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Unravelling 21st Century Riddles – Universal Network Visions from a Human Perspective

Networks are omnipresent and universal. Mankind, for example, forms a social network. Today, information and communications technology (ICT) exponentially accelerates the interaction between the human nodes of this global social network. In that way, ICT appears to evoke a phase transformation, similar to the physical phase transitions of a thermodynamic system which characterise the transformation of matter. Finding that networks are omnipresent and universal, gives a cause for optimism! Indeed, we can profit from the network knowledge in the ICT sector by translating this knowledge horizontally to, for example, other nodes in the sector network of our economy and society. Transferring the knowledge vertically to networks on other aggregation levels, such as the human network, could reward us with astounding insights into the developments for the next 100 years. In addition, awareness of the possible scenarios for the 21st century, and keys for the choice between and control of them, come within reach. In this article, we postulate these exciting visions by travelling through time and on different aggregation levels, discovering some maverick phenomena of transient networks that deepen our understanding of the relevant riddles of our existence. The relatively new ICT sector, enabling connections between all communicating entities, obviously plays a crucial multifold role in this game.

Development of Society from a Nodal Towards a Network Model

The past 11 000 years has moulded the design of today's society and economy, including the corresponding level of well-being and prosperity. About 11 000 years ago, a major transformation took place. Nomadic families started to settle like condensed spring droplets trickling down from the woods in the fruitful valleys during the aftermath of the last ice age and became colonists. The first villages emerged, hosting several families. During the tremendously long period before colonisation, nomadic tribes were entirely self-responsible, almost completely solitary clusters performing all necessary tasks in order to survive as a group. One can consider a tribe to have a collective nerve system, guarding and controlling the well-being and prosperity of this small group.

The early colonist era was characterised by the introduction of agriculture and cattle breeding. People were able to divide tasks between each other (trans-tribal). They started to specialise in specific skills and tasks, such as blacksmith, baker, farmer or soldier, after establishing a trust level in which other people could take over former vital tasks they used to perform themselves. This transformation initialised functional decomposition of tasks in society and the economy, enlarging efficiency and thereby the scale of the economy, growing from local all the way to global. Economic value started to gain importance and herewith the former tribal nerve system gradually started to disappear. On a macroscopic level, our society and economy have decomposed into a number of sectors that together provide the foundations for our daily lives. The sectors for example include healthcare, education, transport, construction, security and, recently, ICT. Together, they contribute to, on a national scale, the gross domestic product (GDP), a barometer of a nation's economic prosperity. At the same time, these sectors are partly responsible for our well-being, which we define as the 'gross domestic service' (GDS). GDS cannot be measured easily in hard figures, but is at least equally as important as GDP. For our (total) quality of life, GDP and GDS together constitute an integral measure as a quantitative economic and qualitative societal contribution, respectively, in two orthogonal dimensions (see Figure 1). Later, we introduce two scenarios – the nodal continuation scenario and the cohesive network scenario; the latter, we believe, will lead to a healthy balance of GDP and GDS.

Some of the sectors are more GDP and some more GDS oriented – one could say

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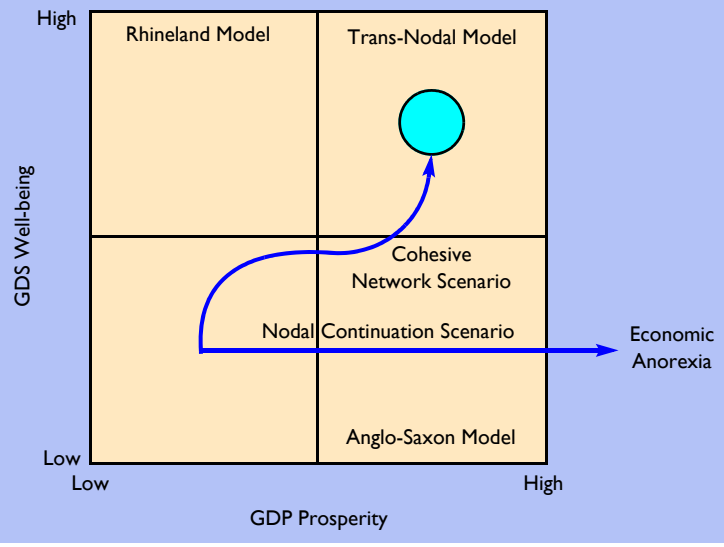
Figure 1 Economic and societal orthogonal dimensions



product and service, hard and 'soft' sectors, respectively (although soft often proves to be harder than hard). The authorities have a special control function; they are responsible for the co-ordination across the sectors, similar to our brain that co-ordinates and supervises the organs in our body. The GDS is about the quality of offered services. For example, are we satisfied with our education system? Do we feel comfortable with the present healthcare delivered by hospitals, nursing homes and residential care homes? Today, the prevailing opinion about quite a few sectors is not positive – they are not in good shape. Are we grinding to a halt in these sectors? Many people feel healthcare and education have been underperforming for years. The situation is not much better when it comes to the traffic and transport sector, with a daily grind of long traffic jams that inevitably cause nuisance, noise, environmental burden and economic damage. A trans-sectoral contemplation seems in place (Figure 2).

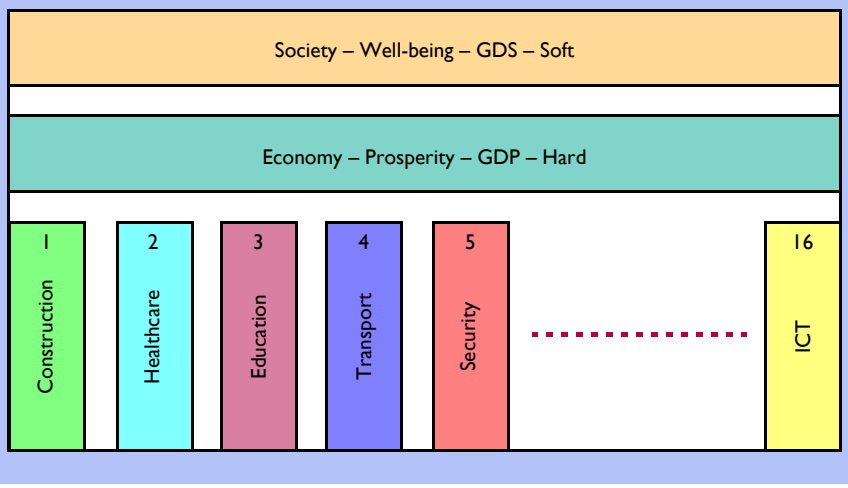
Similar observations can be made on different aggregation levels. We try to explain this in Table 1, which explores equivalents and parallels between processes such as:

- the development of people and their societies;
- evolution of ICT means;
- physical phases of a thermodynamic system.

Looking back to evolution, we detect some interesting (horizontal) isomorphic and (vertical) congruent relations and developments on the same and different aggregation levels, respectively. If indeed we, *Homo sapiens*, evolved from primeval slime, then in this process there are some constant factors, two of which are differentiation and increasing network complexity. Unicellular creatures evolve from relatively simple amoebas towards complex creatures with a plethora of differentiated, specialised cells, such as the dedicated cells in our human organs. On a higher aggregation level, we see exactly the same phenomenon. Analogous to the development of *Homo sapiens*, in the last millennia of our existence, specialisation of human knowledge and skills has led to a functional decomposition of growing societies and economies, fuelled by increasing scales of the latter two. We believe, however, that the 'collective nerve and brain system' on this level is lagging.

In this article, we hope to give the reader some new 'network' insights from a human perspective, some food for thought to open new windows in the coming century (Figure 3).

Figure 2 Overview sectors, economy and society



Signs of the Time – A Nodal Continuation Scenario

From a future studies point of view, we cannot opt for one possible future. Alternatives should be explored. First of all, in this section, we sketch the contours of a 'nodal continuation scenario' that is characterised by extrapolating current trends in our society and economy with a focus on GDP rather than GDS. Al Gore's recent film *An Inconvenient Truth* is an example of an initiative aiming for a fundamental change, away from a 'nodal continuation scenario'. Gathering awareness for such a trend breach requires a lot of energy, let alone the implementation of it.

What will our world look like in a hundred years time? In addition, what will be the major concerns? Before going into more detail, there are some generic certainties to be mentioned. For instance, technology will gradually be fully integrated into people's lives, in such a way that they will almost not be conscious of its existence any more.

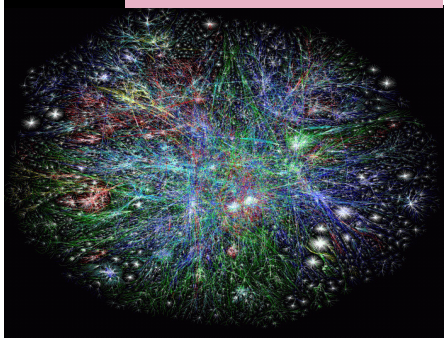
Looking at today's world, obvious trends and developments are:

- change of climate and its consequences for life on earth;
- growth of the world population and the ageing of the population in many societies;
- cost of a social safety-net will increase dramatically and therefore will diminish and become a responsibility of the people themselves;
- global pollution and (natural) disasters will have a higher impact, simply because there will be more people on earth that can be affected;
- real scarcities of fuel, water, energy (and mutual dependencies based on access to resources);
- corruption remains a tenacious blocking issue for a smooth innovation process in most developing countries;

Table 1 Parallels

People	ICT means	Matter Phases	Remarks
Tribal Family < 11 000 yrs ago	Voice communication via air and messages via drawings, smoke signals	'Gas'	Isolated nomadic tribes, occasionally meeting other tribes. Strong social cohesion within a tribe. Elite: chief of tribe, medicine man. Focus on survival of the tribe itself.
Colonist society 11 000 yrs ago up to year 1900	Letters, books, art, music	'Liquid'	Families settling in villages. Living and working together. Start of society decomposition and specialisation among people. Elite: kings, church. Focus on interest of family/village.
Colonist networking society 1900 till today	ICT networks connecting groups of people by telephony, e-mail, data, public postal service Rise of a 'tribalistic' virtual world	'Solid'	Anglo-Saxon economy. Survival of the fittest, rat race. Self-interest based, social fragmentation, conflicts about resources. Elite: prime ministers and captains of industries (managers). Focus on (personal) prosperity.
Linked society (still imaginary)	ICT networks linking virtually all people Rise of a 'post-tribalistic' virtual world.	'Plasma'	Fusion of Anglo-Saxon and Rhineland economy. Post tribalism, solidarity, social cohesion. Trans-sectoral innovation leading to hyper innovation. Elite: trustworthy leaders. Focus on both well-being and prosperity of society and economy.

Figure 3 From a nodal model to a network model



- massive migration of people looking for a better place to live;
- increase of complex political, cultural and religious conflicts with worldwide impact, e.g. 'war on terrorism', shifting and countervailing powers;
- technolism: people's addiction and increasing dependency on technology – people will have to cope with and adopt more and more sophisticated ICT means.

Today's society originates from, and is due to, the individualisation process during the past decades. The individual freedom we acquired has also brought us a (sometimes extreme nodal) focus on 'me, myself and I'. Human behaviour is also strongly influenced by concerns and feelings of uncertainty and unsafety.

Extrapolating from today's trends, we notice a future world displaying diminishing solidarity and disappearing certainties because citizens are responsible for their own lives, work and income. Authorities seem to enforce rather than correct this trend, clinging conservatively to the old paradigm of economic growth, increasing the GDP, whereas the citizens, given a certain standard of the GDP, incline increasingly towards improvement of the GDS[†]. Maybe that is because they, the authorities, cannot repair the apparent lobotomy between the hard and soft sectors nor oversee the trans-sectoral relations of the sectors. They give the impression of being unable to proactively control and progress the sector network as a whole, confronted with the complexity and their political (election) motives. However, increasing complexity and changes in life seem inevitable. All activities seem to speed up and people will have to deal with it, balancing their own gross personal product and gross personal service. ICT applications can be developed such that they are supportive.

Some people might like to 'escape' from these changes. A new option is fleeing into a virtual world. This escape from real physical life could endanger the mental health of some who already struggle with their personality and their identity. 'Future multimedia masks' will be far more sophisticated compared to today's text-based instant messaging hide and seek. Using avatar masks and the possibility to submerge oneself into a parallel virtual world can impoverish or enrich the real physical life.

The above may be interpreted as a transformation from a high-trust society into a low-trust society. People will increasingly fall back on themselves or their next of kin. This family bond is not only the oldest trust structure, but a 'back-up' as well when other trust relationships do not function any more. Imagine a society consisting of a fragmented collection of individuals and families, collective innovation then seems impossible, no matter how hard it is needed.

[†] Awareness of the situation seems to manifest itself worldwide – see, for example, www.wellbeingmanifesto.net/

People point at others, mentioning their responsibilities to solve visible urgent problems. Meanwhile time passes by and the need for short-term solutions increases, conflicts arise and mutual trust keeps on shrinking. Not much happens collectively any more and long-term issues are completely left untouched. The moment collective well-being and prosperity have reached an unacceptable low level, collective change is inevitable resulting either in chaos or (eventually after the chaos) in sustainable solutions showing the contours of a more cohesive network scenario.

A Cohesive Network Scenario

Today, no innovation seems to occur without a clear driver. Innovation only takes place when the outcome is beneficial for every involved individual participant or organisation, every node of the (sub-) network. Partial rationality and self-interest dominate, thus multi-actor (say multi-nodal), prisoners' dilemmas are blocking

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innovation. Novel trans-nodal and GDP-GDS balanced business models must arise that envisage the benefits for the network as a whole or even a new aggregation level. This holds true particularly for more complex challenges. Think, for example, of today's challenges we face on the aggregation level of the economical and societal sectors – traffic jams in the transport sector or the introduction of an electronic dossier for patients in the healthcare sector. These types of challenge are by definition trans-sectoral, i.e. they involve several sectors and actors. They cannot be solved intra-sectoral, i.e. in splendid isolation within one sector. Thus, we distinguish the nodal approach versus the network approach – the 'nodal continuation scenario' versus the 'cohesive network scenario'. The distinct features of these two scenarios remind us of the human brain network and its two sub-networks, the left and right hemisphere.

As counterparts of the GDP and GDS, we could introduce the 'gross personal product' and 'gross personal service' in the left and right column of Table 2 respectively. Making a vertical translation, we transcend to the aggregation level of human social networks. At present, the 'nodal continuation scenario' on this level seems dominated by the 'left side' features in the table and resembles an Anglo-Saxon inclined model. We believe the cohesive network scenario is strongly correlated to a balance of the 'right and left' features, overcoming the disadvantages of the Anglo-Saxon and the Rhineland model. To complete the metaphor, the brain as well functions optimally by interconnection of the two hemispheres. We fully believe that a conscious choice between the two scenarios is vital because it is the choice between chaos and a new type of order. Transcending from a nodal model to a trans-nodal model, from an intra-sectoral to a trans-sectoral model, from a low trust society to a high-trust society, requires energy and empathy of the involved actors.

Table 2 Properties of the brain hemispheres[1]

Left hemisphere	Right hemisphere
Ratio, analysis	Emotion, intuition
IQ	EQ
Male	Female
Conservatism	Outside the comfort zone
Economic talents	Social talents
Quantity	Quality
Efficiency	Effectiveness
Short term thinking	Long-term thinking

An interesting equivalent evolution in the ICT-sector can be observed with today's network transitions of incumbent network operators towards NGNs (next generation networks). Federated control platforms like the service-enabling IP multimedia subsystem (IMS) promise to bridge former monolithical autonomous networks such as PSTN, GSM, UMTS, Ethernet LANs, etc. Considering each former network to be a node, in this context also referred to as stove-pipes, we observe a trans-nodal migration to a federation. A nerve and control system co-ordinating all sessions and transactions will be an integral part of this next aggregation stage in telecommunications†.

We believe our future society and economy require these as well. Such an information and control network is necessary across the sectors, just as our human body cannot function without a nerve system or brain. Although rudimentary, such a network exists, but it has not yet been designed in an integral and cohesive concept. Consequently, an integral trans-sectoral portfolio will arise of new services. In the current situation, there is no trans-sectoral federate nerve or control system. Organisational organs do not even feel each other's pain directly when being destroyed. Maybe, that is why today Anglo-Saxon battles in a global economic war prevail, where it is allowed or even encouraged to outsmart and eliminate competitors.

The cause of current sub-optimal innovation processes can also be explained by the way sectors are organised today. They operate as large stand-alone monoliths, focused primarily on themselves. Each sector considers itself the heartbeat and thus feels it is logically entitled to a lot of attention (and a lot of capital) from political decision-makers. Older sectors have already embedded themselves in the political scene, younger ones have yet to gain a Darwinian foothold.

The political system perpetuates this situation – a functionally decomposed society and economy. This is entirely consistent with the system's nature, because our national authorities are a collection of ministries, each with one or more sectors as the demarcated domain for which they hold responsibility. Potential 'trans-connects' that could improve the functioning of the community at large are rarely established. The limits of this sector model are visible on

† For the incumbents, the success of this huge migration is the difference between chaos and survival; the success of their action will be strongly correlated with their endeavour to balance reducing costs and generating new services.

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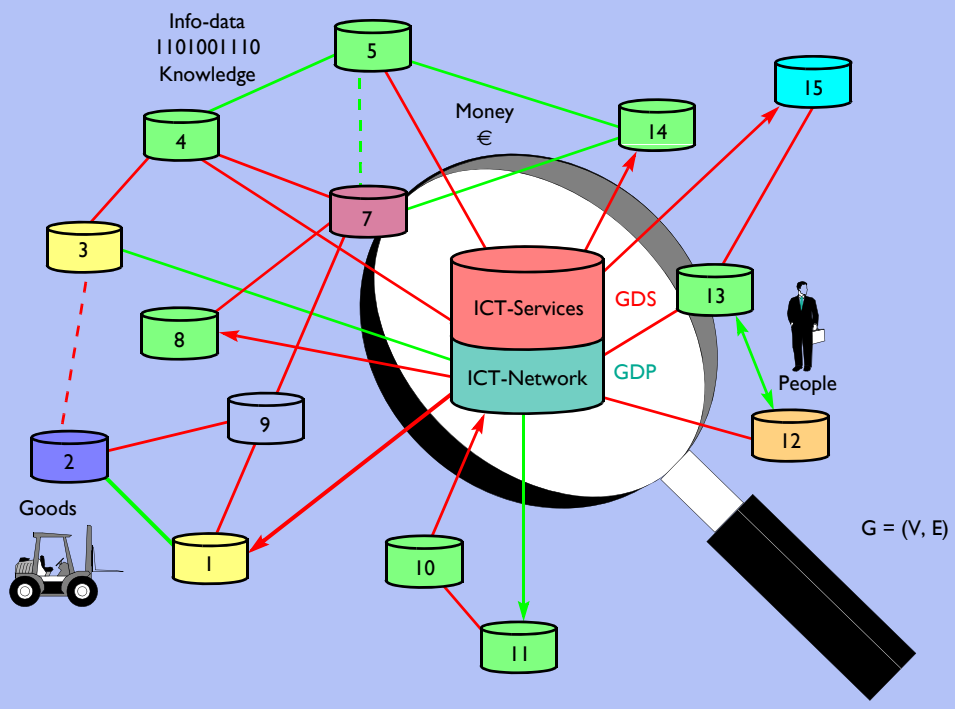
the horizon and their symptoms are here today. Reality is increasingly undermining the idea that sectors have little to do with each other. The interdependence is actually far greater than can be incorporated into the traditional sector diagram (see Figure 2). Therefore, it makes sense to start thinking in terms of a different model – the network model, in this case the sector-network model (see Figure 4).

The network model reflects the mutual dependencies of sectors. The connecting links represent the exchange of goods, money, people, information and knowledge. They are the arteries and nerves of our society and economy. The stronger and more vital the 'traffic' is on those links, the more the community at large may benefit. Nodal material is exchanged as in fusion processes of genetic material of living species. The network is 'alive' with all kinds of sessions going on simultaneously; they enable fruitful transactions and trans-sectoral disruptive innovations rather than intra-sectoral incremental innovations. The vitality, robustness and performance of the network[2] is crucial and cannot be tuned or optimised by nodal considerations, but have to take into account the network as a whole, just as is the case with telecommunications networks.

Graph-theory can help us out here[3], and not just on this aggregation level. Obviously, networks are everywhere on any aggregation level, and the networks on a given level form the basic building blocks for the next higher level.

Therefore, it is quite curious that hardly any insight exists at present into exactly what comes and goes along these links in the sector network. While we know that just

Figure 4 Network model



about everything travels between the nodes, there is scant knowledge about its composition and volume.

The focus remains on what happens in the individual nodes, i.e. the sectors in the previous model, and enforces the continuation scenario. This is true both for policymakers (see above) and for economic leaders. For decades, they have clung to the same guiding principle when setting a course for business – increase the net profits within the sector as much as possible and bring in as much knowledge as possible to pursue this goal. However, this approach will not survive in the network structure now coming about. A wider view is necessary, of people who want to look at ways the society as a whole will move forward.

Knowing that the fruits of their actions will fall ahead in time and laterally in other sectors as well as in their own, they understand that it will benefit their sector as well; however, a trans-sectoral (business) model seems required. One could compare the network structure with a living organism.

The organs (nodes/sectors) appear to function independently, but, in fact, they are dependent on the 'transport' network of blood vessels that supplies them with energy and oxygen. The connecting nerve and control system allows the exchange of information and performs a co-ordinative managerial function for the network as a whole.

Vision

Recent estimations about the world population growth predict the volume will not exceed ten billion people, as forecast in earlier decades. Still, a growth from six to nine billion people is foreseen peaking in the period 2060 – 2080. Later on, the population volume will probably shrink, assuming better education and reduced poverty[4].

Population growth combined with climate change will lead to water and oil scarcity, causing inevitable conflicts and higher prices. Some regions will on the other hand face water abundance. Here lies a driver to balance water shortage and abundance, on a geographical basis. Letting the water work while flowing in regions with significant altitude differences, will generate welcome hydroelectric energy on a larger scale. Creating an oasis in a desert, growing trees offering shade, is better than building air-conditioning systems in developing countries. Tidal power is another means of electricity generation achieved by capturing the energy contained in moving water masses. As tidal power may not show convincing return on investment for years, it will be up to governments to initiate these trans-sectoral tidal projects.

Around 2050 – 2080 natural oil and gas resources will grow scarce. Physical mobility cost will increase. We believe that the transition away from fossil energy sources will drive the need for a virtual mobility concept from an economic perspective. Virtual mobility will offer the possibility to appear anywhere you want to be, regardless whether you are projected in real life or travel in virtual parallel worlds.

A few virtual worlds already exist, for instance Second Life[5], a virtual meeting place for people and non-human entities. Anyway, more virtual parallel worlds will arise and co-exist. It can be assumed that in some of them detailed replications of the real physical world will arise. Within this world, people and organisations will present themselves in a way similar to the 20th century yellow pages. Furthermore, even variable items like the weather, traffic jams, and events like concerts, will be presented in near-real time.

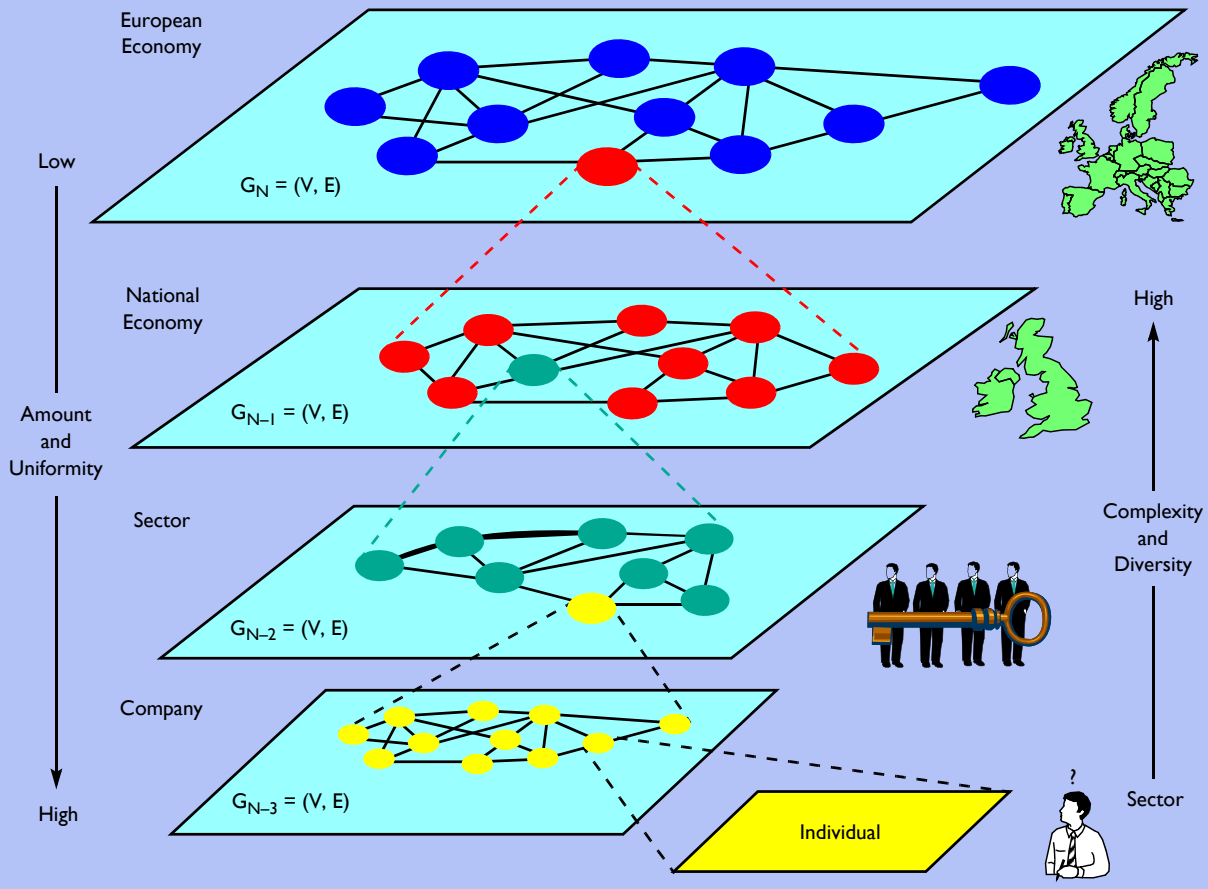
In this article, we use the terms 'real physical world' and 'virtual parallel world'. Various expressions exist, referring to more or less the same. Table 3 presents most associated synonyms.

In general, three classes of worlds can be derived:

Table 3 Synonyms

Real physical world	Virtual parallel world
Real world	Virtual world
Physical world	Cyberworld, cyberspace
Reality	Virtual reality
Real life	Artificial life
Off-line world	On-line world

Trans-X



The prefix '*trans*' frequently recurs in this article. We postulated different concatenating aggregation levels where one can *trans*form into the other. On any given (horizontal) level, we detect networks, graphs **G** = (**V**,**E**), a collection of **V**ertices, isomorphic nodes and **E**dges, say connections or links. In between nodes, *trans*actions take place in 'sessions', and material or immaterial entities, e.g. goods, people, money or information, knowledge and skills respectively, can be *trans*ported or *trans*mitted from the sending (*trans*mitter) node A, the source, towards the receiving (*trans*ceiver) node B, the destination, over the link, say road C, the *trans*mission path. One could say that the networks are alive, *trans*ient – παντα 'ρει, 'everything flows'. To become concrete, let us look at the aggregation level of a national economy. Different sectors together constitute a sector network, once we define one or more specific relations between these nodes. A *trans*-sectoral view of this living network *trans*cends the partial rationality of the sector nodes and benefits the network, and thereby the aggregated values of the Network **G** such as prosperity, $\mathbf{G_{gdp}}$, and well-being, $\mathbf{G_{gds}}$, as a whole. The generic term in this respect for all levels becomes a '*trans*-nodal view'. Thus, we shall have composed a *trans*parent model once we have learnt that we may *trans*fer the isomorphic qualities horizontally and congruent relations vertically. Think in this respect of the *trans*lation of the OSI-model from the ICT sector horizontally to the healthcare or transport sector and vertically to another aggregation level – what does the OSI model mean in relation to the human body?

- the real physical world itself;
- virtual parallel worlds depicting the real physical world;
- virtual worlds where (enhanced) people and non-human entities can meet.

Avatars

Today, artificial intelligence is deployed for specific tasks, for instance:

- data search;
- gaming;
- surveillance and security;
- tracking and tracing systems.

This century artificial intelligence will gradually mature from specific applications to semi-autonomous personal assistants/avatars, bots, interactive Web site hostesses, etc. Avatars will develop into an enormous diversity, some acting on behalf of people as their personal agent, others as agents representing organisations, animals, flora, and precious objects. Avatars will communicate with people and each other and even enable multiple personalities.

Two long-term images about artificial intelligence exist:

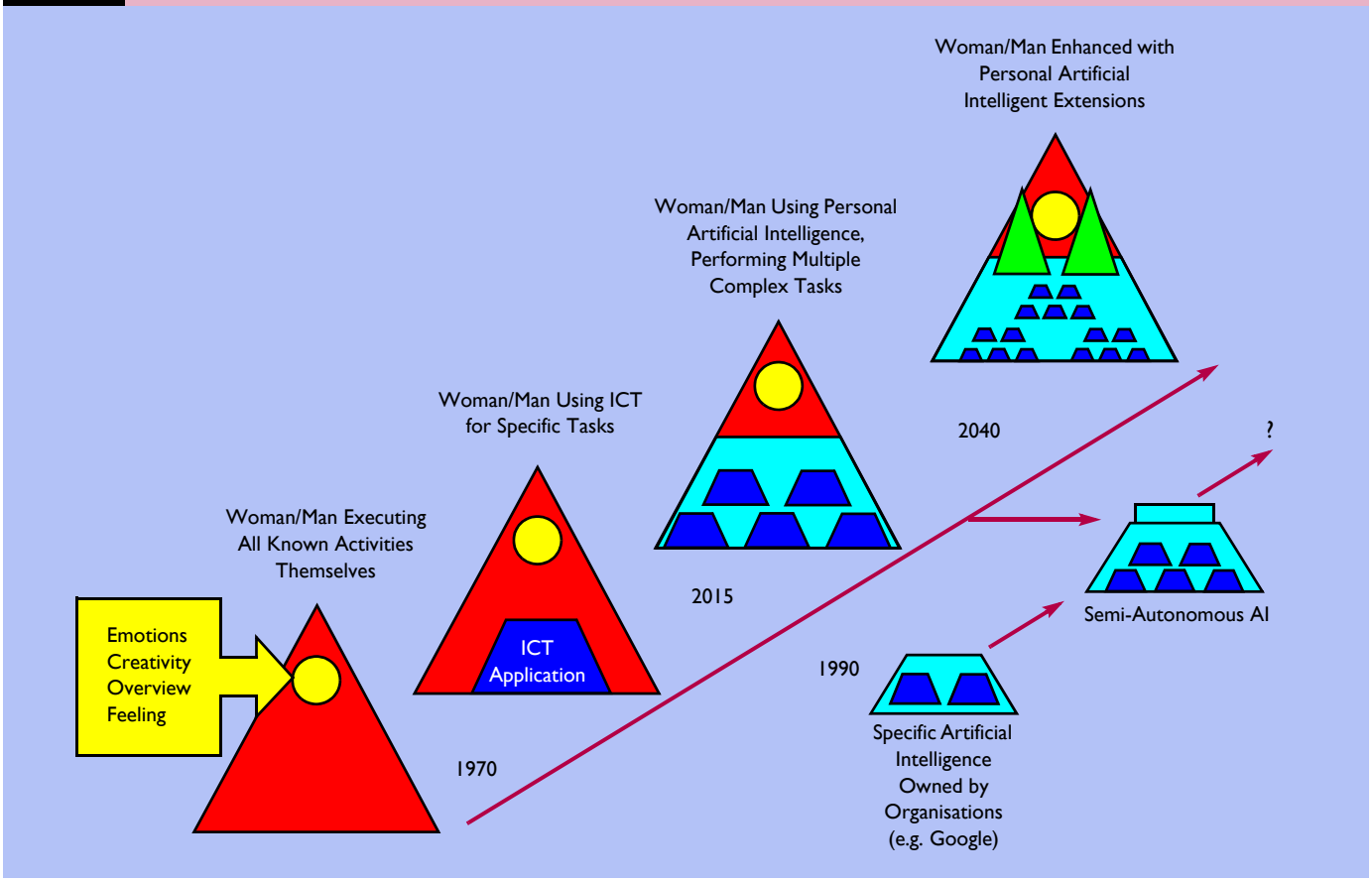
- autonomous intelligent devices gaining importance, being smarter, faster and far more efficient than average people for specific tasks,
- people remaining in the lead, physically enhancing themselves with technological extensions and brain controlled user interfaces.

However, bear in mind that artificial intelligence/avatars will be human-like but never human[†]. Emotions, creativity, overview and feelings (intuition), are typically human properties. These are the most difficult capabilities to implement in artificial intelligence. All other 'functions' will be covered more and more via personal ICT means, thus making life easier (Figure 5).

The combination of virtual worlds, virtual mobility and artificial intelligence will introduce a new spectrum of possibilities[6]. We foresee some moment in time that artificial intelligent entities can generate money autonomously. This may cause conflicts on ownership because within present law these kinds of entities do not have a juristic part. Whatever may be decided concerning lawful implications, the

[†] Stated by Ludmila Menert, independent consultant.

Figure 5 **Maverick evolution**



rise of avatars will lead to possible artificial life and after-life of deceased owners. As both people and non-human entities can easily interconnect via various virtual parallel worlds, a metaphor of a 'plasma state' arises. Comparing a plasma (characterised by a range of new industrial possibilities), to the still-imaginary trans-sectoral innovation stage, we expect hyper-innovation to occur.

ICT developments

The complexity of end-user services is increasing rapidly. This creates the need for more intelligence within the network in order to combine services and create new services. This same process is ongoing within the end-device leading to more powerful and intelligent end-user devices. Next to complexity, the bandwidth demand of these services is increasing as well. This creates new boundary conditions for the wireless access of communications networks, as most services will be enjoyed wirelessly in the future. This will result in shorter radio ranges, as higher bandwidth requires smaller radio cells[7]. A first intermediate step towards the smaller 'pico' cells, is made with the coming of the 'micro cells', e.g. wireless hot spots and the 'streetlight concept' (Figure 6). Joined together with the fixed network, an ICT ecosystem emerges.

As mentioned earlier previous networks become building blocks in a new trans-nodal network federation, e.g. existing networks transform into new nodes. As we have moved from circuit switched to packet switched, networks will develop back into optical circuit switched, switching wavelengths per session[8]. Architectures will flatten over time, for instance the optical layer will be enriched with more intelligent capabilities than are present today in ATM and Ethernet. IP and E.164-based technology will gradually be reduced to addressing schemes and service protocols.

Rules engines enable near-real-time rich presence:

- rules engine technology will change the way we do business today;
- service providers can offer propositions to customers which can be accepted via rules engines enabling near-real-time agreements, transactions;
- rules engines will evolve between wholesale parties such as network and service providers.

Rules are subject to ever changing context. Context awareness is the most difficult aspect to implement.

Governments and politics

Today, politicians present their plans but are not able to overview and correlate all relevant aspects any more due to increasing complexity.

Future political decisions/plans may very well be based on expert systems, hosting forecast models. The surrounding experts that understand and operate the complex models will become more influential in political processes[†]. Nevertheless, there is definitely a role for a facilitating and actively stimulating (international) government to enforce trans-sectoral innovation. Thus, hyper innovation cannot be reached without central non-profit governance.

Basic free ICT access for almost everyone is inevitable because of cost and efficiency benefits. Access will be required for interaction between civilians and authorities. Richer and faster access must be paid for, so metaphorically speaking one could state: 'Bits will be free, bytes will not'[‡], like the analogy of roads. Walking and riding bicycles are free but driving a car requires tax to be paid.

ICT infrastructure will be capable of interconnecting the majority of billions of people becoming nodes in a huge human linked network. ICT will offer efficient, fast

[†] Stated By Ramin Hekmat, Technical University of Delft.

[‡] Stated by Rangarao Venkatesha Prasad, Technical University of Delft.

Figure 6 Multimedia street furniture

and implementable solutions. In the traffic and transport world, too, ICT infrastructure can act as a catalyst. From the outside, ICT may appear to be one of the nodes in the network, but its capabilities are multifold and incredibly versatile. ICT is having a gigantic impact on our entire community, society and economy. Network visions will bring us major innovations and help us to implement and organise them. Understanding the facts and performance of the networks on one part of an aggregation level and transferring this knowledge through the isomorphic and congruent relations horizontally to other parts of the network on the same level and other networks on different levels, respectively, will bring our evolution into an acceleration such that Omega comes within sight.

This reminds us of Teilhard de Chardin†, 'nous sommes amenés à concevoir un Centre premier et supréme, un oméga, en qui se relient toutes les fibres, les fils, les génératrices de l'Univers'[9]. (...we are brought to design a Centre first and supreme, an omega, in which connect all fibres, the wires, generators of the Universe).

The interaction and development of the networks on one level and at different levels will increase hugely, once discovered features and mechanisms can be transferred. For example, in the ICT sector complex sessions can be successfully set up worldwide. Could this benefit the healthcare sector to improve intricate sessions to heal patients worldwide? If so, and we succeed in the coming century to get these mechanisms transparent, the networks themselves will accelerate in their evolution, being only transient steps towards next phases with yet unknown macroscopic changes. First steps, though, may need to be very pragmatic in order to overcome the partial rationalities in many 'multi-actor prisoner dilemmas' that hamper us in solving today's compelling challenges – dilemmas that have to be overcome, if the vital networks on which we depend, and without which the development of the individual nodes grinds to a halt, are not to degenerate in their last phase into chaos. Instead, they should transform to survive to yet a higher aggregation level based on a new collection of more complex nodes. This can only succeed if true (trans-nodal) network interactions take place and nodal material is shared and transmitted across the network to compose novel nodes with an increased intricacy. If this process accelerates time and again, transactions between the nodes speed up continuously and the plasma phase of the network is approaching.

Conclusions

Networks are omnipresent and universal. Mankind, for example, forms a social network and we believe that this network is approaching another aggregation phase in the coming century. Today, information and communications technology exponentially accelerates the interaction between the human nodes of this global social network and appears to introduce a phase transformation, similar to the physical phase transitions of a thermodynamic system that characterise the transformation

† Pierre Teilhard de Chardin (May 1, 1881 – April 10, 1955) was a French Jesuit priest trained as a palaeontologist and a philosopher. His life evolved around one mission: relating the theory of evolution with the Christian religion. Teilhard conceived such ideas as the Omega Point and the Noosphere.

ICT is having a gigantic impact on our entire community, society and economy – network visions will bring us major innovations and help us to implement and organise them

of matter. On another level, networks are also present in our product and service sectors. Think, for example, of the transport or ICT sectors themselves; here we detect important developments in their transient networks. Virtual mobility and virtual reality are just two of the driving forces having both an economic and social impact.

Finding that networks are omnipresent and universal, gave us a realistic cause for optimism. Indeed, we can benefit from the network knowledge in the ICT sector by translating this knowledge horizontally to, for example, other nodes in the sector network of our economy and society. Transferring the knowledge vertically to networks on other aggregation levels, such as the human network, rewarded us with insights into some developments for the next 100 years and gave us food for thought. For example, balancing GPP and GPS, what does that mean for the co-operation and influence of man and woman in the future in our professional and personal lives? Then there is also an opportunity to balance the GDP and GDS. In addition, awareness of a nodal continuation and cohesive network scenario for the 21st century, and keys for the choice between and control of them, come within reach. Definitely, the relatively new ICT sector, enabling connections between all communicating entities, plays a crucial and multifold role in this vital game:

'In the future, ICT will have a significant impact on society in areas such as care, security and education. There is a great deal of potential for ICT innovation in these sectors, which are not moving very fast at the moment. But it must be done – in some cases with pressure from the government – otherwise self-interest will prevail in these sectors'[10].

Furthermore, the game seems to speed up and people will have to cope with and adopt more and more sophisticated technology, especially in the area of ICT. We believe that ICT will provide solutions to improve access to information and for convenient knowledge sharing and for the quality of collective (e.g. education) systems and last but not least for a more effective innovation process:

'The search for new realities and opportunities will drive organisations outside their comfort zone. It will require different skill sets but more difficult even, a different mindset. Opening up for those challenges requires leadership beyond what the industry has seen so far.'[11]

In today's business environment, it is clear that no organisation can innovate by itself and that ease of connection is essential, like the connection of nodes in a communication network. Co-operation, trust and innovation are the key to success. This holds true not only in our professional world but also in our private world. Within a knowledge-driven economy, a new dichotomy in society will become related with the ability to utilise this knowledge:

'As people will have easier access to abundant information, organisation structure will become flatter. The future hotshots will be the people who are able to interpret, sort and use information.'[12]

However, the required, disruptive innovations, often involving ICT, come to a grinding halt if the solutions are sought from within one single domain. Actors from different sectors have to be involved to close the solution both in terms of contributing components (knowledge, skills, infra- and process-building blocks) as well as in a financial sense. In fact, we deal with a network and its performance as a whole. Through a cohesive network vision, both from an economic and human perspective, a new huge set of insights and modelling tools have become available.

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Professor Nico Baken currently holds a part-time chair in the Telecommunications Department at Delft University of Technology alongside his primary position as Senior Consultant/Chief Architect within the Department of Corporate Strategy and Innovation of Royal KPN, the Dutch incumbent Telecom operator in the Netherlands. His main interest concerns Broadband Networks and Services, dealing with a broad range of aspects such as Sensor (RFID), Vehicle, Home and Personal Networks, the first mile and metre, e.g. FTTH and other access infrastructures such as xDSL, fixed-mobile convergence, operations, financial strategies, e.g. the real Option Analysis, managerial complexity and regulations. He is responsible for co-operation with research institutes such as TNO ICT and universities. Given this spectrum, he has been asked to advise the Dutch government on broadband in the national expert group on broadband and in the Andriessen committee (former minister of Economic Affairs) to deal with the feasibility of FTTH for The Hague. Recently, he introduced new concepts such as trans-sectoral innovation, City ICT Architects and 'streetlight' to enhance and accelerate ict-applications in and across sectors such as healthcare, transport and education.

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