Appendices

Master Thesis - Integrated Product Design

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1 - Organism

Eusociality

Ants are seen as one of the few animal species that are considered to be eusocial (others include wasps, honeybees, naked mole rats). Eusociality is the highest level of organization of animal sociality, and is often defined by three (and sometimes four) characteristics (Plowes, 2010):

1. Raising the young is done as a group effort, not necessarily by their parents or other related individuals.
2. Only certain members are allowed, are able, or have been assigned to reproduce.
3. Communities contain an overlap of generations, working together.
4. (Optional): Adults live in groups. Although this criteria can be taken for granted when looking at the previous three.

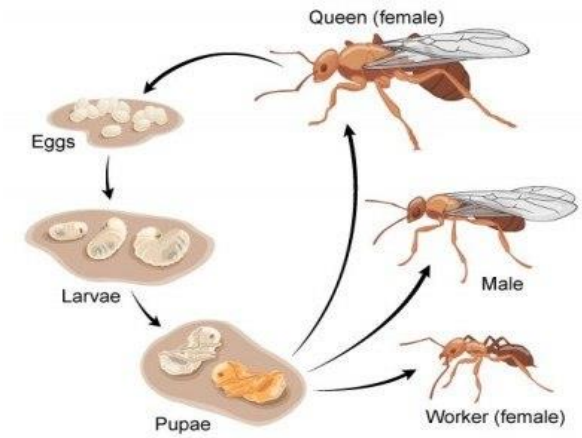


Figure 1: An ant's role is defined at its birth

Hierarchic society

A characteristic feature of ant colonies are the strict social rules that exist within them (Terminix, 2017). Each individual ants has a certain role which has been determined at birth (figure 1). The queen is a female ant with a unique physiology, who flew over from another colony after mating there and established a new colony herself. Out of the first batch of eggs she lays, either males or females can hatch (figure 1). The males are called drones, and have the sole function of mating with the queen to ensure the growth of the colony. The females pupea will become the workers of the colony and basically take care of everything except mating. Their activities include taking care of the young, digging and cleaning the nest, and (most importantly) foraging for food.

Furthermore, different classes can be distinguished within the group of workers (PermaTreat, 2013). First of all, there is a clear physiological difference between workers (maintenance tasks) and soldiers (defensive tasks). Soldier ants grow to be bigger than most of its colony-mates. This includes their heads, which have significantly larger mandibles, to be used as weapons. They fend off any threats to the colony such as spiders of flies, but can even repel animals as large as bears by collectively spraying acid towards them. A worker does not involve itself in all possible maintenance tasks, but usually specializes in one. A colony has groups of foragers, diggers/builders, cleaners, and care-takers.

Communication methods

This project revolves around the way ants communicate by using pheromones as an indirect and multi-target communication method. While this method works extremely well for these animals during their foraging activities, they do use other methods for varying purposes: some to enhance their foraging method and others for different goals. As will be explained later, one step of their foraging method requires direct communication between ants. Scouts that have found a proper source of food store as much as they can of it in their 'social stomach' and return it to the nest. There these scouts directly feed several worker ants their samples in order to recruit them to venture outside of the nest themselves, thus initiating the collection process. This direct communication takes place by the transfer of food from one ant to another. Another reason ants choose to communicate directly is to distinguish fellow nest-mates from ants from other colonies (Sci-news, 2015). This is also done by the detection of pheromones. By touching each other's cuticles (outer shell), ants are able to detect a sort of 'identity-tag' of cuticular pheromones on the other ant. These cuticular pheromones are significantly more complex than the ones used for the formation of trails, and are therefore able to transfer a larger amount of information (e.g. its home colony, the task it's been assigned to) (Sharma et al, 2015).

Tandem running

A particularly interesting direct communication method used by ants is based on touch (tapping of the legs on the abdomen), and is also used (by some species) in their foraging behavior (Franks & Richardson, 2006). The phenomenon is called tandem running, in which a scout recruits a worker ant by personally guiding it to the resource that was found. This run involves bidirectional feedback between the scout and the worker and can be seen as one of (if not) the first example of teaching behavior outside of humans.

This activity replaces the step of the pheromone-based process during which worker ants are recruited by being given a sample of the discovered resource. It can be seen as a more effective way of making sure a worker ant reaches an approved resource, yet at the same time it makes the system less efficient because the workers depend on personal assistance instead of on the pheromone trails.

Figure 2: Tandem running fire ants

Vibration

The last communication method ants are known to use involves vibration. This direct form of communication is used during digging and other nest building activities, and has been observed in leaf-cutting ants which live in tropical areas (Sendova-Franks & Scott, 2012). Many species of ants, including this one, can produce sound by rubbing their body parts together: stridulation. Because of the absence of ears, ants sense these vibrations only when they travel through material such as the soil.

Argentine ant

While observing the behavior of the Argentine ant (Iridomyrmex humilis), however, a different variation of the initiation of this process was discovered. Most commonly, the initial trails are constructed between two points (the nest and a resource), whereas the Argentine ants lay down exploratory trails in a more randomized manner (figure 3). Their initial trails are not restricted to resources and therefore help the ants explore a large area faster. Exploration, in this case, is a collective effort and not just one of specialized scouts. There are only two conditions expected to be needed for this process to be initiated: The workers outside the nest must continuously lay down pheromones, and these workers must leave the nest together in sufficient numbers. The benefit of this method is that many more resource options are considered and more area is explored by the colony before the selection process starts to take place.

Figure 3: Random trail pattern created by foraging voles

2 – Pheromone usage

- Scouting ants set leave the hive in order to search for a point of interest (food source, building materials). On their exploratory journey, they lay down a preliminary trail of pheromones. The pheromones on this initial trail are volatile and are not placed in a continuous line (dotted line).
- When a scout has found a source that he considers to be useful to the colony, it takes a sample and returns to the hive following the trail it left itself. On this return journey it confirms the preliminary trail by adding a continuous line of (still volatile) pheromones.
- The less successful scouts continue their journey until they either find a resource themselves or until they encounter the path of another scout, which they will then start to follow (MUTE, 2017).
- Upon returning at the hive, the scouts recruit regular worker ants by displaying their sample taken from the source. This sample triggers the workers into leaving the hive in order to forage themselves.
- The workers follow the same procedure as the scouts while searching for the food source; they leave a preliminary intermittent trail of pheromones while searching for a food source. This time however, the presence of an existing (and confirmed) trail increases the probability that these workers will be guided to the same food source that the scouts visited. Ants detect the pheromones with their antennas.
- Each time a new ant visits a food source, it adds pheromones to the trail that led to it. This increases the potency of the trail and increases the probability that other ants will follow it, since the strength of the command depends on the quantity of the pheromone.
- When an ants follows a trail and arrives at a resource that has been depleted or is no longer necessary for the colony, the ant responds by no longer adding pheromones to the trail. Since all pheromones used are volatile, the potency of this trail will quickly decrease and the trail will eventually disappear. Some species of ants respond to a depleted/obsolete resource by adding a repellent pheromone to the trail that led them there (Ratnieks, 2008). This actively decreases the probability that other ants will follow this trail, thus causing it to evaporate faster.

Behavioral rules

The rules of the system for the worker ants that embark after the scouts can be summarized like this (MUTE, 2017):

Condition	Action
Not carrying food, not following a pre-existing trail	Walk randomly, deposit a small amount of pheromone
Not carrying food, following a pre-existing trail	Follow trail, deposit a small amount of pheromone
Return to nest without food, following trail	U-turn, follow trail
Reach foodsource	Pick up food, U-turn, follow trail
Carrying food	Follow trail, deposit a larger amount of pheromone
Return to nest with food	Deposit food, U-turn, follow trail

Optional rules, dependent on the use of repellent pheromones.

Condition	Action
Following trail, encounter repellent pheromone	U-turn, follow trail
Reach foodsource, find out it is depleted	U-turn, follow trail, place repellent pheromone at next bifurcation point.

U-turns

A can also extract (very basic) information from the shape of the pheromone trails (Ratnieks, 2008). Basically, the way these trails branch tells the foraging ant which direction leads to a possible food source and which direction leads her back to the nest. The behavior that can occur when ants encounter a bifurcation point (figure 4) can best be described as a U-turn. For example, ants prematurely change their direction when they encounter the aforementioned repellent pheromone which tells them a resource has been deemed obsolete.

However, research has indicated that while a portion of these U-turns can be ascribed to corrective behavior, a large portion of these actions could be an essential component of active trail-maintenance. U-turning ants were found to be very likely to lay down pheromones. Since U-turns are often made several times per journey outside of the nest, a small minority of the foragers spends a lot more time on the trail that the rest. This minority gains a well-informed status about the trails it spends time on, and is therefore more qualified to make decisions about its potency or obsolescence. These specific ants can be seen as the main decision makers, since they have greater control over the potential abandonment of a trail and a switch to another (better) food source. This should ensure a higher level of flexibility within the system which relies on more than the volatility of pheromones.

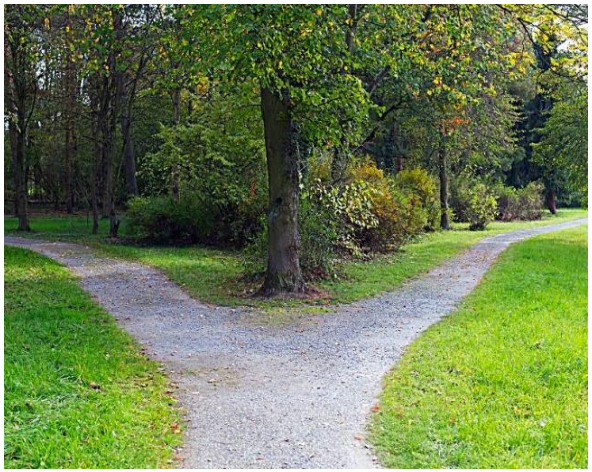


Figure 4: A bifurcation point in a trail

3 - Relevant concepts

Based on the abstraction of the natural model's key concepts, literature research was done to find existing models and theories that relate to the abstracted natural model and help in understanding and designing with them.

Stigmergy

The key concept of these computational models based on ant behavior is stigmergy. It can be described as an indirect coordination between agents or actions, and is more or less similar to the concept of modulatory communication.

"*The principle is that the trace left in the environment by an individual after an action stimulates the performance of a next action, by the same or a different individual*".

"*Individuals leave markers or messages. These don't solve the problem themselves, but they affect other individuals in a way that helps them solve the problem*".

"*Stigmergy represents indirect communication through the products of earlier labour in the environment. It has the potential to amplify stimuli as several individuals could respond to a stimulus from a single nestmate and in doing so could in turn create a bigger stimulus and a subsequent wider response.*" *(Sendova-Franks & Scott, 2012)*

As stated earlier, each individual in the ants' system is ignorant to the greater cause and is just acting according to its instincts. This does not necessarily mean that each individual human in a similar system must be ignorant to the overall system, but that the system should function properly if they were. There might even be advantages to the participants being ignorant in this way, since they will not attempt to influence the results (perhaps with good intentions) and disrupt the system.

Benefits of stigmergy. This paper proposes the following benefits (Heylighen, 2015), which of them apply to the ants' system? Are these still benefits when applied to a human system?

- Individuals do not need to know the future steps or overall goal of the system, all that is relevant for them is their current activity.
    - Other than ants, humans have the ability of becoming aware of a system they are participating in. This awareness, combined with intelligence, would allow them to influence the system.
- Those who participate in the system do not need to remember anything themselves. All necessary information is stored in the communication medium itself.
- No direct communication is necessary between agents. All of it takes place indirectly through the medium. There is therefore no room for negotiation or arguments in general.
- There is no need for participants to be present at the same time, or even at the same place, tasks and progress are stored in the medium and can be picked up at any time that suits the particpants. (Google drive)
- "Tasks are automatically performed in the right order, since an action will not be started until the right condition is in place. The workflow emerges automatically, in a fixed direction

- A division of labour exists among individuals. Each individual will only do tasks for which it is competent enough. There seems to be a degree in confidence (estimation of personal competence) about a task that determines how likely they are to pick it up. This makes sure the most competent individuals end up at the right tasks. Awareness of one's own competence is necessary here.
- The system is self-organizing, because errors are automatically corrected. These 'errors' create new conditions which others will respond to and ultimately 'overwrite' the error.
    - In the case of the ants, one could say there is no such thing as an error since the system is based on chance. Errors can be seen as opportunities in finding and/or ruling out another resource. Besides, the sheer number of ants allow for a certain margin of error.
- There is no need for individuals to commit to a certain task. The tasks it focuses on at a certain moment depends on local conditions and opportunity.

Conclusion

The concept of stigmergy can be seen as an abstracted description of systems that are very similar to the ant's foraging system. Although it is mainly used in computing applications, it still provides us with deeper insights into the properties of the natural model. The main things to take away from this are the benefits of a stigmergy-based system, which will be used as inspiration during the conceptualization phase.

Swarm Intelligence

Swarm intelligence is a term used when a collective system is capable of accomplishing difficult tasks in dynamic and varied environments without any external guidance or control and with no central coordination. It deals with collective behaviors that result from the local interactions of individual components with each other and with their environment. This type of intelligence is generally used in computational models and has led to the development of some successful optimization algorithms. It has been abstracted from the foraging behavior of ant colonies.

Five principles of swarm intelligence (Iniguez, 2016):

- Awareness. Each member must be aware of its surroundings and abilities
- Autonomy. Each member must operate as an autonomous master (not a slave). This is essential to self-coordinated allocation of labor
- Solidarity. Each member must cooperate in solidarity. When a task is completed, each member should autonomously look for a new task (leveraging its current position).
- Expandability. The system must permit expansion where members are dynamically aggregated.
- Resiliency. The system must be self-healing. When members are removed, the remaining members should undertake the unfinished tasks.

Nudge theory

As mentioned, the way pheromones influence the behavior of ants can be described as a form of modulatory communication, which refers to the fact that they only increase the probability that an ant will change it behavior when sensing the pheromone. This characteristic led me to an existing method of human communication, nudging, which shows some conceptual resemblance and could therefore be used for the transition to a communication system suitable for humans.

A nudge is considered to be a "means to trigger desired behavioral outcomes" (Thaler & Sunstein, 2009). It does not, however, aim for the conscious decision-making process of people. It rather aims to alter the environmental context in which a decision is made, thus addressing the subconscious level of the human mind. A cue can be considered to be a nudge when it easy/cheap to avoid. They cannot be mandatory in any way (rules/laws/attached to penalties). It therefore, like the ants' pheromones, only increases the probability that agents will change their behavior based on sensing them. Furthermore, nudges can also be seen as indirect forms of mass-communication, since two parties communicate through a medium (the nudge) and the acting party does not decide exactly who receives their message.

There are also ways in which nudges differ from these pheromones. First of all, the current way in which a nudge is used is in a one-way communication method between an agent with a certain goal (sender) and multiple agents who are often ignorant to this goal. There is therefore no aspect of self-organization of a crowd present here.

Figure 5: A very common nudge

Why does nudging work?

Humans make decisions based on the limitations of their cognitive mind. While we do reason when making a decision, we do not consider every available option and certainly don't make the optimal choice every time. Humans selectively search for a suitable option, often based on incomplete information and a certain degree of ignorance, and choose for the first option they deem sufficient. This does not mean that human decision-making behavior is irrational; the rationality lies in the characteristic of being goal-oriented. We usually have reasons for what we do.

Five (broad) rules

- People often have a default choice, based on past experiences, which they go for if there is a lack of strong convincing signals. A good nudge bypasses this default choice by leading them towards a positive choice.
- When designing a nudge, one should expect errors to be made. A system should be designed that allows agents to immediately learn about these mistakes which they will make.
- A nudge should subsequently give clear feedback, so people can learn the effects of their choice.
- "Policy makers could support citizens by paying more attention to the way they construct mind maps when making decisions and encourage the adoption of mind maps that facilitate better decisions".
- "Since people can have problems when making complex decisions, nudges should provide opportunities for collaborative filtering so that people can learn from like-minded individuals about what works for them, of what choices might suit them as a person. People tend to follow the behavior of their peers".

Largest need

Nudge theory describes the most suitable situation in which nudges can be used. These situations involve people who have to make choices with the following characteristics (Dreibelbis, R. et al.. , 2016):

- Choices with delayed effects. These include choices on whether or not to eat healthy, since any potential weight gain will only occur after a period of days. The same goes for the use of electricity (taking a bubble bath or long showers); the bill comes later.
    - The choice between several stands can be regarded to have a delayed effect, since visitors only discover the quality of their choice after a (sometimes lengthy) conversation with an exhibitor.
- Difficult choices.
    - Especially for less-experienced visitors, stands may contain very little quality information on which to base a choice on. The information that is available is often superficial and well-marketed.
- Infrequent decisions. Closely related to the previous characteristic. When one only makes a certain choice once a month, it is harder to user experience-based knowledge than when one makes it every day.
    - Most trade fairs are only organized once a year, making the choices made in them quite infrequent. Visitors that visit multiple fairs a year still

- Choices that offer poor feedback. It is important for people to see the results of their choices, albeit delayed.
- Choices that have trouble relating the options to experiences. These choices have options of which the results are difficult to imagine by individuals because of a lack of experience.

Choice architecture

The method of choice architecture describes how the decisions we make are affected by the layout, sequencing, and range of choices that are available to us. It can be seen as a form of nudging, because it uses cues that are not often identified as such by the decision maker. Applying choice architecture can be done with six tools. One can see these are almost identical to the rules of nudging,

- Defaults
    - This tool relies on the fact that people are significantly more likely to accept the default choice when making a decision. Examples of this are the opt-in/opt-out systems of donor registration and
- Feedback
- Incentives
- Error expectancy
- Mapping
- Structuring of complex choices

Conclusion

Nudges themselves can be considered to be suitable imitations of the pheromones of ants because of the similar manner in which they transfer information. However, the question of whether these nudges can be taken separately from the system in which they are most commonly used must first be answered. Nudges can be a useful communication method in the case of trade fairs, because of people's limited ability to make cognitive decisions when confronted with unfamiliar environment. In such situations, humans tend to choose for the most familiar of choices. Nudges can help prevent that and make sure an individual allows itself to be guided by the to-be-designed system.

Crowd & Group communication

Several psychological concepts and theories were also explored, in an attempt to gain a better understanding of what drives the behavior of individuals and groups of people. Some of these theories are based on crowd behaviour, while others are based on group behaviour. While trade fair visitors can best be described as a crowd, group behaviour theories have also been studied because they provide insights on how the behavior of multiple agents can be influenced at once.

Mass communication

Mass communication is a process in which a person, group of people, or an organization sends a message through a channel of communication to a large group of anonymous and heterogeneous people and/or organizations (The Business Communication, 2017). Information is sent through a medium; a sender makes changes to that medium, the results of which can be sensed by a large number of recipients. Traditional forms of mass communication media (television, radio, newspapers) has the disadvantage of being expensive and having very slow and indirect feedback.

There are two main theories of how information can reach a large audience; directly or through an intermediary step. The second option is called a two-step flow system. Communication reaches opinion leaders, which then transfer their own interpretation of the information to the group of individuals which they influence.

It is important to know which other factors influence the behavior of people at fairs: "Depending on their quality and coexistence of other determinants, media influences maybe subordinate to, equal to, or outweigh non-media influences. Humans, unlike ants, receive information from many more sources than the media which will be designed. This raises the question of how we can design the pheromone-based communication medium to be the priority influencing factor for wayfinding behavior?

Spiral of silence

Spiral of silence theory suggests that people do not want to be perceived as different and will not display their opinions if they deviate from the majority opinion. People sometimes even change their opinion so that it conforms to the norm. This theory is only valid when we assume that every agent in a certain situation is able to know what the prevailing opinion of the group is. This inherent fear of people might negatively influence the potential of our envisioned system, since it will prevent the emergence of new trails when one or more already exist and are used by a majority of people. This theory has two notable weaknesses however, from which we can learn to counter the effect: Anonimity and a vocal minority.

Behavior change

The core functionality of the system will be to change (or influence) the behavior of visitors of a trade fair. The Fogg Behavior Model (FBM) helps to indicate which factors are necessary to change the behavior of people. This generally depends on three factors: motivation, ability, and triggers. The latter of which is most often the factor that designers control (figure 6).

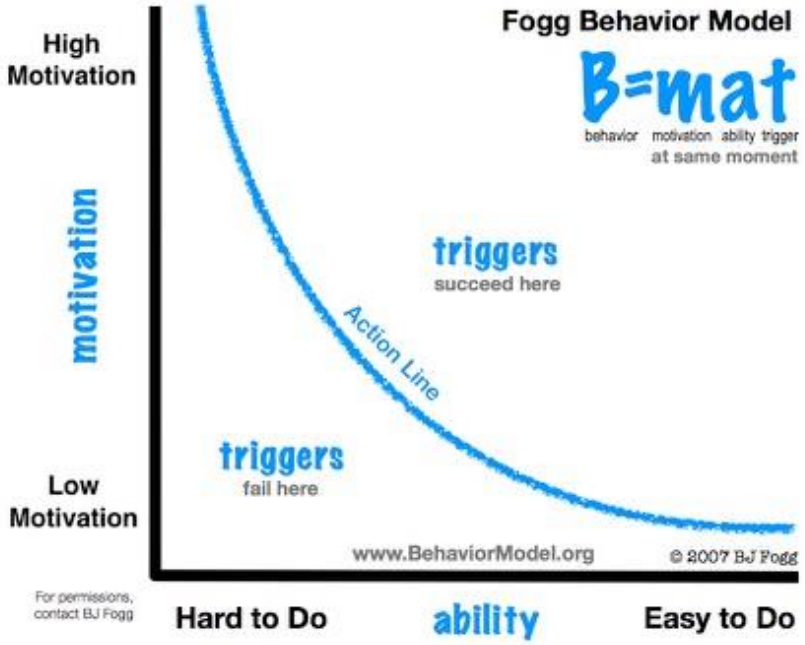


Figure 6: A theory that suggests the required threshold for behavior change

4 - Integrate Life's Principles

An important step in the traditional Biomimicry process is to integrate the Life's Principles into the project (figure 7). These principles can be seen as design lessons from nature (Biomimicry 3.8, 2017). By applying Biomimicry, a designer is not just expected to learn from one specific natural model, but rather from the general way in which nature operates. Since this design project entails a rather system-based way of thinking, these life's principles may prove to be especially inspiring. These principles were used at two points in this project, they were looked at to gain inspiration for the development of concepts, and they were used to evaluate the final design. The paragraphs below describe this evaluation.

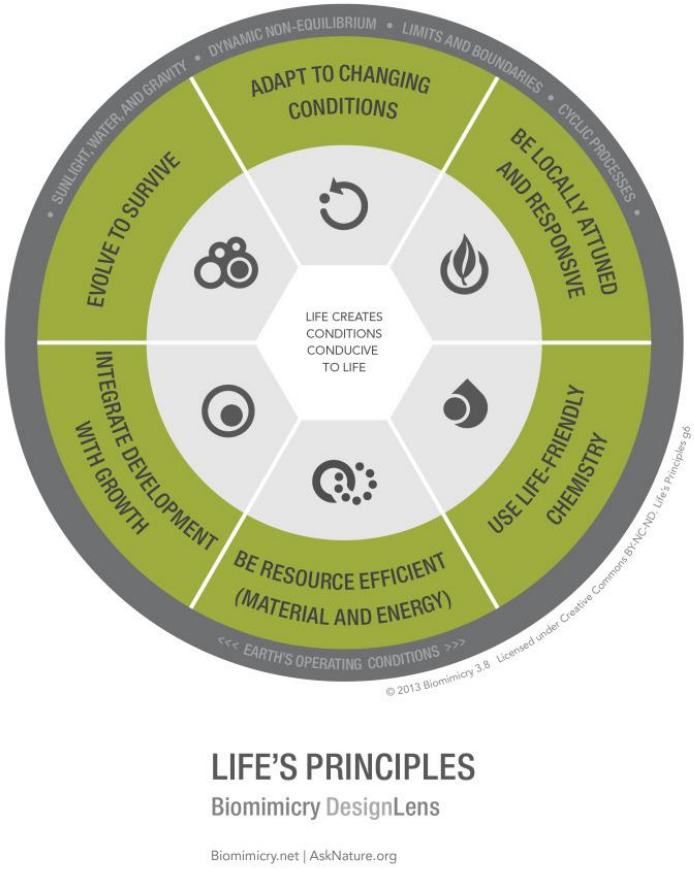


Figure 7: Life's Principles

Be locally attuned and responsive

The final design cleverly takes advantage of several readily available pre-existing features of trade fairs. First of all, it does not add an extra device to the event but rather augments an existing and well-known feature: the visitor badge. Furthermore, it uses an existing registration process as a tool to collect the necessary data. Lastly, the scanning of visitor badges was also already being done, although this familiar feature was drastically changed and placed in the hands of visitors

Evolve to survive & Adapt to changing conditions

Trade fairs have been around since the late 19th century, and have been a key marketing tool for many decades. It has always had to evolve in order to adapt to changes in culture and technology, but is especially vulnerable now that the internet is able to provide potential visitors with an excess of information and new tools like virtual reality are on the rise. The resulting design from this project should help renew the concept of the trade fair so that it stays relevant throughout the coming decades of technological innovation.

Be resource efficient (material and energy)

Efficiency is one of the main value propositions of this project. The overall goal of this project is to help visitors and exhibitors make the most of a short and (for one group) expensive event by helping visitors find the correct stands for them. While this form of efficiency mostly concerns the efficiency of time, it does translate into energy efficiency and even material efficiency.

Energy efficiency is also a result of this system. When people get the most out of a single event they will get the most out of the energy they spent to get there. Less additional steps will have to be taken. Also less disappointing follow-up meetings when visitors are correctly matched with exhibitors.

When the attraction and persuasion of visitors to exhibitors shifts from the sometimes quite random distribution of gifts and booklets/flyers to a method that is able to distribute these promotional products more selectively, a lot of unnecessary material use can be prevented.

Integrate development with growth

The data that lies at the basis of the final design starts off with a small amount of information that is collected prior to an event. As soon as the event begins, this network of data is built from the bottom up by the system's participants. It is constantly being enriched by new inputs, without the need for any external control mechanism.

5 - Trade fair analysis

Trade fair types

Defined by targeted area:

- International
- National
- Regional trade fairs/exhibitions

Defined by sector:

- Multi-branch
    - These fairs exhibit a representative selection of products and services from various industries.
- Professional
- Specialist
    - These fairs focus on a specific (branch of) industry, sector, or group of consumers.
- Congress
- Consumer trade fairs/exhibitions

A distinction is also made between trade visitor oriented fairs and fairs which target the general public.

Information sources

The reason many visitors come to a trade fair is to gain information about the market. This information is delivered to the visitor through five possible sources.

- Independent sources.
- Printed sources.
- Personal contact.
- Suppliers
    - Representatives
    - Technical personnel
- Impersonal commercial sources.

Research indicates that both printed sources and personal contacts are rated highly by visitors in terms of relevance and frequency.

Functions

Trade fairs have several functions, with benefits to both exhibitor and visitor (AUMA, 2016):

- Provide a focus that mirrors selected markets
- Offer entertaining experiences and appeal to all senses
- Guarantee and enhance market transparency
- Open up new markets
- Facilitate a direct comparison of value for money
- Promote an in-depth exchange of information.

Alternatively (Wiegerink, 2002):

- Informative function
    - Providing information: improving market-transparency, technical and economic trends
    - Research and testing of the market.
- Motivational function
    - Increase the motivation of consumers to participate in the market by creating an experience
    - Improvement of team-spirit of employees.
- Influential function
    - Improve the image of the exhibitor
- Sales function
    - Preparation of sales: making contact, negotiating, making a quotation
    - Realisation of sales: placing orders, signing deals
    - After-care: confirmation, handling feedback

Lay-out

Maritime Industry fair in Gorinchem, NL (figure 8).

Figure 8: Lay-out of the Maritime Industry fair


Marshell
100% WHOLE GRAINS
Django

6 - Exhibitor objectives

Objectives that are marked blue are considered to be achievable by a design that is based on the natural model.

Most general objectives

- Explore new markets
- Assessing the overall competitiveness of the market
- Assessing export chances
- Assessing the overall industry situation
- Exchanging experiences
- Forging successful partnerships
- Taking part in professional events
- Spotting new trends
- Tapping into new markets for the company/product/service
- Combining participation with other measures
    - Activities, seminars, company tours
- Meeting competitors
- Increase sales volume

Communication objectives

- Expanding the list of personal contacts
- Meeting new groups of customers
- Increasing brand awareness
- Boosting advertising impact on customers and the general public
- Expanding the range of customers
- Expanding press activities
- Discussing individual customer requirements and client demands
- Cultivating existing business relations
- Collecting new market information
- Implementing a corporate design/branding measures
- Further training for research and sales by sharing and exchanging experiences

Pricing and conditions

- Consistent appearance on the market offering a convincing price-per-performance ratio
- Exploring pricing options

Distribution

- Expanding the distribution network
- Monitoring the levels of trade
- Looking for sales representatives

Product

- Introducing product innovations and prototypes
- Testing market reactions to products and services or a newly introduced product
- Expanding the product range

7 - Visitor data

General behaviour

Preparation

The way visitors prepare for a trade fair indicates the importance they attribute to one, and to which degree his/her visit can be influenced during the event. Research indicates that almost half of trade fair visitors in the Netherlands does not prepare their visit at all (Wiegerink, 2002). Those who do spend an average of 1.3 hours on their preparation. This is mostly done by going through the fair's catalogue (either upon entering the fair or at home). The two most interesting forms of preparation for this project: searching for information on specific exhibitors or products and planning the route of their visit, are both done by almost 30% of the visitors who prepare themselves.

Preparation method	Percentage of all visitors	Percentage of preparing visitors
Read the catalogue at the entrance	16.7 %	30.9 %
Read the catalogue before visiting	12.5 %	23.0 %
Gain information on specific exhibitors	15.5 %	28.6 %
Route planning	14.5 %	26.8 %
Time planning	12.5 %	23.0 %
Announce visit to exhibitors	10.3 %	19.0 %
Make appointments with exhibitors	7.4 %	13.7 %

Moreover, Dutch trade fair visitors rank rather low in terms of preparation for trade fairs when compared to similar research in Germany.

Time

Another important behavioral aspect is the time that visitors spend at fairs, and how they use it. In 2002, the average trade fair visit in the Netherland lasted for roughly 5 hours and 15 minutes. During this time, the average visitor visits around 16 stands of exhibitors, at which he/she engages in 6 to 7 substantive conversations. The way visitors use their time is closely linked to their level of preparation, since the average visitor appears to spend about 38% of their time on orientation (walking through the fair. Roughly 50% of their time is spent with at stands with exhibitors, either gathering information or managing relationships. Some time is also spent on relaxation and lectures/seminars.

Activity of visitor	Average % of time
Orientation	37.7 %
Gathering business-related information	32.2 %
Managing relationships/contacts	21.0 %
Relaxation	6.9 %
Attending lectures or seminars	3.3 %

Satisfaction

There are several reasons why a visitor would consider a trade fair visit to be unsatisfactory. These are mainly a lack of specialism at the fair, or a disappointingly low number of exhibitors. Other reasons are that the fair was too crowded, not easily accessible, not innovative enough, or had poor management of the stands.

Objectives and types

It is important for exhibitors and organizers to focus more on the goals and desires of visitors, since gaps are often observed between the goals of exhibitors and visitors (Wiegerink, 2002). Too many exhibitors still have an approach that does not target specific visitors and their behavior, while competitive forms of media are gaining relevance. In order to establish such a focus, it is important to determine what drives a visitor at a trade fair, and how his or her goals influence his or her behavior. The first thing one will notice is that there is no typical trade fair visit to be defined. There are major differences between visitors concerning their goals, behavior, and results. This is why an attempt will be made to identify specific groups of visitors so that the ultimate design can be attuned to them and be less dependent on overall averages of visitor behavior.

The following goals have been identified to be pursued by visitors of a trade fair (AUMA, 2016).

- Content related (product services)
    - Exploring new products and the range of applications
    - Comparing prices and conditions
    - Looking for certain products
    - Obtaining ideas for company products and product range
    - Spotting trends
    - Finding out about the technical functions and nature of certain products and systems
    - Obtaining information on solutions to existing problems

- Business related
    - Placing orders, negotiating contracts
    - Making contact with comparable companies
    - Assessing the options for participating as an exhibitor.
    - Gaining an overview of related markets
    - Assessing the economic situation and business prospects
    - Meeting new business partners, intensify existing contacts
- Other
    - Attending conferences and special shows (more of a means to a goal?)
    - Professional and personal training
    - Taking part in the supporting programme

Visitor types

Two types of visitors have already been identified (trade and private), and this distinction can also be seen in the nature of the these objectives. Trade, Private, Both. Partly based on these objectives, a distinction can be made within these two groups.

Trade

- Starting entrepreneurs
- Representatives of companies
- Retailers

Private

- Consumers with a specific need
- Recreational consumers
- Professionals looking for inspiration

Other sources propose different classifications of trade fair visitors. One theory is the existence of 6 types of visitors (Wiegerink, 2002).

- The orienting saunterer.
    - These people can be typified as shallow visitors whose main goal is to gain a broad array of information from all types of sources and about all kinds of subjects. Their main activity is to walk through the fair in an orienting fashion, without having properly prepared themselves. The information they collect is brought home in the form of flyers and booklets, where it is looked at once more. They often rate their experience at a fair as poor, because they did not manage to fulfill their poorly-defined objectives.
- The goal-oriented collector of information.
    - These visitors are mainly executive employees of a company looking for products to invest in, and they visit a trade fair with clearly established objectives. Preparation is an important factor in their visits on which they spend a lot of time, which means that they are able to visit a large number of stands following a premade planning. Their visit is likely to result in a number of trade-deals.
- The networkers
    - These visitors see trade fairs as an opportunity to maintain their relationships with their clients and form new contacts. His stand-visits typically contain substantive conversations, and have all been planned to a certain degree.
- The transaction-oriented visitor.
    - Because the visits of these visitors is focused on making transactions with exhibitors, their time at a trade fair is mainly spent on a clear collection of information from a large amount of stand-visits. The visit is well-prepared and always followed-up by the details of their transactions.
- The seminar-goer.
    - As is obvious from the name, these visitors spend a lot more time than average at lectures and seminars. Information is their largest objective, which they often use to rapport back to their organization. They often rate their trade-fair as a positive experience, which suggests the success of information-finding objectives depends on how active a visitor is looking for it.

- The anti-trade fair visitor.
    - This unusual type of visitor often makes up almost 20% of trade fair's visitors. Their 'negativity' is what sets them apart. They generally do not prepare, have no clear objectives, wander around, have short visits, and barely make contact with exhibitors. These people evaluate their visits as negative, and appear to be present because of obligations to their employer or others.

Although this research was conducted 15 years ago, and the following numbers are based on a snapshot of trade fairs, a reliable estimation of the ratio's in which these visitor types visit trade fairs can be given. Roughly 24% of visitors can be identified as orienting saunterers, about 21% can be seen as goal-oriented information collectors, almost 20% are considered to be networkers, another 20% (as mentioned before) are typified as anti-visitors. The two smallest groups are transaction-oriented visitors (12%) and seminar-goers (4.3%). These ratios can vary depending on what kind of trade fair is being looked at.

Another source, that is intended to prepare exhibitors for a successful fair, suggests only three types of visitors (Beurstraining.net, 2017). It also provides a helpful analysis of how these visitors behave, and how exhibitors should play into them.

- The businessman
    - In short, this is the business representative that goes to a fair to close deals with exhibitors. This visitor is known to walk faster and more goal-oriented than those around him. He will often skip several stands completely, and spend more time than average at other stands.
- The collector of information
    - Contrary to the businessman, this visitor is very unlikely to make any decisions at the fair. Most often, his/her goal is limited to gathering information such as the spotting of trends. His behavior is characterized by a slower and more random walk. He/she will visit relatively many stands, and is unlikely to spend a lot of time at them. This visitor often collects brochures and flyers.
- The networker
    - Behaviorwise, this visitor sits inbetween the previous two types. His/her goal at a fair is to establish new relationships or strengthen existing ones.

Attracting visitors

- Personal invitations; these messages are sent in advance of the actual fair and should contain a personal message, preferably addressing the recipient by name.
- Invitation brochures; a more indirect form of advertisement. A message with information about the exhibitor and the trade fair is published on the internet or on other media where it can be viewed by a large amount of potential visitor at a time.
- Admission vouchers; these are usually supplied by the organizing party to the exhibitors, which they can in turn hand out to visitors.
- Gifts; these free hand-outs, no matter how small, have been shown to make it very likely a visitor will stop at a stand. An effective variation is the two-part gift, one part of which is given with the invitation and the other part can be collected at the stand. It is important that the giving away of these gifts does not interrupt the operations at the stand.
- Entertainment at the stand; A main reason visitors come to a trade fair is to experience a product or service firsthand. Exhibitors can take advantage of this by offering (for example) product demonstrations in which the visitor might even be able to participate. This entertainment should always support the informative purpose of the stand.
- Advertisements or banners; placed in professional magazines shortly before the start of the trade fair.
- Advertising in a catalogue;
- Outdoor advertising; advertising in the vicinity of the trade fair (often in front of the entrance, or where traffic is at its busiest) gives visitors a reminder right before entering or after leaving the fair.
- Advertising away from the stand; some exhibitors distribute handouts on the exhibition grounds, but this requires special permission. Some exhibitors also collaborate with 'competitors' in this regard.

8 - Collaborative filtering

This project started off with the decision to apply this communication method to trade fairs, since they had been deemed to be the most suitable field of application based on the needs of its visitors. A meeting with a company that organizes such trade fairs was a logical first step in the process of analyzing these fairs. For this purpose, we contacted Organisatie Groep Zuid (OGZ); one of the largest organizers of trade fairs in the Dutch market today.

During this meeting we learned about a system OGZ currently uses/is planning to use in order to try to enhance the efficiency of their fairs for both visitor and participant. All that can be said about this system is that it is a recommender system. The way it works will not be explained here, out of confidentiality. This recommender system was analyzed, and compared to the natural model to see what could be learned from it.

Collaborative filtering

While this report will not elaborate on the specific recommender system of OGZ, it will analyze recommender systems in general, and its underlying technique in particular. The technique that usually lies at the basis of recommender systems is called collaborative (or collective) filtering (Recommender-systems.org, 2017). This method uses the evaluations of other people to create a profile of them, and uses them to predict which users are likely to agree on similar points as them. It works on the assumption that the recommendations of people with similar interests are valued more than those of others. .Most of the systems that use this method apply the neighbourhood-based approach'. When making a recommendation for an individual, this approach suggests selecting a group of agents based on their similar interests/activities to the individual, and make a prediction for him/her by calculating a weighted average of this group. The weight that is given to the opinion of a member of the group is based on 'the correlation between that person and the person for whom to make a prediction'. A different approach that is often used is the 'Item-to-item approach'. Instead of finding correlations between participants, this approach sets out to find correlations between items (stands/exhibitions, in this case) (figure 9). This is often used by web-shops (although this also goes for the previous approach). The final available approach is the 'classification approach'. Here, a correlation is not determined between the items themselves but between the classes to which the items belong. This class is determined by using a learning method, which is an algorithm of itself.

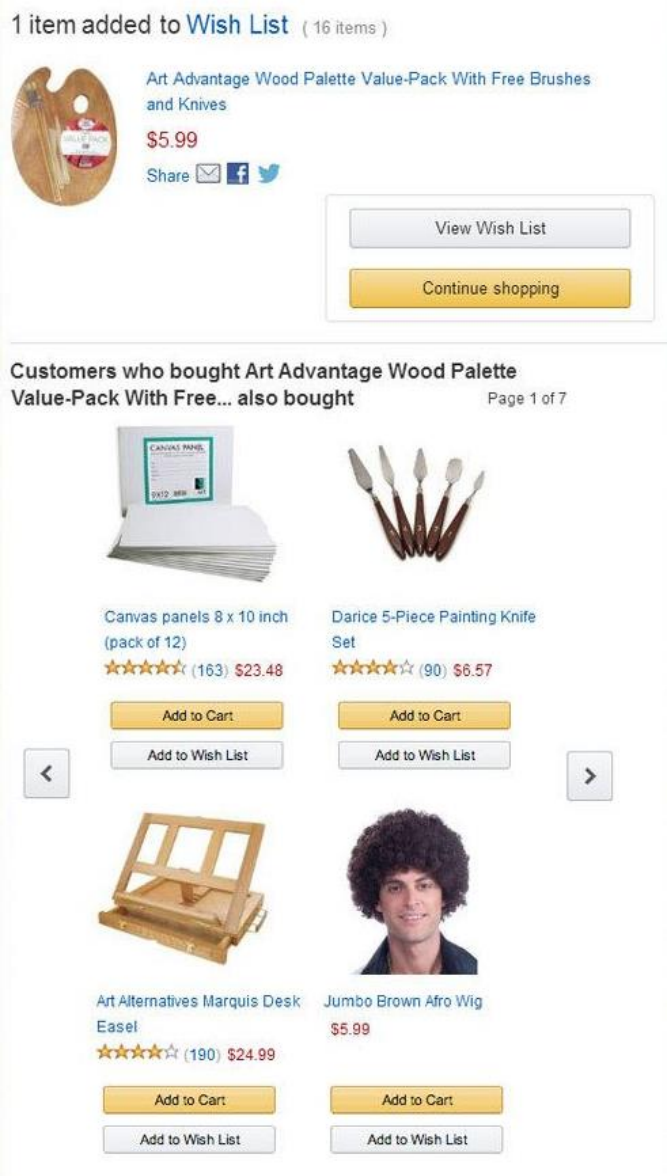


Figure 9: A familiar application of collaborative filtering

Challenges

The method of collaborative filtering can encounter some challenges, of which these are the main ones (Su & Khoshgoftaar, 2009):

Data sparsity

When a recommender system does not have access to a sufficiently large dataset, it's recommendations will be less accurate. The most typical problem is the 'cold start' problem, which occurs when the system starts for the first time and it obviously takes some time to gather data from the actions of agents. The same goes for the adding of new items (stands).

- As we now know, ants deal with the cold start problem by employing scouts which use randomized behavior to establish the first trails.

Scalability

A system designed for a certain crowd size does not scale well with significant increases or decreases in that size.

Synonyms

Most recommender systems or unable to differentiate between the synonyms participants use to describe the same item, and end up seeing them as different items.

Gray sheep

Some agents do not benefit from collaborative filtering because their opinions and preferences do not sufficiently match those of any group.

Shilling attacks

Unless the system is designed to prevent this, agents as intelligent as humans may manipulate the system by giving positive and negative ratings to friends and competitors respectively.

Diversity and the long tail

By constantly suggesting items to people, which have been recommended by others, a system like this can create snowball effect which directs all attention to only a popular selection of the items. This way an individual would most often be directed towards an item that is popular instead of an item that is ideal for him/her. This also depends on the convincing power of the recommendation that is given; will an individual value the recommendation so highly that he/she will no longer look for anything else?

- This challenge is very relevant when looking at the ants' method. It can be seen as the main difference between their version, and a version that would be suitable for humans at a trade fair. When ants find a food source, the colony benefits from a snowball effect so that all of the food is quickly transported to the colony. There is however also a need to keep the trails diverse, as to not miss out on any potential better resources. Flexibility is key here; attractive forces should be volatile and optional to allow for participants to explore all options.

Conclusion

The method of collaborative filtering can prove to be useful in this project, in the search of designing a way to allow visitors to form groups amongst themselves based on their mutual interests. It is important to realize that the quality of a stand is partly objective but mostly subjective. While the topic of a trade fair is set, different kinds of people are looking for different kind of information. It would be beneficial to form groups within the crowd, which would only respond to attractive forces which were placed by group members. This would highly increase the chances that visitors would arrive at a stand they find interesting. Groups could be formed either by a 'higher' intelligence such as the Recommender system, or by the process of self-organization somehow. This is not a part of the ants' system however, since for them a resource is objectively useful and is similar to every ant.

9 - PromZ fair visit

Observations

Map

Before the official entrance of the fair, visitors encountered a large map of the fair they were about to enter (figure 10). It was the same one that could be studied on the website as a means of preparation. The same map could also be found in one of the fair's corners. Besides the standard supply of exhibtors, the organization of PromZ had apparently distinguished between six special segments and had grouped the exhibitors as such:

- Action-marketing
- Gadgets
- Specialists
- Brands
- Machines
- Seminars

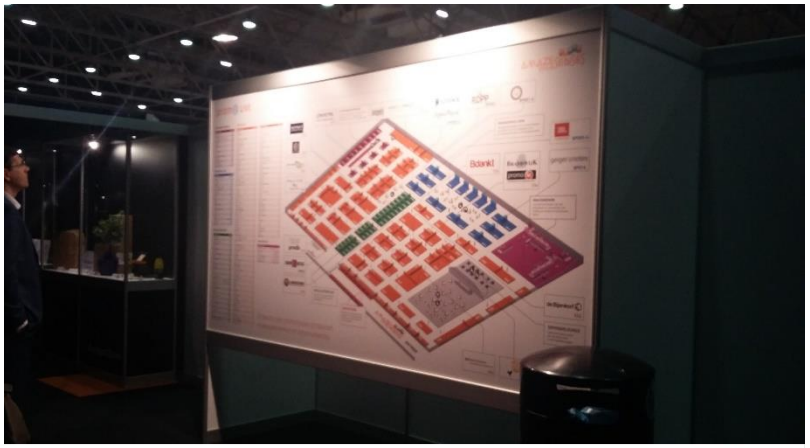


Figure 10: The PromZ map

Stands

The main thing noticed about the stands at this event were the major differences in size, sophistication, height, and the number of employees. As could already derived from the map (figure 10), some companies had large and well-designed stands while others had only a table on which to display their merchandise. This was most likely a result of the budget difference between exhibitors.

Contest

In between the map and the official entrance, visitors were able to observe all gadgets from the fair in a glass display. Since there were no exhibitors present here to promote them, one was able to observe the items unbiased and reasonably undisturbed. The goal for which the organizers had placed this display here was to get people to vote on their favorite promotional product, and therefore involve them more actively in the content of the fair. These items could be looked at before the fair and make visitors interested in certain stands (nudge?, not really because all items were equal), but could also be examined when leaving the fair and act as a reminder for visitors about the content they had seen.

Interviews

In order to identify the goals of visitors at this trade fair and to test the aforementioned theory of the existence of specific visitor groups, several visitors were interviewed.

- The first visitor had been invited to the fair by one of his business relations and regarded it as a day off. He had no clear goal in mind other than to look around. Interestingly enough, while it was his first visit to a trade fair, he did have a systematic approach of visiting all stands. He would first circle the outer edge of the room, and gradually work his way towards the center.
- The second visitor had a clear goal at the fair: to establish new business relations. He was invited by one of the exhibitors, which he used as a starting point for his visit. Other than locating and reading about the exhibitor that invited him, he did not prepare his visit at all, and therefore had no plan. The main problem he faced while achieving his goal was that all of the exhibitors seemed very similar, and he had trouble distinguishing the ones with potential from the rest.
- The third visitor had come to the trade fair with two goals in mind. The first one was to gain inspiration on behalf of his company, and the second one was the personal goal of making deals with companies regarding social workplaces. His main problem at this particular fair was that the exhibitors were too passive in approaching potentially interested visitors. Having worked as an exhibitor a couple of times himself, he expects exhibitors to take control and guide him through their product or brand. Furthermore, he thinks there is too many exhibitors here, with too similar products and services. It makes it hard for him to determine who to talk to.
- The fourth interview was a short one, and conducted with two women. They had been invited by an exhibitor to compose a Christmas package for them. However, the majority of their visit was spent enjoying themselves and wandering around the fair. Because they were just

enjoying themselves, they were 'afraid' to stand still at stands for too long, because they would be approached by exhibitors and would have to explain they weren't interested.

- The fifth interviewee described himself as a networker, and had set out to find new business-relations regarding the transport of goods from the far East (where most of the products here are produced) to Europe. He had combined his clear objectives with a thorough preparation of his visit. Being an experienced trade fair visitor he was able to tell me that, at a single-day fair like this one, he usually plans his walking routes to make his visit efficient. At a fair that last for more than a day, he usually spends the first day browsing around and uses the second day to approach the most interesting exhibitors.

Conclusion

Although it is hard to conclude anything from such a limited number of interviews, the results do suggest that the different visitor types exist and were present at this fair.

The main problem encountered by these visitors was the difficulty to distinguish the value of stands from each other. At this fair in particular, all exhibitors offer more or less the same service albeit in different product forms. Combine this with the superficial nature of the fair, and it becomes very hard for visitors to learn which stands are a match with their specific goals.

Personal experience

For the first part of my visit, I pretended to be a visitor in search of general inspiration about the art of product and brand promotion, and approached the trade fair much like an orienting saunterer would. The goal of this was to learn to understand why a visitor makes certain decisions. Since I lacked any trade fair experience prior to this visit, I knew not what to expect and was equally open to all behavioral stimuli.

Upon officially entering the fair (scanning the ticket), I was immediately offered a bag filled with flyers and promotional items. A few steps further, several exhibitors approached me quite assertively and offered me flyers and gifts. This was quite unexpected, as I expected a more passive approach from exhibitors based on the literature about trade fairs. Since the entrance was crowded with exhibitors, I quickly made my way to a calmer area to settle in and decide on a way to go.

I believe the eagerness of the exhibitors was partly due to me being one of the first visitors at the fair. It was, however, quite annoying for me to want to examine stands while constantly being approached by exhibitors. As the fair progressed, however, this became less of an issue. The room filled up with more visitors and exhibitors were often occupied

As far as wayfinding is concerned, I experienced the fair to be hard to navigate. Stands were packed rather closely together, sometimes only leaving walking aisles of 1,5m wide. In certain areas, stands were also rather tall and view-obstructing. There was also little contrast between different areas of the fair, but this was not as hindering as other factors.

Some areas, on the other hand, were less dense and more open. This made them easier to navigate and to maintain an overview (figure 12).

As already mentioned, there appeared to be few rules regarding the design of the stands, other than the surface area that was available. This resulted in some significant differences which, in my opinion, gave certain stands an attractive advantage compared to others. The characteristic that sets stands apart most noticeably is height. This is the factor that makes visitors register the stand over others. Furthermore, stands that had a framework around them had an advantage in my eye, because they were able to create a clear contrast with their surroundings.

The most common approach of exhibitors was to create a type of artificial room by using a framework. Other (often smaller) stands were designed more like a display, which were accompanied by one or more exhibitors. A large, well-lit company logo was often used to make the stand stand out (figure 11).

Another thing I noticed, and of which I became aware after a while, was the constant playing of background music. This music was rather energizing, which matched the overall character of the fair. It was not too dominant in my experience, and was likely intended to raise the overall level of enthousiasm among visitors and therefore increase their eagerness to participate.

The role of flyers and booklets was also remarkable. They were not really used as a special souvenir for visitors that showed an interest in a stand, but were rather given away to as many people

as possible. Some exhibitors used them as an advertising tool away from their stands, by placing them on the lunch tables.

Interesting note

One exhibitor told me he noticed a lot more people noticed his stand when they approached it at their right side. He wondered if people are more likely to notice something when it is located at the side of their dominant eye/hand/leg.

Figure 11: An example of how stands made themselves visible

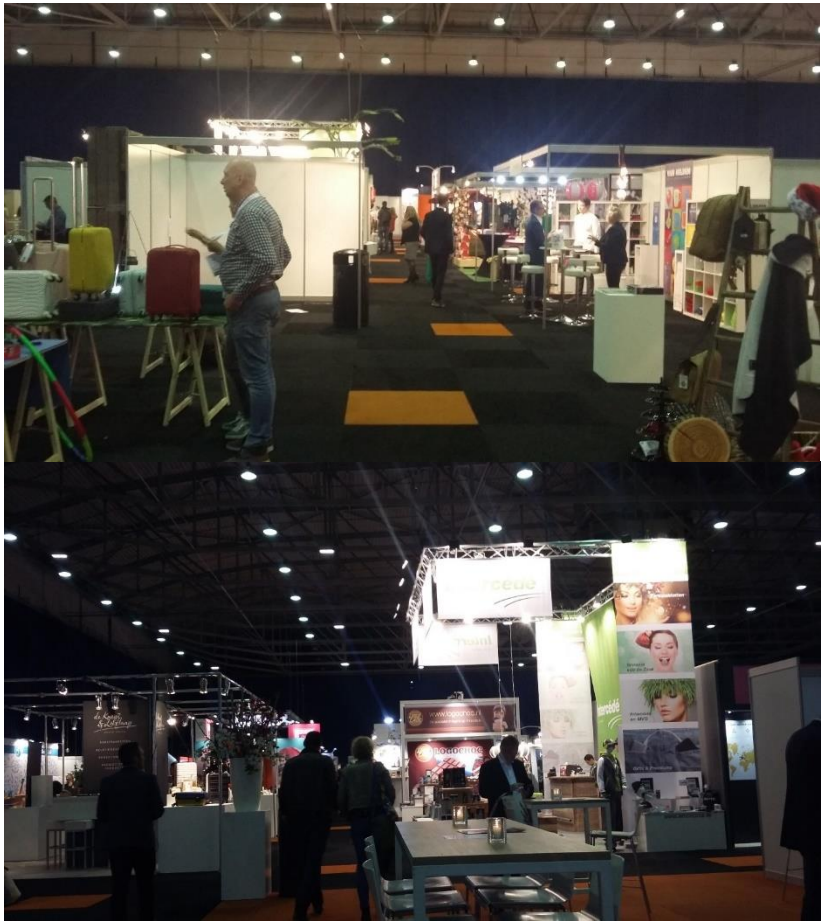


Figure 12: An impression of the ambiance at the PromZ fair

10 - Interview Petra

Based on this trade fair visit, I decided to interview a seasoned exhibitor at fairs in Germany, Belgium, and The Netherlands, with the goal of providing new insights in how exhibitors deal with visitors, attract them to their stand, and determine their value.

The most important moment in attracting visitors to your stand, according to Petra, is the moment of eye-contact when a visitor approaches a stand. This is something I noticed myself during my visit to PromZ. Once you have established eye-contact as a visitor, a form of social obligation arises to at least consider showing an interest in their merchandise. It also often acts as a cue for exhibitors to engage in a conversation with the visitor, although they may also choose for a more passive approach.

Active vs. Passive approach for exhibitors

- A passive approach of engaging with visitors has the advantage of only spending valuable time on those with an intrinsic motivation to visit your stand.
- An active approach of engaging with visitors has the advantage of being able to convince visitors who are unsure of what they are looking for or simply unaware of the potential a particular stand has for them.

About distinguishing interested visitors, Petra was able to mark a particular moment when it becomes clear the two parties are interested in each other, which is the moment in a conversation where the visitor gives out his information to the exhibitor. When an exhibitor presents their product to a visitor, and he/she responds by leaving the stand (even though they take a flyer and promise to stay in touch) Petra knows their level of interest was not high enough to ensure a follow-up activity.

Different types of visitors are also certainly recognized by her. The more casual visitors do still visit the fair in which she participates, but can most often be encountered in the weekend. Petra estimates them to make up roughly 10% of all visitors she encounters. The more professional visitors come out during the week. A new trend that she has spotted, and which started around 2 years ago, is that the younger professionals appear to rush through a fair and use a checklist (either on paper or on a tablet) of stands they planned to visit. Not only have they accurately planned their visit, they are also determined to complete their visit fast. These people feel pressure from within their company to perform, and bring back results from a fair. Older visitors can be observed to have a more relaxed attitude, and worry less about wasting time or wandering off their planning to visit an interesting stand.

11 - Concept choice criteria

- Resembles the natural model
    - The idea of Biomimicry is, of course, to mimic a natural model. This model can be observed to be successful in nature, and it is therefore important for a potential design to be as true to the model as possible. If not, these differences will need to be well-argumented.
- Can be universally applied to various trade fairs.
    - The feasibility of the design depends on the amount of potential users it has. A niche system designed for one specific trade fair is less likely to be realized compared to a system that can be used in many events (perhaps not even just trade fairs).
- Has the potential of achieving the project's goal:
    - To help both visitors as well as exhibitors make the most of their trade fair participation by increasing the chance of them finding the right matches, based on the quality of the content of an exhibitor and both the interests and objectives of the visitor.
- Has a low threshold of participation for visitors (money, effort)
    - Introducing a new feature to a traditional environment has its challenges. As nudge theory describes, most people are more likely to stick to a default option than invest effort in a new alternative. A low participation threshold will therefore increase the chance of a design being accepted by the public.
    - Exhibitors likely do not mind a higher participation threshold for a potential system, because the potential advantages of it are greatest for them (does this count for all concepts?).
- Low implementation threshold
    - Just as visitors are more likely to adopt a new system when the participation threshold is low enough, organizers of trade fairs are more likely to adopt an addition to their current 'products' when they are easy and cheap to implement. Easiness can be judged by the amount and magnitude of changes that need to be made to the current concept of the trade fair.
- It benefits as much of the visitor groups as possible
    - Since there are six different types of visitors, each with their own objectives and behavior, a concept that does not just focus on helping one of these types has an advantage.
    - There is, however, a difference in relevance between some visitor types. Certain types of professional visitors (goal-oriented and networkers) have been noticed to be on the rise, while the more casual visitors are seen less often.

12 - Brainstorm questions

As a first brainstorming method, the key characteristics of the system's core concepts were used to formulate questions. These questions all intend to solve part of the problem and are supposed to provide partial solutions, of which a concept can be composed later on.

What could have an attractive force?

How could people leave information?

How can something be volatile?

How could participants identify each other?

How could participants be grouped?

How can you determine if a visitor is (genuinely) interested?

How can people find their way?

Some additional and more specific questions were added to the process later on, based on some interesting outcomes of earlier sessions.

How can a wearable device influence behavior?

What could act as a nudge?

How can you give the pheromone an advantage over other stimuli?

Furthermore, since the relevance of nudge theory has been demonstrated earlier, part of the brainstorm phase has been dedicated to it. As mention earlier, nudges are designed based on several principles. These principles have been used to formulate brainstorming-questions:

Which default options of choices exist at trade fairs?

- *Walk along the main path(s)*
- *Choose for the least crowded paths*
- *Talk to an exhibitor who approached you*

Which errors can we expect visitors to make?

- *Forgetting to visit a stand*
- *Missing a stand (e.g. one in the far corner)*
- *Spend too much time at a 'wrong' stand*
- *Get lured to a stand by irrelevant factors*
- *Walk down the same path multiple times*

Which incentives do both parties have for certain behavior?

On which choices can we give feedback?

- *Choice of path: 'you have walked this path X times before today'*
- *Choice of stand: 'X people visited this stand today, Y considered it to be interesting'*

How can we structure this complex choice: elimination by which aspects?

- *Distance*
- *Accessibility*
- *Crowdedness around the stand*
- *Unattractiveness*
- *Never heard of the stand*

13 - Partial solutions

- System without wayfinding, more similar to the way termites construct their nests. The probability that visitors will find a certain stand is not increased by a wayfinding method. The only thing that leads visitors to a stand is an attractive force present at each stand, which can be picked up by visitors only at a certain distance from it.
    - This attractive force (pheromone) could, for example, be created by light and the contrast it creates with the environment. Banners or pillars are also an option, which could vary in size or height depending on how often a stand was judged to be interesting.
    - This concept aims to solve the constraint of visitors, which have a hard time distinguishing interesting stands from the rest.
    - By leaving out the wayfinding aspect, stands in other areas of a trade fair are not influenced by the popularity of a certain stand, while a wayfinding system would draw visitors from all over the trade fair to the particular popular stand. This therefore creates an environment in which more stands are considered by all visitors, but where he/she would eventually find the popular stand.

- A system that uses personalized interactive maps that contain nudges on where to go based on 'pheromone' placement. This map is either accessible on a personal device (phone probably) or placed on strategic points at the fair (at a possible nest). Stands that have received the most confirmations of like-minded visitors (collaborative filtering) will stand out on the map more than others, or be suggested through choice architecture.
    - Could be combined with road signs with similar nudging properties: better visibility for popular stands.
    - Well-prepared businessmen on a schedule could enter their list of exhibitors into the map, which then shows them either the shortest route, or the route that was most often walked by others (ant system).
    - In order for collaborative filtering to be applicable here, the maps would have to be personalized in some way. The could appear on each visitor's personal devices. Personal devices could interact with a central map to give a personal version to view.

- Participants are 'nudged' by their personal devices into visiting certain stands that meet a certain threshold of confirmations. These devices will notify their wearer (glow, vibrate, beep) when they are near an interesting stand, or when they are approaching it (warmer-kouder).
    - Intelligent devices are able to apply collaborative filtering on the nudges.

- Device could be a smartphone, badge, glasses, bracelet, watch. Investment costs are not a major problem, because the benefits should be worth it for exhibitors.
- Device could also have a compass-like function, which would emphasize the way-finding aspect of the system. A directional component could also be added with a binaural system of sound, facilitated by earpieces.
- A potential problem is that such a behavioral cue cannot work for two destinations simultaneously. It would have to choose for the most attractive stand in its vicinity.
- A behavioral cue from a wearable device will probably not be subtle enough to be a subconscious nudge. People are likely to become aware of the system.

- Intelligent personal devices that allow visitors to mark themselves, or be marked by others, and display their objectives to be seen by all other visitors and exhibitors. This device acts as an identity tag, and is based on the cuticular pheromones of ants.
  - This concept aims to solve two constraints. The first one is that exhibitors must currently choose between an active and passive approach of engaging with visitors, both of which have their disadvantages. By allowing visitors to display their intentions and expectations (just browsing, looking to network), exhibitors will prevent wasting time by talking to uninterested people.
  - Secondly, visitors who just came to the fair to browse around and look for inspiration, or want to do a round of browsing before engaging with exhibitors, are now more likely to be left alone by exhibitors.
  - Visitors that were interviewed at the PromZ fair also had different expectations of the level of passivity of exhibitors. This is an indication that this concept has potential.

- The use of a large number of road signs at eye-level, which incorporate nudging properties, to influence the direction in which visitors walk. This could be seen as
  - The way road signs could nudge visitors into walking into a certain direction is for example by creating a difference in size between the signs on a pole, and presenting the largest sign as a make-believe 'default option'.
  - These road signs will likely lack accuracy if they only indicate a direction without a destination, depending on how many stands are located along a path. This could be countered by making a sign for each individual exhibitor, although this would quickly clutter.
  - Furthermore, road signs have the advantage of being a well-known wayfinding meme in many cultures. Its familiarity will be its advantage over more unusual types of trails.

- Trails are formed by an AR-program and can only be seen by visitors through a phone camera or custom glasses (something that enhances their senses). An augmented reality pheromone/system has the potential of mimicking the biological system the most accurately, while also incorporating collaborative filtering.
    - Trails could be designed quite literally, as trails on the floor. The accumulative quality of them would be implemented in their brightness, thickness, etc..
    - Trails could also be in the form of any other attractive feature or nudge that was mentioned in the brainstorm. These pheromones do not have to be visual either.
    - The AR-device used by visitors could also lower the threshold for exhibitors to incorporate AR in their presentation techniques.

- System that involves conscious participation. Visitors actively rate a stand they liked by some multiple-choice options or by simply pressing a button. People consciously follow different types of trails based on their interests (groups).
    - Personal devices can be used to discover the identity of other visitors
    - Making visitors aware of the system greatly improves the level of accuracy with which they can be guided to certain stands. Nudging will no longer be necessary, and visitors should have a
    - large enough intrinsic motivation to follow these guidelines.
    - This awareness, however, also comes with some risks. Visitors could manipulate the system, not to mention exhibitors themselves.
    - It is also interesting to only partially inform people about the system. For example, visitors could only be told which color of road sign matches their visitor goals, but not that these road signs change in size/contrast/shape based on the popularity of the stand they point to.

- Rearrange the trade fair in order to design a hive: a central point from which visitors start their visit and to which they frequently return. At this point they can share information, talk to other visitors about their experiences, and give advice to others on where to go. This central area could also function as the place where certain groups are formed within the crowd of visitors. The devices they wear could sense each other, and find people with the same interests that way.

    - Stands could be designed in a way that the further a visitor walks away from the 'nest', the more in-depth information he can find. At first, one will encounter the more attractive and sometimes superficial characteristics: billboards, exhibitors, gifts, prototypes. The further a visitor decides to

walk into the stand, the more in-depth his visit becomes.
        - Not really based on any ant system characteristics
    - An advantage is that more stands have an equal opportunity to be noticed first by a visitor. In order to enhance this even more, the row of stands closest to the nest (the first row) should be less dense (more room between stands) so that the second row is more visible from the central area.
    - Another advantage is that this arrangement would create more oversight for visitors, making it easier for them to (for example) plan their visit, cover the fair faster in a more systematic manner, or remember and retrace the position of their favorite stands.

- Recommender as a starting point. When Han Bosman of OGZ described the Recommender-system they use, he looked at it as more of a starting point for visitors rather than an all-deciding guide for a visit. It sends them to a stand or seminar, based on the data that was found about them. From that point on, visitors can respond to attractive forces of the system.
    - This approach solves/improves the 'cold start' problem of a usually randomly initiated system like the natural model, or that of collaborative filtering.
    - It builds upon an existing method used by OGZ, which would lower the implementation threshold.
    -

- Groups of people with distinct objectives are automatically guided to the right stands because they all respond to different nudges. People who know who they want to visit respond to way-finding nudges (road signs, maps, trails). People who do not yet know what is best for them respond to recommendations, social nudges.
    - This is an interesting alternative to the use of data and intelligent devices when trying to group people.
    - Alternatively: simply ignore the groups that benefit the least from this system. These would be the well-prepared goal-oriented businessmen. By only targeting one group of people, it is more likely that the members of that group have similar opinions on which stands are useful to them.
    - To design this concept, one must ask himself what the differences between the various groups of visitors are. For example, a well-prepared businessman is likely to observe a potential map at the entrance of a fair, since he already knows which stands he will visit. Someone who is still orienting on which stands are interesting for him/her is less likely to pay much attention to a map (or any wayfinding cues for that matter), but is more likely to focus on cues that suggest a stand's quality. Visitors without clear goals or with entertainment purposes are more likely to be nudges by attractiveness.

14 - Concepts

Nudging road signs combined with **augmented reality.**

This concept sets out to help visitors navigate the fair with road signs placed at strategic points throughout a trade fair. These signs, combined with AR-enabled nudging properties (figure 14), will have a twofold function: to nudge the visitor into walking in the direction of a certain stand and therefore increasing the chance he/she will visit it, and to imprint the names of the most popular/relevant stands into their memory, which increases the chance they will consider that stand when they encounter it. In theory, the visitors do therefore not necessarily have to follow the road signs right away in order to be influenced by them.

Natural model

This concept closely resembles the natural model of foraging ants. Trails, although not directly created by participants, are formed through the simple feedback that they give on information sources. The trails are in this case built up by a collection of bifurcation points; points where people have to make a choice. This choice can then be influenced based on the popularity of its options.

Combination

Road signs were chosen as a concept because of their memetic qualities and familiarity. It might, however, prove very challenging to enhance them with nudging qualities, for example a variable size. Augmented reality offers the opportunity to allow each visitor to see the road signs and their respective sizes in their own way, and also allows for the application of a grouping method such as collaborative filtering.

Product design

The products that will have to be designed are the road signs and the AR-enabling device that allows people to see these signs in their own personalized way. The two most obvious options for such a device are the smartphone and AR-glasses, both of which have their own advantages. A smartphone is a device that is already owned by (almost?) all trade fair visitors, which would limit the production costs to the development of an app. A pair of glasses, on the other hand, would have the ergonomic benefit of not requiring a behavioral change (such as pointing the phone towards road signs). This would lower the participation threshold for visitors, assuming the glasses have no other disadvantages (comfort, field of vision reducement).

System

The following diagram indicates in which ways all relevant components of the concept's system interact with each other. More specifically, it indicates how they exchange information amongst each other (figure 13).

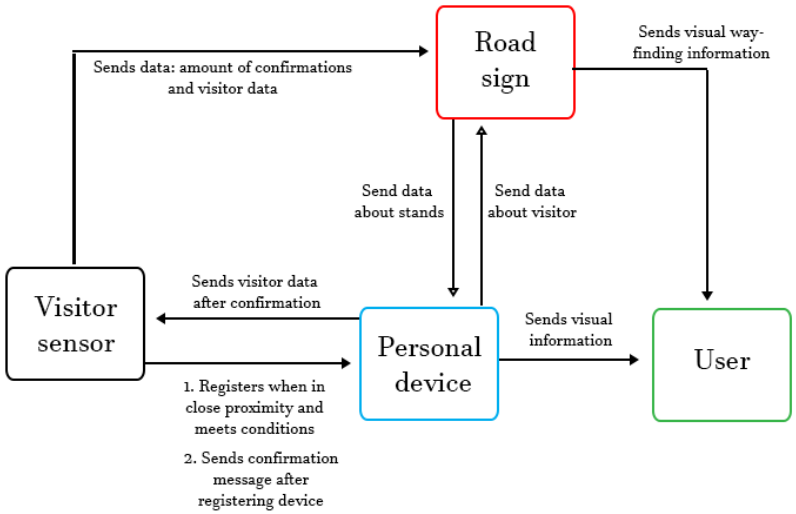


Figure 13: The way in which the elements of this system would interact

Implementation

Implementation of this concept would require road signs to be made specifically for each trade fair, and will require some degree of planning each time. They can, however, be rather straightforward in their design since their essential characteristics will be given to them through augmented reality. The second part of the concept, the AR-enabling device, will be a collection of products that can be universally used at every fair. The road signs can also be designed in a way that allows them to be reused at other fairs (removable exhibitor names), although their visual impact on a fair will require their appearance to either be neutral or adaptable to the character of each fair.

Participation

Some level of effort is required from visitors to optimally participate in this concept. First of all, they will have to be able to detect and read the road signs, although this can be made easier by proper design. Visitors will also have to operate their AR-enabling device. The two obvious options, glasses or smartphone, both have their advantages and disadvantages regarding user effort which were already discussed.

Visitors

The fact that this concept focuses on road signs, and therefore wayfinding, suggests that the targeted visitors are well-prepared goal-oriented professionals who often know where they need to be but not necessarily how to get there. The addition of AR-modifications to these signs, however, makes the concept appeal to orienting visitors and networkers as well, although these might not resort to road signs as their main behavior-influencing factor.

Possible concept variations

- The way road signs nudge visitors. This could be done by a difference in sign size, text size, the order or the signs (top to bottom), etc. Different types of augmented reality could be used for this (iGreet, 2017).
- The AR-enabling device that is used and the way it alters reality for its user

- The design of the road signs themselves. Despite their memetic qualities, traditional road signs might not necessarily be the best option.

Concerns.

The accuracy of this system greatly depends on the layout of the trade fair. When looking back at the maps for the Maritime and PromZ fair, it becomes clear that a road sign will not be able to single out a stand when placed at crossroads. Although the name of the specific popular stand will be present on the road sign, visitors will not be physically guided to one stand in particular but will rather be sent in the right direction. When referring back to the formulated design goal, it does however certainly increase the chance that the popular stand will be visited.

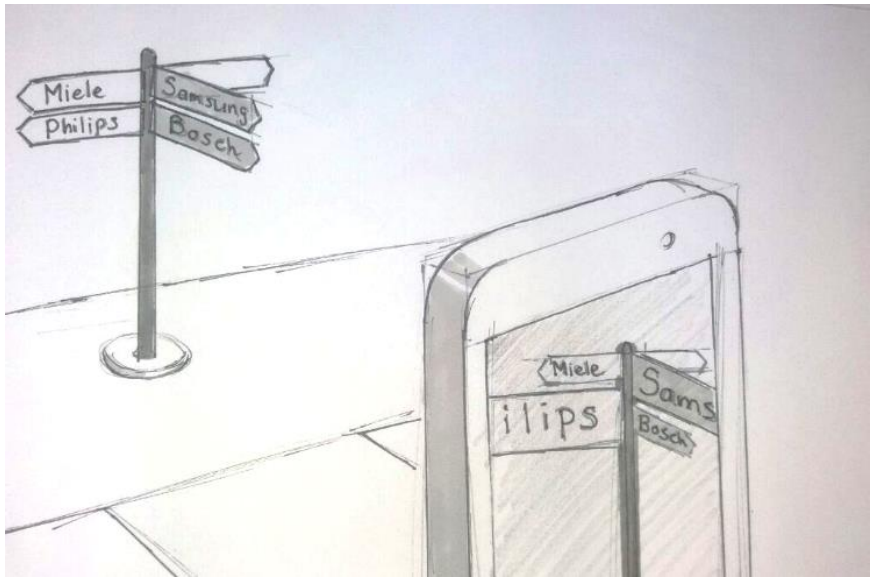


Figure 14: A representation of how a device could augment reality

Identity tag combined with a **nudging personal device**

In this concept, each visitor is given a personal device upon entering the trade fair (which possibly replaces the badges that are usually handed out). This device will be worn by the visitor throughout his visit, just like the traditional badge. While walking through the fair, the device will occasionally give a subtle signal to its user when he or she is in close proximity to a stand that has been deemed as promising by the device, which bases this judgment on the interests and objectives of its user and the opinions of other visitors at the fair. Secondly, the device will display information on itself which will give exhibitors enough information to enable them to decide whether this particular visitor is worth approaching.

Natural model

This concept is partly based on the way ants can passively communicate with others by carrying information with them (cuticular pheromones) which is available to anyone within close proximity. At the same time, this concept forms abstract trails which can only be sensed through a device, making it quite similar to the natural model as well.

Combination

It is a logical choice to combine two concepts which revolve around a personal (wearable) smart electronic device. First of all, the device aims to let its user know when he/she is walking past a stand that has received an amount of X confirmations from other (like-minded) visitors. It then serves as a notification for the exhibitor at that stand how he/she should approach this visitor, and what they can expect from him/her. This concept aims to solve to problems, one of visitors and one of visitors: It helps visitors make a choice between a large number of stands by randomly walking past them, and it helps the exhibitor learn about their visitors so that they can spend their time more efficiently. Some level of synergy can be observed in this combination. While the visitors are guided to the correct stands, the exhibitors gain extra information on which of these visitors they should approach. The benefit of the second effect is therefore greater than it would have been without the first effect.

Product design

The design process and embodiment phase will obviously focus on the personal device, both on a technical as well as on an ergonomic level. It will have to process data received from sensory devices throughout the fair and will have to convert this into an instinctively understandable message to both its user and exhibitors. The main design challenge will lie in making this message minimalistic and instinctive, yet understandable for all visitors. The level of precision with which visitors can be directed with such a message will also be an interesting topic. Will precision be required, or can we depend on increased chance and a certain amount of serendipity?

System

The following diagram indicates in which ways all relevant components of the concept's system interact with each other. More specifically, it indicates how they exchange information amongst each other (figure 15).

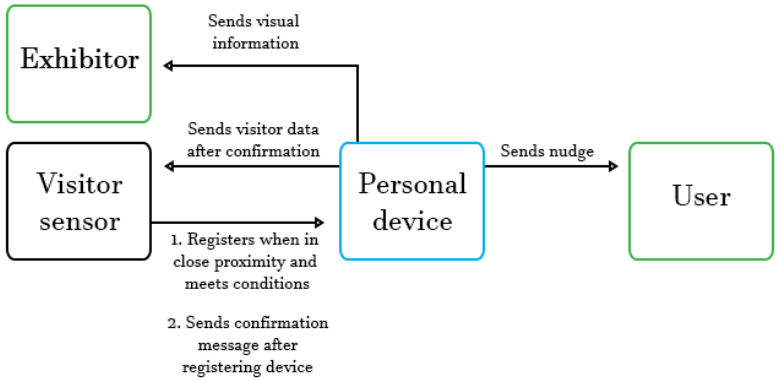


Figure 15: The way in which the elements of this system would interact

Implementation

This system would be relatively easy to implement and does not restrict itself to a specific trade fair. The personal devices will have to be invested in, although one set of these products can likely be used at multiple events. In order for each stand to be sensed by the personal devices, they will have to be equipped with a device of their own. This device will have several functions: to make a judgement about whether a visitor is interested in a stand based on the time he/she spends close to it, to communicate with nearby personal devices that meet certain requirements (information about the user), and to process the previous visits of visitors into profiles and groups. Although depending on the design of these units, they will most likely also be reusable.

Participation

All effort that is required for visitors to participate in this system is that they equip the device that is handed to them, replacing the action that was required with the badges that have been replaced. Their visit would then be hardly any different from a normal trade fair visit, except for their interaction with their device. This interaction will be designed to require minimal cognitive skill, and will entail no more than an instinctive reply to simple cues given by the device.

Visitors

This concept can be seen as one that is able to benefit all types of visitors, including the exhibitors. It is however likely that visitors without predetermined exhibitors, such as orienting saunterers and also networkers, are more likely to respond to a nudging device than their goal-oriented peers.

Possible concept variations

- The exact way in which the device will nudge its user, and how that nudge will be linked to the right stands.
- The way the exhibitor reads the identity tag, and the design that comes forth from that.

Concerns

Does the absence of a long-range wayfinding aspect mean that stands in less favourable locations (far corners) benefit less from this concept?

It might prove difficult to design a nudge that will allow the personal device to make its user consider multiple stands at the same time. What if a visitor finds itself right inbetween two popular stands, to which will the device direct him/her?

15 - Grouping & Judging

Grouping

The research phase pointed out that there are several different types of visitors who come to a trade fair, and these visitor types differ in both objectives and the resulting behavior. It is easy to conclude/assume that, because of these differences, these visitor types are not interested in the same type of stands. On the other hand, one could argue that the quality of a stand is objective instead of subjective: No matter what the objectives of a visitor are (orienting, networking, making trade deals), the quality of the content of a stand is ultimately what determines their interest in it. Furthermore, a non-grouping system could also suggest stands to visitors which do not necessarily fit into their objectives, and in that way offer a new perspective to these visitors and make them consider stands they would normally have eliminated by certain aspects.

While trade fairs are becoming more specialized overall and therefore the content of the stands in them is becoming more homogenous, many fairs still have a division between several distinct topics within them. It is unlikely for the content of stands in different sections of a trade fair to both be objectively interesting for a visitor. It is therefore likely that the existence of such a division in topics would call for visitors to be at least grouped by their preference in one or more of these topics. This information can be, and is already being, collected during the registration process of visitors (figure 16). Besides a visitor's preference in one or more topics of the fair, little other variables will have to be known. As discussed, the objectives of a visitor might not matter when judgingg about a stand, although incorporating this variable into the grouping method would take away the uncertainty about this. I believe that these two variables are the only ones necessary to successfully group visitors.

The process of collaborative filtering, which has been described earlier in this report, does not necessarily have to be used in a system that only groups visitors based on pre-collected preferences.

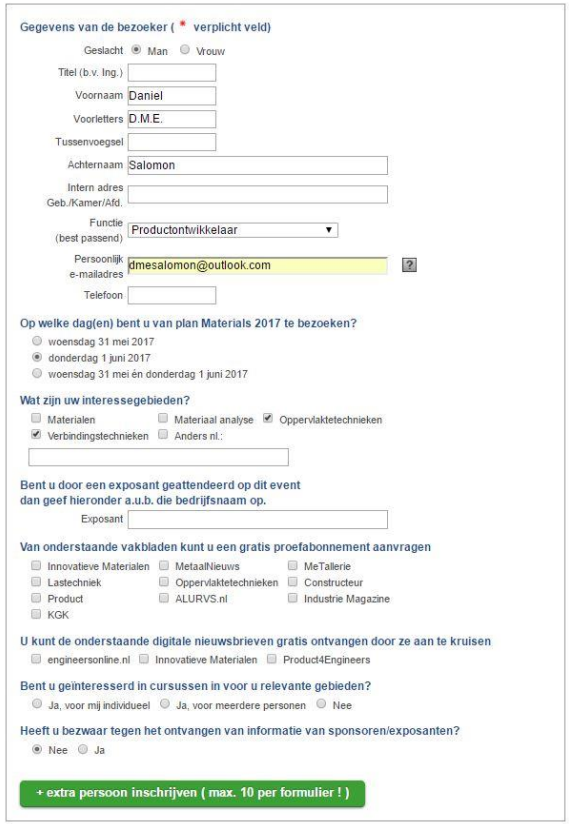


Figure 16: Visitor data being collected during the registration process

Judging

When looking for methods that can be used to judge whether a visitor is interested in a stand, and by doing so generating input data for the system to work with, three possible methods first come to mind: active confirmation by visitors, active confirmation by exhibitors, and passive confirmation.

It is likely that active confirmation by visitors will result in a high participation threshold. Combined with other factors such as forgetfulness, it is unlikely this method will lead to a large percentage of registration of interesting visits. The obvious alternative would be to passively register interesting visits by use of sensory technology. When done correctly, this would lead to a high percentage of registered visits. There is, however, likely to be some degree of error in these registrations because a sensing method had to be designed to fit all visitors while their behavior (even when interested in a stand) varies greatly. Some would spend a lot of time at a stand because they are inexperienced in judging the value of an exhibitor, while others are more experienced and only need 20 seconds to know whether the stand is worth planning a follow-up meeting with. There are also scenarios to be thought of where visitors spend time at a stand because of reasons unrelated to its content.

This brings us to the last option; active confirmation by the exhibitors. They are in a good position to make a judgment about this and have an incentive not to abuse this 'power': They can be informed that falsely marking visitors as interested will work in their disadvantage by attracting other uninterested visitors to their stand, resulting in them wasting their valuable time on the wrong visitors. There might also, although less likely, be a sense of collegiality involved. In a second conversation with Han Bosman from OGZ, however, he expressed his disbelief that exhibitors would not take advantage of their responsibilities in a system like this.

It can be thus far be concluded that none of the three options are perfect, which leads to believe that a combination between them might be the most successful. The combination that seems most promising at first glance is one between passive confirmation and active confirmation by visitors. In this system, a suspicion of interest is created by a sensory device within a stand based on a measurable factor (most likely the time spent at the stand). This suspicion will have to be confirmed by the concerned visitor. Since both concepts involve the use of a personal device, a message could be sent to this visitor asking him/her whether he/she experienced the stand to be useful and/or interesting. Although the required effort from the visitor is very low here, this message will still have to be carefully designed in order to maximize participation percentage as well as accuracy. A design challenge to be expected here, however, is how to send such a message to any other device than a smartphone. Alternatives to this method could be to install an interface in the center of the fair at which visitors can scan their personal device and respond to any verification messages, or to involve the exhibitor into the delivery of the message.

16 - Trade fair visit: Materials fair

As a continuation of earlier field research at the PromZ trade fair in Rotterdam, the Materials fair in Veldhoven was visited. As the name implies, the topic of this trade fair is material science. Since this is a rather broad field, the organizer has divided the fair into four main sections (figure 17): Materials, material analysis, surfaces, and connections. This particular event was selected on the expectation that its character would be the opposite of that of the PromZ fair. The goal of this visit was for a part similar to that of the first visit, but also to evaluate on the ideation and conceptualization that had been carried out up until this point. Three preliminary concepts had at this point been described, and for each of these concepts a research objective was established:

- AR-enhanced road signs: To discover which wayfinding cues are currently being used by the fair's organizer and to which ones visitors actually respond. If possible, it would be interesting to observe the behavior of visitors at bifurcation points (crossroads) and draw conclusions from this.
- Personal device with identity tag: To interview and observe visitors in order to determine whether the previously defined constraints can be confirmed, and to see which methods they currently use to make their judgement about a visitor.
- Stand attractiveness: To focus my observations more on what exhibitors currently use to distinguish their stands from others, and to look for potential in this field.

Furthermore, a second set of interviews was conducted to further explore the constraints of both visitors and exhibitors, as well as to evaluate the first (and also the other) concepts.

Trade fair description

As the name implies, the topic of this trade fair is material science. Since this is a rather broad field, the organizer has divided the fair into four main sections (figure 17): Materials, material analysis, surfaces, and connections. The design of the fair emphasized the division between these four sections by physically separating them from one another.

Figure 17: The map of the Materials fair

The most interesting aspect of this stand were the use of exhibitions; one for each of the four sections. These can be identified as the pink squares on the map (figure 17). These exhibitions consisted of a collection of tables on which physical items were displayed, often combined with written explanation and a link to the stand to which they belong. In two out of the four trade fair sections, these exhibitions we placed in the center of a circle of stands (figure 18 & 19).

An unexpected interview with the organizer of this fair, Timo van Leent, made clear that these exhibitions have several functions. First of all, they intend to create a connection between the visitor and the exhibitor. Most exhibitors at this fair have a scientific background and are not necessarily the best salespersons. By observing visitors when they are looking through the exhibition they are able to better judge if one of them is interested in their content, making the exhibitor more confident to approach him/her. This functionality resembles that of the identity tag concept, which also helps exhibitors identify interested visitors.

Differences

The conclusions that were drawn from these observations will be reported in the form of differences with the PromZ fair visit, so that the two sides of the spectrum of trade fairs becomes clear. Two main differences that could be observed to exist between the PromZ and Materials trade fairs were:

- Superficial attraction vs. Depending on the content quality of the stand
    - Exhibitors at the Materials fair seemed to rely on an intrinsic motivation of visitors to visit their stand, and displayed a very passive attitude towards visitors passing by.
    - Stands were designed in a rather sober fashion compared to those at the PromZ fair. There was little difference between all of them, and their content was all focused on the properties and selling points of their product or service.
    - None of the stands actively handed out gifts at the Materials fair. Only one or two stands had a bowl of mints on them.

- Crowded and narrow vs. Open and spacious
    - The PromZ fair appeared to leave very little space unused, especially when compared to the Materials fair. The maps of both events indicate this clearly. It is likely that this was done for financial reasons since their venue was estimated to be more expensive, but it also resulted into a more intensive experience for visitors. It was much harder for these visitors to "escape" the attractive of stands and their exhibitors.

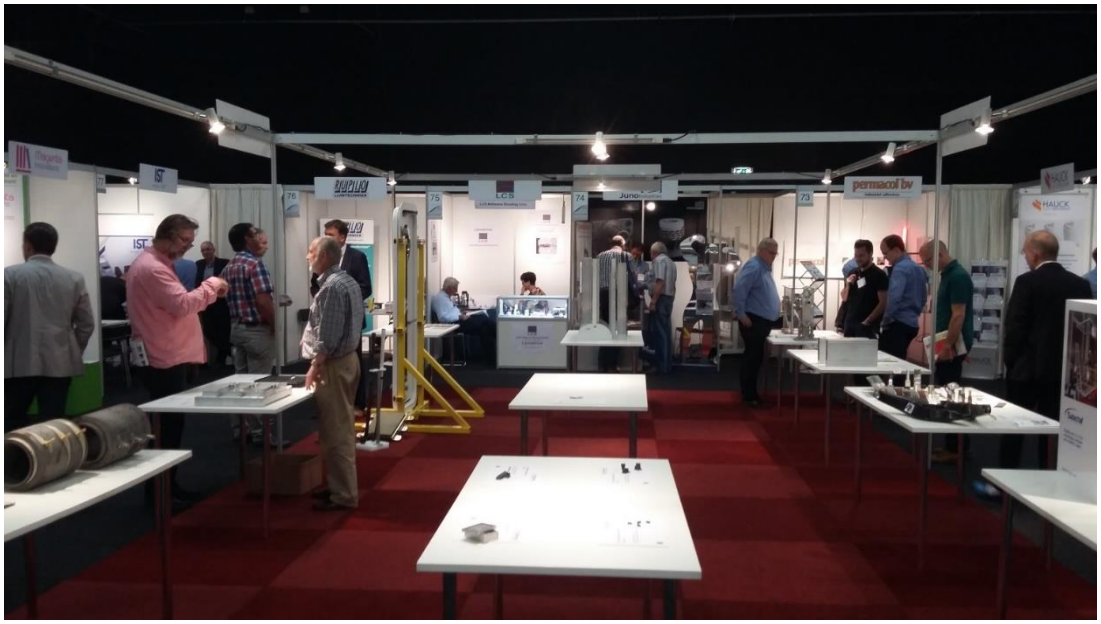


Figure 18: An exhibition and its surrounding stands

Figure 19: A close-up of a table of one of the exhibitions

Interviews

Just like at the PromZ fair, a series of short interviews was carried out in order to learn more about the goals and constraints of visitors, and in this case also of exhibitors. Since the fair was remarkably quiet, I had the opportunity of interviewing several exhibitors as well.

- The first interviewee was an exhibitor who had the goal of promoting an innovative building material. He decided to hang around the exhibition that featured his material so that he could immediately address visitors that showed an interest and further inform them. He mentioned that he regularly had conversations with visitors that were not very relevant for business-purposes, but that he didn't really mind because of the small amount of visitors at the fair and his broad objectives which included creating awareness.

- The second exhibitor that was interviewed had some interesting and outspoken ideas about a trade fair participation. The first thing that came up was whether or not to take an active stance as an exhibitor. At this particular fair he did not feel this was necessary because of its small size and amount of visitors. He was confident he would be seeing each visitor pass for at least a few times, and would maybe address them the third or fourth time. When he exhibits at larger fairs like the ones in Germany, however, he feels it is necessary to take an active stance and approach as many visitors as possible. When being this active, he did often feel the regret of seeing potential visitors pass by while he is talking to others. He does however feel that it is important to considering every visitor, because every conversation could lead somewhere.

  When asked about the colorful and branded motorcycle-suit he was wearing, he stated that he felt it was very important to make yourself stand out as an exhibitor. Making visitors remember you, for any reason, was a psychological trick he had been using for years.

- A third exhibitor that was interviewed did not really have a traditional stand, but rather a collection of posters about scientific research projects. He had the goal of promoting his company to students and acquiring new projects. The main problem he experienced was a lack of student visitors, and frankly a lack of visitors overall.

- The first visitor that was interviewed had a rather specific personal goal, but was also planning to browse the fair out of general curiosity. The way he goes about his visit it to study the catalogue, and select stands that are most relevant to his market. Besides this, he had very briefly prepared his visit and runs into no problems whatsoever.

- Another visitor had the very specific goal of only attending seminars, and was only interested in gaining knowledge. He had made a schedule of which seminars he wanted to attend of what times, which made for a very predictable and effortless visit.

- The third interviewed visitor had a rather unique way of going about his visit. He made distinction, based on experience, between educational facilities and companies. At this fair, he would first visit all educational facilities to discover which innovations are currently being researched and/or developed. He would subsequently visit the stands of companies to see whether they had caught on to these innovations, and made a judgement based on this.

- The last interviewed visitor was a product developer and had come to the fair with an objective of gaining information and inspiration on most available topics. He had only slightly prepared his visit by scrolling through the website. We talked about which factors he uses to judge a stand on, and he was able to tell me that innovation (as opposed to optimization) plays a crucial role in his appreciation of a stand.

The main thing to be concluded from these interviews is that several exhibitors indicated that they simply addressed every passing visitor at this fair, mostly because it wasn't crowded. While they stated that every visitor is potentially interesting, one of them often feels overwhelmed at more crowded trade fairs and actively approaches as many visitors as he can at such events. Visitors that were interviewed experienced no constraints at the fair. They took their visits seriously (planning, systematic visit), which matched the nature of this trade fair. Interviews with visitors were little revealing, apart from that the majority of them approached their visit in a rather systematic way.

Concepts

AR-enhanced road signs

In regards to the road sign concept, it was interesting to see the way in which the organization wanted to help their visitors navigate between the four predefined sections of the fair. This was attempted by placing large round stickers on the ground (figure 20), which would highlight one of the four sections and literally point towards it. These wayfinding cues were (strategically) placed around the center of the fair, at the edges of each of the four sections. At first, this seemed like a good, subtle, and unobtrusive way to allow visitors to navigate across the fair. However, after talking to some visitors and observing them, it became clear that hardly anyone was even aware of their existence. The reason for this was most likely that they were placed too far out of the eye-level of a normal visitor. It was disappointingly difficult to observe

Figure 20: Wayfinding cues placed on the floor

the behavior of visitors at crossroads, since the design of the fair did not create the distinct crossroads I had grown to expect from the visit to PromZ. Visitors were usually led into walking a circle around an exhibition, or found themselves in pathways that were too wide to form a recognizable bifurcation point.

Personal device with identity tag

Input on this concept mainly came forth from talking with exhibitors, which (as mentioned earlier) stated that an identity tag worn by visitors would mainly be useful at the larger events because it would allow them to identify the most relevant visitors to approach.

Furthermore, a second conversation with Petra (the aforementioned experienced exhibitor at the ISM fair for sweets and snacks) brought forth an interesting anecdote in which visitors representing Albert Heijn (a major potential client for all exhibitors) would take their badges off during their visit in order to prevent exhibitors from flocking to them and treating them differently when they just wanted to gain unbiased information. This indicates that some visitors do have a need for a product that could influence the way in which exhibitors see them and respond to them.

Stand attractiveness

As mentioned, this fair was not particularly suitable for gaining inspiration on ways to make stands attractive. All stands were rather bland and similar to each other, especially in size (figure 21). Those who did make an effort used a display of their innovative products or materials, or placed large banners besides their stand.

These findings indicate that at least this particular trade fair, and likely other similar science-oriented ones, can be seen as a blank slate for the addition of opinion-based attractive forces since there are hardly any other attractive forces with which to compete.

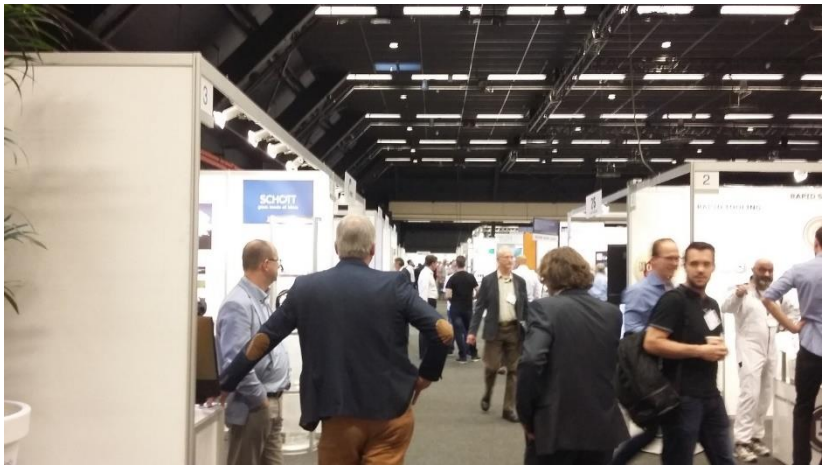


Figure 21: Exhibitors made little effort to be noticed

17 - First concept choice

After an evaluation of the concepts, partly in a conversation with Wim Poelman and Han Bosman, the decision was made to drop the third concept which was based around the termite method and the attractiveness of stands. The reason for this is that the personal device/identity tag concept essentially sets out to solve the same problem, and can already be observed to have a significantly lower implementation threshold. Furthermore, both concepts solve this problem in a somewhat similar way. The personal device sets out to nudge visitors into visiting a stand when they approach it, while the termite method also relies on proximity before an attempt can be made to change visitor behavior.

The reason that the third concept was initially developed was that the difference in concepts was not necessarily based on the problem they solve but more on the way they solve it. This is a useful way to diversify in the ideation phase, but it is more efficient to filter out any overly similar concepts before elaborating on them.

Since some aspects of the concepts, such as the exact way in which the personal device or roads signs will nudge visitors, have been left open for further ideation after the choice has been made. The concepts have been elaborated on to the point where an informed choice can be made, and the next step is another divergence and convergence cycle which will determine the final form of the chosen concept.

Weights

The concept choice criteria were given the following weights:

1. Has the potential of achieving the project's goal 10
   Since the formulated goal entails the core problems that visitors and exhibitors experience at trade fairs, a concept will have to be able to fulfill this goal as well as possible to have a valid *raison d'être*.
2. Has a low participation threshold 8
   The likelihood of visitors to take the necessary steps to participate in this system will for a large part determine its effectiveness at an event.
3. Has a low implementation threshold 8
   The score of a concept on both of these criteria will determine the likelihood of it being accepted by the three existing parties, and therefore succeed as a design.
4. Resembles the natural model 6
   Although being an important factor, the natural model is not the entire basis for the success of a design. That is why it is weighted lower than the two criteria that determine its acceptance.
5. It benefits as many visitors as possible 5
   Although a design that greatly benefits one specific visitor group can be seen as valid, one that benefits multiple types or even all visitors will have an advantage. The latter type of concept will be more likely to be accepted by the organizer, and will be more effective in the eyes of exhibitors.
6. Can be universally applied to many trade fairs 5
   Another factor that determines the likelihood of acceptance is a concept's level of universality. This in turns defines the potential market size of the design.

Method

As a method of choice, weights will assigned to each criteria after which the compliance of each concept to these criteria will be rated on a scale of 1 to 7. Although the use of numbers implicates a degree of measurability, they should be seen as more of a way to indicate the difference between the concepts by giving them a relative score.

Score

Criteria	AR road signs concept	Personal device concept	Factor
1	6	5	X10
2	4	6	x8
3	3	6	x8
4	6	4	x6
5	5	6	x5
6	4	7	x5
Total	197	235	

Key scoring differences

To clarify the thought process behind the scoring and the result, the key differences in scoring will be elaborated on.

The most obvious deciding factor is the difference in score regarding the implementation threshold criteria (nr. 3). The reasoning behind this has for the most part been explained in the concept description, and comes down to the fact that the first concept needs an additional product to be implemented which requires a custom design for each fair and of which only the core elements can be reused.

The road signs concept scores higher on its resemblance to the natural model because it incorporates the wayfinding aspect of it more extensively. Just like in the foraging system of ants, visitors will be subjected to the feedback of other agents from (potentially) a large distance. This increases the value of the feedback a stand receives because it is communicated to a greater amount of visitors.

The judgment about which concept benefits the most visitors is a tough one. At first glance, the first concept would score higher because its road signs benefit both goal-oriented as well as orienting visitors, albeit in different ways. The second concept, however, focuses mainly on the orienting group of visitors which has been determined to be the largest. On top of this, it also directly (and indirectly) benefits exhibitors. While they are not considered to be a visitor group, they do make up an important section of trade fair participants.

Value of wayfinding

Another important factor in this choice has been that the road signs concept was considered to fulfill the aforementioned design goal the least. The reason for this is that it is too heavily focused on wayfinding compared to the other concept.

One of the differences between the natural model and trade fairs is that trade fairs occur in a confined area which contains predefined walking paths. One result of this fact is that the value of wayfinding instructions (especially for orienting visitors) drops, depending on the size and complexity of the fair, because they are likely to visit every part of the fair and therefore consider visiting every stand anyway. On top of this: while ants walk randomly, most trade fair visitors have an intrinsic motivation to walk past and consider every stand at a fair because they want to consider each option to ensure they haven't missed a potentially great exhibitor.

Then why was this concept developed and selected in the first place? First of all, not all visitors have an intrinsic motivation to consider each stand at a fair. Well-prepared goal-oriented professionals, a supposedly growing group of visitors, are mainly/only interested in specific and pre-selected exhibitors and would benefit from a system that guides them to these stands in order to make their visit more efficient. Second of all, wayfinding is not the road sign concept's only value proposition. As mentioned, it also promotes popular exhibitors by displaying their name/logo more prominently. This is expected to cause visitors to develop a subconscious interest in those exhibitors before even seeing their stand, just as in the way modern advertising works.

18 - Concept variables

In order to explore the possible forms in which this concept can manifest itself, another divergence step will be taken. This will be done by identifying a number of the concept's variables, and their respective options.

Nudge

Although incomplete, a brainstorm session on how a personal device can nudge its user was already conducted. The results of this brainstorm allowed for a categorization of the main principles with which a device can send a message to its user.

- Vibration
- Sound
    - Text
    - No information: indicates that a condition has changed
- Visual
    - Light
    - Projection
    - Orientation
    - Text

Type of message:

- Directional
- Binary, proximity threshold
- Text

Device

The type of device is an important variable. Although this won't define its function, it does define the interface of the entire system and therefore determines how participants and exhibitors interact with it. The most promising potential devices were incorporated into the morphological chart

Badge

This device continues with the current way in which visitors reveal their identity to those around them and therefore has the obvious advantage of being the first thing exhibitors look for. It is easy and comfortable to wear and can easily be seen by anyone.

Bracelet

This device has the advantage of being more stealthy than a badge, which gives visitors more control over whether or not they will to be approached. It is worn in a spot that is far more noticeable for the wearer itself, and is in direct contact with the skin which likely allows for a more intimate and therefore more persuading nudge.

Smartphone (app)

The main advantage here is that the device is already owned by the visitor and is already capable of making the necessary required calculations, which lowers the implementation threshold. On the other hand, it would require visitors to install an application which would go hand in hand with a method to log in with their visitor profile. Although these actions are simple, they do add a

level of user initiative that raises the participation threshold. One rather obvious problem with this device is that is almost always carried in a hidden place (figure 22), although some people hold it in their hands for the majority of the time. Information to exhibitors will therefore have to be sent in another way.

Information to exhibitors

The remaining two variables concern the identity tag functionality of the design: how will information regarding the visitor be communicated to the exhibitor, and what will be the nature of this information?

Information type

Binary

- All the exhibitor can see is whether or not the visitor matches their desired visitor type

Gradient

- The exhibitor can also see how strong this match is, and can compare this to other potential visitors in their vicinity.

Compound (displays different conditions separately)

- The exhibitor can see to which of

Communication method

- Visual
- Digital

Figure 22: Examples of the considered personal devices

19 - Second concepts

Glowing badge

The first combination uses the traditional visitor badge as its foundation. It aims to nudge its user by emitting light in a binary fashion whenever it finds itself in close proximity to a stand that is deemed interesting by a certain number of visitors whose profiles match that of its user.

This concept is meant to be efficient, in the sense that it uses the same light-based visual cue to inform exhibitors about the match between the visitor and the stand. However, because of the display potential of the badge, exhibitors are also able to read more detailed information about the visitor's profile (topics of interest and objectives) so they themselves can also judge whether the visitor is interesting for them without solely relying on the recommender system.

As mentioned, the information that the badge provides exhibitors with can be more complex than a binary indication of a match between visitor and stand. It must, however, still be easily (almost instinctively) understandable by all exhibitors if the device is to be used at crowded fairs. Two variables will be used to compose this information with: a visitor's objectives and a visitor's specific interests. In both categories, the visitor is able to select multiple options.

Several pieces of technology will be used in this concept. Their required functions and the design requirements that follow will be described here:

- The first functionality that has to be enabled is the processing of information regarding the visitor's profile. A microprocessor-chip will have to store this information, and compare it to incoming values. This information will also have to be uploaded to the microcontroller at the start of the fair.
- This visitor information will have to be sent to nearby sensory devices which are found in stands. Since the most likely form of stand confirmation at the moment is the act of scanning the personal device at the stand, technologies like NFC or RFID will most likely be the best choice for this. On top of that, information about the visitors that have previously confirmed a stand will have to be received by the personal device. This must be done over a larger distance, since the device will have to determine a match between its user and a stand before he/she enters the vicinity of the stand. The personal device (as well as the sensory device) will therefore have to be equipped with a sufficiently powerful antenna.
- The way the conclusions of the microprocessor will be communicated to the user and exhibitor is by the use of LED's. These LED's will have to be able to emit light at different intensities and their light must have sufficient intensity to stand out in a well-lit environment.
- Since the device will have to be carried around the fair and must therefore be wireless, a battery will be required to provide all other components with the necessary power.

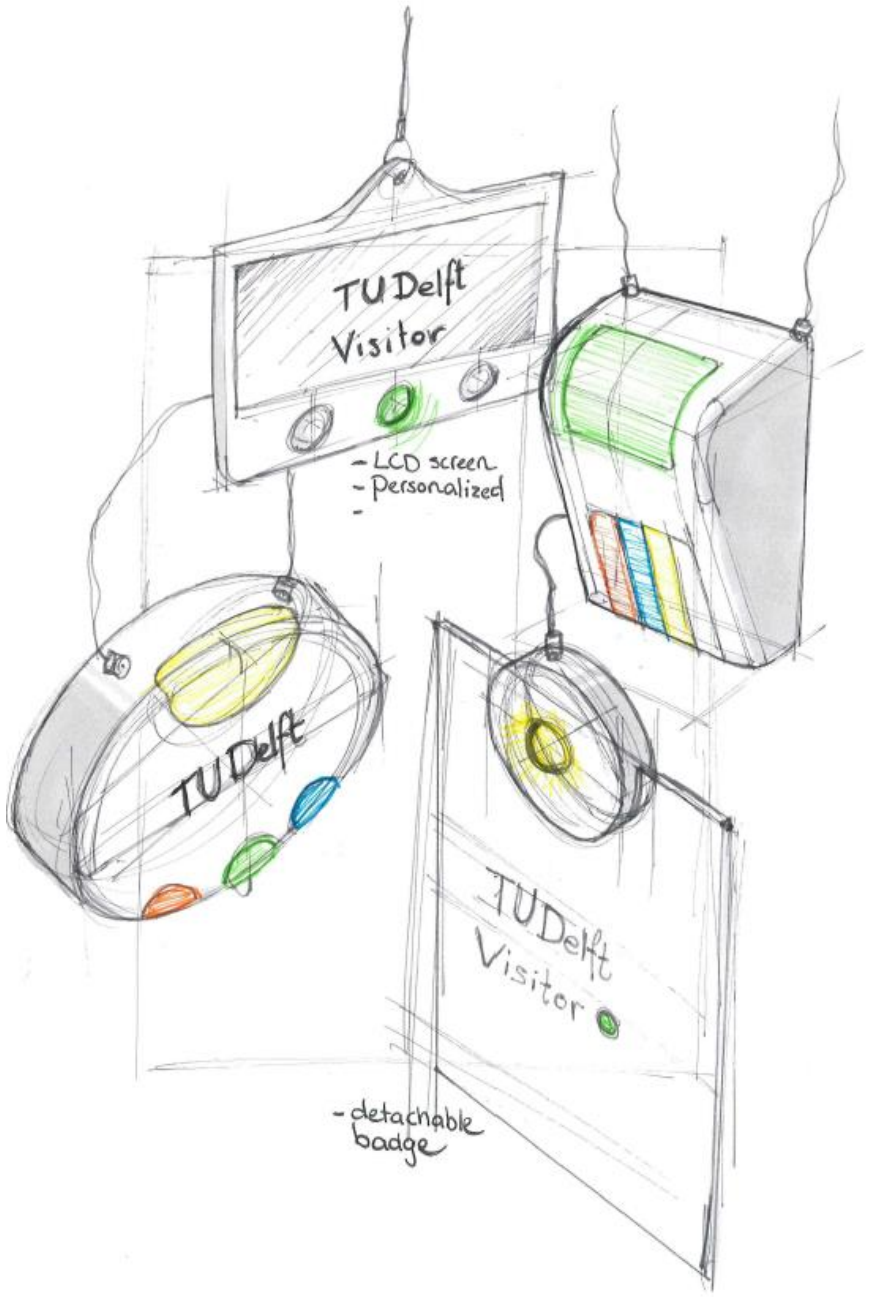
This battery must be potent enough to last for the maximum duration of a trade fair and must be rechargeable in order to allow for a repeated use of the device at other fairs.

Pro's

- The badge is able to visually communicate detailed information to exhibitors in a simple and instinctive way.
- Badges are already used in practically every trade fair, which makes using them in this system more instinctive.

Con's

- Of the three devices, the badge is arguably the most challenging one to send a verification message to.
- When worn, a badge is not in the direct field of vision of its user. The glare of moderately strong light can however be easily noticed by the user, as a brief test pointed out.



Glowing and vibrating bracelet

While the second combination also nudges and informs its user and exhibitors by using light, it does this in a different way. First of all, the device that is used to convey these messages is a bracelet. This allows users to more easily see the nudging light. The bracelet will glow with a gradient of intensity, based on the amount (relative, % of visitors) of confirmations the stand has received from like-minded visitors. The brighter it glows, the more potent the match is. A certain threshold of confirmations will still have to be reached for the bracelet to start glowing in the first place, so the user can still distinguish between stands with and without a recommendation.

The way a bracelet visually communicates information to exhibitors is less evident than that of a badge. This device is generally harder to spot because of its size, location below eye-level, and the possibility of being obscured by clothing. This is countered by the facts that a participant will prevent clothing from obscuring it for his own benefit, and that exhibitors are actively trying to see the devices. The exhibitor will receive the same information as the visitor: whether or not they match with the stand and how strong this match is.

Several pieces of technology will be used in this concept. Their required functions and the design requirements that follow will be described here:

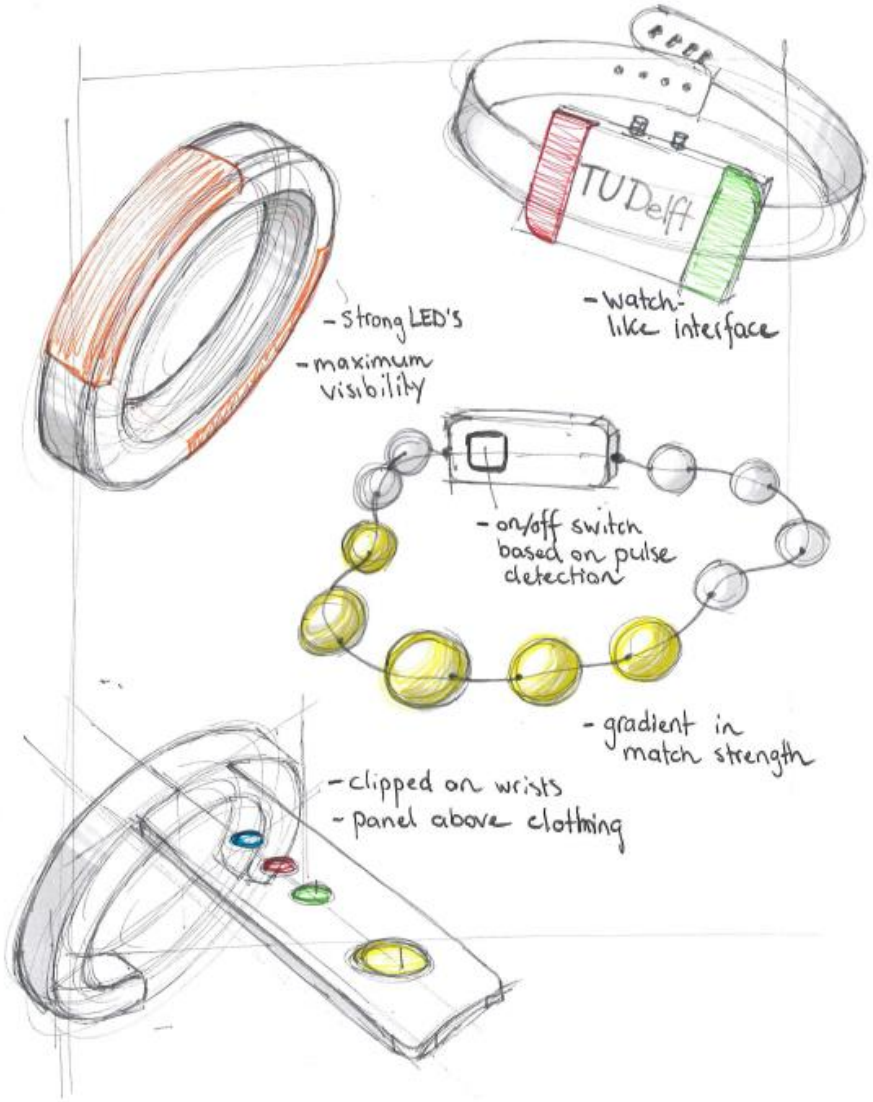
- The first functionality that has to be enabled is the processing of information regarding the visitor's profile. A microprocessor-chip will have to store this information, and compare it to incoming values.
- This information will also have to be uploaded to the microprocessor at the start of the fair.
- This visitor information will have to be sent to nearby sensory devices which are found in stands. Since the most likely form of stand confirmation at the moment is the act of scanning the personal device at the stand, technologies like NFC or RFID will most likely be the best choice for this. On top of that, information about the visitors that have previously confirmed a stand will have to be received by the personal device. This must be done over a larger distance, since the device will have to determine a match between its user and a stand before he/she enters the vicinity of the stand. The personal device (as well as the sensory device) will therefore have to be equipped with a sufficiently powerful antenna.
- The way the conclusions of the microprocessor will be communicated to the user and exhibitor is by the use of LED's. These LED's will have to be able to emit light at different intensities and their light must have sufficient intensity to stand out in a well-lit environment.
- Since the device will have to be carried around the fair and must therefore be wireless, a battery will be required to provide all other components with the necessary power. This battery must be potent enough to last for the maximum duration of a trade fair and must be rechargeable in order to allow for a repeated use of the device at other fairs.

Pro's:

- The bracelet is an intimate and noticeable device, which helps strengthen the convincing strength of the nudge it gives its user.
- A gradient in the match indication system allows exhibitors to more precisely select which visitors they approach, which is especially useful at crowded trade fairs.

Con's:

- While visitors can reveal the device to themselves whenever they wish, it may often find itself outside of the line of sight of exhibitors. This could be because it is hidden by a long sleeve, or because the arm simply hangs on the side of the body opposite to the exhibitor.
- When exhibitors are searching to catch a glimpse of these devices, they will be staring at waist-height of visitors while they would prefer to make eye-contact with them to create a more personal and human connection.



Smartphone-based

The third combination revolves about the device that is already owned by every visitor: the smartphone. In this app, the user can choose between two possible ways he/she will be notified by the device: a binary message by means of vibration, or a directional binaural sound message through earphones. Since it is very impractical for exhibitors to directly read visual information from the smartphones of visitors, this information will be wirelessly sent from these devices to the phones of exhibitors. It is safe to assume that exhibitors also already own this device, and that they are more than willing to go through the effort of installing and using an application for their own benefit.

- This method would require a way for the exhibitors to match their incoming profiles with visitors near their stand. The most obvious way to do this is by adding a profile picture to the visitor profiles. This picture could be uploaded when signing up for the fair, or taken upon entrance.

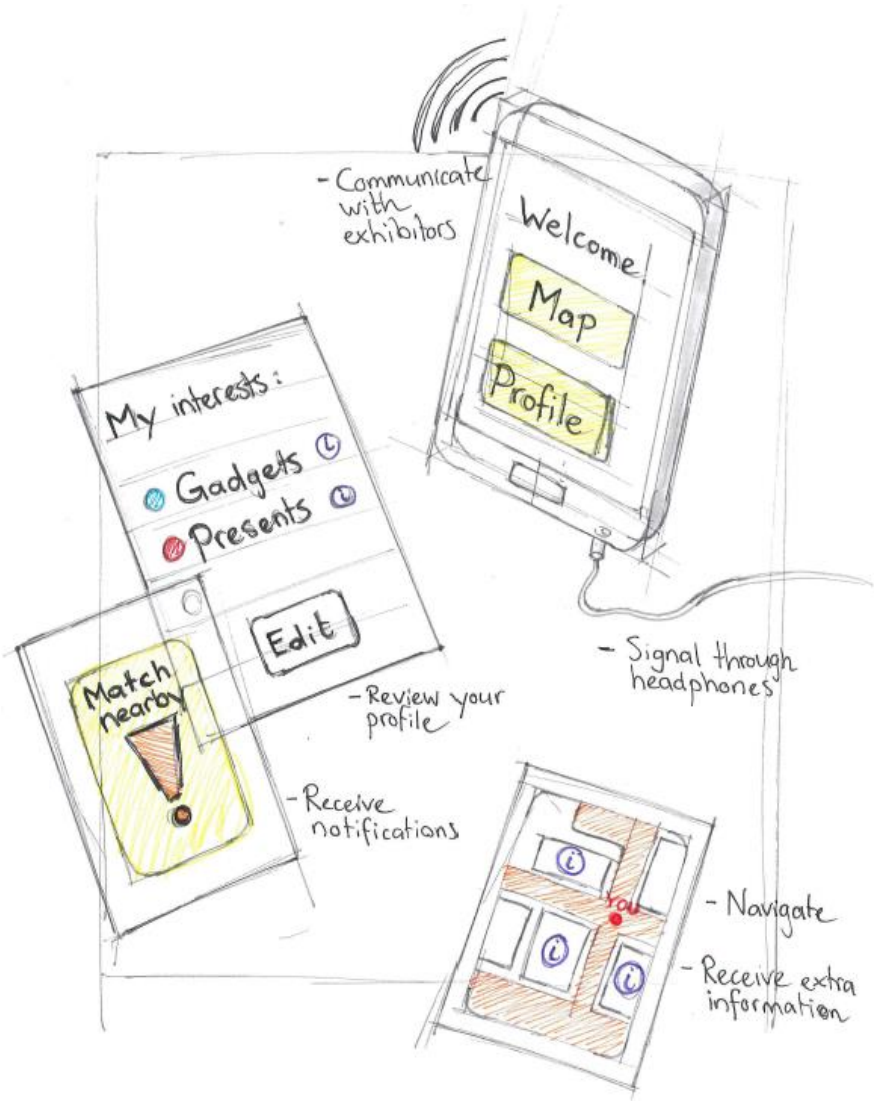
As far as enabling technologies are concerned, this concept is rather unique. The personal device already contains all necessary technology for (almost) all functionalities. The only feature it misses is program that can access this technology, use it for the intended purposes of the system, and create an interface through which it communicates with its user. The standard format for such a program is a mobile application, which will have to be designed.

Pro's:

- The obvious advantage of this is that the implementation threshold is minimal, since most required hardware is already owned by the participants of the system. This hardware, the smartphone, also very likely has more advanced specifications than the other two options will have. It is, however, not likely that these more advanced specifications will contribute to a more successful design since the core functions are quite basic.

Con's:

- The choice for this device means that visitors will have to take the initiative to install an application on their personal smartphone. Although the willingness of people to do this at similar events has not been researched yet, it does add to the participation threshold of the system.



20 - Inspiration

A way to gain new insights on how to further develop a concept is to look at existing design solutions for a similar problem, similar products that solve a different problem, or both. In this case, it is interesting to look at similar product types like a smart badge or bracelet, to see how interaction currently takes place between these devices and their users.

EASYFAIRS Smart Badge

This product is described by its creators as a virtual goodiebag (Easyfairs, 2017). These badges, which look just like ordinary badges, can be used by visitors in a so-called "Touch & Collect" system. By scanning their badge at a device in a stand, they automatically sign up to receive more information from that exhibitor, while the exhibitor receives data from the visitor. The process of scanning the badge is done by actively holding the badge next to an obvious scanning device, after which this device beeps and emits a green light. The day after the fair, visitors who used the smart badge receive an overview of all the stands they have visited and scanned their badge at (figure 23).

- Just as in the concept, every visitor has a personal device and every stand has a sensory device.
- This system allows visitors to indicate whether they are interested in a stand. It uses an active judgment method by the visitors for this. These confirmations are not used during the fair itself, however, but are only used as a way to facilitate follow-up meetings. This way of judging a stand could be interesting in the future design, since it would allow us to disguise the action as a way to request more information about a stand. This happens to be an excellent way to tell if someone is interested in the first place

Conclusion

Scanning of the personal device at a stand is an interesting added functionality to the design, especially because it can be used as a way to allow visitors to actively leave a pheromone without them being aware of it. This scan could also allow the visitor and exhibitor to exchange contact information, possibly as a cover for the true function of it.

Figure 23: A description of EasyFairs's smart badge

Apple watch

When searching for a device to compare a smart bracelet to, the Apple watch is for many people the first product that comes to mind. This intimate device, which was described by Tim Cook as 'the most personal Apple device ever", is intended to replace the function of the traditional watch, while also adding many of the functionalities of the smartphone (iCulture, 2017). Because this device is always in close and direct contact with its user, Apple was able to add new functions to this particular device. These include a heart rate monitor and an exercise tracker (figure 24).

Interaction with the Apple watch is for a large part based on the extensive experience that people have with traditional watches (Apple, 2017). For example, the devices can be turned on when it detects a certain type of movement. This movement is very similar to the way normally look at their watch: rotating their wrist and moving it towards their face. Another way the watch can be turned on, and which also acts as the main interaction mechanism (scrolling through menus), is the digital 'crown' on the side of the product (figure 24). This too mimics the way traditional watches are controlled.

Conclusion

As suspected, a personal device around the wrists allows for a more intimate connection with its user. An interesting idea is to involve movement of the wrist of arm in the way nudges are given to the user, or in the way users communicate with exhibitors (see Shake-On). A potential bracelet design will also benefit from using interface techniques similar to those in watches.

Figure 24: Apple's Apple Watch

Alex posture tracker

Nudging personal devices can also be found in the field of healthcare. An example of this is the Alex posture tracker. This device does not fit into one of the three device categories, but is still interesting to look at because of the way it nudges its user.

The user is aware of the goal of the product and therefore requires minimal information from the nudge itself. The user has an intrinsic motivation to perform the action that is suggested by the nudge, he/she simply has a tendency to forget about it. A simple vibration pulse from the device is enough to (temporarily) remind them and is therefore enough to change their behavior. The device is worn behind the ears, and its main component rests in the user's neck (figure 25). This design was necessary to allow the device to measure someone's posture, but it is also likely to give the nudge more convincing strength by linking it to a part of the body that is relevant to the desired change of behavior.

The device works alongside a 'companion coaching app' which allows the user to customize their experience by altering the frequency and intensity of the nudges. It also gives feedback on the user's behavior over a period of time and tracks one's progress and improvement. This app appears to be an important factor in the success of this product, since it makes its positive effects tangible and understandable.

Figure 25: The Alex posture tracker

Conclusion

Giving feedback to users could also be applied in the final concept, either during or after the visit. One possibility is to develop a smartphone application besides the personal device (only when the smartphone concept is not selected) that allows people to scan their device with their phone to extract data from it. This could tell remind users where they have been and which exhibitors they liked. Since this application would be optional, and not at all required for the system to function properly it would not raise the participation threshold, and it would be of benefit for those visitors who are determined to make the most of their visit.

Shake-On

A product that is especially interesting to look at is the Shake-On; a smart bracelet that allows two individuals to exchange contact information by simply shaking hands (figure 26). This product is very similar to the current concept of the personal device, since it can also be described as a smart wearable device containing personal information which is used to leave this information at agents in which the user is interested.

What makes this product even more interesting to evaluate is that is suggests a unique way for visitors to indicate their interest in a stand and 'deposit their pheromone'. This method is unique in two ways: it shares the initiative of the action between the exhibitor and visitor, and it combines the scanning process (which is simply based on proximity) with the common and relevant social act of shaking hands.

Conclusion

The main thing to take away from this device is the importance of the semantics of an action with which contact information is exchanged. A handshake makes the interaction feel much more valuable than, for example, a simple quick scan of a badge. The final design should take this in mind, and place value in this interaction.

Figure 26: The Shake-On

21 - Second choice

Revised criteria

In order to be able to make a choice for one of the second set of developed concepts, a new set of criteria has been formulated. These new criteria partly come forth from the original set. Some of these criteria, however, were too general to be able to make a distinction between the new concepts. Additional criteria were therefore added which are more specific for the concept that was chosen.

1. Strength/feasibility of the nudge/behavioral cue
    - The main factor that determines the effectiveness of the design is the likeliness that visitors will respond to the nudge that is produced by their personal device. However, more convincing power is only good to a certain extent. The system is only intended to increase the chance that people will visit certain promising stands, not to ensure that they will visit them. This probability factor is also incorporated by the lack of a (long-range) wayfinding.
    - Its strength will mostly depend on how closely it is related to the desired outcome/stand, the likelihood that the user will sense the nudge, and whether or not the user understands it purpose and changes his/her behavior correctly.
2. Accessibility of visitor information to exhibitors
    - Exhibitors will benefit from the system most if they can easily and instinctively sense the information they need to judge the value of a visitor.
3. Has a low threshold of participation for visitors (money, effort)
    - Introducing a new feature to a traditional environment has its challenges. As nudge theory describes, most people are more likely to stick to a default option than invest effort in a new alternative. A low participation threshold will therefore increase the chance of a design being accepted by the public.
    - Exhibitors likely do not mind a higher participation threshold for a potential system, because the potential advantages of it are greatest for them
4. Has a low implementation threshold
    - Just as visitors are more likely to adopt a new system when the participation threshold is low enough, organizers of trade fairs are more likely to adopt an addition to their current 'products' when they are easy and cheap to implement. In this decision, costs will be the main determining factor.

Methods

While the choice made earlier was done via the weighted-criteria method, we will now use the Pugh's method of concept selection to determine which of the options is most promising and worth elaborating on. The main reason this method was chosen is because it is based on a direct comparison between the available options. Since the options in this scenario are relatively similar, this method is expected to deliver a more conclusive result. Another advantage is that subjective decisions, like the ones about the strength of a nudge, can be made more objective.

Applications of this method often use an existing solution as a benchmark to compare new concepts with. While this is a good method, it is not very suitable for this situation. Instead, the three options will be ranked in how well they meet each criterion.

An alternative to this method is to make a choice by using Harris profiles. Each concept receives a score (-2, -1, 1, 2) on how well it conforms to a criterion. This method also uses a more subjective way of determining which concept is most suitable, but is more accurate in the individual scoring of concepts. Since both methods can sometimes be rather inconclusive (their results are often open to interpretation), it will be useful to have two sets of results to point towards the ideal solution.

A last thing to note before applying these selection methods, is that they will not necessarily lead to a definitive choice for one of the current options. They are also used to point out the flaws of each concept. These flaws will be evaluated, which may lead to an adaptation of a concept before it is selected.

Pugh's method

In this interpretation of the Pugh selection method, the three options are ranked in how well they conform to each criterion. Visual aids (colours) are added to the results to make it easier to determine which option has the most potential, much like the Harris profile method. As one can see, this method has not provided any definitive results other than a possible elimination of the smartphone concept. The badge concept does well by being the best option in two categories, but scores poorly in the most important criterion. The bracelet concept can be seen as the option which is able to nudge its user best, and scores acceptably in terms of displaying information for exhibitors and in user participation threshold.

Criteria	Badge	Bracelet	Smartphone
1	3	1	2
2	1	2	3
3	1	2	3
4	2	3	1

Harris method

When using the Harris method for this choice, the results look like this. Again, the results are inconclusive. Naturally, these results are quite similar to those of the first selection method. There are, however, some differences which validate the use of this second method. Unlike before, it is no longer necessary to give all concepts a different score. Additionally, the scores for one criterion can now be seen in perspective to the others. A concept that ranked 3rd in the Pugh method might actually score quite decently on that criterion, but is just unlucky that the other options score slightly better.

Criteria	Bracelet			
1				
2				
3				
4				

Criteria	Badge			
1				
2				
3				
4				

Criteria	Smartphone			
1				
2				
3				
4				

Scoring explanation

Nudge strength

The criterion of nudge strength appears to have a large impact on the results of both methods, which is not surprising as it has been deemed to be the most important of the four criteria. The bracelet concept consistently scores the highest here because of the following reasons:

- It is very visible to its user when worn, which benefits the light-based nudge it has been combined with.
- Unlike the other devices, it is not usually 'worn' at a trade fair. This is expected to increase the user's awareness of the device.

The smartphone scores lower than the bracelet, mainly because of the fact that it communicates with its user for more reasons that just this system. While it is not usually kept in sight, it is a device that users will be aware of simply because of their general dependence on it. The badge concept scores the lowest, mainly because it is not worn in the line of sight of the user, which makes light-based nudges less effective. Furthermore, a badge is such a common sight at trade fairs that visitors take it for granted and tend to forget about it over the course of a visit (partly speaking from personal experience), also because there is no reason for them to interact with the badge.

While this criterion is seen as the most important towards achieving the design goal, it is also clear that it is the most dependent on the design of the concept (the nudge in particular), and is therefore more sensitive to optimization in the embodiment phase.

Accessible information for exhibitors

The reason that the badge concept scores significantly higher on this point of comparison is mainly because badges are already used (in the vast majority of trade fairs) as the most basic way of communicating visitor information to exhibitors and will therefore be instinctively looked at by exhibitors. This device also has the most potential to display (complex) visual information. The bracelet is much less visually accessible, and has less potential to display visual information. The smartphone concept scores even lower, because the most suitable method of providing exhibitors with information through this device is to send it digitally. This would require exhibitors to redirect their attention from nearby visitors to the device that would be receiving this information and perhaps even compromise their performance at the fair.

Participation threshold

The smartphone concept scores the lowest here because the required initiative from the visitor to install and use an application has been deemed to overrule the comfort of being able to use a personal device that they are already familiar with. The badge and bracelet concepts both require very little effort from their user, but the badge scores better because it is expected to require no additional effort at all compared to a traditional trade fair visit.

Implementation threshold

The smartphone concept will not require any hardware to be implemented, except for the devices found in each stand. While the remaining two concepts both require an additional piece of hardware to be implemented, the badge concept would be

replacing/improving an existing part of the event and therefore scores slightly higher.

Conclusion

The main conclusion to be drawn from these selection methods is that there is no clear optimal choice between the three concept options. The badge concept arguably scores best in both selection methods, but is held back by its relatively weak capability to nudge its user. Its positive scores on the remaining scores, however, still suggest that this concept is the best option of achieving the design goal on the condition that its nudging method is reviewed and (where possible) improved.

Based on the scoring of the badge concept, one could conclude that the choice to combine a badge with a light-based nudge (because of its efficiency with the displaying of information for exhibitor) was not optimal.

The badge could be designed in a way that makes its nudge more convincing to its user by learning from both the other concepts and the existing personal devices that were discussed earlier:

- Use an alternative nudging method
    - Vibration
    - Sound
        - The option of attaching earphones
- Make the badge more physically accessible to its user
    - Detachable
    - Extensible
    - Readable with a smartphone

- Make the badge more visually accessible to its user
    - More bulky redesign
    - Alternative placement on the body

22 - Devices' functions

The following two diagrams were used to identify the required functions of the two key devices. They are constructed by stating the primary function(s) of each product, and then listing the primary function(s) required to fulfill that function below it. This process is repeated until each primary function has revealed all its required functions (figures 27 & 28).

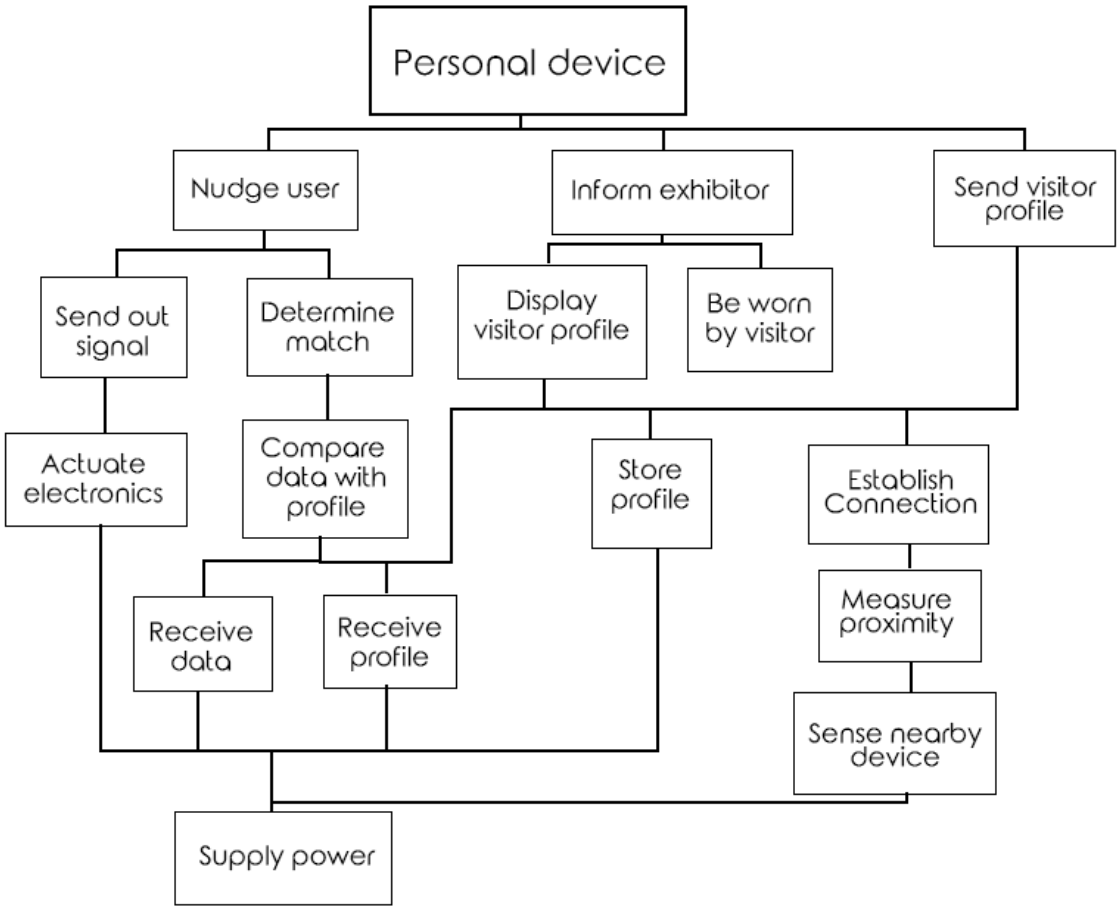


Figure 27: Functional analysis of the personal device

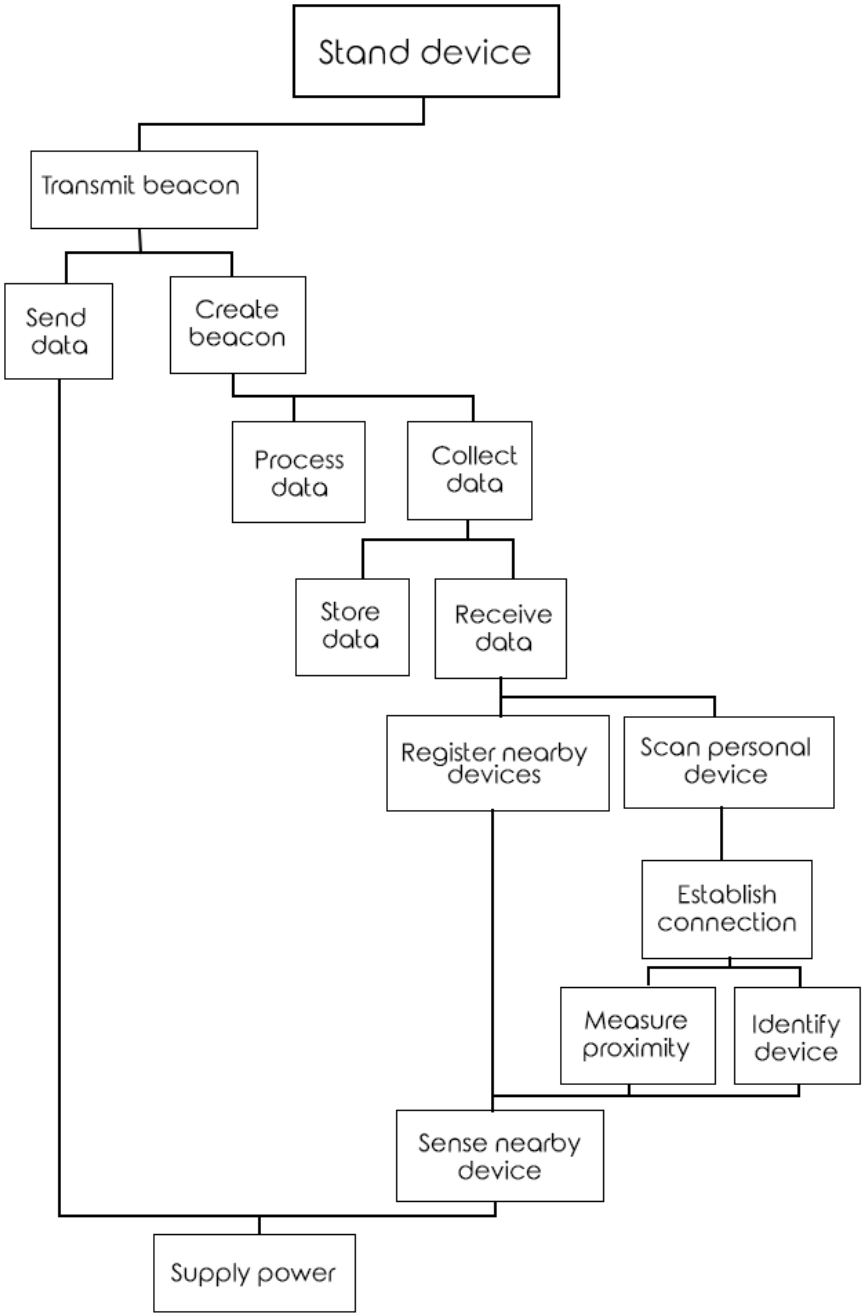


Figure 28: Functional analysis of the stand device

23 - Visitor-system interaction

This diagram indicates how the two parties, visitors and the system, would interact with one another once the system has been implemented at any trade fair. In this diagram, all participating visitors are seen as a collective unit because they all (indirectly) interact with each other because of the presence of the system (figure 29). This diagram also indicates the two devices that form the interface through which visitors create the network of data, and which will be the focus of this embodiment phase.

Outside factors that influence the behavior of visitors are also incorporated in this diagram, and have been identified as the environment (direct contact with other visitors, lay-out of the trade fair, other attracting factors of exhibitors) and the interaction of visitors with exhibitors.

An interesting note is that the personal devices can be found in both parties in this diagram. While they are unmistakably part of the system, they also function as the senses of the visitors. They transform visitors into agents that resemble the ants on which this system is based, by making them able to deposit information and read the information that was deposited by others.

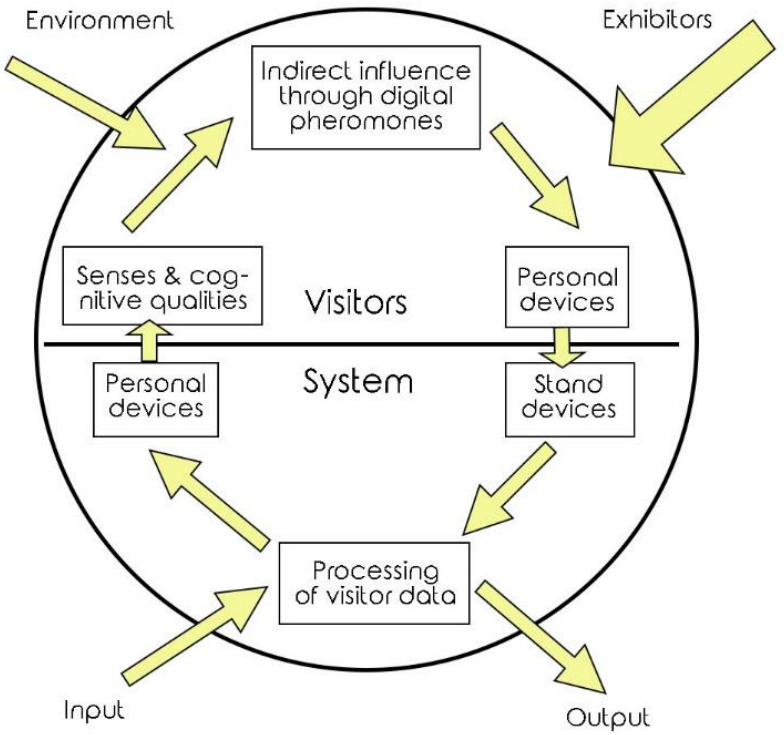


Figure 29: The interaction between this system's data and trade fair visitors

24 - Nudge

Probability

When looking back at the natural model, it suggests that encountering the 'pheromone' only leads to a probability that the behavior of an agent is changed. This probability factor was found to be somewhat related to the flexibility of the natural model: if ants were certain to follow each pheromone trail they encountered, there would be almost no further exploration of the area until the resource at the end of that trail were depleted. The main function served by the probability factor, however, is that it allows for the convincing power to increase as pheromones accumulate. This gives food sources with more confirmations an advantage over others and increases the probability that an ant ends up at the ideal location.

When applying this to the environment of trade fairs and this design in particular, one can conclude that the flexibility factor is not as relevant here (explained later). The difference in attractiveness can prove useful in a scenario where, for example, a visitor matches with too many stands at a single fair and needs a way to determine which stands to visit and which to ignore regardless of the received nudge.

In the current form of the design, this variation in behavior-changing probability is not integrated in the nudge but rather in the visual information that the badge provides exhibitors with. By showing exhibitors compound information about how their visitor profiles are constructed, these exhibitors will have a higher chance of approaching (and therefore attempting to change the behavior) visitors who best match with what the exhibitor is looking for. This type of probability does have a major difference from the natural model which can be considered to be a flaw: It is not based on the data left by other visitors but only on the opinions of exhibitors.

Strength

When making the decision for one of the personal device variations, it became clear that the badge will not likely be able to provide its user with a sufficiently convincing* nudge based on light alone. Brief user testing with light shining from the location of a badge strengthened this suspicion. Because of this, the nudging method has been redesigned.

*able to influence behavior

Since the light-based nudge still synergizes well with the communication of information to exhibitors, it will not be discarded. The most logical step is add something to it, or change the way in which the nudge is received. As of now, two measures were taken:

- A vibration-based signal was added to the badge as a way for the device to draw the attention of its wearer (figure 30).
- The chord to which the badge is connected will be designed to be extensible, so that visitors will be able to react to the initial vibrational signal by pulling the device

away from their bodies into their line of sight. From here, the visual nudge

Vibration was chosen as an additional nudging method because it has been observed to be used in many notification-systems used by other personal devices. This familiarity of people with it is a great advantage.

- Sound not chosen as it will likely interfere with the nudges of other devices, because trade fair visitors often find themselves packed closely together in walking aisles.

Figure 30: The personal device's nudging process

25 - Design process

Required characteristics

Personal device

The visual design of this device must accomplish several things. Its main objective is to visually communicate visitor data to nearby exhibitors. This means that the visual display of information must be above all: clear, rapidly understandable, complete, and distinguishable. Secondly, it must be able to provide its user with a clear light-based signal. The keywords here are accessibility and understandability. Furthermore, the personal device must be able to contain all required electronics while still being compact enough as not to be an annoyance for visitors while they wear it.

Another important consideration is that the design must enable both devices (but the badges in particular) to be universally useable in many trade fairs. This mostly means that the way visitor profile data regarding the different sections of a trade fair is presented must be adaptable to the amount of different sections each trade fair has. This could be accomplished by, for example:

- Designing the badge in a modular fashion to allow it to be personalized for each specific trade fair.
    - Enabling the integration of traditional printed badges.
- Equipping the badge with a (LCD) screen which allows an organizer to precisely adapt the visual information to their fair.

The decision to use QR codes as the ideal means to transfer visitor data from badges to stand devices (explained later) has led to the conclusion that it would be best to design the personal device in a way that allows for the attachment or insertion of a printed paper badge.

Stand device

The design of this particular component of the system will have a major influence on the participation of visitors in the scanning process. A well-designed stand device should help visitors notice the device, understand its function, and guide the scanning-process. To work towards a design that is able to accomplish all this, an inventory of required design characteristics was made:

- Noticeable
- Approachable
- Friendly
- Understandable

Based on these characteristics, a collage of products with similar perceived qualities was made (figure 31). This was then used as an inspiration for an ideation on a suitable product form, although it will also be used for reference in regards to color, texture, and detailing.

Figure 31: An collage made for design inspiration

Ideation

This ideation phase led (figure 32) to some interesting ideas on how the stand device will appeal to visitors. The main idea here was to create a match in visual design between the personal and stand device, to make participants aware of the fact that the two products are somehow related. Depending on how strong these similarities are, it could even suggest that the two products are supposed to interact with each other. Another idea was to facilitate the necessary precision that comes with the use of QR codes by adding a slot to the stand device in which the personal device must be inserted. Such a slot would be a clear use-cue for visitors and help them understand how to quickly scan their badge.

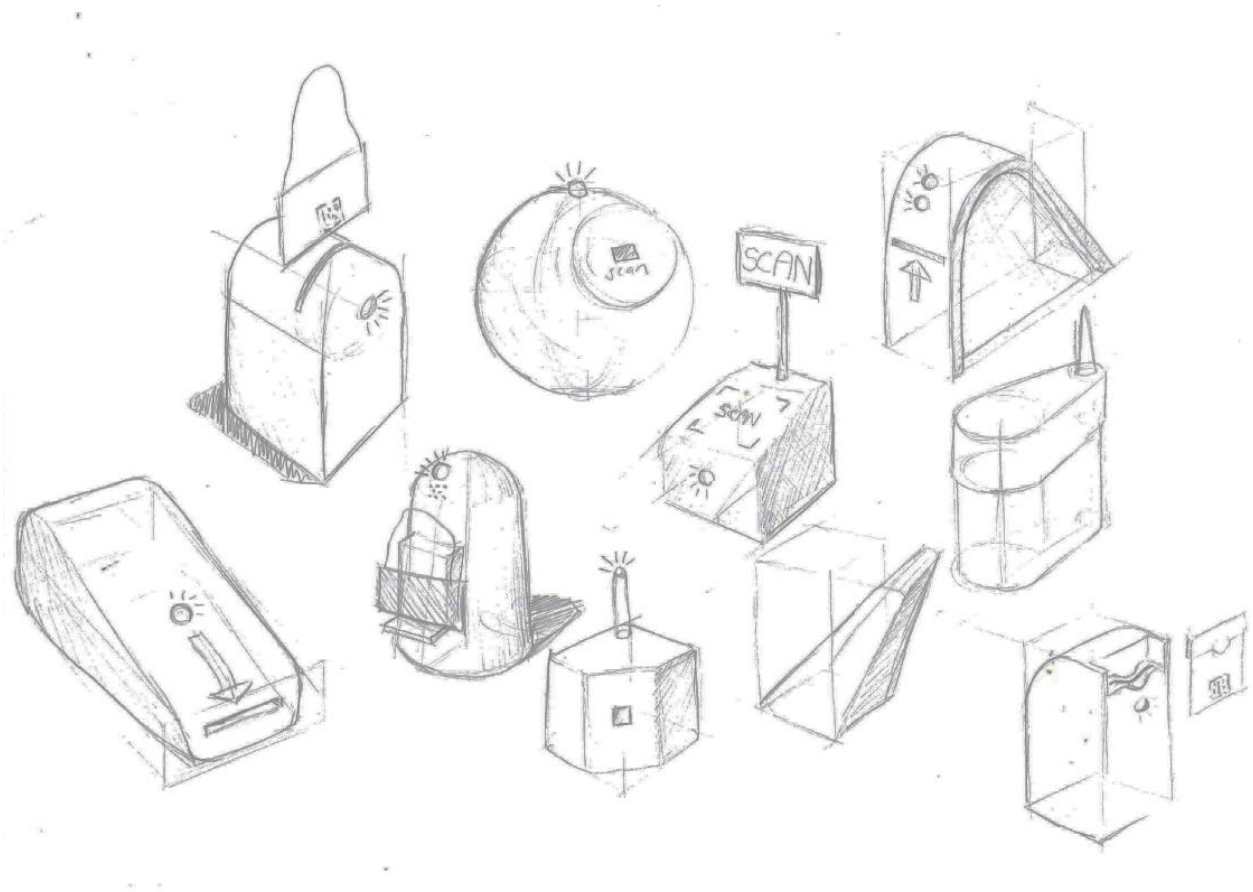


Figure 32: Part of the form ideation phase

Form concept

As can be seen in this concept (figures 33 & 34), the match between both devices has been exaggerated to the point that the personal device 'completes' the shape of the stand device. This makes it seem as if the two products are meant to be joined together and strengthens the connection between them.

The fact that the badge will have to be inserted into the stand device rather precisely could be seen as a participation threshold-increasing factor. However, since this action excludes hardly any visitors from being able to participate (exceptions: Parkinson, visually-impaired) and will take no more than several seconds longer than the alternative, this is not seen as a significant concern. On the contrary, one could argue that this added precision gives the scanning operation more semantic value: since it takes more effort to complete an action, the reward must be more significant. The stand device's slot would in this case be given an increased width at the top, so visitors can more easily fit their badges into it.

Figure 33: The way the personal device would fit into the stand device.

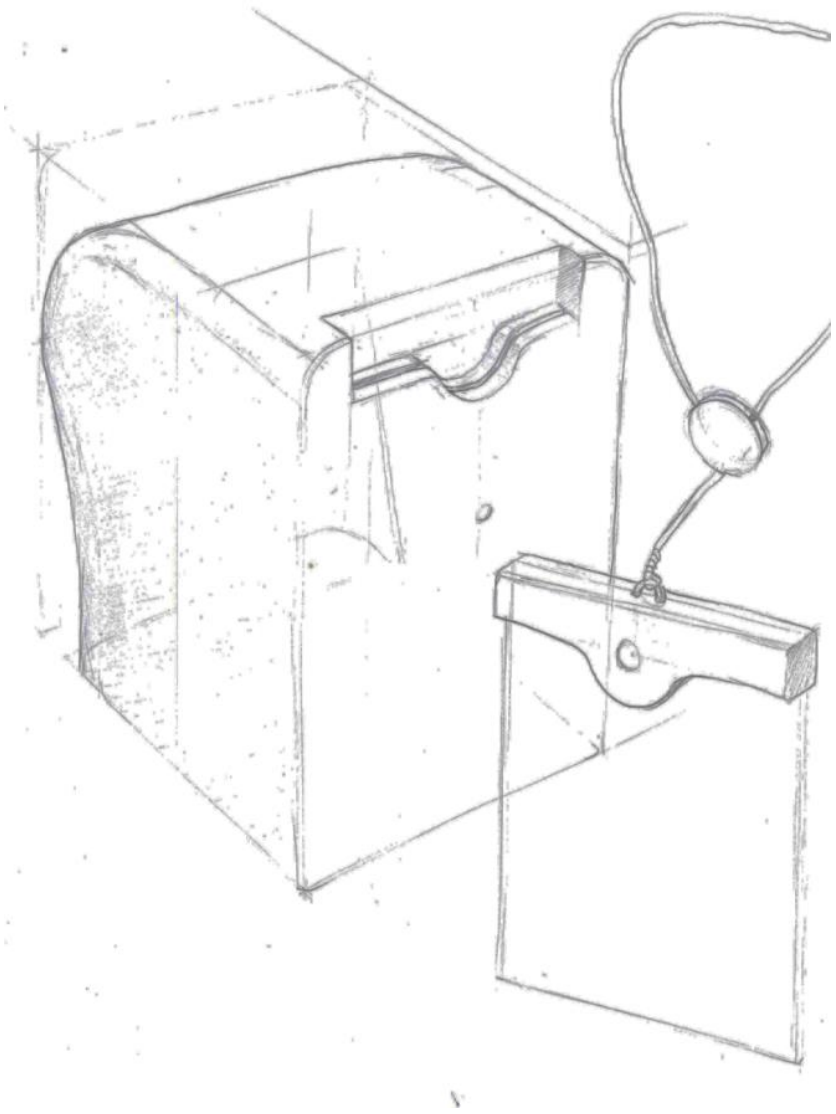


Figure 34: The match in form between the two devices

Form concept ideation

This form then went through an extra ideation phase (figure 35).

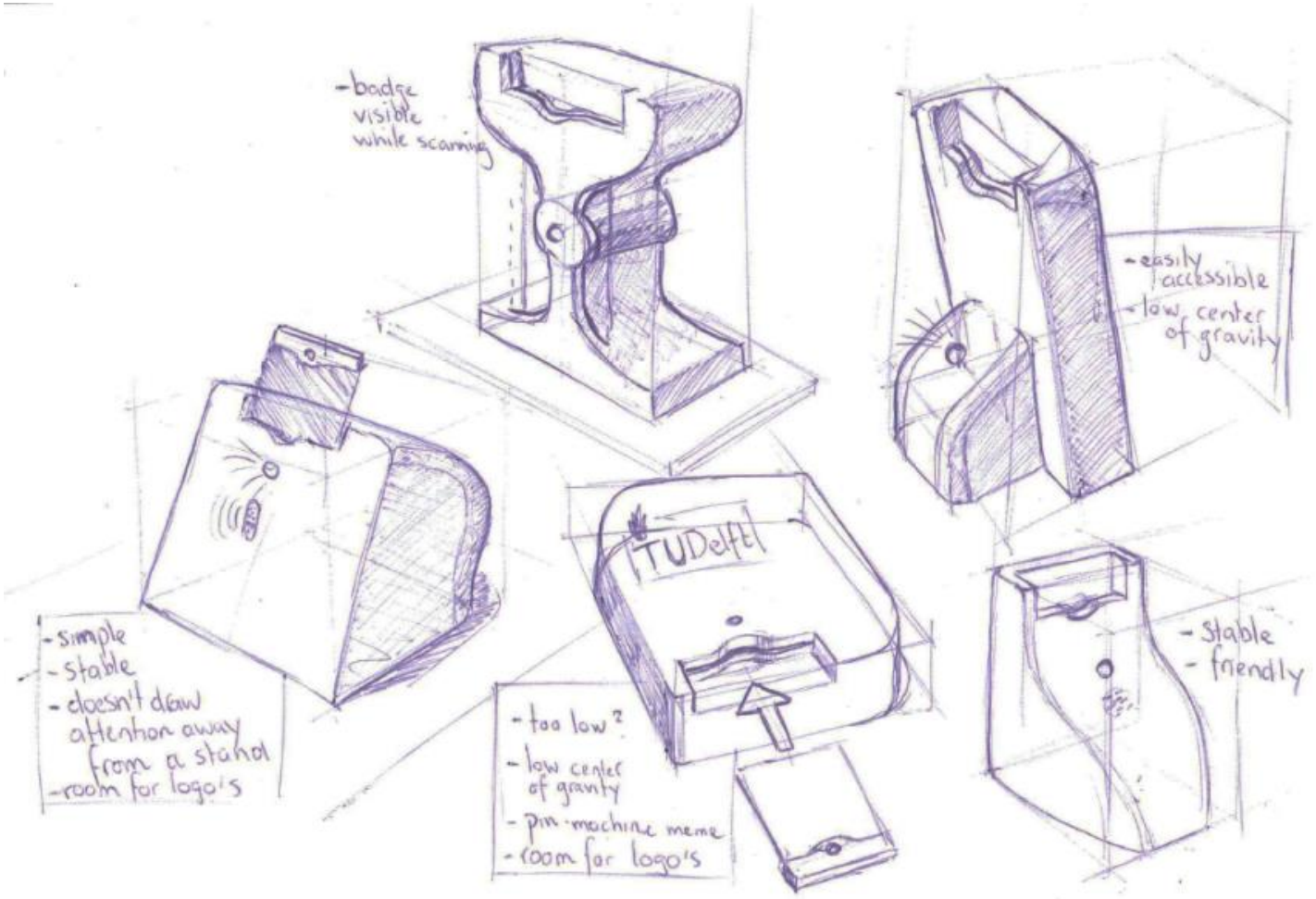


Figure 35: An ideation on how this form concept could be applied

Preliminary design

This design was created after a brief brainstorm session on how to apply the aforementioned form concept into a more noticeable, accessible, and visually appealing design. Its accessibility was enhanced by tilting the device forwards and therefore presenting its slot to the visitor. The frontal extrusion at the bottom allows the device to be rather tall yet still stable, and creates room for electronic components; the QR-code scanner in particular. It also allows for an instruction message to be displayed to the visitors (figure 36).

After some evaluation, however, this design had some room for improvement. Although the reasoning behind its shape is sound, it's aesthetic quality is not as good as it can be. This is especially important in the world of trade fairs, where the design of a stand and its content can be a determining factor in the success of an exhibitor. Furthermore, this design would require the personal device to be rotated before being inserted before its QR code can be scanned. This unexpected operation might cause a number of scans to fail.

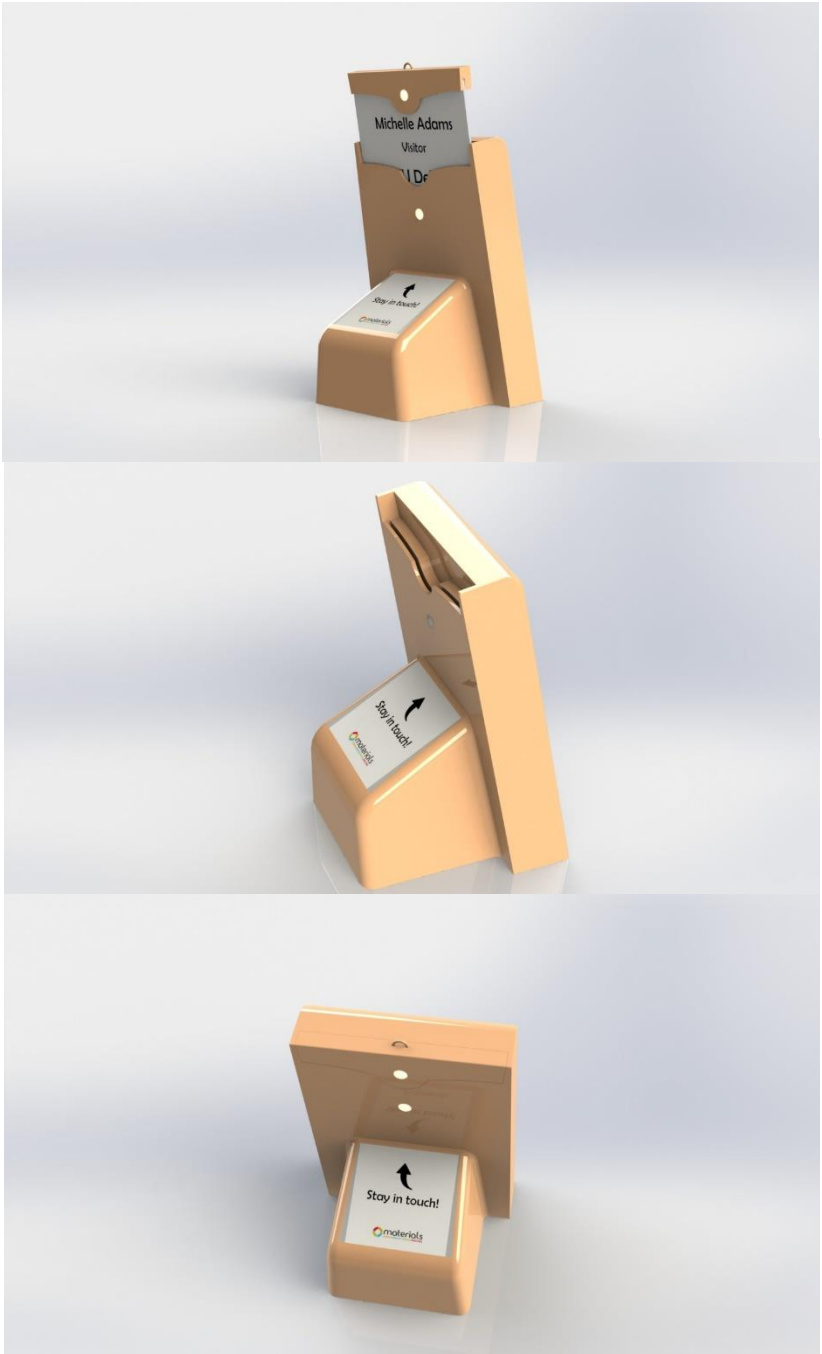


Figure 36: The preliminary design of both devices

Brainstorm session

The importance of the stand device's role in the creation of the system's data has led to an exploratory brainstorm session regarding its design. The goal of this session was to look critically at the current design and all its implications (position in a stand, operation required by visitor), and allow enabled designers to give their opinion on how these two devices should look like (and function).

An issue that was identified by the participants of this session was that the ergonomic quality of the scanning operation requires more attention. Although not previously mentioned in this report, the current plan has been to attach the personal device to a retractable lanyard (figure 37) which was to be worn around the visitor's neck. The badge could then be pulled away from the user's neck whenever they want to scan the device at a stand. While this is a valid option, it has several downsides: it limits the orientations in which a badge can be held or placed relative to a stand device, and it can be experienced as uncomfortable by the visitor.

Another critical note was made in regards to the role played by the QR code in this system, especially in regards to the current and future modernization of trade fairs. While these codes where partly chosen because they are already commonly seen at these events, they can already be seen as old-fashioned and do therefore not contribute to the modernization of the trade fair business. Another point that was brought up is that their application is rather devious. Simpler methods like NFC or fingerprint recognition were preferred.

The scanning method that was preferred by these participants was to lay the badge onto a surface (much like a piece of a jigsaw puzzle) rather than to insert it into a slot, or to loosely place it into a cavity. When inserting it into a slot, they suggested to design the personal device in an asymmetrical manner so that the right orientation becomes more obvious to the visitor.

The feedback received in this session has been used to improve the aforementioned design of the two devices and make them visually more appealing, more instinctively useable, and more inviting.

Figure 37: Retractable lanyard badge holders

Badge Design

First iteration

The badges initial design only used colour coding, and made it quite hard for exhibitors to distinguish between the colours used to indicate objectives and those who referred to interests (figure 38).

Figure 38: The badge design's first iteration

Colour study

A colour study was done to determine the optimal colour to match the aforementioned product character features (figure 39). This was done by making an inventory of potential colours (partly taken from the aforementioned collage, figure 39). These were then applied to the SolidWorks model and rendered under realistic lighting in order to be able to make a well-informed choice.

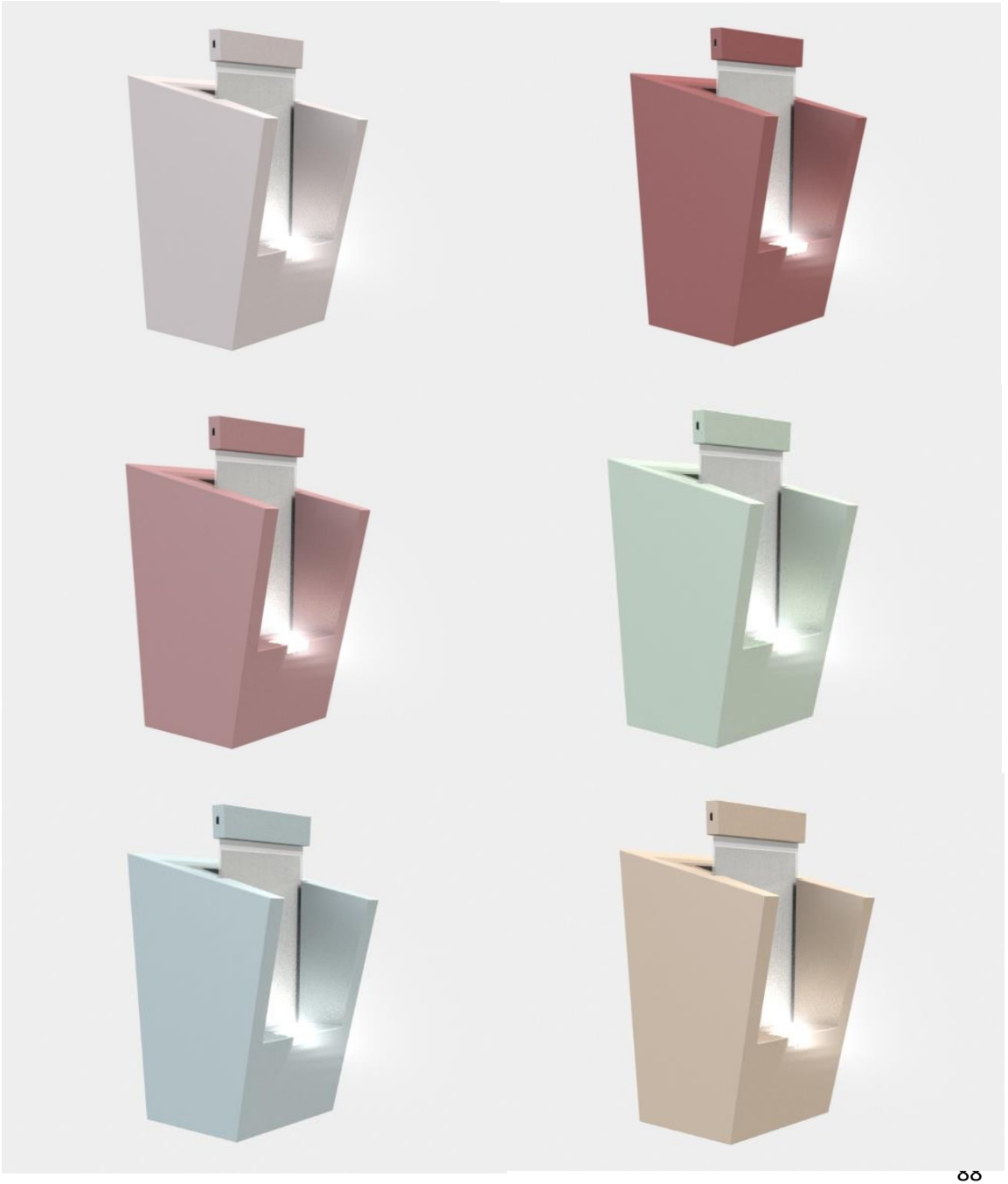


Figure 39: Colour study

26 - Communication options

Stand device to personal device

As far as the longer-range communication (stand device to personal device) is concerned, several options were considered:

- The first one was that the personal device would take an active role in discovering matches with exhibitors by transmitting visitor data to a stand device when in close proximity to it. The stand device would then process the data and determine the presence of a match, and send this binary signal back to the personal device so it could alert its user accordingly. This method would take most processing requirements away from the badge, possibly allowing it to be designed smaller.
- The second one was that the stand devices would take the active communicative role by transmitting data about the visitors that had scanned their devices at them. The personal device would in this case only receive data from the stand device, and use this data to calculate the existence of a match itself. No data would be sent back to the stand device.
- The third option is a combination of the previous two. The stand device takes an active role in discovering matches by transmitting a simple identification signal. Upon receiving this signal, the personal device would respond by sending its visitor data to the stand device. The stand device would then calculate the existence of a match, and (in case of a match) send an activating signal to trigger the personal device's nudge.

Of these three options, the second one has been deemed to be most suitable in this system because removes the need for a transmitting component in the personal device which would have major consumer of power. The choice to calculate the existence of matches in the personal device rather than in the stand device was made to keep communication paths as simple as possible, and to keep the requirements for the communication module in the personal device as low as possible.

27 - Communication technology

Beacon transmission

Bluetooth Low Energy

While searching for a suitable broadcasting method for stand devices, it was discovered that the communication method Bluetooth is already being applied in hardware that very closely resembles the envisioned functionality of stand devices : Bluetooth beacons. The fact that the analogy of a beacon has been used in the abstraction of the natural model also suggests that this technology could be useful in this system.

Bluetooth beacons, more accurately called Bluetooth Low Energy beacons, are devices that continually or periodically broadcast information (such as their location) to be picked up by nearby devices. Two main BLE-beacon technologies on the market today are iBeacon (Apple) and Eddystone (Google) which are supported by available hardware (BlueUp, 2017). These devices are usually small (dimensions of no more than a few centimeters), and are able to send out a one-directional signal containing a small amount of data (Pointr, 2017). The fact that all these qualities match the functionalities of the stand devices is further confirmed by looking at existing products and discovering that some of them (e.g. the BlueBeacon Mini) are already being applied at, amongst others, trade fairs (BlueUp, 2017).

As mentioned earlier, proximity/range is an important factor in choosing the right technology. While the potential range of such beacons (up to 70m) is more than sufficient for the intended application, it is important to note that the type and level of interaction of a device with the beacon differs based on how close they are to each other. Most protocols distinguish three ranges: far, near, and immediate, and offer different effects to devices depending on which range it finds itself in. This optional characteristic is often used make recipients aware of their position relative to the beacon.

The hardware that will be required to enable stand devices to communicate with this technology are BLE chips; one for each device. The chip in the personal device has lower requirements, since its only function is to receive data and transfer it to a microcontroller. The stand device's chip will have to continuously transmit data. Each of these two chips therefore has different specifications (figure 40). A combination of the two is called a chipset (Argenox, 2017). The nRF51822 module will be integrated into the stand device and will act as the transmitter. The nRF8001 module will be integrated into the personal device and will act as the receiver, as this component will have no use for RAM or Flash memory. As can be seen, the nRF51822 module has an integrated processor with sufficient RAM and Flash memory to store individual data entries and chain them together to create the data strings it will transmit.

	Mode	Integrated Processor	Flash	RAM	Current Consumption BLE (RX/TX)	Average Current 1 sec / 4sec connection interval
TI CC2540/CC2541	Single Mode v4.0	8051	128kB/256kB	8kB	17.9mA / 18.2mA to 14.7mA / 14.3mA	24uA / 6.8uA
Texas Instruments CC256x	Dual Mode Classic + BLE/ANT	No - External	None	None	-	-
Texas Instruments CC26xx	Single Mode BLE v4.1	Cortex-M3	128kB	20kB	5.9mA	-
Nordic Semiconductor nRF51822	Single Mode v4.1 / ANT	Cortex-M0	128kB / 256kB	16kB / 32kB	9.7mA / 8mA	15.5uA / 5.6uA
Nordic Semiconductor nRF8001	Single Mode v4.0	None	None	None	14.6mA/12.7mA	-
Dialog Semiconductor DA14580	Single Mode BLE v4.1	Cortex-M0	32kB OTP	42kB + 8kB	4.9mA / 4.9mA	-
Cypress Semiconductor PSoC 4 BLE / PRoC BLE	Single Mode BLE v4.1	Cortex-M0	128kB / 256kB	16kB / 32kB	15.6mA / 16.4mA	18.9uA / 6.2uA
CSR CSR101x	Single Mode BLE v4.1	16-bit RISC	64kB	64kB	16mA	28uA / 10.8uA

Figure 40: The selected BLE modules

BLE might be slightly overqualified for the current design, but allows for the potential expansion of functionality of the personal device in particular. While, at the moment, the module in the personal device only transmits an ID-number to the stand device to provide exhibitors with the aforementioned scanning percentage data, it could be used in the future to send more data with additional benefits. Possibly also to receivers other than the stand devices.

Range

While BLE transmitting modules have a range of up 100 meters (Sponas, 2016), stand devices will not make full of this potential. Since the stands at trade fairs are often packed rather closely together, it is important to limit the range of transmission of stand devices so that a personal device does not send a nudge to its user when he/she is not close enough to the concerned stand.

BLE range depends on the following factors (Jon Gunnar Sponas, 2016):

- Output power of the transmitter
- Sensitivity of the receiver
- Physical obstacles in the transmission path
- Antenna properties

Physical objects are not expected to be an issue at trade fairs. While at crowded events (like the PromZ fair) walking aisles can be quite filled with visitors, the stand device will want to reach only those at the edges of the aisles in order to avoid ambiguous nudges. This characteristic actually helps the system, since neighboring stands (especially those behind a stand) will prevent the signal from reaching visitors on another aisle.

Another possible range-limiting method is to program a peripheral module to only connect with a central module when it is within a certain range, or vice versa. This would be more precise, and when the stand devices are programmed this way it would allow for them to be customized based on their location and surroundings.

Scanning personal devices

Scanning personal devices

The second way in which the personal devices and stand devices interact with each other is through a scanning process. Unlike the previous communication method, this one must be precise. Only personal devices that are intentionally being scanned by its user must be registered, which is why this communication method must filter out other devices by only connecting with those at very close proximity (<10cm).

A second scenario in which a similar close range wireless communication method can be used, but for which a data transfer method has not yet been chosen, is the act of uploading a visitor data profile from the central computer at the reception desk to each personal device. The design of the personal device would certainly benefit from the efficiency (both in terms of costs as well as size) of using the same communication principle being used for two purposes.

Near-field communication (NFC)

NFC is a short-range (<10cm) wireless communication principle based on the principle of radio frequency identification (RFID) (Trasher, 2013). It allows two devices to exchange information, on the condition of both devices containing an NFC module (Unitag, 2017). Besides being more precise than the general principle of RFID, NFC also enables a two-way stream of communication: a device that has been equipped with an NFC-module can act as both a receiver and transmitter (figure 41).

Figure 41: A well-known application of NFC scanning

Quick Response (QR) code

Another method that was considered is the use of QR codes. These would be individually generated for each personal device

An important difference between QR and NFC is that the latter is easier and faster to use because it only requires close proximity (Nearfieldcommunication.org, 2017). The scanning of a QR code also requires a precise location and orientation of the personal device relative to the stand device. While this may initially sound as a disadvantage because it requires more effort from users, it actually prevents other devices from being scanned accidentally. This issue of increased user effort can however be solved by clever design of both devices. The badge already has a natural

orientation from the way it is worn and the way text is placed on it, which further diminishes this potential issue.

Interesting to note is that the visitor badges at the PromZ fair also featured a QR code on them. These were used to scan the visitor badge (which had to be printed by the visitor on beforehand) at the entrance of the fair in order to register their presence.

Conclusion

While there is only need for a one-way stream of data in both of the scenario's, the fact that NFC allows for a two-way communication does benefit this design. It means that the personal device will only have to be equipped with one NFC-module. The use of QR codes, however, appears to offer more benefits on the one condition that user-centered design prevents any visitor from failing to scan their QR code at the stand device. There will also have to be another way to upload the visitor profile to the personal device, since data in the form of a QR code cannot be used by the device to determine a match.

Central communication

Central communication

Visitor data collected by the stand devices must be sent to a central computer, either during or after the fair. This is necessary for the organizer to be able to send feedback to its visitors regarding their scans. Furthermore, at trade fairs which chose to implement the interactive map will need to collect this data in real time to be used by these devices. An inventory of four options to realize this communication path was made:

- Equip the stand device with an additional module (e.g. Wi-Fi), capable of transmitting data over a sufficient distance to communicate with a central computer at a trade fair of any size.
- Use stand devices as a chain of communication. Stand devices that are too far away from the central computer send their data to a more nearby device until it reaches a device which can send it directly to the central computer or the interactive map.
- Use a mobile collection device, perhaps carried by a trade fair employee. This device would have to frequently come into BLE-range of each stand device in order to be effective. Could be integrated into the personal device.
- Use wired communication paths between the stand device's and the central computer

While solid evidence is missing, sources from within the BLE-module manufacturer (Nordic, 2017) strongly suggest that modules from the nRF5-series can be used to relay a transmission from one BLE module to a central collector. This collector would in this case either be another nRF51822 module, the event's central computer, or the optional interactive map. This functionality would require each stand device's BLE module to be programmed like this:

- Attempt to connect to a device with the central computer's ID
    - If successful, transmit collected data

- If unsuccessful, connect to farthest available nRF51822 module and transmit collected data.

In regard to the first option, Han Bosman of OGZ expressed his concern about using a WiFi network for this application because of the large number of other networks present at such a crowded event. An alternative to WiFi was suggested by an exhibitor at the Big Data Expo. This representative for a company that specializes in cloud storage, and suggested the use of a mobile data network by equipping the stand devices with pre-paid SIM-cards. This network would then be used to store all data in the cloud.

Conclusion

As will become clear later in this report, this system will require significantly more personal devices than stand devices (estimated ratio of 1:42). This means that an investment in the stand device will not significantly increase the production costs of all the system's necessary components. This is why the option of adding a long-range communication module to the stand device will be regarded as the second option, in case the relaying of a BLE signal turns out not to be feasible. More research will be necessary to determine whether or not the first option is feasible.

28 - Additional hardware

Power supply

In many modern personal devices, the smartphone for example, the battery is the limiting factor in terms of size. This will also be one of the determining factors in the choice for the personal device. A relevant factor for both devices is battery life. As stated in the program of requirements, the minimal battery life for both devices must be attuned to the longest possible trade fair duration in a single day. Optimally, the devices are usable for multiple days without being recharged or replaced in between.

Both rechargeability and replaceability have their (dis)advantages. Equipping a device with a rechargeable battery is usually more cost-efficient in long term situations. It does, however, require the purchase/production of a set of chargers, resulting in a higher investment cost. Since the system will consists of a large number of devices it will also require a multitude of chargers to refuel the system in time for the next event, although the number depends on the charging time and time between trade fairs. A replaceable battery has a lower investment cost, but its costs will catch up with (and exceed) those of a rechargeable battery over time. Their main practical advantage is the speed with which they allow empty devices to be usable again.

In practice, the choice between these two functionalities comes down to the choice between a Lithium-polymer (rechargeable) and Coin cell (replaceable) battery, as far as the personal device is concerned (Tran, 2016). The former type of battery comes in many different sizes, including small enough versions to fit in the personal device. They also lend themselves to be produced in a custom size.

Coin cell batteries have a fixed shape (that of a coin). Their size ranges from 5 to 25mm in width and 1 to 6mm in height, making them an excellent choice for a flat device like the envisioned smart badge. These batteries have a restricted charge capacity, and are generally used in devices that require a low power draw over a long period of time (Batteries.com, 2017).

The stand device will also be equipped with a replaceable battery. However, because this device will draw significantly more power than the personal device and there is a lot more room available, a battery type with a higher capacity will be chosen. Two AA batteries have been chosen for this, because (as will be explained later) the circuit will require a supply of 3V.

Conclusion

A coin cell battery will be used in the personal device because of its expected low power requirement. Also, since it won't be used very often in a year the battery will not have to be replaced frequently. For the stand device, even if its power consumption turns out to be low, double AA batteries appear to be the best choice because there is no real space restriction in this device's casing. Choosing a battery with a larger capacity means it will have to be replaced less frequently.

29 - Battery life personal device

Assumptions

- Nudge is given for 4 seconds once every 10 minutes.
    - 0.67% of the time.
- BLE-chip is constantly receiving data with 1s intervals
- The microcontroller has to compare its data to an incoming message every 20 seconds, which takes 2 seconds.
    - 10% of the time

Battery

- Standard 2032 3V coin cell battery
    - 235mAh

Power consumption per part

- LED: 350mA
    - Could be optimized
    - 350 x 0.67% = 2.345mA on average

- Vibration: max. 60mA
    - 60 x 0.67% = 0.402mA on average

- nRF8001 (Nordic, 2017):
    - peak current: 12.5mA
    - average current: 0.009 mA (receiving at 1s intervals)
    - The nRF8001 chip has "a DC/DC voltage regulator that, when enabled, can further cut current consumption by up to 20% when running from a 3V battery cell."

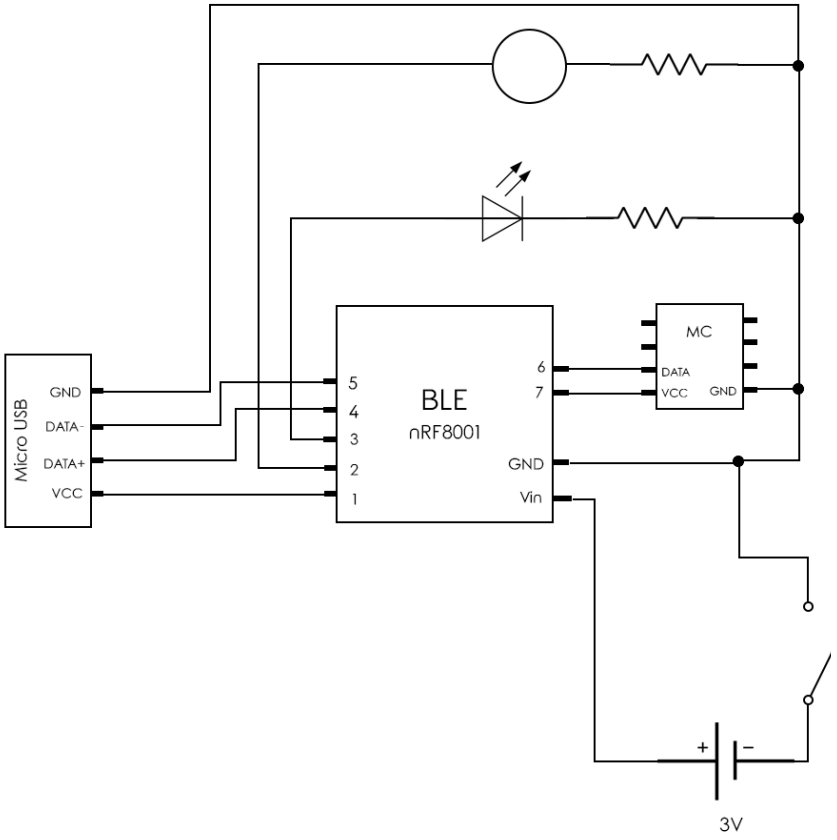
- feedback LED:
    - 10mA
    - Optional replacement:
        - 1.9V - 2mA green LED
            - L-7104LGD, Kingbright
- Microcontroller:
    - 25mA source/sink current
        - 25 x 10% = 2.5mA on average
    - 100nA = 0.0001mA sleep current (negligible?)

Total current consumption

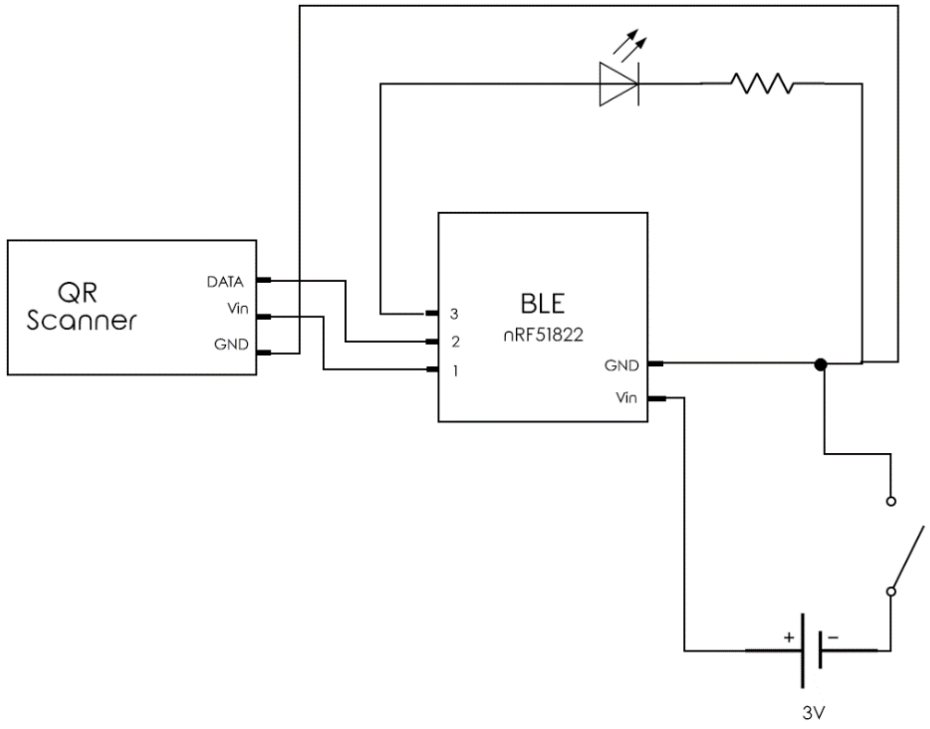
- 2.345 + 0.402 + 0.009 + 2.5 + 2 = 7.256 mA
    - 235 mAh/ 7.256 mA = 44 hours = 5,5 days

30 - Electronic circuits

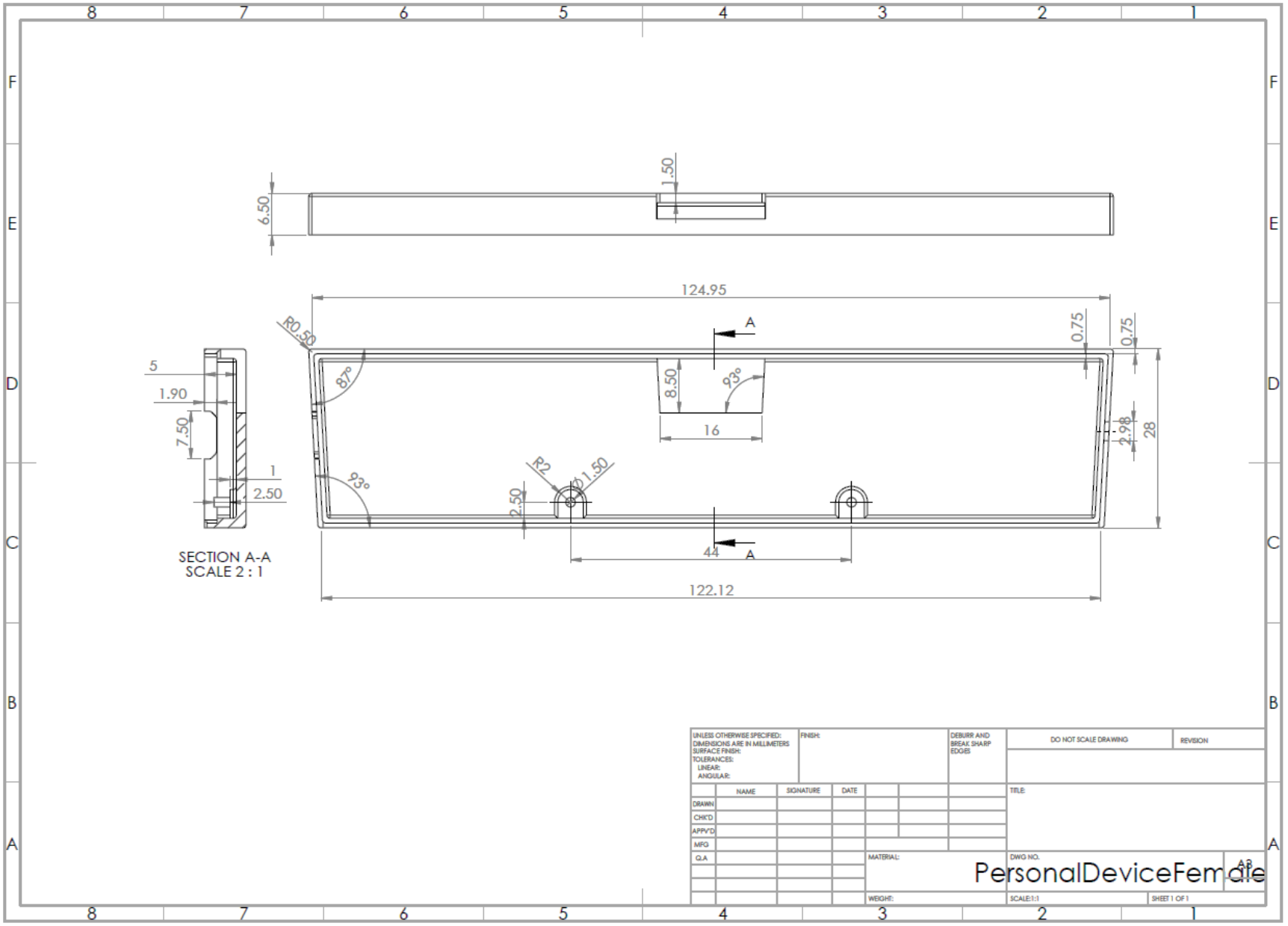
Personal device

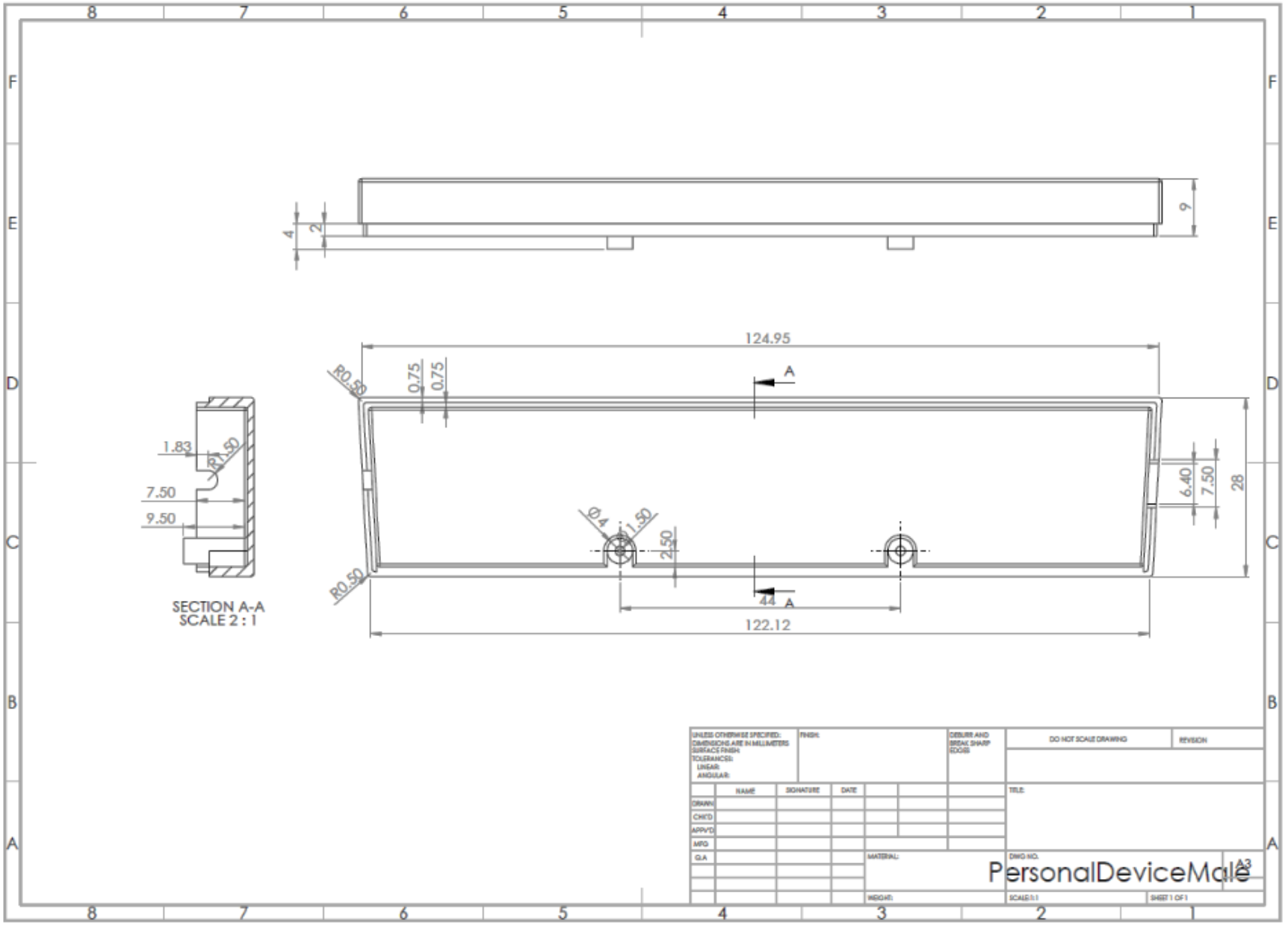


Stand device



31 - Technical drawings

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122.12
44
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7.50
9.50
R1.50
R0.50
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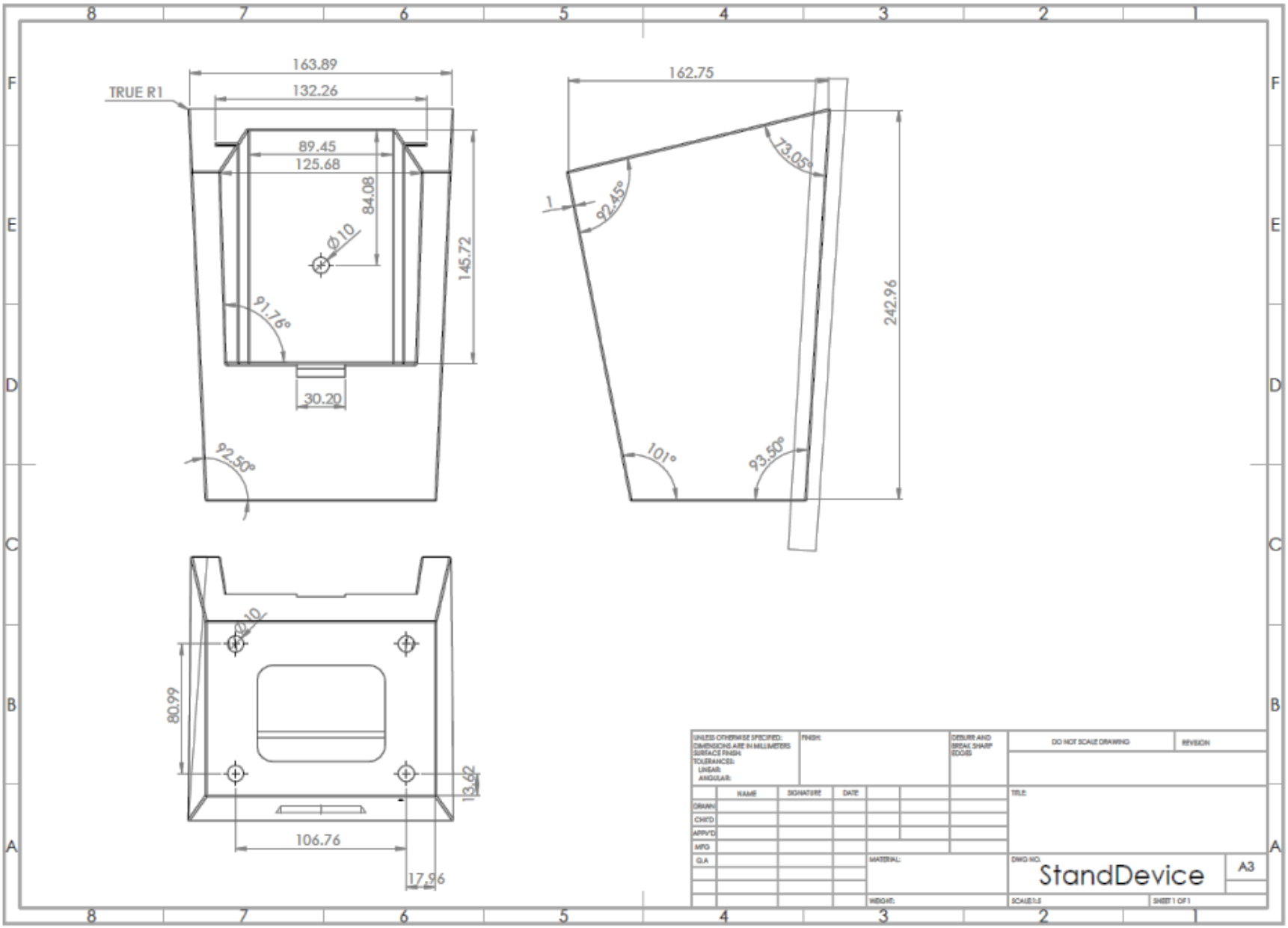
PersonalDeviceMale
A3


163.89
132.26
TRUE R1
89.45
125.68
84.08
Ø10
145.72
91.76°
30.20
92.50°
162.75
73.05°
1
92.45°
242.96
101°
93.50°
Ø10
80.99
13.62
106.76
17.96
DO NOT SCALE DRAWING
REVISION
TITLE:
StandDevice
A3
SHEET 1 OF 1

32 - Business Model Canvas

Key Partners

Trade fair organizers

Major exhibitors

Software designer

Hardware suppliers

Custom part producers

BLE-beacon platform

Key Activities

Before the product is usable by customers, it must be produced, customized for a particular fair, and transported to its location.

Key Resources

Patent

Visitor data

Investment capital

Storage facility

Value Proposition

The product enables trade fairs to become more effective for both visitors and exhibitor, by increasing the chance both parties will establish a contact based on the content of the stand and the objectives and interests of the visitor

The organizer benefits from this because their participants become more satisfied with the event and are therefore more likely to return

Customer Relationships

This system will have relatively few customers. A key of its success will lie in maintaining good customer relationships with these clients, as their events return every year

Channels

The product will be bookable online, and delivered to the trade fair's location.

Customer Segments

The intended users of this product are organizers of trade fairs in The Netherlands and optionally in Belgium. The larger the fair, the more it will benefit from this product.

Optional future clients of a slightly redesigned product could be musea, exhibits, or festivals

Cost Structure

The costs of this system mainly lie in the production of its two hardware components. Because of irregular customers (time & location), transportation costs will also be relatively high.

Revenue Streams

Revenue will be generated from the leasing of a product set to various trade fairs throughout the year. A customer can lease the product once, but can also make a long-term deal for multiple events at a reduced price.

33 - Visitor and exhibitor numbers

All data has been taken from the official websites of each event.

Overall

Stand device: derive from average number of exhibitors on main trade fairs in the Netherlands

Personal device: derive from average number of visitors at main trade fairs in the Netherlands

- Buitenland Beurs: 110 exhibitors, 6,000 – 8,000 visitors
  2 days
  V/E = 63.6

- Big Data expo: 80 exhibitors, 3500 visitors
  2 days
  V/E = 43.8

- Materials fair: 82 exhibitors, over 1,000 visitors
  2 days
  V/E = 12.2

- PromZ fair: 198 exhibitors
  2 days

- Maritime Industry fair: 507 exhibitors, almost 14,000 visitors
  3 days

- Webshop vakbeurs (BE): 60 exhibitors, 3,000 visitors
  2 days
  V/E = 50

As can be seen from these numbers, the sizes of these six trade fairs are rather uniform with the exception of the Maritime Industry fair. Since this is also the only event which takes 3 instead of 2 days, it has not been included in this estimation.

OGZ events

- Buitenland Beurs: 110 exhibitors, 6,000 – 8,000 visitors
  2 days
  V/E = 63.6

- Big Data expo: 80 exhibitors, 3500 visitors
  2 days
  V/E = 43.8

- Webshop vakbeurs (BE): 60 exhibitors, 3,000 visitors
  2 days
  V/E = 50

- Onderwijsbeurs Zuid: 110 exhibitors, 20,000 visitors
  2 days
  V/E = 182

- Onderwijsbeurs Noord-oost: 98 exhibitors, 13,000 visitors
  2 days
  V/E = 132

- StudieBeurs West: 60 exhibitors, 9,000 visitors
  2 days
  V/E = 150

- Studiekeuzebeurs Midden: 58 exhibitors, 10,000 visitors
  2 days
  V/E = 172

- TABAK Retail: 40 exhibitors, 1300 visitors
  2 days
  V/E = 32.5

34 - Costs

Stand device

LED

$0.83 = 0.70 euro per piece (LEDsupply, 2017)

BLE module

€5.58 per piece (figure 42, (Mouser, 2017))

Figure 42: The price for 106 nRF51822 modules

Battery holder

€0.81 per piece (figure 43, (Mouser, 2017))

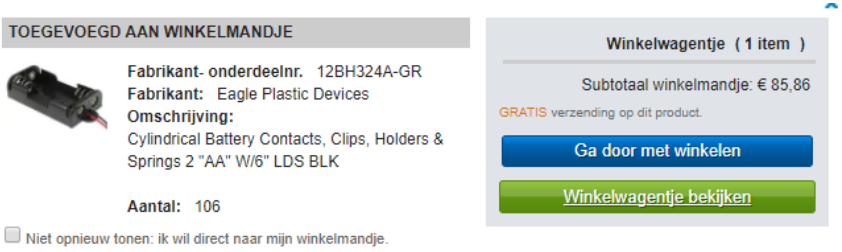


Figure 43: The price for 106 double AA battery holders

Battery (AA)

€0.219 per battery (250 pieces)
€0.438 per stand device (Mouser, 2017)

QR code scanner

$13 = €10.92 per piece (Alibaba, 2017)

Personal device

BLE module

€1.79 per piece (figure 44, (Mouser, 2017))

Figure 44: The price of 3650 nRF8001 modules

Keycord

€1.48 (Promofit, 2017)

Micro USB port

€0.281 per piece (figure 44, (Mouser, 2017).

Figure 44: The price of 3650 micro USB ports

Badge holder

$14.06 per 50 = $0.28 per piece = €0.23 per piece (DHgate, 2017)

Vibration motor

Roughly €0.30 per piece (AliExpress, 2017)

Microcontroller

$0.42 = €0.35 per piece (Microchip, 2017)

Battery (coin cell, 3V)

$0.88 = 0.72 euro per piece (MedicBatteries, 2017)

Battery holder

€0.585 per piece (figure 45, (Mouser, 2017))

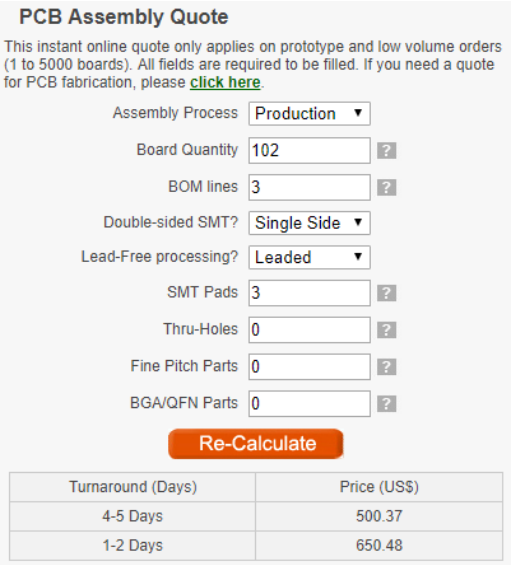
Figure 45: The price of 3650 coin cell battery holders

Battery feedback LED

€0.173 per piece (figure 46, (Mouser, 2017))

Figure 46: The price for 3650 feedback LED's

PCB Assembly (Bitelle, 2017)



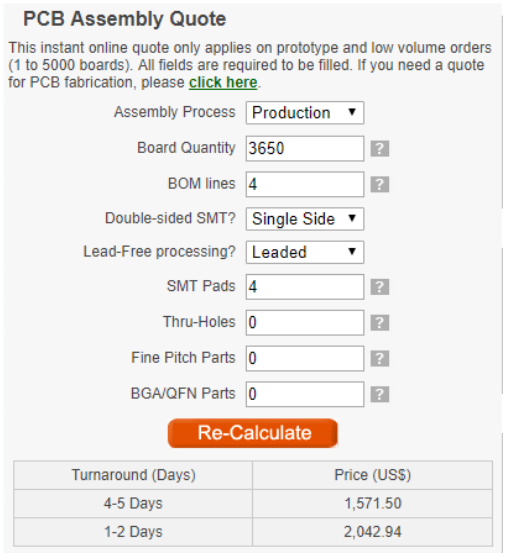
PCB Assembly Quote

This instant online quote only applies on prototype and low volume orders (1 to 5000 boards). All fields are required to be filled. If you need a quote for PCB fabrication, please click here.

Assembly Process	Production
Board Quantity	102
BOM lines	3
Double-sided SMT?	Single Side
Lead-Free processing?	Leaded
SMT Pads	3
Thru-Holes	0
Fine Pitch Parts	0
BGA/QFN Parts	0

Re-Calculate

Turnaround (Days)	Price (US$)
4-5 Days	500.37
1-2 Days	650.48



PCB Assembly Quote

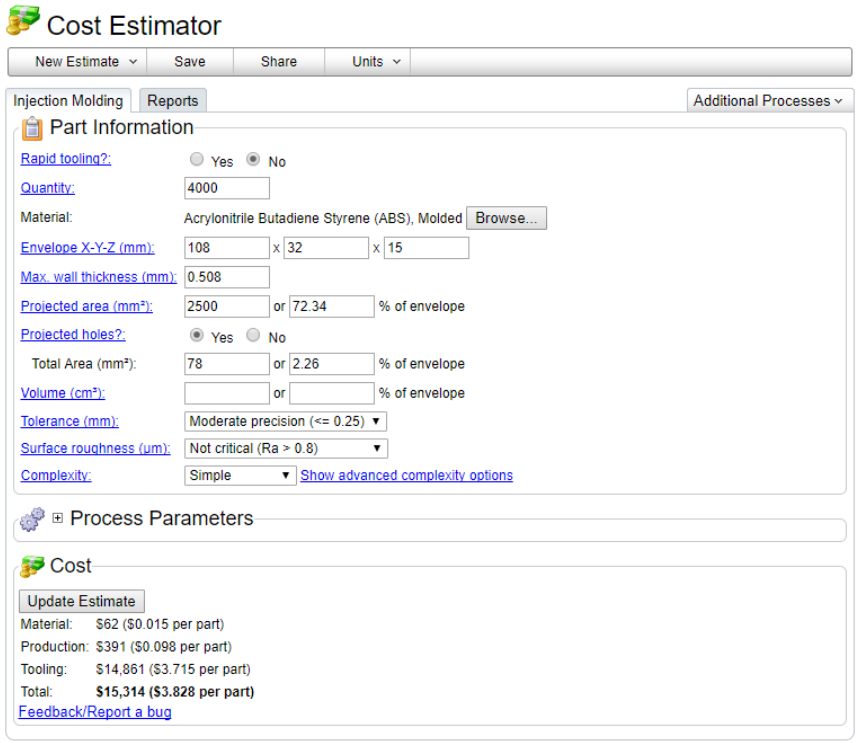
This instant online quote only applies on prototype and low volume orders (1 to 5000 boards). All fields are required to be filled. If you need a quote for PCB fabrication, please click here.

Assembly Process	Production
Board Quantity	3650
BOM lines	4
Double-sided SMT?	Single Side
Lead-Free processing?	Leaded
SMT Pads	4
Thru-Holes	0
Fine Pitch Parts	0
BGA/QFN Parts	0

Re-Calculate

Turnaround (Days)	Price (US$)
4-5 Days	1,571.50
1-2 Days	2,042.94

Injection molding (Custompart.net, 2017)



Cost Estimator

New Estimate | Save | Share | Units

Injection Molding | Reports | Additional Processes

Part Information

Rapid tooling?	Yes / No
Quantity:	4000
Material:	Acrylonitrile Butadiene Styrene (ABS), Molded [Browse...]
Envelope X-Y-Z (mm):	108 x 32 x 15
Max. wall thickness (mm):	0.508
Projected area (mm²):	2500 or 72.34 % of envelope
Projected holes?	Yes / No
Total Area (mm²):	78 or 2.26 % of envelope
Volume (cm³):	or % of envelope
Tolerance (mm):	Moderate precision (<= 0.25)
Surface roughness (um):	Not critical (Ra > 0.8)
Complexity:	Simple — Show advanced complexity options

Process Parameters

Cost

Update Estimate

Material: $62 ($0.015 per part)
Production: $391 ($0.098 per part)
Tooling: $14,861 ($3.715 per part)
Total: **$15,314 ($3.828 per part)**

Feedback/Report a bug

Stand device casing

The following quotation was received from Formit BV, a sheet plastic production company located in Valkenswaard. It was made after an analysis of the SolidWorks model and accompanying technical drawings of the stand device's casing.

Formit

PROJECTS ENGINEERING
SHEET PLASTIC PRODUCTS
ASSEMBLY

Formit B.V.
Dragonder 15b
5554 GM, Valkenswaard
Phone: +31 (0)40 - 2662920
Fax: +31 (0)40 - 2662921
Email: info@formit.nl
www www.formit.nl

Rabobank Valkenswaard 108208893
K.v.K. Eindhoven: 17104677

Firma	:	Daniel Salomon
T.a.v.	:	Dhr. Daniel Salomon
Aantal bladen	:	1 (incl. voorblad)
Onze referentie	:	**FI1709126**
Uw referentie	:	E-mail 19-09-2017

DATUM: 2 oktober 2017

Beste Daniel,

Onderstaand onze offerte met richtprijzen voor de gevraagde kunststof behuizing.

Omschrijving	:	**Behuizing Vorm 3**				
Bestelnummer	:					
Bestel serie	:	10 stuks	25 stuks	50 stuks	100 stuks	200 stuks
Stuksprijs	:	142,75 EUR	97,05 EUR	75,95 EUR	59,80 EUR	52,35 EUR

Eenmalige kosten : 1150,00 EUR (prototype- en programmakosten).

Condities:

Prijs	:	Alle prijzen zijn netto, exclusief btw, in EURO's.
Verpakking	:	Exclusief.
Geldigheidduur offerte	:	3 maanden na offertedatum.
Levering	:	Af fabriek.
Levertijd prototype	:	4 weken na ontvangst schriftelijke opdracht.
Levertijd serie	:	4 weken na ontvangst schriftelijke opdracht en vrijgave prototype.
Betaling	:	30 dagen netto na levering.

Opmerkingen:

Materiaal	:	HIPS met éénzijdig zandnerf. Dikte 3 mm.
Kleur	:	Eén van onze standaard kleuren.
Opbouw	:	Volgens de gemailde STEP-file, waarbij de opbouw enigszins moet worden aangepast aan onze kunststof plaatwerk techniek.

We vertrouwen erop je met het bovenstaande een interessante aanbieding te hebben gedaan en zien nadere ontwikkelingen in deze met belangstelling tegemoet.

Met vriendelijke groet,

Rob van der Haar
Formit b.v.

Data sheets

QR code scanner (Alibaba, 2017)

Snelle Details

type interface:	usb, com, USB Virtual com, USB ...	kleurdiepte:	8 bits Mono	plaats van herkomst:	China(vasteland)
naam van het merk:	TOTINFO	modelnummer:	E413	scannen element type:	ccd
Max. papierformaat:	N/a	type:	barcode scanner	scansnelheid:	300 Scans/sec
optische resolutie:	3mil	producten de status:	voorraad	gezichtsveld:	50 °
gericht:	zichtbare rode LED	afmetingen (Lx W x H):	alleen 22.5mm * 11.6mm * 8.3m...	Scan Modus:	Trigger/Commando/Gevoel mod...
Scherptediepte:	40mm ~ 560mm	Print Contrast:	25% minimum reflectie	Bedrijfsstroom:	< 90 mA typ @ 3.3 V
lage Power Huidige:	< 0.3 mA	Ingangsspanning:	3.3 VDC ± 0.3 V	symbolieken:	alle 1D

Microcontroller (Personal device, (Microchip, 2017))

Features

- Available in either SOT-23 or 2x3 DFN packaging
- Precision 4 MHz internal oscillator
- Baseline Core with 33 Instructions, 2 Stack Levels
- All single-cycle Instructions except for program branches which are two cycles
- 12-bit wide instructions
- 8-bit wide data path
- 25 mA source/sink current I/O
- Low power (100nA) sleep current
- One 8-bit timer (TMR0)
- Watchdog timer (WDT)
- In Circuit Serial Programming™ (ICSP™) capability
- In-Circuit debugging support
- Programmable code protection

Parameter Name	Value
Program Memory Type	Flash
Program Memory (KB)	0.375
CPU Speed (MIPS)	1
RAM Bytes	16
Timers	1 x 8-bit
Temperature Range (C)	-40 to 125
Operating Voltage Range (V)	2 to 5.5
Pin Count	6

BLE Modules (Nordic, 2017)

NORDIC SEMICONDUCTOR

nRF51822

Multiprotocol *Bluetooth*® low energy/2.4 GHz RF System on Chip

Product Specification v3.3

Key Features

- 2.4 GHz transceiver
  - -93 dBm sensitivity in *Bluetooth*® low energy mode
  - 250 kbps, 1 Mbps, 2 Mbps supported data rates
  - TX Power -20 to +4 dBm in 4 dB steps
  - TX Power -30 dBm Whisper mode
  - 13 mA peak RX, 10.5 mA peak TX (0 dBm)
  - 9.7 mA peak RX, 8 mA peak TX (0 dBm) with DC/DC
  - RSSI (1 dB resolution)
- ARM® Cortex™-M0 32 bit processor
  - 275 µA/MHz running from flash memory
  - 150 µA/MHz running from RAM
  - Serial Wire Debug (SWD)
- S100 series SoftDevice ready
- Memory
  - 256 kB or 128 kB embedded flash program memory
  - 16 kB or 32 kB RAM
- On-air compatibility with nRF24L series
- Flexible Power Management
  - Supply voltage range 1.8 V to 3.6 V
  - 4.2 µs wake-up using 16 MHz RCOSC
  - 0.6 µA at 3 V OFF mode
  - 1.2 µA at 3 V in OFF mode + 1 region RAM retention
  - 2.6 µA at 3 V ON mode, all blocks IDLE
- 8/9/10 bit ADC - 8 configurable channels
- 31 General Purpose I/O Pins
- One 32 bit and two 16 bit timers with counter mode
- SPI Master/Slave
- Low power comparator
- Temperature sensor
- Two-wire Master (I2C compatible)
- UART (CTS/RTS)
- CPU independent Programmable Peripheral Interconnect (PPI)
- Quadrature Decoder (QDEC)
- AES HW encryption
- Real Timer Counter (RTC)
- Package variants
  - QFN48 package, 6 x 6 mm
  - WLCSP package, 3.50 x 3.83 x 0.50 mm
  - WLCSP package, 3.50 x 3.83 x 0.35 mm
  - WLCSP package, 3.83 x 3.83 x 0.50 mm
  - WLCSP package, 3.83 x 3.83 x 0.35 mm
  - WLCSP package, 3.50 x 3.33 x 0.50 mm

Applications

- Computer peripherals and I/O devices
  - Mouse
  - Keyboard
  - Multi-touch trackpad
- Interactive entertainment devices
  - Remote control
  - Gaming controller
- Beacons
- Personal Area Networks
  - Health/fitness sensor and monitor devices
  - Medical devices
  - Key-fobs + wrist watches
- Remote control toys

NORDIC SEMICONDUCTOR

nRF8001

Single-chip *Bluetooth*® low energy solution

Product Specification 1.3

Key Features

- *Bluetooth* low energy peripheral device
- Stack features:
  - Low energy PHY layer
  - Low energy link layer slave
  - Low energy host for devices in the peripheral role
  - Proprietary Application Controller Interface (ACI)
- Hardware features:
  - 16 MHz crystal oscillator
  - Low power 32 kHz ± 250 ppm RC oscillator
  - 32.768 kHz crystal oscillator
  - DC/DC converter
  - Temperature sensor
  - Battery monitor
  - Direct Test Mode interface
- Ultra-low power consumption
- Single 1.9 - 3.6 V power supply
- Temperature range -40 to 85°C
- Compact 5x5 mm QFN32 package
- RoHS compliant

Applications

- Sport and fitness sensors
- Health care sensors
- Proximity
- Watches
- Personal User Interface Devices (PUID)
- Remote controls

Costs of devices

Stand device

Component	Price per unit	Total costs (102 units)
nRF51822	€5.58	€591.22
LED	€0.70	€74.2
Battery	€0.44	€44.88
Battery holder	€0.81	€82.62
Battery feedback RG LED	€0.17	€17.34
QR code scanner	€10.92	€1,157.52
Casing*	€71.30	€7,272.60
PCB Assembly**	€4.91	€500.37
Total	€94.66	€9,655.32

*material, production, and tooling costs

**wires, switch, resistors, breadboard (estimate)

Personal device

Component	Price per unit	Total costs (3650 units)
nRF8001	€1.79	€6,533.50
Microcontroller	€0.35	€1,277.50
Micro USB port	€0.28	€1,025.65
LED	€0.70	€2,555.00
Battery	€0.72	€2,628.00
Battery holder	€0.59	€2,153.50
Battery feedback RG LED	€0.17	€631.45
Casing*	€3.83	€13,979.50
Badge holder	€0.23	€839.50
Retractable lanyard	€1.48	€5,402.00
Vibration motor	€0.30	€1,095.00
PCB Assembly	€0.43	€1,571.50
Total	€10.87	€39,675.50

35 - Return on investment

Optimistic scenario

Financiele evaluatie	ROI Event Nudge											
return-on-investmentberekening												
		%	0	1	2	3	4	5	6	7	8	5
Benodigd aantal badges	4500											
Gemiddeld aantal badges per beurs	3650											
Aantal evenementen per jaar	8											
verhuur badge per stuk				3650	3650	3650	3650	3650	3650	3650	0	
marktprijs	1			1	1	1	1	1	1	1	1	
bruto omzet (kosten organisatie)	a * b		0	3650	3650	3650	3650	3650	3650	3650	0	
verhuur stand device per stuk				100	100	100	100	100	100	100	0	
marktprijs	50			50	50	50	50	50	50	50	50	
bruto omzet	a * b		0	5000	5000	5000	5000	5000	5000	5000	0	
bruto omzet totaal (x aantal beurzen)			0	69200	103800	138400	173000	138400	103800	69200	0	
verhuurkosten badges	1		0	3650	3650	3650	3650	3650	3650	3650	0	
verhuurkosten standdevices	10			1000	1000	1000	1000	1000	1000	1000	0	
productiekosten totaal (x aantal beurzen)				37200	55800	74400	93000	74400	55800	37200	0	
onderzoek & ontwikkeling			10000									
software			70000									
introductiekosten (promotie)				10000								
verkoopkosten (tussenpersoon, doorlopend)	10%	10	0	6920	365	365	365	365	365	365	0	
totaalkosten			0	101570	5015	5015	5015	5015	5015	5015	0	
investeringen badges	10.87			48915	0	0	0	0	0	0	0	
investeringen standdevices	94.66			9466	0	0	0	0	0	0	0	
totaal investeringen			80000	58381	0	0	0	0	0	0	0	
cumulatief				138381	138381	138381	138381	138381	138381	138381	138381	
afschrijvingen	k/100*	0.1	0	13838	13838	13838	13838	13838.1	13838.1	13838.1	13838.1	110705
geinvesteerd kapitaal	Ek-El		0	124543	124543	124543	124543	124542.9	124542.9	124542.9	124542.9	13838
werkkapitaal	o/100*	10	0	365	365	365	365	365	365	365	0	
totaal kapitaal	m+o+j		0	226478	129923	129923	129923	129922.9	129922.9	129922.9	124542.9	13838
verandering vh/ kapitaal	Dp		0	226478	-96555	0	0	0	0	0	-5380	-110705
aftrekbare kosten	j+l		0	115408	18853	18853	18853	18853.1	18853.1	18853.1	13838.1	110705
belastbare inkomsten	s=c-r		0	-46208	84947	119547	154147	119546.9	84946.9	50346.9	-13838.1	-110705
vennootschapsbelasting	s/100*	25	0	0	-11552	21237	29887	38536.725	29886.725	21236.725	12586.725	-3460
cash-flow	s-t-q		0	-272686	193054	98310	124260	81010.175	55060.175	29110.175	-21044.825	3460
cumulated cash-flow	Ev		0	-272686	-79632	18678	142938	223948.45	279008.625	308118.8	287073.975	**290534**
discounted cash-flow		20	0	-227238	134065	56892	59925	32556.172	18439.5412	8124.11559	-4894.353689	1390
cumulated disc. cash-flow	Ex		0	-227238	-93173	-36281	23644	56200.38	74639.9213	82764.03689	77869.6832	79260
bruto projectrendement:	20	%										
kapitaalkosten:	5	%										
bijdrage overheads:	10	%										
netto rendement	5	%										

Normal scenario

Financiele evaluatie	ROI Event Nudge											
return-on-investmentberekening												
		%	0	1	2	3	4	5	6	7	8	5
Benodigd aantal badges	4500											
Gemiddeld aantal badges per beurs	3650											
Aantal evenementen per jaar	8											
verhuur badge per stuk				3650	3650	3650	3650	3650	3650	3650	0	
marktprijs	2			2	2	2	2	2	2	2	2	
bruto omzet (kosten organisatie)	a * b		0	7300	7300	7300	7300	7300	7300	7300	0	
verhuur stand device per stuk				100	100	100	100	100	100	100	0	
marktprijs	50			50	50	50	50	50	50	50	50	
bruto omzet	a * b		0	5000	5000	5000	5000	5000	5000	5000	0	
bruto omzet totaal (x aantal beurzen)			0	98400	98400	98400	98400	98400	98400	98400	0	
verhuurkosten badges	1		0	3650	3650	3650	3650	3650	3650	3650	0	
verhuurkosten standdevices	10			1000	1000	1000	1000	1000	1000	1000	0	
productiekosten totaal (x aantal beurzen)				37200	55800	74400	93000	74400	55800	37200	0	
onderzoek & ontwikkeling			10000									
software			70000									
introductiekosten (promotie)				10000								
verkoopkosten (tussenpersoon, doorlopend)	10%	10	0	9840	730	730	730	730	730	730	0	
totaalkosten			0	104490	5380	5380	5380	5380	5380	5380	0	
investeringen badges	10.87			48915	0	0	0	0	0	0	0	
investeringen standdevices	94.66			9466	0	0	0	0	0	0	0	
totaal investeringen			80000	58381	0	0	0	0	0	0	0	
cumulatief				138381	138381	138381	138381	138381	138381	138381	138381	
afschrijvingen	k/100*	0.1	0	13838	13838	13838	13838	13838.1	13838.1	13838.1	13838.1	110705
geinvesteerd kapitaal	Ek-El		0	124543	124543	124543	124543	124542.9	124542.9	124542.9	124542.9	13838
werkkapitaal	c/100*	10	0	730	730	730	730	730	730	730	0	
totaal kapitaal	m+o+j		0	229763	130653	130653	130653	130652.9	130652.9	130652.9	124542.9	13838
verandering vlhl kapitaal	Dp		0	229763	-99110	0	0	0	0	0	-6110	-110705
aftrekbare kosten	j+l		0	118328	19218	19218	19218	19218.1	19218.1	19218.1	13838.1	110705
belastbare inkomsten	s=c-r		0	-19928	79182	79182	79182	79181.9	79181.9	79181.9	-13838.1	-110705
vennootschapsbelasting	s/100*	25	0	0	-4982	19795	19795	19795.475	19795.475	19795.475	19795.475	-3460
cash-flow	s-t-q		0	-249691	183274	59386	59386	59386.425	59386.425	59386.425	-27523.575	3460
cumulated cash-flow	Ev		0	-249691	-66417	-7031	52356	111742.2	171128.625	230515.05	202991.475	**206451**
discounted cash-flow		20	0	-208076	127274	34367	28639	23866.072	19888.3936	16573.66131	-6401.103874	1390
cumulated disc. cash-flow	Ex		0	-208076	-80802	-46435	-17796	6070.2288	25958.6224	42532.28372	36131.17984	37521
bruto projectrendement:	20	%										
kapitaalkosten:	5	%										
bijdrage overheads:	10	%										
netto rendement	5	%										

Pessimistic scenario

return-on-investmentberekening													
		%	0	1	2	3	4	5	6	7	8	5	
Benodigd aantal badges	4500												
Gemiddeld aantal badges per beurs	3650												
Aantal evenementen per jaar	8												
verhuur badge per stuk				3650	3650	3650	3650	3650	3650	3650	3650		
marktprijs	5			5	5	5	5	5	5	5	5		
bruto omzet (kosten organisatie)	a * b		0	18250	18250	18250	18250	18250	18250	18250	18250		
verhuur stand device per stuk				100	100	100	100	100	100	100	100		
marktprijs	50			50	50	50	50	50	50	50	50		
bruto omzet	a * b		0	5000	5000	5000	5000	5000	5000	5000	5000		
bruto omzet totaal (x aantal beurzen)			0	23250	46500	69750	93000	116250	139500	162750	186000		
verhuurkosten badges	1		0	3650	3650	3650	3650	3650	3650	3650	3650		
verhuurkosten standdevices	10			1000	1000	1000	1000	1000	1000	1000	1000		
productiekosten totaal (x aantal beurzen)				37200	55800	74400	93000	74400	55800	37200	4650		
onderzoek & ontwikkeling			10000										
software			70000										
introductiekosten (promotie)				10000									
verkoopkosten (tussenpersoon, doorlopend)	10%	10	0	2325	1825	1825	1825	1825	1825	1825	1825		
totaalkosten			0	96975	6475	6475	6475	6475	6475	6475	6475		
investeringen badges	10.87			48915	0	0	0	0	0	0	0		
investeringen standdevices	94.66			9466	0	0	0	0	0	0	0		
totaal investeringen			80000	58381	0	0	0	0	0	0	0		
cumulatief				138381	138381	138381	138381	138381	138381	138381	138381		
afschrijvingen	k/100*	0.1	0	13838	13838	13838	13838	13838.1	13838.1	13838.1	13838.1	110705	
geinvesteerd kapitaal	Ek-El		0	124543	124543	124543	124543	124542.9	124542.9	124542.9	124542.9	13838	
werkkapitaal	c/100*	10	0	1825	1825	1825	1825	1825	1825	1825	1825		
totaal kapitaal	m+o+j		0	223343	132843	132843	132843	132842.9	132842.9	132842.9	132842.9	13838	
verandering vh/ kapitaal	Dp		0	223343	-90500	0	0	0	0	0	0	-119005	
aftrekbare kosten	j+l		0	110813	20313	20313	20313	20313.1	20313.1	20313.1	20313.1	110705	
belastbare inkomsten	s=c-r		0	-87563	26187	49437	72687	95936.9	119186.9	142436.9	165686.9	-110705	
vennootschapsbelasting	s/100*	25	0	0	-21891	6547	12359	18171.725	23984.225	29796.725	35609.225	41422	
cash-flow	s-t-q		0	-310906	138578	42890	60328	77765.175	95202.675	112640.175	130077.675	-33122	
cumulated cash-flow	Ev		0	-310906	-172328	-129438	-69110	8654.7	103857.375	216497.55	346575.225	**313454**	
discounted cash-flow		20	0	-259088	96234	24821	29093	31252.08	31883.1832	31435.80558	30251.90984	-13311	
cumulated disc. cash-flow	Ex		0	-259088	-162854	-138033	-108940	-77687.85	-45804.6633	-14368.85768	15883.05216	2572	
bruto projectrendement:	20	%											
kapitaalkosten:	5	%											
bijdrage overheads:	10	%											
netto rendement	5	%											

36 - Prototyping

Hardware

Radio Frequency

While BLE is the most suitable protocol for the actual design, its modules are rather overqualified (and expensive) for the objectives of this prototype. Unlike in the actual design, the communication module in the personal device will not have to be able to transmit. For this reason, a one-way radio-frequency communication channel was used. Two RF modules enable this channel: a 434MHz transmitter and receiver (SparkFun, 2017) (figure 47).

Nudging

As described, visitors will be nudged by their personal devices via two types of sensory stimuli; light and vibration. To enable this, two basic components were necessary: a vibration motor and an LED (figure 47) (SparkFun, 2017).

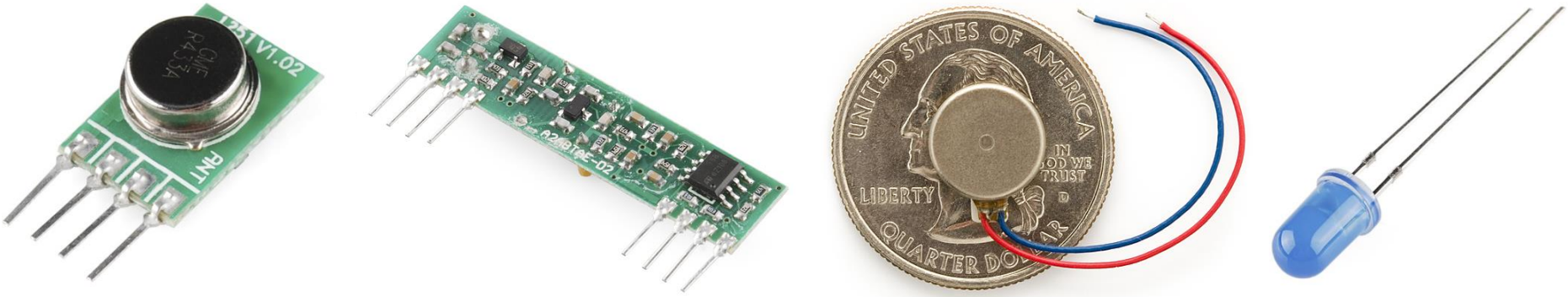


Figure 47: The prototype's RF transmitter, RF receiver, vibration motor, and LED

Microcontrollers

The two prototypes were controlled by Arduino microcontrollers. Because size was irrelevant for the transmitting device, the relatively large Arduino Uno was used (figure 48). The smaller Arduino Micro was used in the receiving device, to enable it to fit in a container that could be worn around the neck (figure 49).

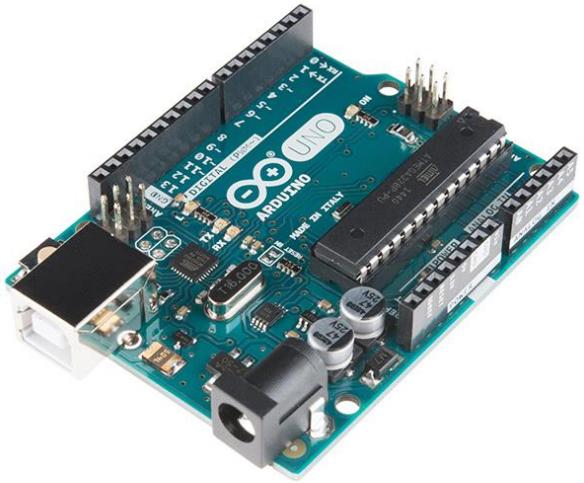


Figure 48: Arduino Uno

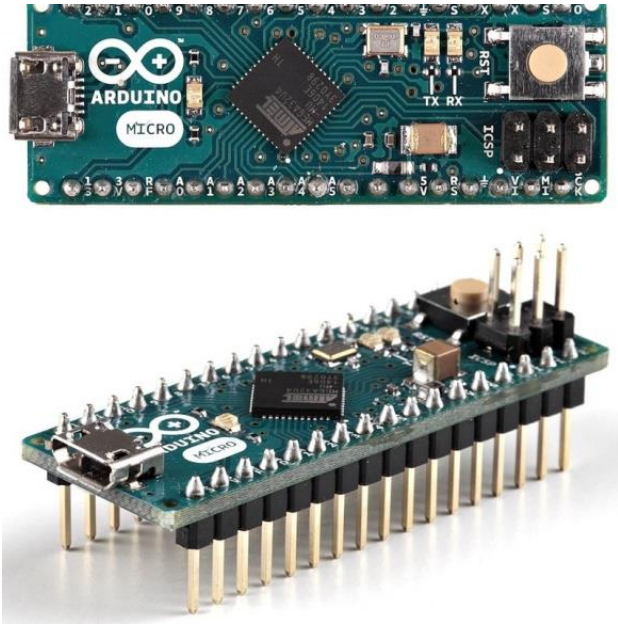
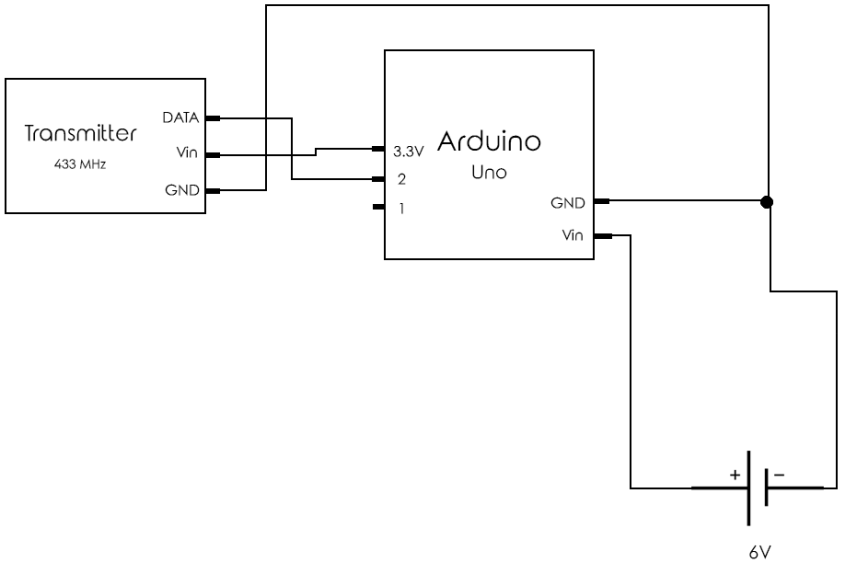


Figure 49: Arduino Micro

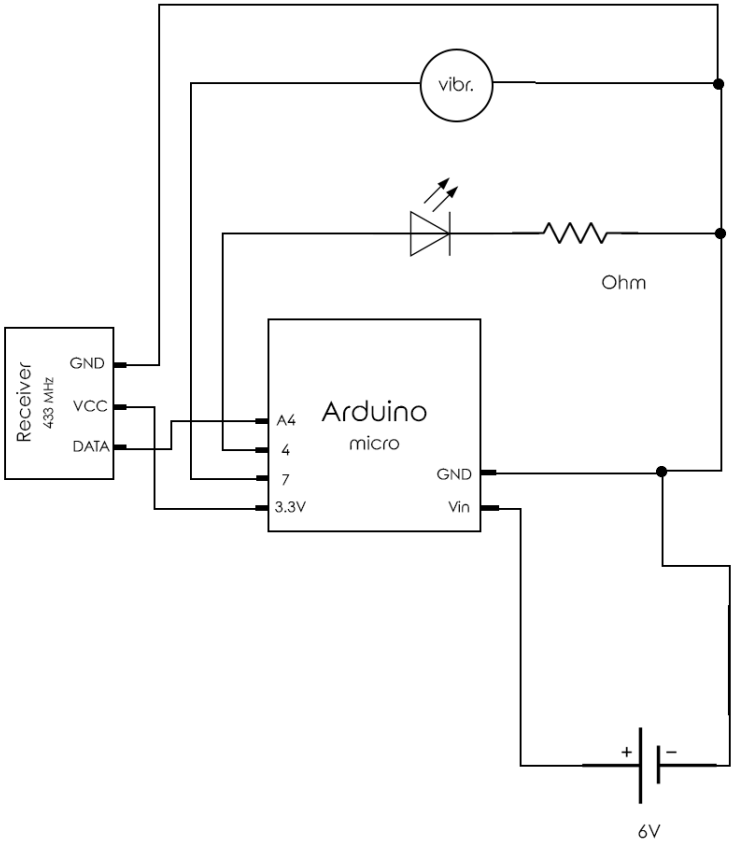
Circuit diagram

These diagrams show how all components were connected.

Transmitter



Receiver



Code

Both devices have been programmed via the Arduino software, with the addition of the VirtualWire library (McCauley, 2013) which contains pre-programmed commands specifically designed for establishing wireless connections. The basis of this code was taken from instructables.com, and modified to fit these specific circuits.

Stand device (transmitter)

This code tells the RF-transmitting module to send alternating messages of '0' and '1' at 2000Kbps (figure 50).

```
#include <VirtualWire.h>
char *controller;

void setup() {
pinMode(13,OUTPUT);
vw_set_ptt_inverted(true); //
vw_set_tx_pin(2);
vw_setup(4000);// speed of data transfer Kbps
}

void loop(){
controller="1" ;
vw_send((uint8_t *)controller, strlen(controller));
vw_wait_tx(); // Wait until the whole message is gone

digitalWrite(13,1);
delay(2000);
controller="0" ;
vw_send((uint8_t *)controller, strlen(controller));
vw_wait_tx(); // Wait until the whole message is gone
digitalWrite(13,0);
delay(2000);

}
```

Figure 50: Transmitter Arduino code using the VirtualWire library

Personal device (receiver)

This code tells the Arduino Micro to subsequently activate the connected vibration motor and LED whenever its RF-receiver receives the message '1', as sent by the transmitter (figure 51).

```
#include <VirtualWire.h>
void setup()
{
    vw_set_ptt_inverted(true); // Required for DR3100
    vw_set_rx_pin(A4);
    vw_setup(2000);  // Bits per sec
    pinMode(4, OUTPUT);
    pinMode(7, OUTPUT);

    vw_rx_start();       // Start the receiver PLL running
}
    void loop()
{
    uint8_t buf[VW_MAX_MESSAGE_LEN];
    uint8_t buflen = VW_MAX_MESSAGE_LEN;

    if (vw_get_message(buf, &buflen)) // Non-blocking
    {
      if(buf[0]=='1'){


   digitalWrite(7,HIGH);
   delay(850);
   digitalWrite(4,HIGH);
      }

      delay(3500);
   digitalWrite(4, LOW);
   digitalWrite(7, LOW);

   delay(120000);

}
}
```

Figure 51: Receiver Arduino code using the VirtualWire library

37 - Redesigned nudge

These test results have led to the consideration of a redesign for the personal device, with the goal of improving the chance that visitors will notice its vibrational signal. An in important insight that was gained is that the device's lanyard is the part that most intimately connects with the user. It can therefore be seen as the part with the highest potential of sending its user a noticeable vibrational signal. Several ways of utilizing this part in this way were considered:

Integrating the vibrational motor into the lanyard

This option is hindered by the presence of the retractable lanyard, which does not allow any electrical wire to go from the neck to the device's casing. This could be solved by choosing for another method which would enable users to pull the device downwards without having to adjust their posture. An earlier analysis indicated that this required downward displacement is not as large as initially assumed, and could therefore be achieved by other methods. A viable option is to integrate a piece of extensible wire (figure 52) into the lanyard. This type of wire is known to be able to contain electrical wire (e.g. in old-fashioned phones). The two ends of this chord could then easily be attached to the device's casing by sandwiching it between its two halves (figure 53). The vibrational element could then be placed on the top of this chord, although receiving a vibrational signal in the back of the neck might be confusing for a visitor. Such a signal potentially directs a recipients attention to the back, while the stand it refers to is mostly in front of him/her. While this effect would have to be tested, it is probably better if this vibrational element were to be integrated into another part of the chord. This would however decrease the added value of integrating it in the chord in the first place, especially when comparing it to the option of connecting the lanyard to the vibration motor inside the casing.

Integrating all electronic components into the lanyard

This is an alternative to the previous option, which still allows for the use of a retractable lanyard. The entire casing of the device is in this case integrated with the lanyard (figure 54). Inspiration for this option (and also the previous) was found in the Alex posture tracker, which is worn on the neck and nudges its user by vibrating. The obvious downside of this option is that the device can no longer nudge its user with light, which weakens the nudge and makes it harder for exhibitors to identify potentially interested visitors.

Connecting lanyard directly to the vibration motor

Another, less drastic, option to focus the vibrational signal onto the lanyard is to connect the end of the lanyard directly to the element that generates this signal.

Figure 52: An extensible electric wire

A downside to this option is

that the use of a retractable lanyard or extensible wire might negate this effect, as they would probably act as a damper. This would also have to be tested.

Changing the orientation of the vibration motor to increase its effect on the lanyard.

The least radical adaptation to the current design would be to alter the orientation of the vibration motor so that its vibrating motion is in line with the length of the lanyard. This would then in theory exert more force on the lanyard, causing the visitor to sense the signal through the lanyard. However, the vibration motor that was used in these tests was already theoretically oriented correctly for this purpose. Furthermore, quick tests with this same component did not appear to indicate that this orientation had any significant effect on the signal that was given.

Alternative options to increase the strength of the nudge that do not involve the lanyard were also thought of. These could also be combined with the aforementioned redesign options.

Increasing the intensity and/or length of the vibration motor

This can be seen as the most obvious option of them all, and is meant to increase the chance that visitors notice the signal. It does not likely deal with the possibility of the badge being worn over a thick coat or other clothing, however. An increase in vibration intensity would require a different component than the current vibration motor; one which is able to deliver a stronger signal at the same voltage (Sensorwiki.org, 2017).

Increasing the length of the signal is another method of achieving the same goal, and has some additional benefits. The primary benefit of this measure is that visitors have more time to become aware of the signal, thus increasing the chance that this will eventually happen. It can also help prevent the interference of momentary background noises by simply outlasting them. There is also a greater chance that the device is directly touching the visitor at some point during a signal when it lasts longer, in case the visitor is walking and the device is moving because of this.

Improving the adherence of the personal device to the body

The last option that has been considered is to take measures to enhance the physical connection between the device (its casing in particular) and the visitor. This would naturally enhance the intensity of the signal felt by the visitor.

- By using a subtle adhesive similar to Velcro, or an extrusion which hooks behind clothing.

Conclusion

To conclude, out of the many considered options only a few were considered to be an actual improvement over the current situation. Since the user tests at the Big Data Expo were only partially negative in regards to the strength of the nudge, a drastic redesign (first two options) will not be implemented unless future user tests suggest their necessity.

For now, the measures that will be taken are an increase of vibration intensity and length, and the internal attachment of the device's lanyard to its vibration motor. Future tests will have to point out if additional measures are necessary.

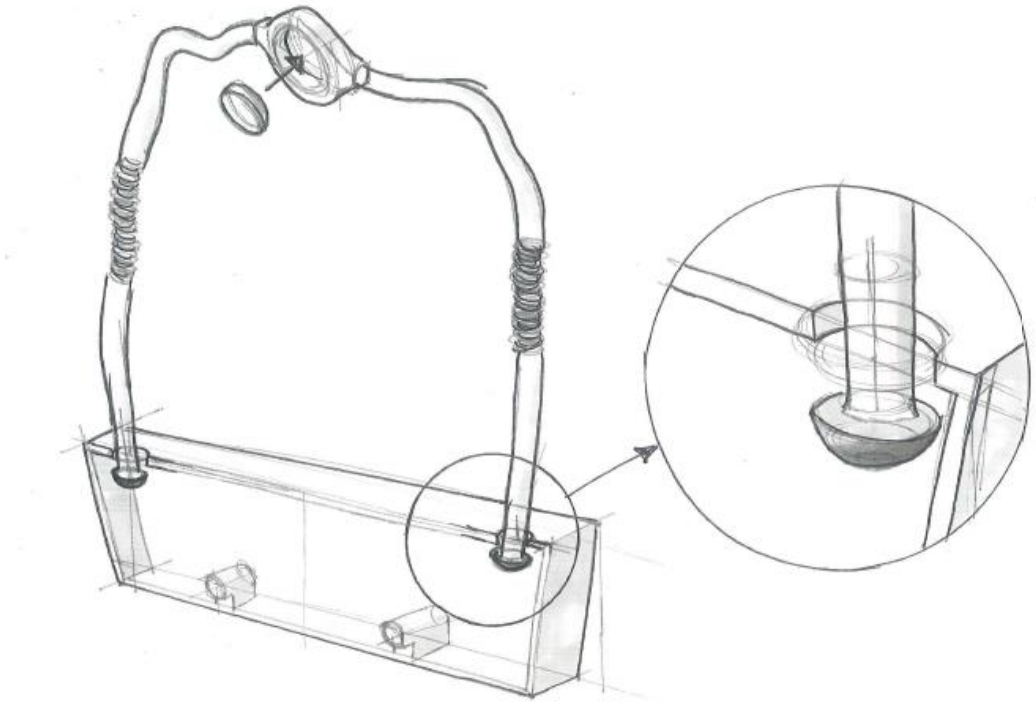


Figure 53: A conceptual integration of the vibration motor in the lanyard, and the connection of this lanyard to the personal device

Figure 54: A conceptual integration of all electronic components into the lanyard

38 - Evaluation

Objectives

One way to evaluate the chosen concept and explore any further opportunities, primarily in the field of data collection, is to make an inventory of things each party would like to know after an event and which they can use to evaluate their personal event. This list has been composed with the help of Han Bosman of OGZ..

Organizer:

- What did exhibitors think of the quality of visitors?
- What did exhibitors think of the amount of visitors?
- What did exhibitors think of the crowdedness of the fair?
- Did exhibitors miss a particular type of visitor?
- Has the trade fair lived up to the expectations of exhibitors?
- What did visitors think of the quality of exhibitors?
- What did visitors think of the amount of exhibitors?
- What did visitors think of the supporting facilities (e.g. lunchroom, bathrooms)
- How long did visitors stay at the fair?
- At which times are the most visitors present?
- Which routes did visitors take during their visit?
- Which areas of the fair were most crowded?
    - How did the lay-out of the fair influence this?

Exhibitor:

- What type of visitors were interested in me?
    - Objectives
    - Interests
    - Age
    - Gender
    - Job title
- Why were visitors (not) interested in me?
- How many visitors were interested in me?
- What percentage of visitors who walked past me ended up visiting me?
- How did the location of my stand affect my performance?
- Did I approach the correct visitors?

Visitor:

- Which stands did I find interesting?
- At which exhibitors did I leave my contact information?
- Have I considered/visited all exhibitors?

Besides all the mentioned advantages it offers, this design will be able to provide all parties with information they are not yet collecting at this moment. These have been highlighted. As can be seen, this design mainly caters to the exhibitors and visitors in this regard. This is partly due to the information wanted by the organizer being mainly qualitative: 'what were the opinions of people?' Some of this qualitative data can, however, be collected by this system. Exhibitors are better able to judge on the types of visitors present on the fair because of the "identity tags" they are wearing.

Risk analysis

Use scenario

In addition to the behavioral flow chart that has been used earlier in this project, which covered the unspecified concept of a smart personal device, a detailed use-scenario for the final design will also be presented. It will describe the visit of Alex, a goal-oriented business representative who has been described in the personas earlier in this report. This scenario would of course vary slightly for different visitor types. In the case of Anna, for example (a more orienting type of visitor), this scenario would be slightly different. She might not prepare her visit as well, and wouldn't likely aim for certain exhibitors during her visit. This means she would depend more on the nudges from her device and would therefore be more susceptible to them.

- Alex has just decided to visit the event and is registering himself online a week before it starts. During this process, he is asked to select his objectives (business) and to choose the fields in which he is interested.
- He prepares his visit at home by browsing the event's website and making an estimation of which exhibitors could be relevant for him. He even visits some of these exhibitors' websites for further investigation.
- Upon his arrival at the event he checks in at the reception. This is where the receptionist retrieves his visitor profile from the database and generates a unique visitor badge. This paper badge is printed right away, and is inserted into the personal device's badge holder. The personal device is then connected to the reception desks computer, and the visitor profile is uploaded to its microcontroller.
- Alex is then asked to wear the badge at all times and is told to scan his badge at any stand he finds interesting, because it allows him to easily exchange contact information with the exhibitor. Alex is also told to "Enjoy your visit, and keep an eye out for your badge, it might have some suggestions for you". This rather vague tip is meant to make visitors more aware of any potential nudges on beforehand.
- He then enters the event and starts his visit. The first thing he does is check the map in the catalogue that he picked up at the entrance. He checks to see which of the exhibitors he planned to visit is closest.
- After making a choice on which stand to visit first, he sets out to find it. It doesn't take long before he reaches the stand, and upon arrival he is enthusiastically approached by one of its exhibitors. This woman refers to Alex's badge when talking about how she thinks he came to the right place. She then proceeds to explain her product to him.
- After Alex feels like he has received enough information, he decides that he would like to keep in touch with this company. The exhibitor informs him that they can stay in touch if he scans his badge at the device standing on their counter. He approaches the device, and can already tell he is probably supposed to place his badge in its opening. As he brings his badge towards it he notices the grooves on either side of the opening and slides his badge all the way in them. A light on the device starts burning, and Alex

hears a simultaneous beeping sound. He figures this means the scan was successful, and takes his badge out again.

- Alex continues his visit and sets out to find the second exhibitor he planned to visit. While walking through an aisle on his way there, however, he feels a vibrating sensation on his abdomen. As he looks down, he sees that a light on his personal device is glowing. He remembers what the receptionist told him, and wonders if this signal has anything to do with the stand he just walked past. Even though he did not plan for it, he decides to visit this stand out of curiosity.
- He examines the stand as he waits for its exhibitor to finish his conversation with another visitor, after which he strikes up a conversation with him. After this conversation, Alex is pleasantly surprised by the relevance of this company for his objectives, and decides to leave his contact information by scanning his badge again.
- After visiting several more stands either planned or unplanned, some of which he didn't find interesting enough to scan his badge at, Alex feels like he has fulfilled his objectives and decides to go home. Upon reaching the exit, he is guided to a counter with a sign reading "badge drop-off point". He gives the trade fair employee there his badge, who then asks him if the device helped him in his visit.

Risk analysis

The following analysis has been made to identify (all) possible constraints in the designed system, and to think of possible solutions for them in order to be one step ahead. These solutions will then serve as modifications to the current design and the required services that come with it, or as future recommendations.

Situation	Possible constraint	Effect	Solution
Registering online	Visitor is in a rush, or unmotivated	Inaccurate profile is created	Place emphasis on these two questions. Allow applicants to read more about the event's fields of interest and about visitor objectives.
Visitor checks in	He/she did not register on beforehand	Visitor needs to create profile at the spot: some pressure	Employees can guide these visitors into correctly filling in their profile.
Visitor checks in	Uploading takes too long	Long queues start to form	Make sure sufficient check-in points are available, especially during peak hours.
Wearing the badge	Device is dropped	Casing falls apart (or other malfunctioning)	Install a helpdesk at a central location
Wearing the badge	Battery dies	Device is unusable	Install a helpdesk at a central location
Taking a break (lunch/toilet)	Device is removed and stored in a bag	Visitors forgets to put the device back on	Exhibitors and employees can notify visitors who aren't wearing a device.
Taking a break (lunch/toilet)	Device is removed and put on the table	Visitors continues and forgets to bring device	Lost devices can be brought to the helpdesk, and visitors without a device should be asked to retrieve it
Receiving a nudge	Visitor doesn't sense it	Visitor doesn't visit a matching stand	Aforementioned measures to increase chance nudges will be noticed
Receiving a nudge	Visitor senses but ignores it	Visitor doesn't visit a matching stand	Although visitors have the right to ignore these signals, exhibitors should approach visitors with glowing devices themselves.
Receiving a nudge	Visitor has already visited that stand	Visitor could link the nudge to another nearby stand	Stand device could register personal devices which have been in close proximity for a certain period of time, and increase the matching threshold for them.
Receiving a nudge	Visitor has already visited that stand	Visitor becomes confused and will place less value in the device's signals	Stand device could register personal devices which have been in close proximity for a certain period of time, and increase the matching threshold for them.
Talking to exhibitor	Exhibitor pressures visitor into scanning	Pollution of data	Educate exhibitors on beforehand. Make them realize that ingenuine scans are only in their

	device		own disadvantage.
Scanning badge	Visitor can't find stand device	Visitor decides to leave the stand	Trade fair employee checks whether all devices are properly placed.
End of visit	Visitor forgets to hand device in	Device is lost	Place employee at the exit to remind leaving visitors
End of visit	Visitor forgets to hand device in	Device is lost	Place special stand device at exit to make the personal devices send a final nudge

Use scenario: Reception desk employee

- Preparation:
    - Open the EvAnt database software and update it in case of any last-minute registrations.
    - Turn on personal devices to check their battery level. Replace the battery of any whose LED's indicate a too low power level. Turn them off again until they are handed out.
    - Supply printer with paper, and run a few test prints
- Greet visitor
- Ask for his/her name
    - Could be faster? Perhaps a self-service machine? Visitors could type their name on a tablet device and then select their own profile and send it to the printer. Employees sees which profiles the visitors choose on their own screen, and can upload it to a personal device while the badge is being printed. This method could be faster, but puts some faith in the speed of the visitors. It could also be considered to be less friendly than personal contact with employees. Visitor could be asked to bring a digital or already printed ticket, containing a bar- or QR-code. This code could then simply be scanned to reveal the corresponding profile in the database. Signs saying: "hold your ticket ready" could be used to speed it up even more.
- Search for his/her profile in the database, via the computer at the desk.
- Use the profile to generate a visitor badge (or select one that has already been generated automatically) and send it to the printer.
- While the badge is being printed, Grab a personal device and turn it on.
- Plug in the personal device to the computer with a micro-USB cable, and upload the profile to the device.
- Slide the printed bade into the device's badge holder.
- Hand the fully prepared device to the visitor, and provide him/her with the following instruction: "Enjoy your visit, and keep an eye out for your badge, it might have some suggestions for you".