			
		Meta-cognition - Recognition: recognise that certain knowledge / methods are not possessed / not know (consciousness about deviations in the judgement process)			
		Judgement: determine that a judgement of a colleague is necessary to form a valid judgement			

FIGURE B.4: Third iteration of the Cognitive Task Analysis performed in case study 1, providing information of the difficult cognitive activity corresponding to one of the tasks in the process

Step	Difficult Cognitive activity	Cognitive skills	Why difficult?	Common errors	Cues and strategies used
	Know that multiple protocols can be used in a judgement of an individual case	Judgement: determine that the line of reasoning of the claim can be done (partially) by a relevant protocol			
	Indicate which conclusion is derived from the important facts	Judgement: judge which conclusion follows from the line of reasoning			
	Indicate which important facts are missing to form a legit judgement	Judgement: judge which facts need to be added			
	Indicate if a fact can be used in the judgement of a claim	Judgement: determine which presented facts are relevant, valuable and objective, and as such can be used in the judgement of the claim			
		Judgement: determine is the information if reliable enough to be of use in the judgement of the claim			
	Know if the judgement is logically derived from the established line of reasoning	Judgement: judge whether the judgement is logically derived from the line of reasoning			
	Know how to establish a line of reasoning	Meta-cognition - Reasoning: be able to come to a line of reasoning for a new type of claim			
The judgement of a claim by establishing a line of reasoning (Meso)	Know that a similar case already has been treated	Recognition: recognise that this claim has come up before Recognition: recognise a type of claim based on the characteristics of the claim Meta-cognition - Reasoning: reason if the similar claim has been treated already → pattern recognition Reasoning: reason which historic claim has comparable characteristics (= similar case) Recognition: recognise the line of reasoning of a claim	Do to this, lot of experience is needed with the assessment of claims, since only then patterns could be noticed. One should be able to relate the words/concepts that are present in the information are similar to a previous claim.	Misinterpretation of the facts. Incorrect match to a previous claim.	Words and terms present in the information. Search through previous claims to find a similar one.
	Know that a claim is not treated in the same way	Reasoning: reason that the judgement structure of similar cases are not unambiguously enough			
	Know that the line of reasoning can be (partially) adopted by one of another claim	Judgement: determine that the line of reasoning of a similar case is applicable on this claim			
	Determine that a case can be treated in the same way as a similar claim	Judgement: determine that standardisation is possible without loss of quality	Checking if the claims are indeed the same	Misjudgement of the equality of claims	Word and terms present in the information. Appeal to knowledge and experience on medical concepts and claim assessment.
		Judgement: determine that the deviation in content can be avoided in the future			
	Know that a claim can be treated in the same way as a similar claim	Learning: learn when a case can be treated in the same way as a similar claim	Checking if the current claim is indeed the same as a previous one		
	Know that it is legit to treat a claim the same way as a similar claim	Learning: learn that frequent arising claims of similar cases can easily be judged with the use of a new protocol			
	Establish a new protocol to judge similar claims in a legit way	Reasoning: reason how a new protocol to judge similar cases will look like			
The establishment of the advice	Know that the formed judgement is legit	Reasoning: reason if the formed judgement is legit			

FIGURE B.5: Third iteration (continued) of the Cognitive Task Analysis performed in case study 1, providing extra information of the difficult cognitive activity corresponding to one of the tasks in the claim-assessment process

Step	Difficult Cognitive activity	Cognitive skills	Why difficult?	Common errors	Cues and strategies used
The extraction and listing of relevant and valuable facts	Indicate the facts within the information	Perception: percept the facts in the information	To recognise the facts in the claim information, one needs a proper understanding of a wide variety of medical concepts, master the corresponding vocabulary (knowledge) and how such claim dossier is constructed (knowledge)	Not all facts are recognised in the first shot, which can have several reasons	Scanning through all information, paying attention to medical terms and words describing the context of the claim.
		Recognition: recognize the facts contained in the information			
	Indicate which facts are relevant for the line of reasoning	Reasoning: reason which facts are relevant for the judgement of the claim	Reasoning and judging about the relevance and value of all facts in the claim information is difficult, mainly because these processes are performed very iteratively. The relevance and value of a fact can constantly change when a new fact is considered, resulting in a (mental) list of facts sorted on their relevance and value.	The value of the facts are not assessed properly, leading to miss-judgements. The relevance of the facts are not assessed properly, leading to miss-judgements. Wrong judgement, although based on the correct facts.	Consideration of each fact. Looking out for 'key' facts; facts that often are important for the assessment of the claim.
		Reasoning: reason which facts are valuable for the judgement of the claim			
		Judgement: determine which facts are relevant to come to a legit judgement of the claim			
		Judgement: determine which facts are valuable to come to a legit judgement of the claim			
	Indicate which facts relevant for the line of reasoning are missing	Reasoning: reason which facts are missing	To reason what relevant and valuable facts are missing, proper knowledge about medical concepts and claim assessment is needed	Neglect relevant facts that should be included. Include irrelevant facts that should not be included	Words and terms present in the information, and reason which words and/or terms are likely to be relevant
	Find the necessary extra facts				
The judgement of a claim by establishing a line of reasoning (Meso)	Know that a similar claim already has been treated	Reasoning: reason which of the characteristics of the claim are comparable to a existing case	Do to this, lot of experience is needed with the assessment of claims, since only then patterns could be noticed. One should be able to relate the words/concepts that are present in the information are similar to a previous claim.	Misinterpretation of the facts. Incorrect match to a previous claim.	Words and terms present in the information. Search through previous claims to find a similar one.
		Recognition: recognise that this claim has come up before			
		Meta-cognition - Reasoning: reason if the similar claim has been treated already → pattern recognition			
		Reasoning: reason which historic claim has comparable characteristics (= similar case)			
		Recognition: recognise the line of reasoning of a claim			
	Determine that a case can be treated in the same way as a similar claim	Judgement: determine that standardisation is possible without loss of quality	Checking if the claims are indeed the same	Misjudgement of the equality of claims	Word and terms present in the information. Appeal to knowledge and experience on medical concepts and claim assessment.
	Know that a claim can be treated in the same way as a similar claim	Learning: learn when a case can be treated in the same way as a similar claim	Checking if the current claim is indeed the same as a previous one		

FIGURE B.6: Fourth iteration of the Cognitive Task Analysis performed in case study 1, presenting the identified cognitive capabilities corresponding to one of the tasks in the claim-assessment process

C | Analysis of IBM Watson software

IBM Watson is a technology platform that uses natural language processing and machine learning to reveal insights from large amounts of unstructured data. This appendix presents the intermediate results of analysis of the commercial software variant of IBM Watson, which is the AI software suite under review in both case studies of this research. They complement the results of the analysis of IBM Watson presented in Section 5.2 and Section 5.3.

AI commercial software	Functions (according to IBM)	Service output	Formal concept	..is a sub-field of..	..is a sub-field of..	..is a sub-field of..	Example	Cognitieve functionaliteit
IBM Watson service *Language*								
AlchemyLanguage	Entity Extraction	entities	Entity linking	Information Retrieval	Information Extraction	Natural Language Processing	Lars Reeker = Person	Perception, Recognition, Knowledge
	Sentiment Analysis	sentiment	Sentiment Analysis	-		Natural Language Processing	The sentiment of this text/entity is positive/negative/neutral, score on five general	Recognition, Knowledge, Comprehension
	Keyword Extraction	keywords	Keyword Extraction	Information Retrieval	Information Extraction	Natural Language Processing	Lars, student, Delft University of Technology	Perception
	Concept Tagging Concept Insights	concepts	Latent-semantic indexing	Information Retrieval	Information Extraction	Natural Language Processing	Education, Technology, Profession	Recognition, Knowledge, Comprehension
	Relation Extraction	relations	Relationship extraction	-	Information Extraction	Natural Language Processing	[Lars]subject is a [student]action of [Delft University]object	Comprehension
	Taxonomy Classification	taxonomy	Classification	Multivariate statistics	-	Natural Language Processing	dit artikel valt binnen *travel/transports/sea travel/cruises* en *law, govt and politics*	Reasoning, Knowledge
	Author Extraction	authors	Keyword Extraction			Natural Language Processing	Stephanie = author	Perception, Reasoning
	Language Detection	language	Keyword Extraction			Natural Language Processing	Language = English	Perception, Recognition
	Text Extraction	source of text	Keyword Extraction			Natural Language Processing	Source = tudelft.nl	Perception, Recognition
Dialog	Script of expert conversations	chat using natural language and get pre-written	Dialog system	-	-	Natural Language Processing	Pizza bestellen via chat met chatbot	Language, recognition, (comprehension, reasoning)
Language Translation	Translate text real-time	text in target language	Machine Translation	Computational linguistics	-	Natural Language Processing	Lars is een student aan de Technische Universiteit Delft	Language, learning
Natural Language Classifier	Interpret and classify natural language with confidence	Classes ordered by confidence	Document classification	Document retrieval	-	Natural Language Processing	Classification: education Confidence: 90%	Learning, Language
Personality Insights	extracts and analyzes a spectrum of personality attributes	A tree of cognitive and social characteristics	Statistical inference				Big 5 characteristics Needs Values	Comprehension, Knowledge

FIGURE C.1: IBM Watson's services and their corresponding cognitive capabilities (1)

AI commercial software	Functions (according to IBM)	Service output	Formal concept	..is a sub-field of..	..is a sub-field of..	..is a sub-field of..	Example	Cognitive functionality	Cognitive capability
Tone Analyser	linguistic analysis to detect and interpret emotional, social, and writing cues found in text	hierarchical representation of the analysis of the terms in	Classification	Multivariate statistics	-	Natural Language Processing	computes emotional tones, in addition to social and writing style tones.	Reasoning, comprehension	
Speech									
Speech to Text	convert speech in multiple languages into text	ranscriptions of the audio with recognized words	Machine translation	Computational linguistics	-	Natural Language Processing	-	Language, knowledge	The cognitive system is able to translate a textual document into another language
Text to Speech	synthesize speech audio from an input of plain text	speech in multiple languages	Machine translation	Computational linguistics	-	Natural Language Processing	-	Language, knowledge	
Vision									
AlchemyVision	denote a picture's content and context	tagged images, face detections, confidence scores	Image processing Pattern recognition Statistical Inference	-			tree, people. mountain with 0-1 confidence, provides similar images	Perception, Recognition, Reasoning	
Visual Insights	match images based on appearance or semantic content	concept scores, clustering on visual appearance or semantic content	Image processing Pattern recognition Statistical Inference	-			nature, city, 0-1 confidence	Perception, Recognition, Reasoning	
Visual Recognition	provides scores for relevant classifiers representing things such as objects, events and settings of an image	set of classifiers and likelihood scores	Image processing Pattern recognition Statistical Inference	-			tiger, 99%	Perception, Recognition, Reasoning	The cognitive system is able to recognise objects in a static image
Data Insights									
AlchemyData News	provides large database of news and blog articles	news and blog content	Detection theory	-			Donald Trump, Apple, ...	Perception	
Tradeoff Analytics	helps people make decisions when balancing multiple objectives	optimal options and highlight the trade-offs between them	Visual analytics	-			Visual tradeoff support tool, multi-critera, filtering and selection	Reasoning, Jugement, Decision making, Goal generation	The cognitive system is able to support decision making through visual mathematical representation decision criteria
Watson Knowledge Studio	supervised learning omgeving		Entity linkingKeyword extraction Relationship extraction	Information Retrieval	Information Extraction	Natural Language Processing	[Lars Reeker]*persoon_1/student_aan_uni_1* studeert aan de [TU [Delft]*loc/uni_1*. [Hij]*persoon_1* is aan het afstuderen.	Perception, Recognition, Knowledge	The cognitive system is able to learn from previous textual documents to improve its linguistic functionalities

FIGURE C.2: IBM Watson's services and their corresponding cognitive capabilities (2)

D | Validation of Conceptual Design

This appendix presents results of the validation of the conceptual design as envisioned in Chapter 7 to complete this validation step. This validation is executed by utilising the CDP, and specifically the Cognitive Requirements Design Process, in the second case study of this research. The results of this validation exercise can be found from the next page onwards.
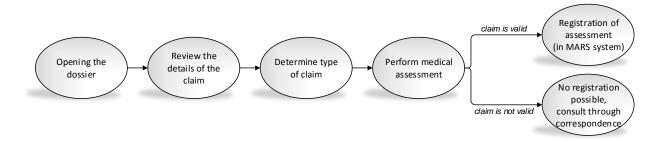

FIGURE D.1: Step 1 of ACTA in second case study (1)

Step	Name	Description	Extra information	Cognitive skills involved
1	Opening the dossier	To assess a claim that is within the teams file system, the claim processor can target a claim to assess by opening its corresponding dossier.		Perception, Recognition
2	Review the details of the claim	The client to which the claim concerns should be correctly referred to in the claim details (NAW should match the claim details). Check if the claim is matched to the right person, if not, match correctly	The client data is stored in enterprise wide systems, the claim data is stored in the dossier/file, transferred by email to the insurance company and internally via an application	Perception, Recognition, Judgement
3	Determine type of claim	● Which support tool is asked for reimbursement? ○ Alarmering ○ Prothese ○ Stoel ● Use of work instructions to assess the claim step by step	The work instructions tell: - Where to pay attention to in the claim information - Which step to execute - Exceptions	Recognition, Reasoning, Goal-generation
4	Perform medical assessment	● Set the medical indication of the claim ● Does the claim comply to the medical indications as presented in the claim dossier? ○ Check price of the offer corresponds with the agreements with the (contracted) suppliers ○ Determine the claim history of the client (first claim or repetition)		Reasoning, Recognitions, Judgement, Knowledge, Memory, (Decision-making)
5A	Registration of assessment (in MARS system) *If the claim is correct*	● Register the claim assessment as approved in the system ● To do that: ○ Check information of client, health provider and supplier ○ Adopt the important information	Types of claims: ● Claim: claim assessment ● Nota: invoice medical assessment ● Dispute: resubmitted claim	Reasoning, (Goal generation), Decision-making

FIGURE D.2: Step 1 of ACTA in second case study (2)

		from the claim dossier ○ Register the claim as approved		
5B	No registration possible, consult through correspondence	Correspondence: ● Send letter ● Call ● Internal note	Have to know what to send, and to who.	Reasoning, Decision-making, Language
X	Main screen of claim dossier (WAM)	Information to provide by claim processor: ● Date of start of claim (offer) ● Registration of application ● Medical transaction (type of support tool)		Knowledge, Reasoning

X	Work instructions (one for every type of medical implication)	● Registration details:
		  ○ All information available in dossier?
		  ○ Determination of asked support tool
		● Medical assessment:
		  ○ Type of referring person (doctor, general health provider, specialist, supplier)
		  ○ Extra information
		● Handling:
		  ○ Approve claim
		  ○ Reject claim
		  ○ Request additional information
		● Extra:
		  ○ Policy about this support tool / clause		

FIGURE D.3: Step 1 of ACTA in second case study (3)

Aspects of expertise	Cues and strategies	What makes it difficult	Cognitive skills involved
Past & Future	- Medical indication - Codes	- Work with medical codes - Work with systems (sometimes difficult, not well integrated to each other) - Medical knowledge needed - Knowledge about laws and regulations is sometimes necessary - When has health insurer to pay, when the hospital, municipality, etc. - Every claim (situation) is different, correct interpretation is essential. Understand the context of the incoming claim.	Knowledge (Medical indication, support tool, etc.) Perception Recognition Language Reasoning Judgement (able to link indication to support tool and assess if it is correct) Problem Solving (A+)
Big Picture	- New suppliers of support tools - New insurance policies - Identify claim and assess similarities with previous claims	- What has been assessed in history - What was the assessment?	Learning, Goal generation (health providing task of company) Judgement

Job smarts	- Many information can be found in different systems
	  - KIM
	  - Databases
	  - Protocols
	  - Work instructions
	  - Colleagues
	  - A+
	  - Medical Advisors
	  - Google
		- Information is spread, have to know where to search	Recognition, Language

Improvisation	- Every claim processor works differently, have to deal with that.
	  - Supervision
	  - Controls
	  - Coaching
	  - Content-wise, difference is assessments
		- Every claim assessor works differently → assesses differently	Learning
			Knowledge

FIGURE D.4: Step 2 of ACTA in second case study (1)

Opportunities	- Improve mistakes in work instructions - Suppliers offers → solve problems - Internal central knowledge systems have to be up to date and clear	- Dynamics in information (medical indications, treatments, etc.)	Problem solving, Learning Reasoning
Self monitoring	- Sequence of assessment of claim has to be in such way that it is in favour of speed - Different treatments can be best approach differently - The registration systems supports sometimes in checking relevant facts in the dossier	- Self-reflection should be available	Recognition Comprehension Reasoning
Anomalies	- Indication + treatment = differs from standards - New treatments or new indications ask for new/different assessment - Communication with Medical Advice group:	- Be able to deal with diversions in work patterns.	Recognition Reasoning Language Learning
Equipment Difficulties	- Prices of treatment products - Codes / Terms - Work instructions	- Difficult to know all codes and terms - System is sometimes difficult to work with	Knowledge Learning
** Flow of filtering	Email → Workstock (linking to client) → filtering on type of treatment → claim assessor selects a claim to assess		

FIGURE D.5: Step 2 of ACTA in second case study (2)

Events	Actions	Situation assessment	Critical cues	Potential errors	Cognitive skills involved
Opening of (untreated) claim *Within the WAM list*	• Select and open claim • The screen displaying the claim dossier will open	• Look at the list of claims, process the claim that is first in row • System can automatically assigns claims to claim processors	• List of claims		Perception Recognition

Claim dossier is opened and displayed on screen	• First look into cover page
	• Open email correspondence
	• Open the attachments:
	  ○ Offer
	  ○ Statement of medical expert
	  ○ Health plan of supplier
		• Overlook all documents in the (email) correspondence
		• View the information in the attachments
			• The format / layout of the cover page, claim, offer, statements, etc.
			• Names of files
			• Scanning of content of files, keywords / other information
					Perception, Recognition, Goal generation

Determine claim history of client	• Consult MARS system to check the history of claims	• Are there previous claims? • What type of claims are these? What is being asked? • Is this the same as the current claim? • Is it a repetition of the current claim?	• Description of previous claims • Date of creation	• Overlooking the previous claims • Missing information in previous claims relevant to the current claim	Perception, Recognition, Reasoning

FIGURE D.6: Step 3 of ACTA in second case study (1)

Events	Actions	Situation assessment	Critical cues	Potential errors	Cognitive skills involved

Propose claim to Medical Advisor for expert advice	• Ask advice about
	  ○ Offer prices, necessity of support tools
	  ○ Complex assessments / decisions
		• Sound argumentation?
		• Ask A+ advisor
		  ○ They provide advice
		  ○ And a written reaction / argumentation
			• Not able to come to a sound judgement → advice is needed		Perception, Recognition, (Reasoning)reaction of advisor, Judgement

Comparison of current claim with previous assessed claims	• If the current claim is not a repetition of a precious claim, it can be assessed as a new claim	• Information / description of the claim	• Noticing that it a different support tool / implication / treatment is being asked for.	• Too little knowledge of all medical concepts (existence and their purpose) to notice or work with these concepts	Knowledge, Judgement
	• Check if it is repetitive claim: if so, no medical assessment is needed ○ Determine the reason for replacement • Check for inconsistencies	• History of claim • Claim information • (Previous) Medical assessment • Missing information? • Offer according to agreement with supplier?	• Check for a similar claim in the claim history • All information in the dossier	• Misinterpret previous claims with current claim • Not able to notice faults in the claim information	Reasoning, Knowledge, Judgement

FIGURE D.7: Step 3 of ACTA in second case study (2)

| Events	Actions	Situation assessment	Critical cues	Potential errors	Cognitive skills involved
Checking an offer	• Check prices on offer ○ Time charged for diagnosis / treatment ○ Check total time	• Price of support tools and labor	• Compage time and prices in the codebook • Codes on the offer	• Able to understand the codebook	Reasoning(math)
Performing the assessment	• Agree on offer • Agree on the reason for reimbursements • Medical assessment of health provider / supplier	• Check if everything is okay or not		• Overlook important specifics	Learning, Logical reasoning, Knowledge (Medical terms, support tools, offers, medical assessment)
Preparation of assessment in WAM	• Fill in the treatment (verrichting) ○ Type of claim ○ Description • Fill in the supplier which will deliver the support tool • Date of creation of claim	• Provide information in the system to complete the assessment	• Incomplete dossier	• Too little knowledge about medical terms, support tools, offers, medical assessment, ...	Knowledge, Reasoning, Judgement
Registration of claim assessment	• MARS system automatically transfers information from dossier of WAM ○ Supplier ○ Client ○ Date • To be filled in: ○ Description of medical indication / treatment ○ Price asked	• Screen + claim information provide setting			Recognition, Reasoning, Decision Making
	○ Refinement of description if needed • Formally approve or reject claim				
Aftercare of claim	Correspondence via phone, email, etc. registration in KRIS, which can be viewed.				Language
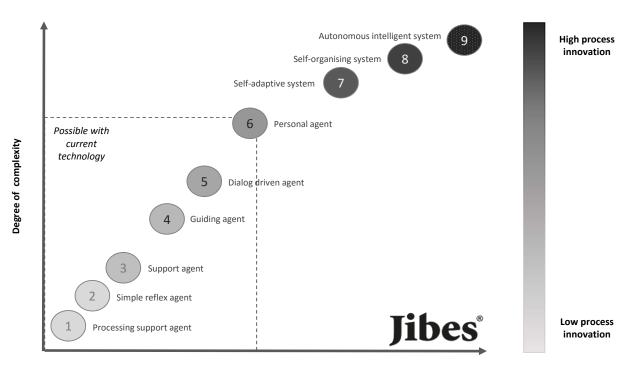
FIGURE D.8: Step 3 of ACTA in second case study (3)

E | AI Systems Solutions Model

To strengthen the shared understanding of the possibilities of AI systems in organisations, a model is developed that can and is used as a talking board to discuss with organisations about such possibilities. This model is an additional outcome of this research, and presented in Figure E.1 on page 158. It is constructed during the research, and used in several client meetings by Jibes Data Analytics B.V.

The model identifies nine AI systems solutions, scaled to three measures. The first measure is the the degree of autonomy, which entails the degree to which the solution performs autonomously in the operation of the business (x-axis). The second measure is the degree of complexity, which entails the level of complexity of designing, developing and implementing such solution (y-axis). The last measure indicates the impact of the solution in the process and the level innovation it can provide to the business (colour bar). The table below the graph describes the nine solutions pin pointed in the graph.

Categories of AI system solutions

FIGURE E.1: AI Systems Solutions model produced during the research