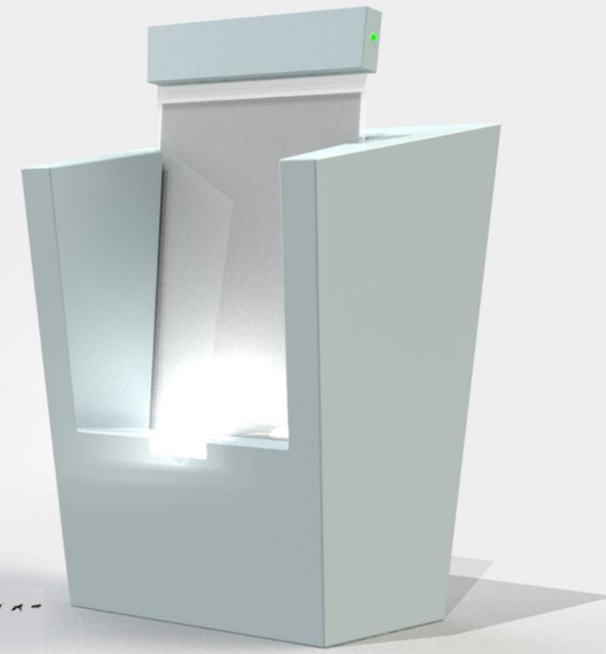
The EvAnt Matchmaker

A nature-inspired improvement of the trade fair matchmaking process



TU Delft

Master Thesis – Integrated Product Design

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October 2017

Executive summary

This report will describe the analysis of two topics: the pheromone based communication method used by ants in their foraging behaviour, and the phenomenon of trade fairs. This natural communication model has been analyzed and its defining characteristics have been abstracted, after which they have been used to design a product that solves the problems experienced by the visitors and exhibitors that participate in trade fairs: The EvAnt Matchmaker. This product can best be described as a self-enriching system of indirect mass communication, in which trade fair visitors receive subtle suggestions on which stands to visit based on the opinions of previous like-minded visitors. The purpose of this design is to help visitors find the rights exhibitors during a trade fair visit, on the basis of their actual content rather than superficial factors. Visitors and exhibitors interact with the data in this system through two products: a personal device worn by all visitors and a stand device present at each exhibitor. These two products allow visitors to leave their profile (personal interests and objectives) at interesting exhibitors by scanning their personal device at their stand devices similar to the way ants leave their pheromones at interesting food sources. Stand devices then use this collected data to find potentially interested visitors by transmitting it to the personal devices of those who are in close proximity, which then nudge their user towards the exhibitor whose previous visitors best match his/her profile. Furthermore, this design allows exhibitors to visually acquire information about a visitor's profile by simply reading their badges. This allows them to be more efficient in their work by focusing their effort on visitors they expect to be a good match based on their interests and objectives.

Acknowledgements

The project started out rather adventurous, with no knowledge whatsoever on how the final design would manifest itself and if there was even a true need for it in the chosen field of application. With the help of several people, the past 7 months have become a great learning experience resulting in a design I am personally proud of.

The project started off with a conversation with Lydia Fraaije of Stichting Biomimicry NL, who provided me with inspiration about the possibilities of nature and the Biomimicry design method. After I had selected a natural model, she provided some more guidance on how to successfully analyze it.

Another great source of advice has been Han Bosman of OGZ, a leading organizer of trade fairs in the Benelux. He helped me determine whether the chosen field of application of trade fairs was worth pursuing, He was also available to provide feedback on my progress at crucial stages of the design process. Lastly, facilitated the final user tests at his own event; the Big Data Expo by inviting me as a VIP and allowing me to make use of one of his stands.

A special thanks also goes out to my chair and mentor: Catelijne van Middelkoop. and Wim Poelman. Thank you both for choosing to believe in this project even when its potential was still unclear, and thank you Wim for investing such time and enthousiasm in it every single week.

Table of Content

Biomimicry

The inspiration for this project was found in the Biomimicry design method in which designers study the problem-solving methods of living organisms, abstract their defining features, and apply them in a human-centered design. The design method that will be used in this project has been defined by the consultancy agency Biomimicry 3.8 (figure 1). They define the Biomimicry design process by dividing it into four main phases: scoping, discovering, creating, and evaluating. From these steps, they propose two design processes to emerge.; one that starts at a design problem and analyzes this context to find and apply a natural strategy which could solve the problem (challenge to biology), and another that starts at an interesting and promising natural strategy for which the optimal design application is selected (biology to design, figure 2)..

In order for this design approach to be more suitable for the graduation assignment format of the Integrated Product Design program at the Industrial Design faculty at TU Delft, a mix of both the processes mentioned above will be used (figure 2). After choosing a natural model to learn from and some basic research into its characteristics, a design context was selected in the form of trade fairs. This step was needed to make the project more feasible and assessable within the limited time that is set for it.

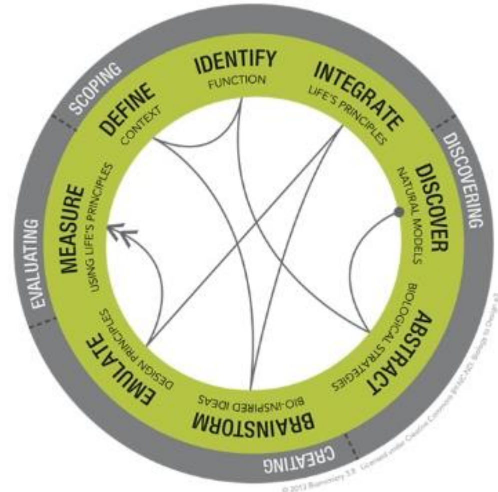

Figure 1: Traditional 'Biology to Design' design method

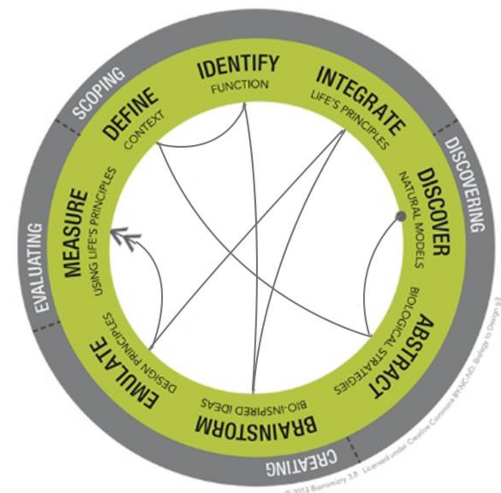

Figure 2: Modified Biomimicry design method

Analysis

The first part of this report will focus on the exploration of two topics: the pheromone-based communication method used by many ant species in their foraging behavior (from now on referred to as 'the natural model'), and the field of application: trade fairs.

The goal of this analysis is to reveal the key characteristics of the natural model and the design potential and requirements that come with them, as well as the key characteristics of trade fairs and the constraints faced by their involved parties. These constraints can then be translated into design opportunities, and be matched with the potential offered by the natural model. This process has been mainly based on the Biomimicry method, but also on the design process suggested by this project's supervisor Wim Poelman (figure 3). In this diagram, the technology can be seen as the result of the analysis of the natural model, while the product to design can be seen as the result of the analysis of the trade fair phenomenon.

This report starts off with trade fairs already being chosen as the targeted field of application. This choice was made prior to the official start of this project. The natural model and the environment in which it functioned were briefly analyzed, and their key characteristics were used as a basis for a brainstorm regarding a suitable field of application. Trade fairs were ultimately chosen because, just like in the natural model, a large group of individuals are confronted with an unknown environment in which they set out to find resources that fit their needs.

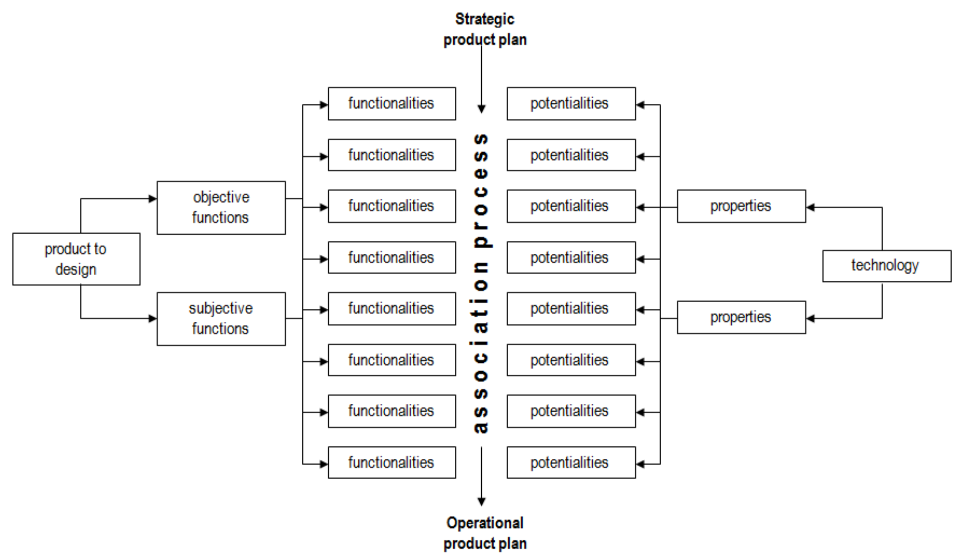

Figure 3: The association process of a new technology (right) with a field of application (left)

Natural model

This chapter contains a thorough analysis of the pheromone-based communication method used by many ant species to enhance their foraging process. This analysis will cover the process in which these pheromones are used, which elements this natural model consists of, and what the defining characteristics of these elements are.

Organism background

The first step in understanding the natural model is gaining a better understanding of the organism around which it centers: the ant. While there are over 12,000 known species of ants (antARK, 2017), many key characteristics can be observed in all of them (Appendix 1). Ants are eusocial organisms and live in hierarchic societies, which suggests that communication plays a crucial role in their survival strategy (figure 4). The fact that ants have developed several different ways of communication with each other confirms this. Tandem running (where an ant personally guides a nestmate to a discovered foodsource by use of touch) and vibration (where an ant instigates behavior in a number of nestmates by rubbing body parts together) are two commonly used methods used by a number of ant subspecies (Jackson & Ratnieks, 2006)

The communication method which has been deemed to be the most interesting, however, is one in which ants leave trails of pheromones in an attempt to guide nestmates to useful resources. This method has been selected before the start of this project to be the basis of the Biomimicry-process, and will be deeply analyzed and abstracted in the following chapters.

Figure 4: Communicating ants

Pheromone-based communication method

The communication method around which this project revolves is, as already mentioned, based on the use of pheromones while foraging. When ants leave their nest to search for resources (most often food), they do so by following trails on the ground (figure 5(. These trails consist of pheromones and were created by other ants who went before them, in a process that will be explained later on. These pheromones exert an attractive force on other ants which increases the chance they will follow a trail, purely out of instinct. Each ant is individually ignorant to the overall network and is simply responding to local conditions.

Figure 5: Ants following a trail

Goal of communication

This communication method can be seen to have two main goals. First of all, the pheromone trails act as a wayfinding tool that helps navigate the worker ants of a specific colony to navigate through the surrounding area to available resources. It helps these organisms compensate for their lack of other senses, such as sight.

Not only does this system guide ants towards these resources, it also helps them select the optimal ones. Ants forage in, especially from their point of view, large areas in which a great number of potentially useful resources can be found. Through a process of natural selection, this communication method allows for the optimal resource (often the most nearby) to emerge.

Formation of trails

The start of the process can be visualized like this, as it describes the behavior of four scouting ants (A,B,C, & D) (MUTE, 2017). This behavior can be summarized by several instinctive rules, which can be found in Appendix 2.

1. All the scouts leave the nest by walking randomly in different directions, each leaving a weak trail of pheromones (figure 6).
2. When an ant finds food (ant A) it returns to the nest on its own trail and deposits more pheromone.
3. Meanwhile, the other scouts have continued walking until they find a food source themselves, or until they encountered the trail of another scout. Ant D has started following ant A's double-strength trail. Ant B has found the food source on its own. Ant C has started following the trail of ant D.
4. There are now two trails between the nest and the food source, which both get confirmed by ants who travel across it. The trail that is shortest, however, will grow to be the most attractive because its length allows for more passages per unit of time.
5. In the end, many paths through the environment have been explored and the shortest one of these has emerged as the one used by most of the colony.

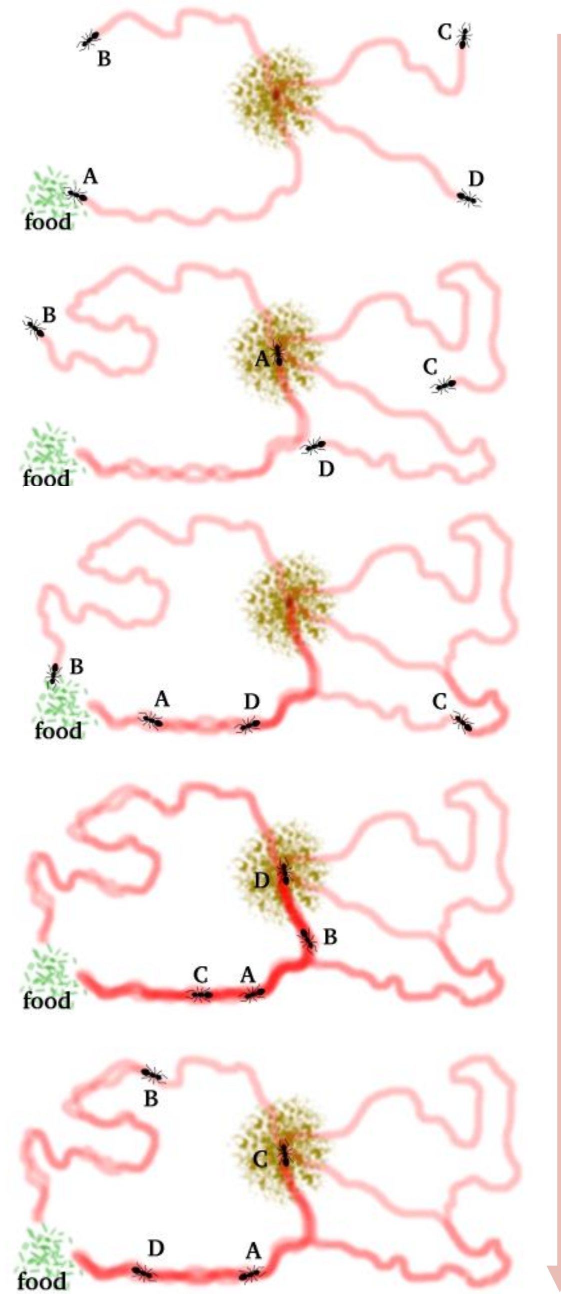

Figure 6: The trail-making process of ants

Pheromone characteristics

This communication system functions properly with the use of one basic type of volatile pheromone with an attractive function. There are, however, species of ants that have been shown to use additional types of pheromones to enhance their communication methods.

Composite trails

Another study, of the same Pharaoh ants, suggests that the basis of this communication system is more complex than a single type of pheromone (Ratnieks, 2008). First of all, it appears that that trails are made up of three types of pheromones: two attractive and one repellent. Secondly, it appears that these ants extract information about the polarity (which direction leads to the nest and which to the resource) of the trail from its geometric properties. Lastly, there seems to be a distinction between ants that specialize in laying down trails and ants that specialize in detecting trails.

The hypothesis for the existence of multiple trail pheromones is that the different types complement each other. Of the two attractive pheromones, one is volatile and the other one has a longer duration. The volatile pheromone evaporates after approximately 20 minutes, and has the function of keeping the trail relevant and to determine its potency. The non-volatile pheromone can have life-span of up to two days, and acts as a sort of memory. For example, some species of ants only forage during specific times of a day, which means they ignore their trails for hours on end. A memory like this helps them re-establish their trails quickly when they restart their activities. This long-lived pheromone is detected by specialist "pathfinder" ants that walk more slowly and with their antennae touching the ground.

The third type can best be described as a repellent pheromone. There is strong reason to believe that Pharaoh ants (Monomorium pharaonic) use this kind of pheromone to mark trails that lead to resources that are no longer interesting (depleted/obsolete). Ants that are following a trail and encounter this pheromone appear to have a significantly higher chance to make an U-turn at a bifurcation point (where this pheromone seems to be concentrated on, figure 7) and follow the trail back to the previous bifurcation point.

Figure 7: An analogy of a repellent pheromone placed at a bifurcation point

Changing conditions

The environment in which ants forage for resources is far from static. It is subject to many changing conditions such as the weather, resource exhaustion, and large animals that disarrange the soil. The way the natural model deals with these changes and ensure that their trails remain relevant is by having the pheromones evaporate over time. This volatility causes trails are no longer being added to (because the destination is no longer relevant) disappear, so that ants don't waste energy by continuing to follow it.

Accumulation

The amount of ant passages along a trail is directly related to the longevity and attractiveness of a pheromone trail. In other words, the more often a trail has been confirmed by the deposit of additional pheromones, the longer it will take for this trail to evaporate entirely, and the higher the chance is that ants who encounter it will start to follow it (Jackson et al., 2006). This phenomenon can be seen in other situations too, such as when a mammal crosses a field of vegetation and causes the plants to stop growing at those points. More passing animals along that same trail amplify this effect and cause it to become more visible (thus more likely to be followed) and more lasting (harder for the plants to recover). At a certain level of pheromone density, however, ants will no longer add to the trail. This negative feedback loop probably has the goal of preventing the waste of pheromones (Czaczkes et al., 2013)

Personal profile

As mentioned earlier, a form of direct communication between ants also takes place. This is enabled by a special kind of pheromone blend which is found on the body of each ant Pittalwala, 2015). These hydrocarbons can be detected with great detail by the ants' antennas, which allows them to convey more information than the ones used for laying down trails. These pheromones, which have a very low volatility (they last longer), allow for ants to gain information about another individual at very close proximity within a crowd (figure 8).

The set of pheromones present on an ant's cuticle can best be described as a blend, the composition of which acts as a personal profile of the sender (Sharma et al., 2015). The most important information the recipient can learn about the sender from these pheromones is to which colony it belongs, from which it can decide whether to treat it friendly or hostile. Interestingly, these same pheromones are also found on the inside of the colony's nest, albeit in different proportions.

Figure 8: Ants identifying each other through their cuticular pheromones

Probability

This method qualifies as modulatory communication: the signals (pheromones) that the ants send out only increase the probability that other ants will change their behavior in response to that stimuli, and are therefore not as coercive as direct individual communication. While this may sound inefficient at first, it is important to remember that the ants that do change their behavior based on this stimuli will confirm it and add pheromones to it, assuming they experienced the trail to lead to a potent food source (Ratnieks, 2008). After some time, this will have drastically increased the chance that the ants follow a trail that is favorable to them (to their specific task). At the same time, the weak persuasive power of the initial pheromones makes it easier for individuals to ignore unwanted ones and therefore be able to explore other options before a sufficiently convincing trail has been created.

Modulatory communication is most often found in the most complex animal societies (ants, honey bees), where many individuals simultaneously perform different tasks (Schneider & Leiws, 2004). Ant colonies and similar situations require such a sufficiently flexible system because they need to efficiently distribute their available energy across a variety of tasks. The signals are indirect and one-way, and can be picked up by any agent with the right receptors. This allows one ant to communicate to many agents at once, and facilitates the self-organization of multiple agents.

When looking at honeybees, one can see the same form of communication manifest itself in another way. These similarly eusocial insects organize labor in their community by using a vibration signal (figure 9). This signal is indirect and aimed at multiple bees at once, and causes "*a non-specific increase in activity that may alter responsiveness to a wide array of stimuli, and thus may influence the performance of many different tasks simultaneously (Schneider & Lewis, 2004)*". In other words, while signals for many individual tasks already exist, this modulatory signal aims to alter the responsiveness to these signals. The goal of this extra signal (vibration in this case) is to "adjust the degree of behaviourial integration within and among worker groups". This increased level of integration would be necessary at times that call for more complex group efforts. In the case of the honeybee, these times would be: when colonies emerge from hibernation, when afterswarms are produced during colony reproduction, or when a swarm finds a new nest.

Figure 9: A communicating honeybee

Termites

The use of pheromones as a communication method is not a tool that is exclusive to ants. Other species are also known to communicate by depositing these chemical substances. Termites, for example, have developed an interesting alternative to the standard natural model discussed in this report. These insects use pheromones in the same was as ants; as a wayfinding system while foraging for resources. However, they also use them in another way: as a guidance system for efficient construction (Dorigo et al., 2000). In order for termites to build their characteristic nests (figure 10), they use soil pellets as their building material. In the first phase of construction, they initiate the build by randomly depositing pheromone-infused soil pellets. These infused pellets act as markers for the following delivery of soil pellets to be placed on top of. Because of the accumulative attractive force of the pheromones, the largest collections of pellets will eventually be the only ones that attract more termites to deposit on them. This creates a number of pillars which act as the basis of the nest's construction.

To conclude, this building method is very similar to the foraging method of ants. It starts with random actions and deposits of pheromones. A structure then manifests itself through the confirmation of some of these random actions and the accumulation of pheromones. Both processes can be described as a natural selection of attractive pheromone build-ups. The main difference between the two methods is that termites do not incorporate long-range way finding, but rely on close-proximity attractive forces.

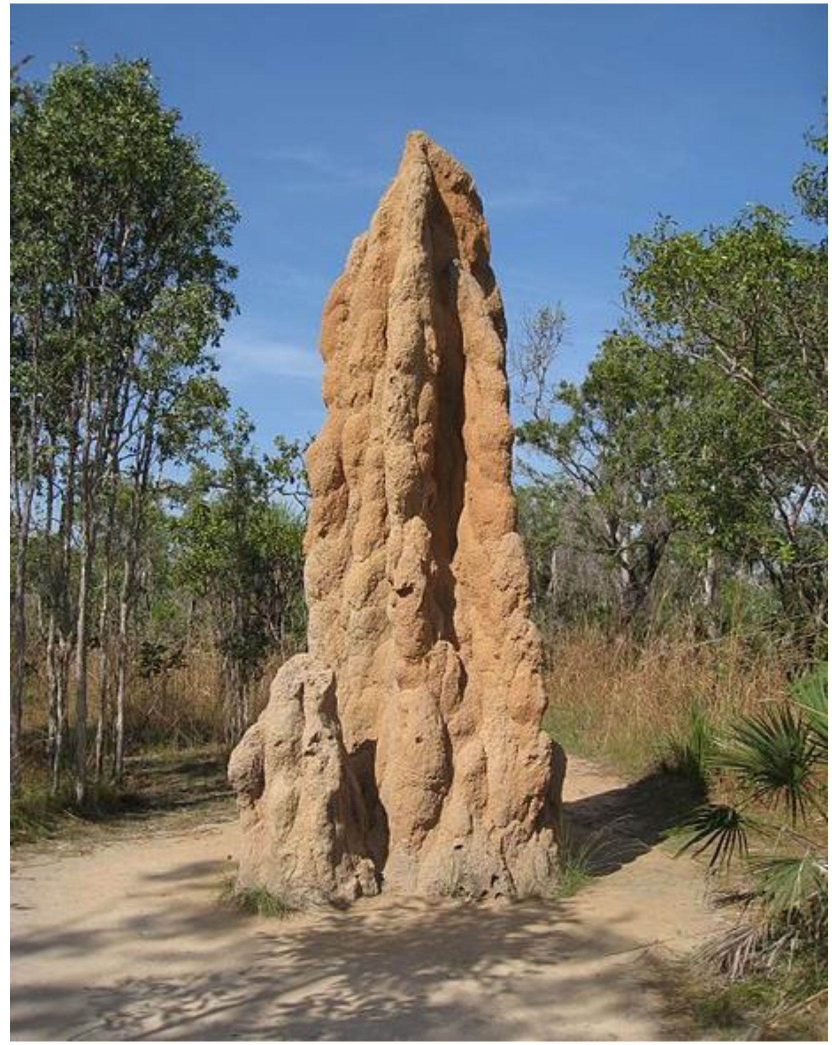

Figure 10: The final result of the termites' building method

Abstraction

The abstraction of a natural model into terms that can be used to apply it into a human-centered design is one of the defining steps in the Biomimicry design process. The act of abstraction can be defined as such: "*The act of considering something as a general quality or characteristic, apart from concrete realities, specific objects, or actual instances.*"

These general qualities and characteristics are what will be used to create the link between nature and design. By infusing a design with an abstracted form these qualities, one can create a system or product that offers people similar benefits as the natural model offers ants. In order to translate a communication method of animals into one for humans, it is very helpful to abstract it down to its core characteristics and functionalities in order to arrive at a set of requirements for the to-be-designed system or product.

Key concepts

Before being abstracted, the key components of the natural model (as well as the system itself) will first be described in a concrete manner. Dividing the natural model into these components facilitates the abstraction process.

Communication system

This natural model as a whole can be described as a system of communication, in which all the ants participate. The purpose of this system is to allow resources to be collected and returned to the nest, by enabling ants to communicate their findings to their nestmates, and to help navigate these colony members to them.

Ant

The ants are the participants in this system of communication. They are the ones that create it, use it, and benefit from it, yet they do all this through very basic actions out of instinct.

Pheromone

This is the chemical that is deposited by ants while they are foraging for resources, and which evaporates over time. Its presence attracts other nearby ants. Accumulation of the pheromone causes it to have a stronger attractive force, as well as taking longer to evaporate.

Trail

The trails are constructed by the ants with the use of pheromones. These lines of pheromones originate from the nest, and are what allow ants to follow the paths taken by their nestmates.

Cuticular pheromones

These are chemicals that can be found on an individual ant's exoskeleton. It's more complex than the pheromone used to compose trails with, and contains information about (at least) an ant's colony and its role in it. It can be read and understood by other ants who are in close proximity.

Foodsources

These can be seen as the goal of ants who participate in the foraging behavior. Ants set out to find them and to bring their contents to the nest.

System

Can be abstracted as:

A randomly initiated collection/network of attractive forces that allow large groups of like-minded individuals to passively communicate within each other by following instinctive cues, and ultimately leads to the self-organization of the group with the goal of helping individuals find their way to the most useable resource(s). It's attractive components are selected through natural selection and are temporary, which makes the system flexible to changing conditions.

Ant

Can be abstracted as:

An individual with the objective of finding a useful resource that participates in the system by instinctively responding to behavioral cues in its environment, while also participating in the creation of the system's attractive components by adding to the (or creating new) 'pheromones' left by others.

Pheromone

Can be abstracted as:

A beacon of information that is deposited by an individual and which has an accumulative yet volatile attractive force on nearby individuals with similar objectives. It is used to indirectly communicate through mass communication, and is used to increase the chance that other agents are guided to a resource which they are most likely to find interesting.

Cuticular pheromones

Can be abstracted as:

Information that is present on an individual concerning one or multiple pieces of information about one's identity, which can be read by other individuals at close proximity.

Trails

Can be abstracted as:

A network of temporary directional cues, formed in a randomly initiated process of natural selection by the feedback of individuals regarding their destination, used to change the wayfinding behavior of individuals which encounter it.

Bifurcation points

Can be abstracted as:

"Points on a trail at which a choice must be made by an individual"

Nest

Can be abstracted as:

An area from which agents start their participation in the system, and to which they frequently return to use and share the resources they have collected.

Relevant concepts

These abstract definitions of the natural model's components have been used as a starting point to look for relevant concepts in the fields of psychology and system design. The concepts of stigmergy (which describes computational models based on the foraging behavior of ants) and nudge theory (which describes how the decision-making process of individuals can be subconsciously influenced) were the most relevant ones. The insights gained while exploring these concepts have helped with the application of the aforementioned abstracted concepts into a functional design. More information can be found in Appendix 3.

Trade fairs

Why trade fairs?

As part of the preparation for this design project, a field of application for which to design for was chosen. This choice was based on a first analysis of the key characteristics of the pheromone-based communication method, which were distilled down to the following question: '*In which situation is there a need for a large group of people to navigate through a new and unknown area in search of specific locations, and where would individuals of this group benefit from communicating any findings within the group?*'

Description

A trade fair can be defined as: "*A large, stage-set, and usually regular trade event at which a large number of manufacturers from a particular industry present their products and show their capabilities to distributors, wholesalers, retailers, and end-users* (BusinessDictionary, 2017)".

As can be derived from its definition, a trade fair can manifest itself in many different forms. It is important to be aware of these different types, because they are likely to attract different visitor types and provide a designer with varying opportunities. These types can be defined by the event's targeted area, or by its sector (Appendix 5). The only demarcation of this project is that it will focus on trade fairs in The Netherlands. As this definition also indicates, the general function of a trade fair is to allow manufacturers to display their products and capabilities to potential customers. This general function can however be dissected into multiple sub-functions which gives us a better understanding of the inner workings of these events (Appendix 5).

There are a number of characteristics that set trade fairs apart from other, often more accessible, media. Two important ones in particular are:

- The exhibitor is able to establish personal contact with its target audience, which takes the initiative itself. Since the visitors chose to be at the fair, they can be expected to be motivated to communicate with exhibitors. This results in more meaningful interactions.
- The exhibitor is able to appeal to all of the visitor's senses and emotions.

Figure 11: A classic example of what a trade fair looks like

Lay-out

Unlike the forests and other natural environments in which the ants conduct their foraging behavior, trade fairs are designed to be very accessible. Visitors are unlikely to encounter any obstacles except for each other.

Placement of potential trails will be far less random than in the natural model, since the areas where the redesigned 'pheromones' can be placed have been predetermined by the designers of the trade fair; stands have been set up so that pathways are formed between them and all stands are equally accessible (figures 12 & 13). More examples can be found in Appendix 5. This of course is different from the environment in which ants navigate, although they also have to deal with physical obstacles and perhaps even base their seemingly random scouting paths on the accessibility of nearby terrain: the path of least resistance.

Similar to the environment of ants, although more prevalent at trade fairs, is the geographical advantage that some resources have over others. For example, stands closer to the entrance have a higher chance of being visited (and at least of being considered by visitors) than stands at the outer edges of a room. In a system based on the natural model, stands at the edges of a room will likely still have a lower initial chance of being visited than the ones near the entrance. However, when a visitor has eventually visited that distant stand and found it interesting, the chances of a second person visiting that stand have been increased. In the current state of trade fairs, this chance would not increase unless word-of-mouth advertising would take place.

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Figure 12: The geometric layout design of a typical trade fair

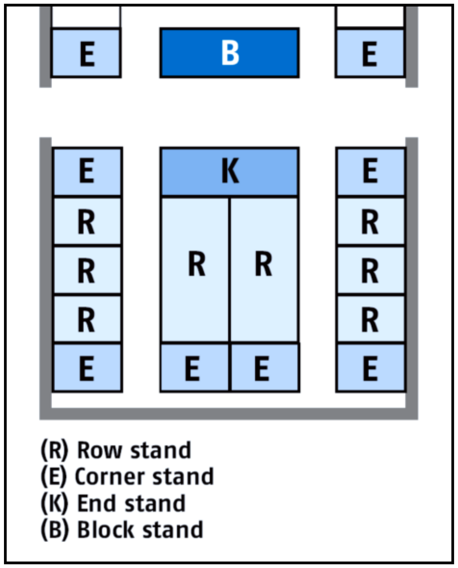


Figure 13: A generalized trade fair lay-out

Concerns

There are of course some disadvantages to using trade fairs as a marketing tool. The main one is that participation for an exhibitor is expensive, time-consuming, and takes a lot of preparation. While the biggest risk is accounted for by the exhibitors, all three parties have some concerns. The organizer, for example, wants exhibitors to have a successful event so that they may return next year and ensure the continuity of the fair. They also care about the satisfaction of the visitor, since their behavior determines the success of the exhibitors. The visitors themselves can be considered to have the fewest concerns in this situation, since they are only investing a day of their time in the event. However, when an industry-specific trade fair is only organized once a year, it might be crucial for a company to extract the right information from it in order to be able to establish a business plan based on the most recent developments.

Three parties

The trade fair is a phenomenon that is formed by the interplay of three parties: the exhibitors, the organizer, and the visitors. The latter is expected to bring exhibitors and visitors together, and match the need for information and communication of the visitor with that of the exhibitor. An organizer makes all the decisions regarding the concept of the fair: time, place, content. The following diagram shows in which the three parties interact with each other (figure 14).

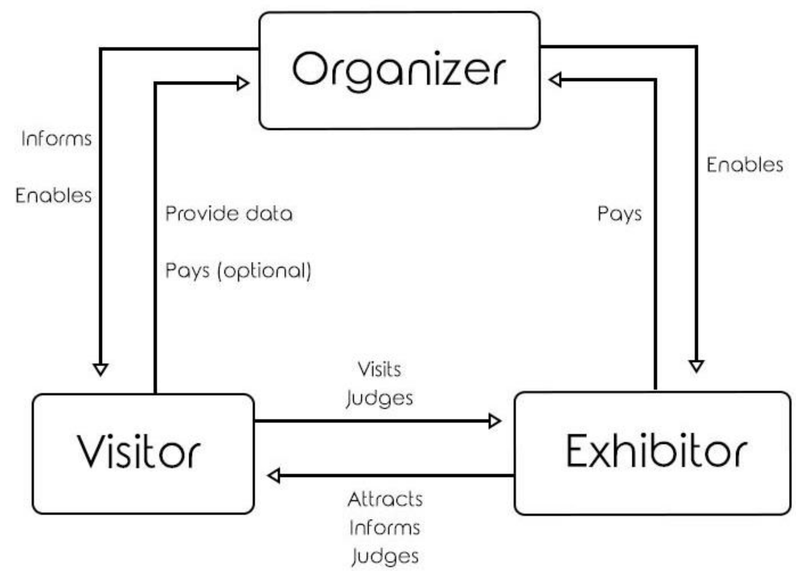


Figure 14: The way in which the three parties interact with each other

Exhibitors' objectives

Exhibitors have a manifold of objectives when attending a trade fair, which depend on the type of exhibitor, the type of trade fair, and other factors. Besides general objectives, exhibitors also want to achieve goals in the fields of communication, pricing, distribution, and products.

Out of a list of all possible exhibitor objectives at a trade fair (Appendix 6), as defined by AUMA (AUMA, 2016), it is important to determine to which goals a potential ant-based design can contribute. It doesn't take long to conclude from this that the vast majority of exhibitor goals can be addressed by a system that sets out to more efficiently match visitors with exhibitors in which they are interested.

Visitors

General behavior

Independent from visitor typology, general data on the behavior of trade fair visitors was also analyzed. This slightly outdated data referred to the way visitors prepare for their visit, how they spend their time during a visit, and their satisfaction. What was concluded from this is that almost half of all trade fair visitors does not prepare their visit, while those that do mainly read the event's catalogue. Furthermore, visitors spend an average of 38% of their time on orientation, which suggests that there is room for more efficiency. Lastly, it was found that the main cause of dissatisfaction about a trade fair visit is due to a lack of specialism at the event, or a low number of exhibitors. More information on this can be found in Appendix 7.

Attracting visitors

Exhibitors use a variety of methods to attract visitors to their specific stand, which target both the event itself as well as the time and events prior to it (Appendix 7). For this project it is more interesting to look at the methods used during the actual fair, rather than prior to it.

From this, it is important to understand that visitors do not arrive at a trade fair without being already influenced by the exhibitors. Their decision making process has already been influenced by personal invitations or by reading brochures or advertisements. When at the trade fair, they are likely to be drawn to companies that they recognize from these sources, or might not even consider visiting other stands. Furthermore, the future ant-based system will have some competition in terms of attractive forces at a trade fair. Gifts and sources of entertainment will have to be taken into account as strong influences on the decision making process of the visitor (figure 15). The attractiveness of the redesigned pheromone will have to compete with, avoid, or take advantage of this.

Figure 15: Examples of typical superficial trade fair gifts

Collection of visitor data and evaluation

Many exhibitors choose to analyze their performance after a trade fair. To enable this, data of the visitors at their stand is collected (AUMA, 2016). This is usually done by staff members filling out a data sheet. This might take a while, but is often found to be well worth the effort. The stand holders only fill out these sheets if a visitor is serious about their visit, and has shown interest in the product or service. Electronic visitor registration systems are also an option, and can provide an exhibitor with more yet less thorough information. It can be concluded that there is room for improvement in this activity which is considered to be valuable to exhibitors.

Visitors' objectives and typology

The most common typology of trade fair visitors differentiates between six different types (Wiegerink, 2002): orienting saunterers (24%), goal-oriented information collectors (21%), networkers (20%), transaction-oriented visitors (12%), seminar-goers (4%), and anti-visitors (20%). After an analysis of these visitor types that are found at trade fairs, and the set of objectives which they have (and often share) (Appendix 7), a number of personas were created. These fictional personas bring these categorizations of visitors and objectives together, and help envision which types of people are likely to walk around at a trade fair, and how they might behave.

Alex. Business representative.
Transaction-oriented visitor

He is visiting a trade fair on behalf of his company, and is planning to visit several stands from exhibitors who sent him a personal invitation. Two of these stands belong to companies with which he is already in business, and with whom he wants to discuss the placement of orders of a new product and intensify their relationship. Other companies' stands are relatively new to him, and with these he wants to evaluate the prospects of being future business partners. At the same time, he wants to keep an eye on the competition and emerging trends in the market that is company is active in. Alex has quite a busy schedule, but after his scheduled visits he does explore the rest of fair a bit to see if he can discover some interesting new names in the industry. Because of his experience he is able to quickly judge stands, and only stops at those he deems interesting enough. He is less likely to be influenced by superficial attractive factors such as gifts.

Michelle. Starting entrepreneur.
Goal-oriented collector of information

She has recently started her own specialized store in her hometown, and is visiting the fair with the hopes to make deals with companies who can offer suitable products to be sold by her. She has read about the fair via advertisements and online brochures, and also received some personal invitations from several companies. Despite these invitations, she goes to the fair with an open mind and is planning/willing to explore all options to make sure her store has the best possible merchandise. Since she is new to the industry, het priority is to get a clear overview of the products it has to offer and the prices that go with it. She is also interested in trends that could help her store get a competitive advantage. In spite of her open-minded approach, she is well aware of what she wants and is therefore not likely to be influenced by superficial factors such as gifts or entertainment.

Anna. Inspiration seeker.
Orienting saunterer/Seminar-goer

Anna is a dedicated teacher who has decided to visit an education fair to learn about new developments in her field, with the aim of keeping her teaching method relevant and up to date. She is therefore mostly looking for new trends and inspiration, although she might consider informing herself about business relations so that her school might adopt a product or service entirely. She will definitely attend several pre-selected seminars to help her fulfill her objectives. She learned about the fair from both an education magazine as well as a brochure sent to her employer. She visits the fair with an open mind but with a clear goal as well. She might be attracted by gifts and entertainment, but has a strong focus on the content that stands have to offer.

Ronald. Recreationist. (Only at certain fairs)
Orienting saunterer

He visits trade fairs simply for his own enjoyment. The reasons he has chosen for a trade fair are his broad field of interests and hobbies, and an urge to learn about innovations and the world in general. He does not always have a personal connection to the industry of the fair that he visits, but enjoys it nonetheless. He decides on which fair to go to by reading brochures online, or by hearing about them from friends. While at a fair, his goal is his enjoyment. He wants to learn about the most interesting stands, and be entertained by them. His behavior is quite impulsive, and can be influenced by anything that appeals to him.

Conclusion

The most important thing to conclude from these persona's is the behavior of each type of visitor, in order to be able to determine how the system of the ants should be applied in this situation. The visitor type that displays the most similar behavior to that of ants is described by both Betsy and Anna. While they both have a clear goal in mind, but are not yet sure which stand (resource) they should visit (let alone where to find it) to reach this goal.

The design of the system will depend on the quantity of each type of visitor at an average trade fair. If it turns out that the vast majority of trade fair visitors are business representatives, the system will have to be designed in a way that matches their behavior (e.g. more focused on wayfinding). While the aforementioned source (Wiegerink, 2002) has already suggested orienting visitors are the most prevalent type at most fairs, field research will be used to confirm this.

Trade Fair Development

The main source used in this report regarding the behavior of trade fair visitors stems from research conducted in 2002. It would therefore be helpful to discuss how the role of a trade fair and the behavior of their visitors have changed over the years, and how a new system would be able to play into this change.

Societal changes

The most obvious developments that have taken place in society is the growing popularity of the internet and the emergence of the smartphone. The combination of the two has drastically improved the accessibility of people to information, which has likely had an influence on the role of trade fairs in the marketing mix as well as on the behavior of visitors at a fair. This has transformed trade fairs from a large buyer's event for capital goods (figure16), to a place where information is exchanged and personal relationships are established or strengthened through face-to-face meetings (AUMA, 2016). This can be seen in combination with the rise of smartphones, which have offered people a way to have access to the internet wherever they are, including at a trade fair. Visitors are no longer solely dependent on the information they can obtain from a stand, and are far more flexible in their communication which enhances the process of making follow-up meetings a reality.

This increased accessibility to information does however not necessarily have a negative effect on the relevance of trade fair, since information has always been widely available in the form of adverts, catalogues, and letters. Just like internet research, these sources can only offer an abstract impression of the content that can be personally experienced at a trade fair by all the senses of a visitor.

The great number of possible face-to-face meetings will likely always be an unique selling point of trade fairs, since personal trust is a determining factor when business relations are established. This graph (figure 17) shows that companies continue to value trade fairs highly in regard to business-to-business communication (AUMA, 2016).

Figure 16: A Siemens stand at the Hannover Messe in 1954

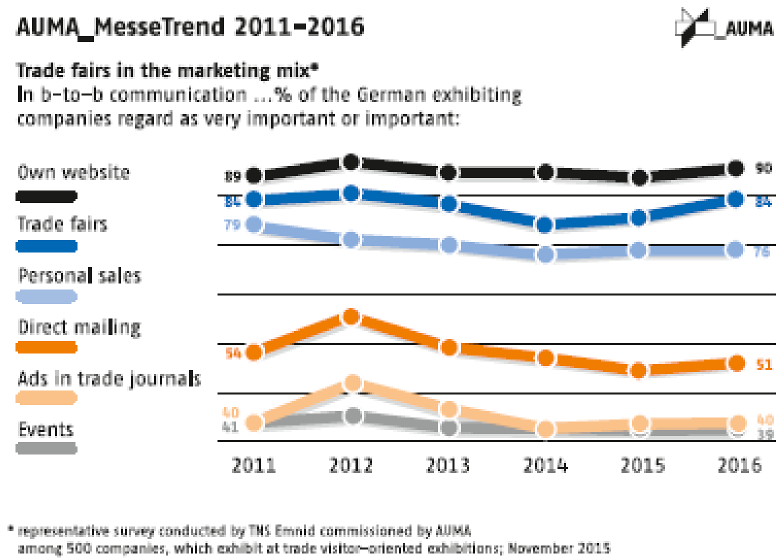


Figure 17: The relevance of different communication channels over the years

Focus

While the relevance of trade fairs appears to be relatively stable, their content has noticeably shifted over the years. The main trend that can be spotted is a shift from sales to networking as the main objective of exhibitors (evantbranche.nl, 2015). Companies focus on the selling of their brand 'experience', the sharing of information about their products or services with visitors at their stand, and networking with new and current partners.

Conclusion

The final design of this report will likely be able to take advantage of the "trends" mentioned above, and help the phenomenon of the trade fair remain relevant in the upcoming decade(s). The influence of smartphones and the internet on such a long-lived event will certainly benefit the design, which will appear to revolve around big data.

Field Research: PromZ fair

In order to experience the phenomenon of a trade fair myself, I visited the PromZ fair in Ahoy Rotterdam. This trade fair specializes in promotional products and gifts. A full report of the visit can be found in Appendix 9. This visit had three goals: to objectively observe the elements on the event, to assume the role of a visitor in order to gain insight into their experience, and to interview actual visitors to find out how they experience the event and what constraints they face in achieving their objectives.

Several insightful observations were made during this visit. It featured two prominently displayed, physical maps of the event, which grouped exhibitors into six categories based on their content. There was great variation in the size, sophistication, height, and professionalism of stands. A contest was being held at the entrance/exit of the fair which featured a product from every exhibitor, in which visitors were able to judge these products without being influenced by external factors and vote on their favorite item.

One of the main experiences as a simulated visitor was an unexpected level of assertiveness and intrusiveness of many of the exhibitors, starting right upon entering the event and slowly decreasing as the day went on. Furthermore, wayfinding was rather difficult because of the high density of stands, the narrowness of aisles, and the lack of contrast between the different areas of the fair which had been identified by the aforementioned map. Lastly, energetic background music was played, most likely in an attempt raise the level of excitement among visitors to match it with the character of the event.

Interviews with a number of randomly selected visitors offered some insights in how they approached their visit, what their objectives were, and how well they considered their visit to be going. The main insight gained from this is that many visitors had trouble distinguishing a stand based on its value for them. The nature of this trade fair had resulted in a large number of similar products and services, which made it hard for visitors to choose between them. These interviews also seemed to confirm the existence of the different visitor types that were mentioned earlier.

After this trade fair visit, another interview was held. This time with an experienced trade fair exhibitor (Appendix 10). This provided some insights on how exhibitors experience these events.

Figure 18: An impression of the ambiance at the PromZ event

Constraints

As a conclusion of the research in the field of trade fairs and their visitors, a number of constraints have been formulated which reflect all the aspects of a trade fair with which any of the three major parties (organizer, exhibitor, visitor) struggle. These constraints will be used to formulate a design goal and act as a basis in the conceptualization phase.

- Visitors experience an inability to judge and distinguish stands because of the lack of information they provide at first glance, their often similar appearances, and (at some events) the similarity of the services they offer.
  - A stand at a fair cannot display much in-depth information about the company or products. It is designed to attract visitors and to spark interest in them. This makes it hard for visitors with the goal of making trade deals to judge a stand at first glance (or second glance).
  - Many fairs these days are specialized for a particular industry (sweets, promotional gifts, webshops), which naturally means there is less drastic variation between the content of different stands.
- It is hard for some visitors (particularly the ones with a general interest and who are browsing the fair) to get an unbiased impression of a stand, because they are often approached by an exhibitor. The performance (charisma, convincing power) of the exhibitor will, for a great deal, influence the way the visitor experiences the stand.
- On the other side of the fair, exhibitors also have a hard time distinguishing relevant visitors from the rest. A conversation with passing visitors is the current way of doing that, but takes time. They therefore face a dilemma between an active and passive approach (Appendix 10). Choosing a visitor to speak to could make you waste time on an uninterested visitor, while waiting for interested visitors to speak to you could cause many to ignore your stand.

Design goal

These constraints have allowed for the formulation of a design goal, which will act as a guide throughout the upcoming conceptualization process:

"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."

Requirements

The following set of design requirements has been composed based on the abstraction of the natural model. These requirements dictate which properties a communication system based on the natural model must have. Unlike a traditional set of requirements, it is not obligatory to follow these at all times. Requirements may be ignored when, for example, new insights render them impractical. Nevertheless, the aim is to follow them, and therefore the natural model, closely.. A second set of criteria has been added, which are related to the trade fair analysis and are complementary to the aforementioned constraints.

Requirements: Natural model

- Participants must be able to leave information at points of interest.
- The pieces of information that are left by participants must act as beacons, and exert an attractive force on other visitors. Either towards all visitors, or only a selection of them.
- This resulting attractive force must be instinctively understandable for all visitors.
- These beacons must be volatile; they must fade away over time when not added to.
    - Underlying requirement: The system takes the currentity of data into account, and places higher value in recent deposits of information.
- The attractive force of the beacons must be accumulative.
    - An accumulation of information deposits at the same point of interest results in a stronger or prioritized attractive force.
- The beacons left by visitors must allow for mass communication: one sender with multiple recipients.
- Information from the beacons must be indirectly transferrable; there is no need for sender and recipient to be present at the same time and/or place.
- The system must be self-organizing. It should function without a leader or a higher intelligence. WHY
- Data within the system must be stored in the communication medium

Requirements: External

- Participants must be able to sense and respond to the 'pheromones' of others.
- The system must have a low monetary, motivational, cognitive, and physical participation threshold for visitors, and preferably also for the other two parties.
- The system must respect the privacy of participants
    - It may not disclose their information to 3rd parties.
    - It may not use involuntarily acquired information.
    - Participants must be informed on what happens with their information.
- The system must be able to determine when a visitor is genuinely interested in a point of interest (e.g. a stand).
- The system must be universally implementable in existing fairs in The Netherlands.

Key differences

As is the case in many applications of a natural strategy in a human field, there is no perfect match between the two. Since in this case the field of application was chosen sooner in the process than usual, this effect has potentially been amplified. There are several differences to be identified here, some of which come forth from the differences between humans and ants and some from the difference between a trade fair and the forest floor.

Based on these differences, a designer can see whether the characteristics of the natural model can be further abstracted till a point where they match the field of application. For example, the nest of an ant colony can also simply be seen as the starting point of trails, or the place that is most visited by agents.

A designer can also redesign the field of application so that the benefits of the natural model can be used to its full potential. For example, a form of nest can be created at a trade fair, from which visitor start their journey and of which they have the motivation to frequently return.

Another option is to discard the characteristics that cannot optimally be mimicked in the field of application. Successfully mimicking a part of a natural strategy is arguably more useful than forcing certain aspects into a solution in which they do not optimally fit. Furthermore, a designer could also choose to solve parts of the design problems with parts of the natural strategy.

Differences: Ants and humans

- Individually, humans are significantly more intelligent:
    - We are able to think critically about their behavior rather than act solely on instincts. This also makes the behavior of humans less predictable, and not likely to be definable by a similar set of rules as mentioned earlier (Appendix 2).
    - We are able to become aware of the system we are participating in, and could choose to manipulate it: for their own advantage or for the sake of anarchy.
    - We are able to remember larger quantities of information ourselves, instead of needing to store it all in a communication medium.
    - We are able to individually process and communicate larger quantities of information at once.
- Humans have more senses on which they can rely. They are able to plan ahead based on sight, for example.

While members of a group of trade fair visitors do have a similar goal, they do not necessarily have a collective goal (certainly not one as strong and all-encompassing as that of ants: the survival of the colony). While they all set out to find a stand from which they think they can learn or benefit, it is not their primary concern if other members of the system are successful as well. There is therefore no real (extra) incentive to help each other. Several different goals can also be identified amongst a crowd of visitors, which further complicates the situation.

Differences: Natural model and trade fairs

- A trade fair has no form of central point of departure and return to which people continuously travel back to, like to the ants' nest (figure 19). This causes a major difference in the way trails are formed and confirmed. In the case of trade fairs, trails will therefore be formed in a more continuous manner. Things that are similar are resting areas, lunchrooms, and optional VIP lounges. The entrance of the fair could also be seen as a point of departure, but is normally only visited twice.
- As mentioned, a trade fair has predetermined walking areas, which means that walking patterns of visitors cannot be as random as those of ants in an open environment. This limitation in options is expected to lead to a faster determination of an ideal route (figure 19).
- As opposed to (certainly in the eyes of ants) a foraging area of unlimited size, trade fairs occur in demarcated areas. (figure 19)
- The collective goal of a swarm of ants succeeds when they manage to direct all traffic towards one potent foodsource at the time. This is not a desirable situation at a trade fair, where it is better to direct visitors to several interesting sources of information at once so that they spread across the trade fair.

Figure 19: Open terrain around a nest vs. an organized and demarcated fair

Conceptualization

After a thorough analysis of both the natural model and the phenomenon of the trade fair, an application of the former in the latter will be designed. While the analysis phase has provided some insight into the feasibility of such an application, the conceptualization phase will fully determine whether or not trade fairs can benefit from a design based on the natural model. If so, it will be decided in which form this design can best improve trade fairs both the three involved parties: visitor, exhibitor, and organizer.

This chapter will first explain the starting point of the creative process, after which it will describe the way in which ideas were generated which attempt to achieve the design goal. Two conceptualization steps were then taken to arrive at a final concept: one to determine the main outline of the design, and another to arrive at a more concrete vision on how this design will manifest itself.

Starting point

The first step towards a design application is the formulation of the most basic system that will be designed. This system will be formulated in the form of a visitor scenario and will act as the foundation for this conceptualization phase. It copies the way the natural model works onto a trade fair visit, but does not yet specify how these functionalities will be realized. A subsequent ideation phase will explore how this can be done.

- Visitors arrive at a trade fair.
- Either before or during the trade fair, information about these visitors will be collected by the system, so that they may be placed into groups.
- They start walking through the fair and browsing exhibitors, looking for an interesting one to visit.
- As the visitors walk through the fair and/or visit exhibitors, they leave behind information regarding the exhibitors they deemed to be interesting. This information will be readable, either directly or indirectly, by other visitors. Preferably by members of the same visitor groups.
- Visitors that receive this information left by their peers will be influenced by it. It will suggestively guide them towards one or more exhibitor(s) which were deemed to be interesting by other visitors. Preferably by members of the same visitor group.
- The information left by visitors will have a certain degree of persuading strength. This strength will increase as it is confirmed by multiple visitors: the more visitors find a stand interesting, the stronger similar visitors will be persuaded to visit it.

Ideation

As mentioned, the basic system that has been described (combined with the conclusions from the analysis phase) will now function as the basis for an ideation phase in which the possibilities for a design application will be explored

Concept choice criteria

In order to select the best conceptual design for further development, several criteria were established prior to the development of concepts (Appendix 11). These help establish the most important characteristics of the concepts on which must be elaborated, and will also be used to select the most suitable design at the end of this process.

Partial concepts (ideas)

As a first step, brainstorming questions regarding the abstracted natural model and relevant concepts were used to generate problem-solving ideas (Appendix 12). The results of the brainstorm sessions on the aforementioned questions were evaluated, and a number of design ideas were formed from the most promising results. These partial design solutions can be found in Appendix 13.

Combinations

The aforementioned partial solutions were then elaborated on and combined with each other to form the following two conceptual design solutions. Both have been sufficiently elaborated on to be able to be judged by the concept choice criteria.. A summary of both design concepts can be read here, their full descriptions can be found in Appendix 14.

Augmented reality-enabled nudging road signs

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 nudging properties, 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. The way augmented reality is incorporated is that visitors will be able to observe these road signs through a (to be determined) personal device, allowing them to see a personalized version of these signs based on their personal visitor profile and the opinions of like-minded visitors on the exhibitors seen on these road signs (figure 21). In this augmented reality, the road signs of highly valued exhibitors will be given a subtle advantage (e.g. size, brightness, contrast) over the others (figure 20). The second concept iteration step will have to focus on the exact way the road signs will nudge visitors, and on the type of device that will have to be used to access this augmented reality.

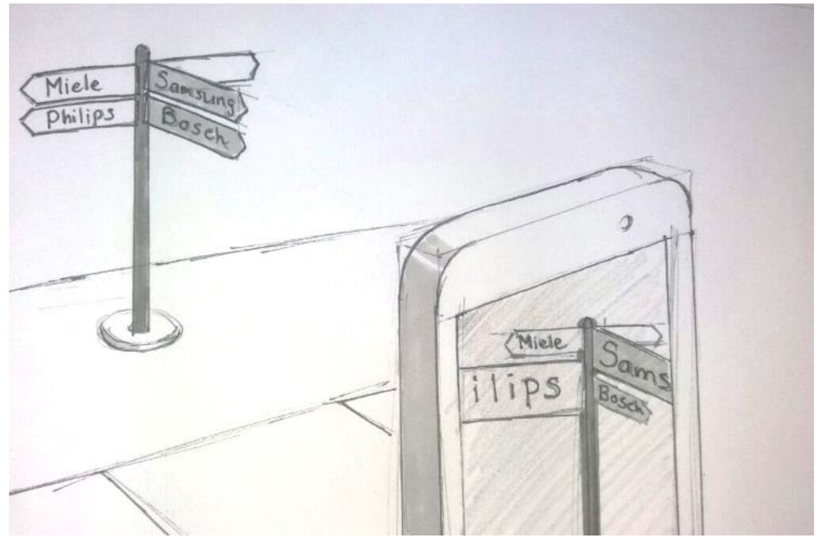


Figure 20: The way in which a personal device could augment reality

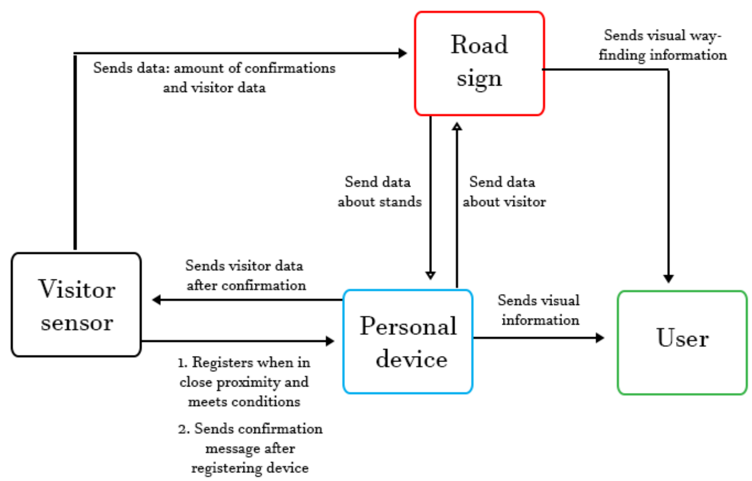


Figure 21: The way in which the elements of this concept interact with one another

Nudging personal devices and identity tags

In this concept, each visitor is given a personal device upon entering the trade fair. This device will be worn or carried by the visitor throughout his visit, similar to the traditional visitor 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 profile of its user and the opinions of other visitors at the fair (figure 22). 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, most likely by using color coding.. This second functionality will help exhibitors work more efficiently by helping them focus their time and effort on visitors with more matching potential, and is based on the aforementioned cuticular pheromones used by ants. Just as in the previous concept, the system will have to determine when visitors are genuinely interested in a stand. The second concept iteration step will have to focus on the type of the device that will be used, and how it will deliver a nudge to its user.

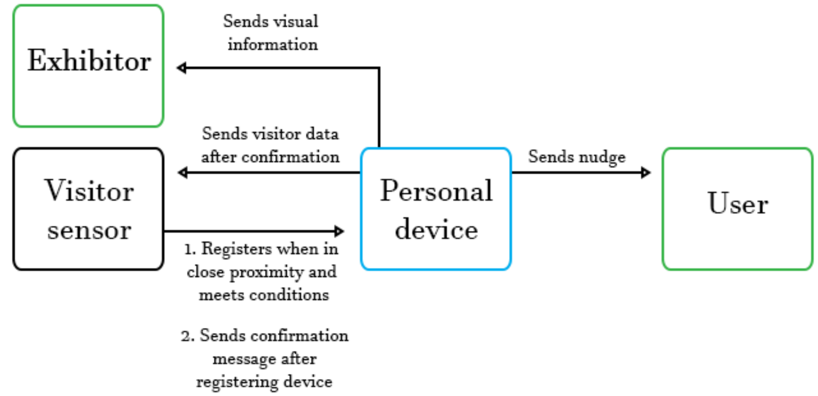


Figure 22: The way in which the elements of this concept interact with one another

Grouping and judging

Regardless of which concept will be chosen and elaborated on, there are two influential features that will be incorporated into the designed system. These are the way in which visitors are grouped or linked to others based on their shared interests or behavior, and the way the genuine interest of a visitor in a stand will be registered. Choices were made to group visitors based on the information they provide while registering for an event because information is already being collected this way, and that the best way of judging the interest of visitors in a stand is probably by combining an active approach of visitors with a passive confirmation method (Appendix 15). This last decision implies that visitors will be able to indicate interesting stands themselves, and will receive a message asking them to confirm this interest in order to ensure a genuine interest.

First choice

After a visit to the Materials fair in Veldhoven, during which insights were gained on h the feasibility of the proposed concepts through observations and interviews (Appendix 16), the next step is to make a choice for a design to elaborate on.

By using the aforementioned concept criteria, a weighted-criteria choice method indicated that the personal device/identity tag concept has the most potential at resulting in a viable design and in fulfilling the design goal in general. This is mostly due to it having far lower expected implementation and participation thresholds. This concept also focuses more on the orienting visitor types, which make up the largest part of the visitor base. More information on this choice can be found in Appendix 17.

Elaboration

In order to optimize the chosen concept, a second ideation phase was gone through to explore the optimal choices regarding the variable factors of the concept that were mentioned in its initial description: The exact way in which the device will nudge its user and how that nudge will be linked to the right stands, and the way the exhibitor reads the identity tag and the design that comes forth from that.

The way variations within this concept will be created is by the use of a morphological chart (figure 23). The variables within the concept will be listed, and a brainstorming method will be used to diverge on and explore these variables. Subsequently, the most promising options will be selected and added to the chart.

Combinations between options of each variable will then be made to form a variety of new concepts. The variables and their options can be found in Appendix 18.

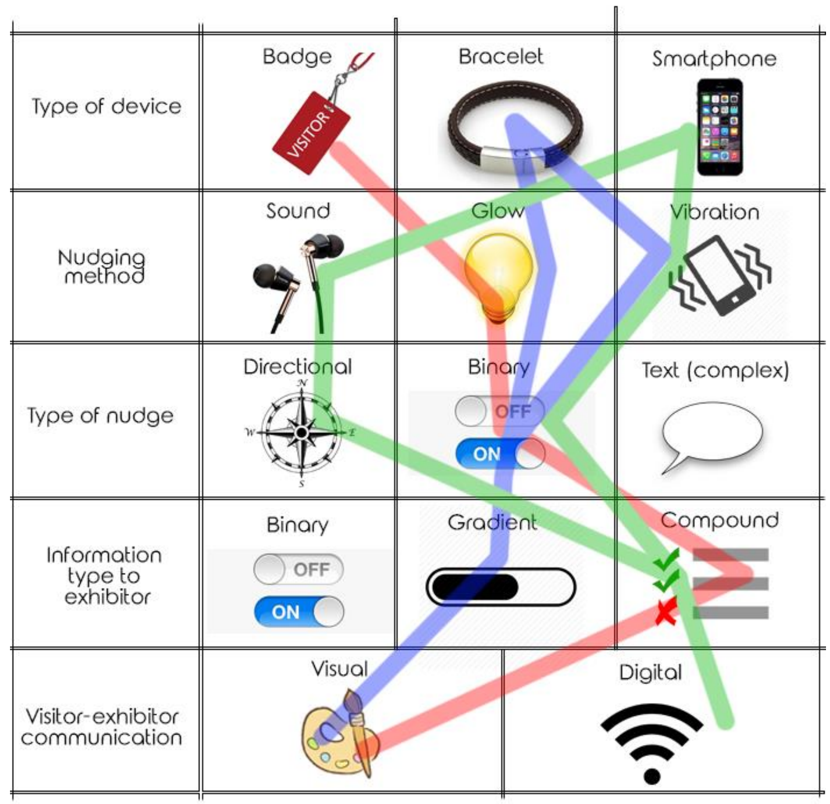


Figure 23: The morphological chart and the ways

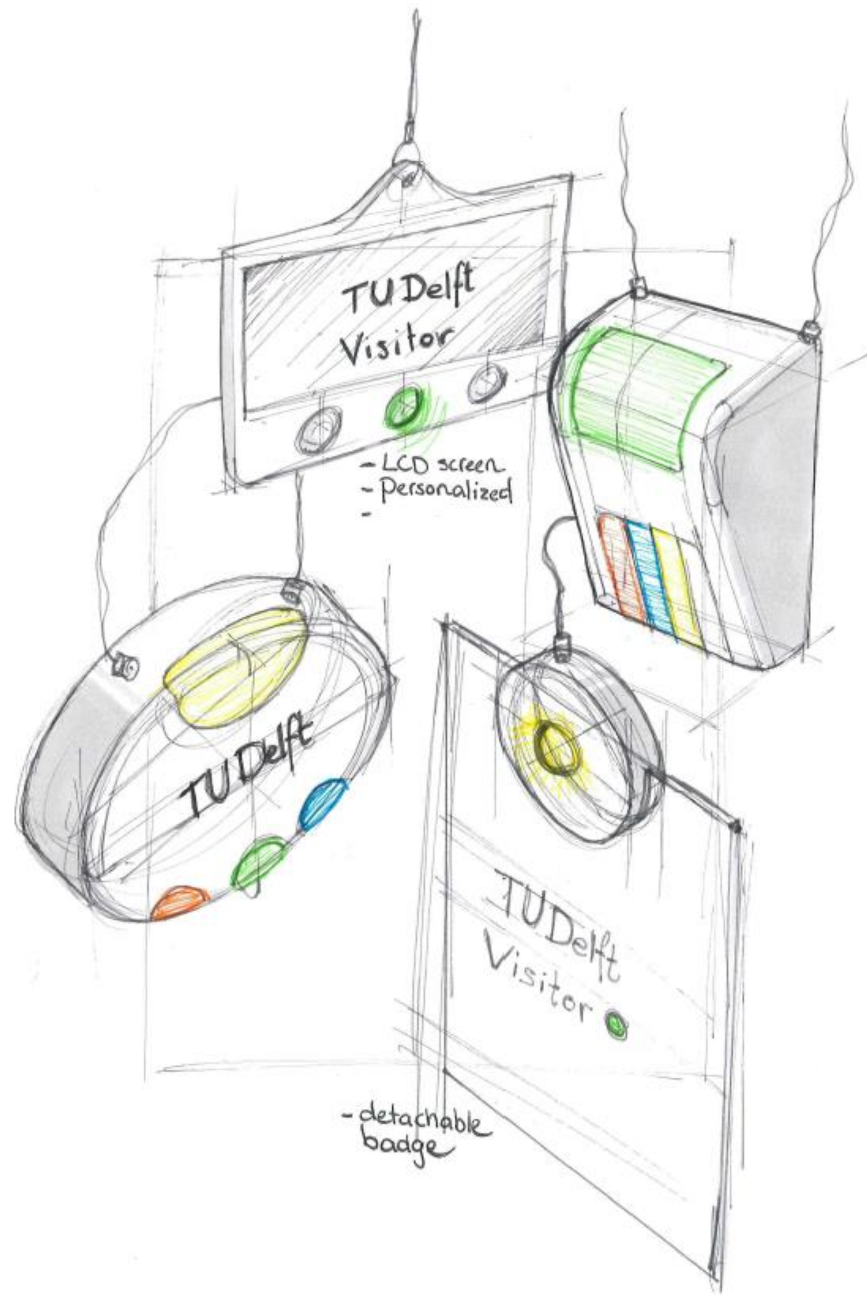
New concepts

The most promising combinations made with the aforementioned morphological chart will now be described and elaborated on till the point a well-considered choice can be made between them. These descriptions have been summarized, their full versions can be found in Appendix 19.

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.

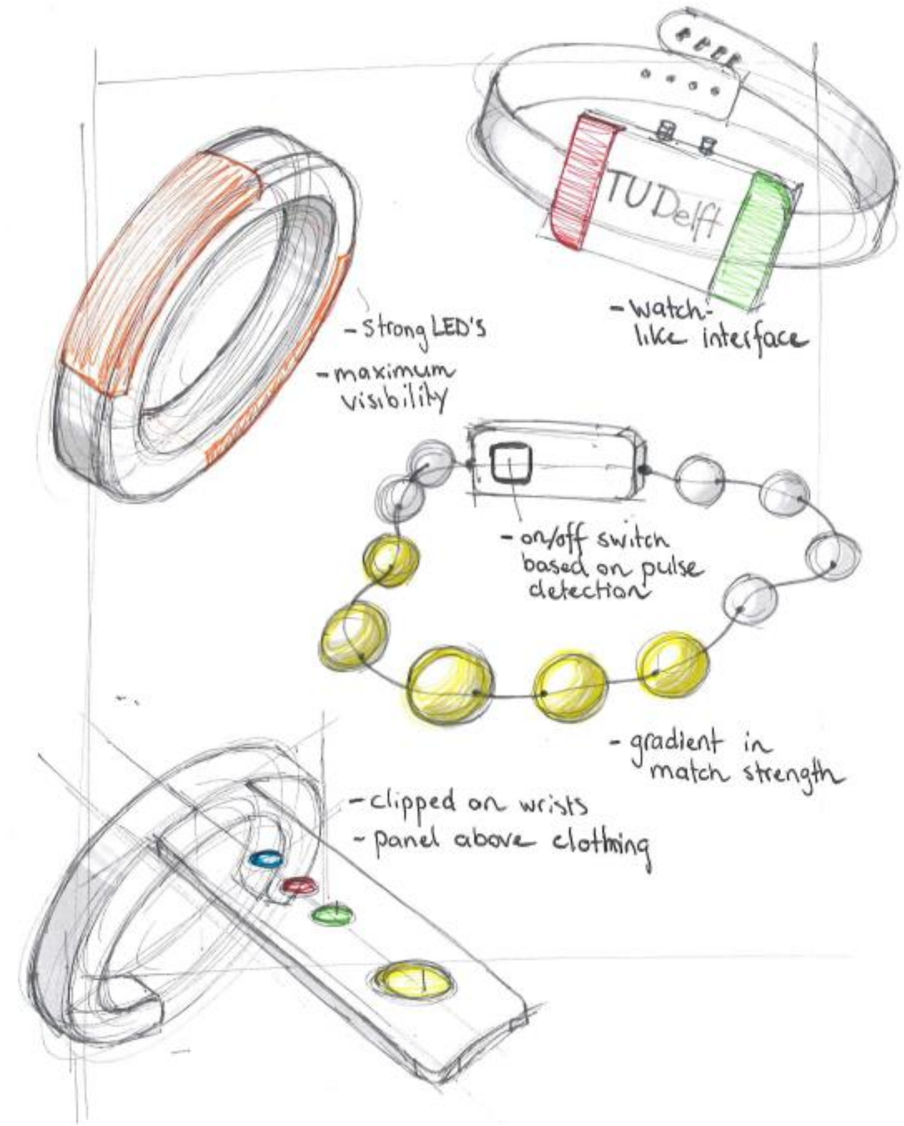
As mentioned, the information that the badge provides exhibitors with can be more complex than a binary indication of a match between visitor and stand. It must, however, still be easily (almost instinctively) understandable by all exhibitors if the device is to be used at crowded fairs. Two variables 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.



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 addition of a vibrational signal, however, has been deemed necessary to ensure that its users notice the nudge. The vibration is meant to draw attention to the device, will the glowing signal confirms this attention. The exhibitor will receive the same information as the visitor: whether or not they match with the stand and how strong this match is.

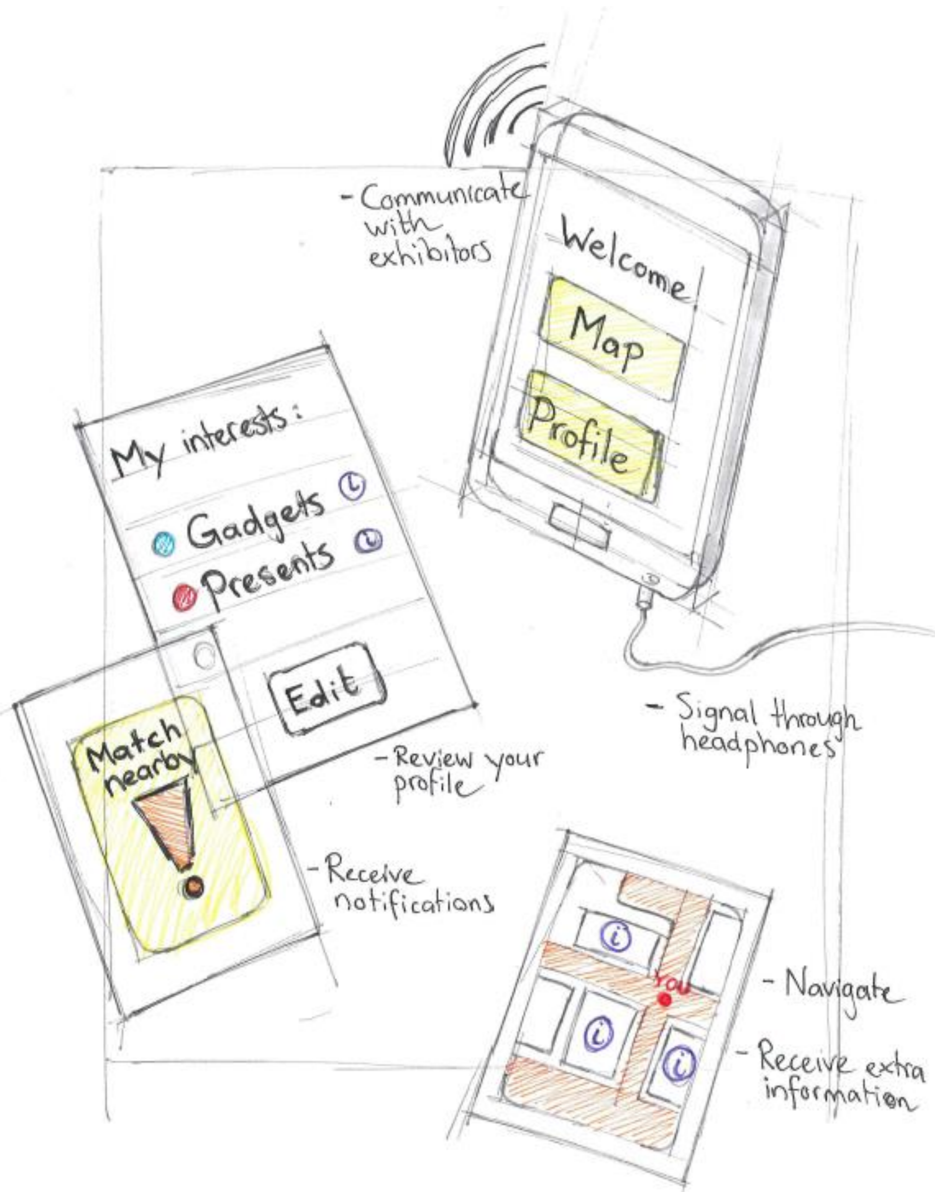


Smartphone-based

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. The success of this concept rests on the assumption that exhibitors 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.



Behaviour

To better understand the main choices a visitor makes at a trade fair visit, and the way any of these three personal devices facilitate these, a behavioral flowchart was constructed (figure 24).

The traditional flowchart has in this case been combined with a network planning, by defining a default activity for both agents. As can be seen, certain actions and decisions will cause the agents to deviate from this default activity and others cause them to return to it.

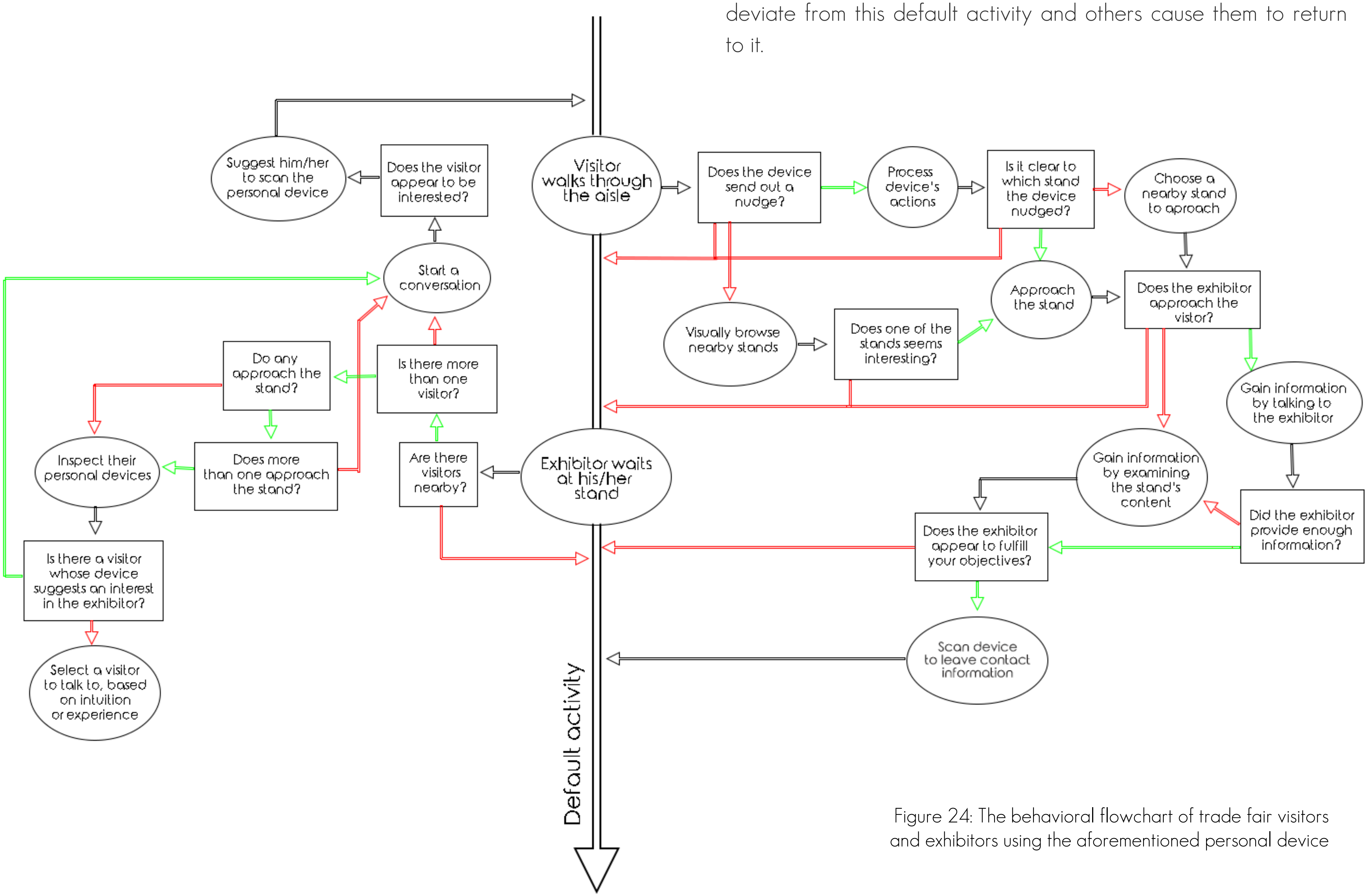


Figure 24: The behavioral flowchart of trade fair visitors and exhibitors using the aforementioned personal device

Choice

As a next step of convergence, a choice will be made between these three devices and their corresponding concepts. This choice will be made by using a revised set of criteria which can be found in Appendix 21. For this choice, a combination of two rather subjective methods was used to arrive at a well-argumented decision. A description of these methods and their application can be found in Appendix 21

The conclusion drawn from the results of these methods is that the glowing badge concept has the most potential based on its high accessibility of information for exhibitors, and a low participation and implementation threshold. Its nudging method will have to be reviewed, however, in order for it to become a viable product to be used in trade fairs. The smartphone concept was rejected because installing an app was deemed to be more effort than visitors are willing to invest in a one-time event, which was later confirmed by Han Bosman.

Embodiment

After analyzing and abstracting the natural model, researching the world of trade fairs, and combining both into a conceptual design, this report will now describe the choices that have been made in the realization of this concept. This chapter will describe the system and its characteristics, the visual and physical design of this system, and the technologies that have been selected to allow the design to enable its functionalities.

EvAnt Matchmaker

The design on which this chapter will elaborate has been named the EvAnt Matchmaker, and can best be described as a self-organizing system of indirect mass communication in which trade fair visitors receive subtle suggestions on which stands to visit based on the opinions of previous like-minded visitors., and in which exhibitors are able to identify potentially interested visitors in order to increase the efficiency of their performance.

This system uses a pool of constantly enriching data, which is created by the visitors themselves through their interaction with two devices (figure 25, Appendix 23). These two products are the embodiment of this system.

The first of these products is a personal device which is worn by all participating visitors. This device will closely resemble the visitor badges that are currently being worn by visitors at trade fairs, but will be redesigned and equipped with the necessary technology to allow visitors to both leave their information at interesting stands and sense the information that was left by other visitors, and allow exhibitors to better identify the objectives and interests of visitors. The second product can best be described as a stand device, and acts as the medium of indirect, mass communication by interacting with the personal device in two ways: scanning the devices of interested visitors to allow them to deposit their information, and sending the data they have collected through these scans to other nearby personal devices. Upon receiving this collection of data, a personal device will then compare it to the profile of its user. When sufficiently similar, the device will notify its user. A detailed breakdown of both devices' functions is found in Appendix 22.

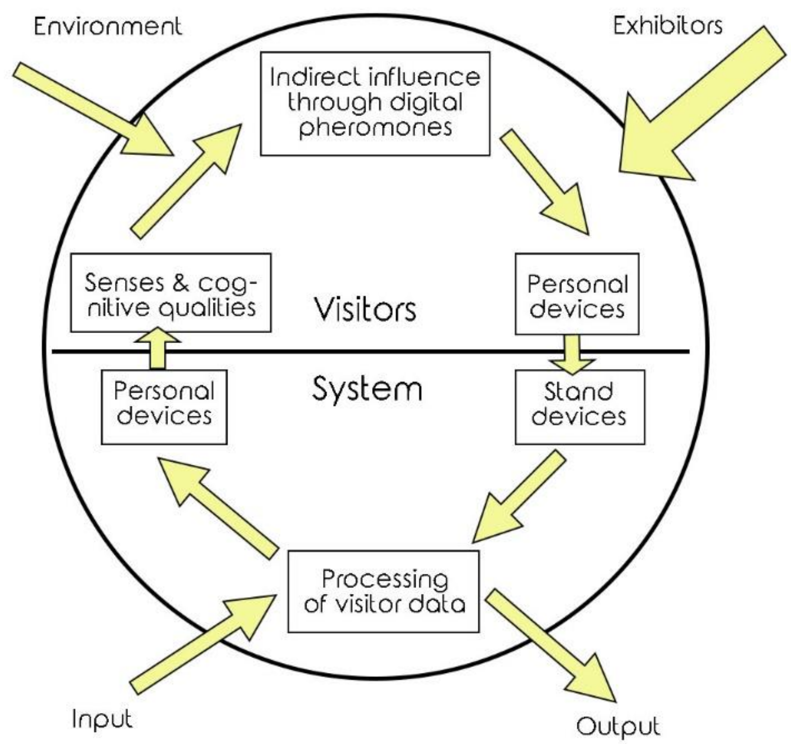


Figure 25: The interaction between this system's data and trade fair visitors

Design

As mentioned before, the personal and stand devices form the interface through which visitors create the communication system. For that reason, their appearances play an important role. The design of the personal device has a main objective of communicating visual information regarding its wearer to exhibitors, as well as to nudge its user to visit a certain stand. The stand device plays an even more important role because its appearance has to help visitors notice it, understand its function, and scan their personal devices.

Process

The first step in the process towards a final design was to make an inventory of the required characteristics of it (Appendix 25). After establishing these, an ideations phase led to a form concept which suggested users that their personal device needed to interact with a stand device by designing the former to fit into the latter as a piece of puzzle (Appendix 25). The badge was to be inserted into a slot here, to enable a precise orientation of the QR code as well as to increase the experienced value of the operation by visitors. This form concept then led to a preliminary design (Appendix 25). This design was evaluated, and followed up by a brainstorm session with the goal of improving (amongst other things) its aesthetic quality. This brainstorm session provided new inspiration which led to the final design of both devices (figure 26)..

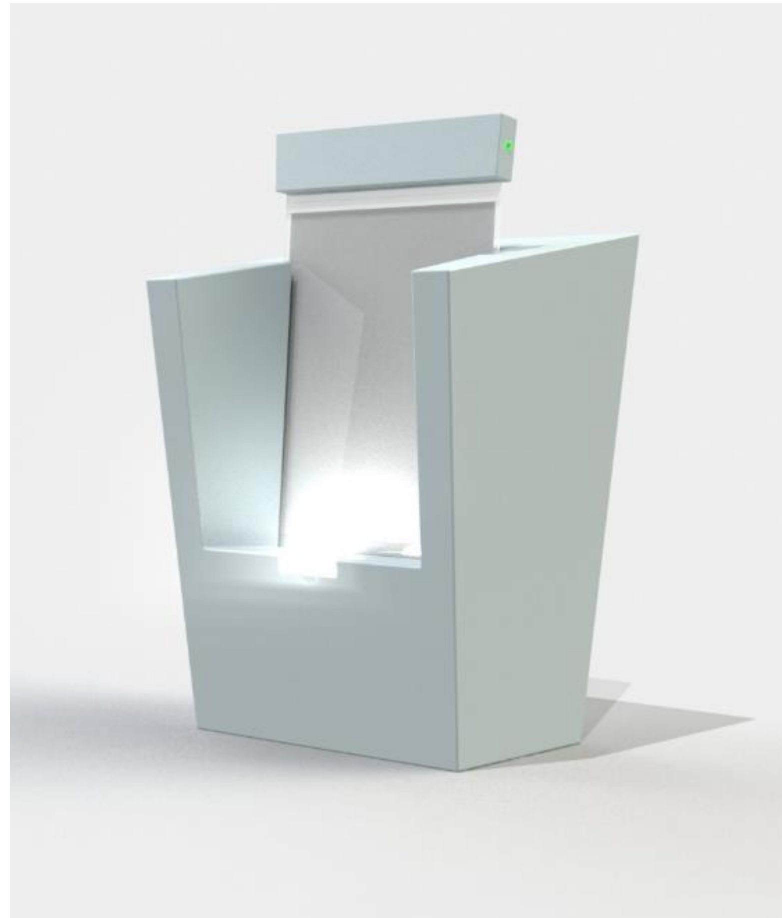


Figure 26: The final design of both devices

Final design

The new design is based on a single geometric shape, which intends to invite visitors to interact with it by leaning forward and having a upwardly diverging form (figure 26). No unnecessary fillets, extrusions, or irregularities in general have been added, as not to distract from the message this shape conveys. A compromise has been made between inserting the personal device into a slot or placing it into a wider cavity. In this design, the personal device must be placed in a cavity while being guided by two grooves on the sides of it (figure 27). This ensures the QR code is still correctly placed in front of the scanner, while making the product feel more accessible.

Furthermore, this design allows visitors to insert their badge without having to rotate it first, as was required in the initial design. Once inserted, a light at the bottom of this cavity will be turned on as a form of feedback.

Its color was selected by making an inventory of colors that appeared to match the inviting, universal yet noticeable character of the devices. These colors were then compared to a variety of trade fair environments and some were applied in renders of the final model, until the most suitable color emerged.

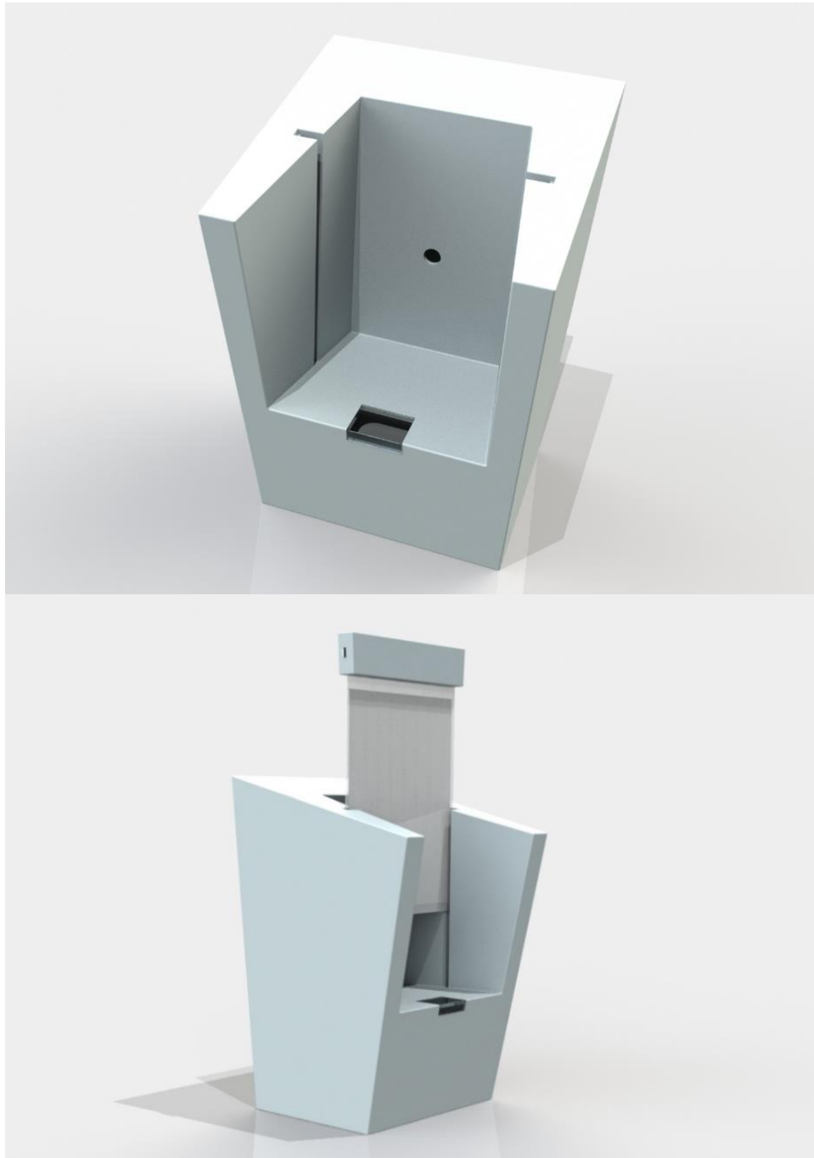


Figure 27: The accessible design also guides visitors in their interaction with it

Stand

A feature that was added in the final stages of this design process is a removable structure that acts as a stand (figure 28). This will be necessary in two scenarios: when an exhibitor's stand does not have a table or counter to place the stand device on, or when the location of this table/counter does not allow the transmission range to efficiently cover its adjacent aisles (figure 33). It has been designed to match the stand device's form by extending its angles downwards.

The stand will be produced out of hollow aluminium tubes with a rectangular cross-section. The base in which these tubes rest will be made from the same material as the stand device's casing. Instead of electronics, this part will be filled with an appropriately shaped block of steel to ensure the stability of the entire construction.

Whenever an exhibitor has the opportunity to place the stand device on a counter or table at the correct location in its stand, this stand will not be necessary. In this scenario, which will be pursued with priority, suction cups will be inserted in the bottom of the stand device instead of this stand. These will also ensure the stability of the device.

Figure 28: A stand device mounted on its stand

Accessibility

Since accessibility is an important required quality of the stand device, its ergonomic qualities should also be reflected upon. The main thing that comes to mind here is the height at which the stand device sits on a standard counter (88.9cm – 99.1cm), and what this implies for the visitor's ability to reach it with their personal device. A Dutch man of average height will be able to insert his badge into the stand device by only having to pull it down slightly. A Dutch woman of average height would be able to effortlessly place their badge in the stand device (figure 29). Visitors taller than 183cm would require the retractable lanyard to scan the badge without having to adjust their posture, while visitors smaller than 169cm would have to lift the badge upward before being able to scan it. Either scenario is not expected to result into such discomfort that would prevent visitors from scanning their personal device.

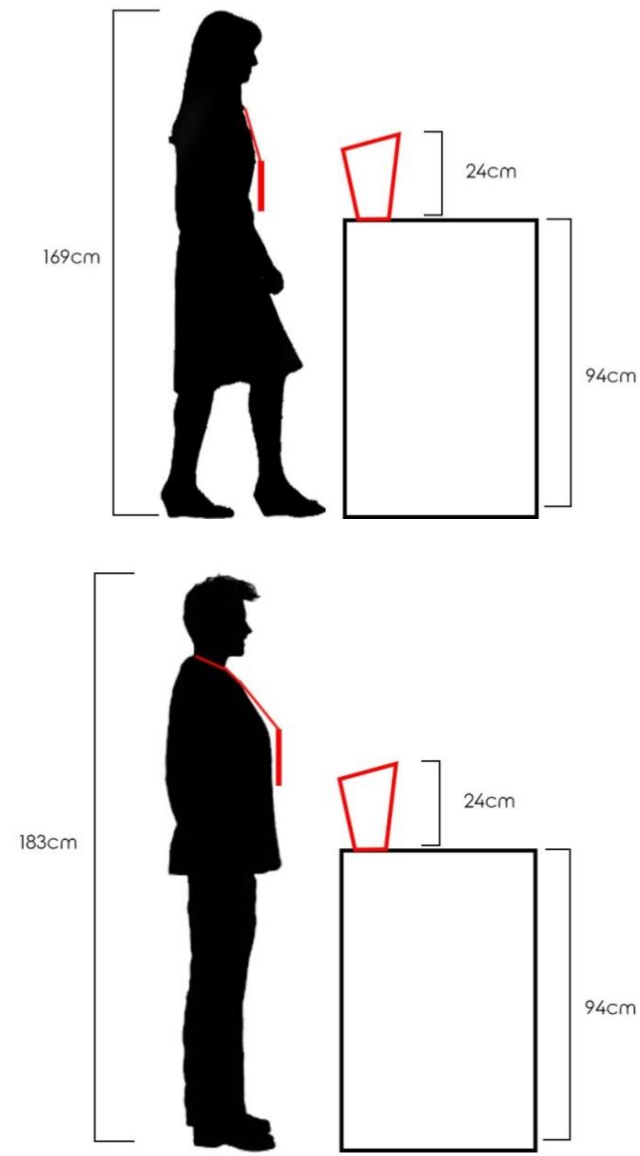


Figure 29: The relative height of the stand device and average visitors

Personal device & Badge

As a result from the design decisions regarding visitor profiles and scanning methods as well as inspiration from existing visitor badges, a badge design has been composed (figure 30). This badge will be printed upon the arrival of a visitor at the event, and will be inserted into the personal device. As can be seen, the design features classic information about the wearer (name, role, company), trade fair logo, QR code, and the visitor profile represented by color and shape coding. The most relevant basic information, the wearers role at the fair, has been given the largest font size followed by their employer and name.

It is important to note that the badge shown here is not a fixed design, but that each trade fair organizer will be able to adjust it to suit its own preferences and events. The location and size of the QR code and the presence of color and shape coding are the only hard requirements here. As an example, the badges shown here have been designed to match OGZ's Big Data Expo. This includes the logo of this event, as well as the coloured hexagonial shapes on either side which represent the 6 fields of interest of the event. The series of coloured shapes at the top of the badge represent the three visitor objectives.

A badge for the aforementioned fictional visitor Michelle would display her visitor profile by displaying only those colored shapes which refer to her chosen interests and objectives (figure 30). It is from these colored shapes that exhibitors will be able to determine a visitor's profile, after which they can make a decision of whether or not to approach this visitor.

Figure 30: The badge design: Full, personalized, and used in the personal device

Nudge

A key characteristic of this design is that is uses subtle behavior-influencing cues exerted by visitor badges to make visitors aware and help them take advantage of data that flows through the system. While these cues no longer fully resemble nudges as they were described in the book Nudge Theory (e.g. they are no longer subconscious) they will still be referred to as such.

The method with which the personal device will attempt to steer its user towards the right stand can be described as a two-step signal (figure 31). When a match between visitor and exhibitor occurs, the personal device will vibrate for one second after which it will start to emit light. The point of the vibrational signal is to draw the visitor's attention towards the device, while the point of the light-based signal is to confirm this attention. This change (as compared to the concept proposal) has been made as a response to the aforementioned concerns about this device's nudge strength (Appendix 24). A vibrational signal has been chosen because of its observed success in other nudging devices (Appendix 20) and the impracticality of sound in such a crowded environment.

While the nudge's strength has been revised, probability still plays a role in the behaviour change it intends to achieve. Firstly, the nudge is not entirely clear on which stand to visit and depends on the cognitive effort of the visitors. Secondly, visitors will always be able to ignore the device and continue with their planned visit. The benefit of this is, just like in the natural model, that the system remains flexible and that other options will always continue to be explored.

Unsuccessful nudges

Because of this probability factor, nudges that aren't followed by a scan of the personal device at the concerned stand will also be registered. Knowing the percentage of visitors who do not find the stand they have been nudged to interesting is important in evaluating the system in its implementation phase, as it helps evaluate the chosen visitor profile variables. Exhibitors can also use this data to evaluate the performance of their staff. To enable this, stand devices will register personal devices who have matched with them and have been in their proximity for more than 20 seconds. This filters out any visitors who have simply ignored their nudge and have therefore not spent any time at the stand.

Figure 31: The personal device's nudging process

Software characteristics

While this project does not have the resources to write the devices' software in its entirety, its defining features will be explained. These features include: the composition of visitor profiles, the composition of data strings transmitted by the stand device, and the conditions

Visitor data

The data that will be used to construct the personal profiles of visitors and which will define that visitors receive will consist of the following two factors: fields of interest and objectives. While not all trade fairs may have a division of topics within them, these two variables have been deemed to be the only ones necessary to base recommendations for other visitors on and sufficiently inform exhibitors. This information will be collected during the registration process prior to the start of the trade fair. Many organizers already currently collect this information (primarily fields of interest) and their collection methods need little change. The different objectives visitors will be able to choose from are based on the aforementioned literature analysis (Appendix 6) and trade fair visits:

- Market orientation
- Business
- Networking

These three basic visitor objectives were derived from the literature about the distinction in visitor types and their objectives. Based on this, it is expected that 'market orientation' will be chosen by the most visitors since it combines the objectives of two already quite large visitor groups: 'orienting saunterers' and 'goal-oriented collectors of information'. The objective of business can be traced back to the 'transaction-oriented visitors', while the networking objective unsurprisingly refers to the visitor group of 'networkers'. The second categorization of trade fair visitors that was found in the analysis phase of this project confirms this choice of objectives since it differentiated between three groups: the businessman, the collector of information, and the networker.

Based on the persona's that were composed earlier on in this report, an example of a visitor profile can be given (figure 32). This profile assumes that the visitor in question is visiting the Materials fair in Veldhoven, which was divided into four clear topics.

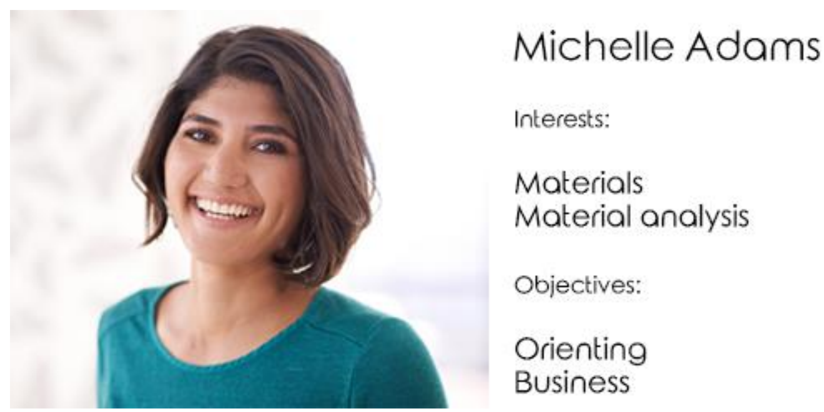


Figure 32: An example of a visitor profile

Matching

When visitors leave their profile data at an interesting stand, it will be processed into information to be sent out to other visitors. Whether or not this information leads to a match with the profile of a personal device will depend on the similarity between the profile of the receiving visitor on the one hand, and the collection of profiles of a stand's device on the other hand. Both variables have more than two options and visitors can select more than one of these options, which complicates the comparison process.

When looking at the visitor profile of Michelle (figure 32), we see someone who has selected 2 out of 4 possible interests, and 2 out of 3 possible objectives. In this case, there are 5 different ways to determine whether or not this profile matches with the beacon of a stand device:

Michelle will only match with a stand when that stand was found interesting by a certain number of other visitors who…

- *Have either at least 1 of the same interests or 1 of the same objectives*
- *Have at least 1 equal interest and 1 equal objective.*
- *Have the same 2 objectives and at least 1 equal interests*
- *Have the same 2 interests and at least 1 equal objective*
- *Have the exact same visitor profile.*

These 5 options rank from low to high regarding the threshold by which matches are created. The first option will cause many matches to form, while the fifth option will make matches (and therefore nudges by the personal device) a rare event. While one could choose for one of these options, it makes more sense to apply different methods to different situations. The first option (with the lowest threshold) is actually quite suitable for small trade fairs with few visitors, because the probability of finding even such a rudimentary similar visitor significantly decreases in such an environment. The fifth option could be applied at the most crowded fairs

The options change when a visitor profile contains more or less than 2 chosen options for one or both of the variables. When a visitor chose only 1 of each, there are only 3 possible methods left for forming a match. For each numbers of options above 2 that is chosen for one of the variables, an extra possibility is added.

Personalization

The best option to go with in a standard situation appears to be the second one. This method still has a relatively low matching threshold, while having an identical combination of interest and objective makes a match stronger and more relevant. It will, however, be important to adapt the processing method to the specific trade fair at which it will be used. It will, however, be best to involve the organizer of the fair in this decision, since the choice can depend on the following circumstances:

- The amount of expected visitors and exhibitors, and more importantly the ratio between them.
- The level of difference between the topics of the fair. When the topics have quite a lot of overlap for example, the matching process should not place the most value in interests but rather in objectives.

Example

The table below shows how this comparison process would go. The left column gives a list of 7 fictional visitor profiles which were collected from the corresponding visitors scanning their personal device at the stand device. Once again, the Materials fair is used as a scenario. The numbers marked with X represent the topics in which the visitors are interested in, while the numbers marked with O represent their objectives. The matching conditions that are used in this case are: "Have at least 1 equal interest and 1 equal objective", combined with a required percentage of 50% similar visitors in the data string. Nearby visitors that would receive a match notification on their personal device have been highlighted (table 1)

Beacon data string		Nearby visitors	
Interests	Objectives	Interests	Objectives
X1 X3	O2	X2 X3	O1
X1 X3 X4	O1 O2	X1 X3 X4	O2 O3
X2 X3	O2	X3	O2
X1 X4	O2 O3	X1 X2	O3
X3	O3	X1 X4	O2 O3
X1 X2 X3	O2 O3		
X3 X4	O1		

Table 1: A comparison of scanned profiles (left) with nearby visitors (right)

Alternative data string

An alternative to this method of forming the data string would be to count each entry of an interest or objective and add them like this:

X1: 4 O1: 2
X2: 2 O2: 5
X3: 6 O3: 3
X4: 3

Such a data string, however, does not allow for a direct comparison between visitors and therefore limits the amount of options that can be used to determine a match. Since it doesn't offer any benefits besides this, it will not be used in the final design.

Volatility

A requirement that comes forth from the way pheromone trails work in the natural model is that the currentity of data must be taken into account when forming these beacons. This means that old data inputs must have a lower attractive force than new ones. The result of these measures will be that, just like in the natural model, the system becomes more flexible and responsive to changing conditions.

When evaluating this requirement, however, the question arises of whether the environment of a trade fair is subject to relevant changing conditions that would justify the extra complexity of a flexible system? The changing conditions that can be thought of are:

- Seminars which influence opinions
- Word-of-mouth communicated opinions between visitors
- Different types of visitors at different times in a day

Although their impact is hard to prove, they have been deemed relevant enough to include the currentity of data in the composition of data strings to some degree. This could, for example, be achieved by deleting all data entries of over 5 hours ago every 1 hour. This exact time would have to be determined for each event, and would (at the most crowded events) depend on the memory capacity of the stand devices. Table 2 gives an example of how data would be discarded in this way. In this quite drastic scenario, the software removes 1 hour old data every hour.

Time	Visitors	
	Interests	Objectives
9:48	X1 X3	O2
9:59	X1 X3 X4	O1 O2
10:12	X2 X3	O2
10:20	X1 X4	O2 O3
10:21	X3	O3
10:40	X1 X2 X3	O2 O3
10:49	X3 X4	O1
11:09	X1 X4	O2 O3
11:18	X3	O3
11:21	X1 X3	O2
11:30	X1 X3 X4	O1 O2

Discarded at 11:00 Discarded at 12:00 Discarded at 13:00

Table 2: An example of discarding data based on its currentity

Long-term memory

An aforementioned characteristic of the composite pheromone trails of some species of ants is that they contain a 'memory pheromone' which has a low attractive value, but lasts long enough to be picked up after a period of inactivity. Applying this feature to this design would enable exhibitors, who use this system for the second time at the same event, to avoid the cold-start problem (Appendix 8). The collected data of such an exhibitor would have to be stored by the event's organizer and uploaded to the correct stand device the next year. It can then be used as a data string with reduced attractiveness (higher matching threshold) until enough data is collected from visitors at the current event.

Proximity

Proximity plays an important role in different aspects of this system. The main aspect in which this plays a role is the match determination process of personal devices. The distance from a stand at which these devices receive a data string, calculate a match, and nudge their users is a crucial factor in the success of this design, because it will partially determine how well visitors can link their nudge to the correct stand. If this distance is too large, visitors will link their nudge to the wrong stand, and when it is too small visitors might not walk through it and never receive a nudge to begin with.

Optimally, the range of the stand device's transmitters should be set in accordance to the width of the aisle as well as to the distance of adjacent stands (figure 33). The goal of these settings is to never have two stand devices' ranges overlap on the aisle on which visitors walk. This way, a visitor who receives a nudge while walking through an aisle will always be closer to one stand than to others. This will greatly help the visitor link this nudge to the right stand and therefore improve the accuracy of the system.

To make this possible, stand devices will be programmed with a fixed range depending on the layout of the specific trade fair they will be used in. To determine this range, it will be assumed that all stand devices will be placed at the edge of an aisle with a constant width, as seen in figure 33. In most cases, however, many devices will have to individually programmed to comply with all the irregularities in a trade fair's layout. This will be done in agreement with the client, and by using their predetermined lay-out.

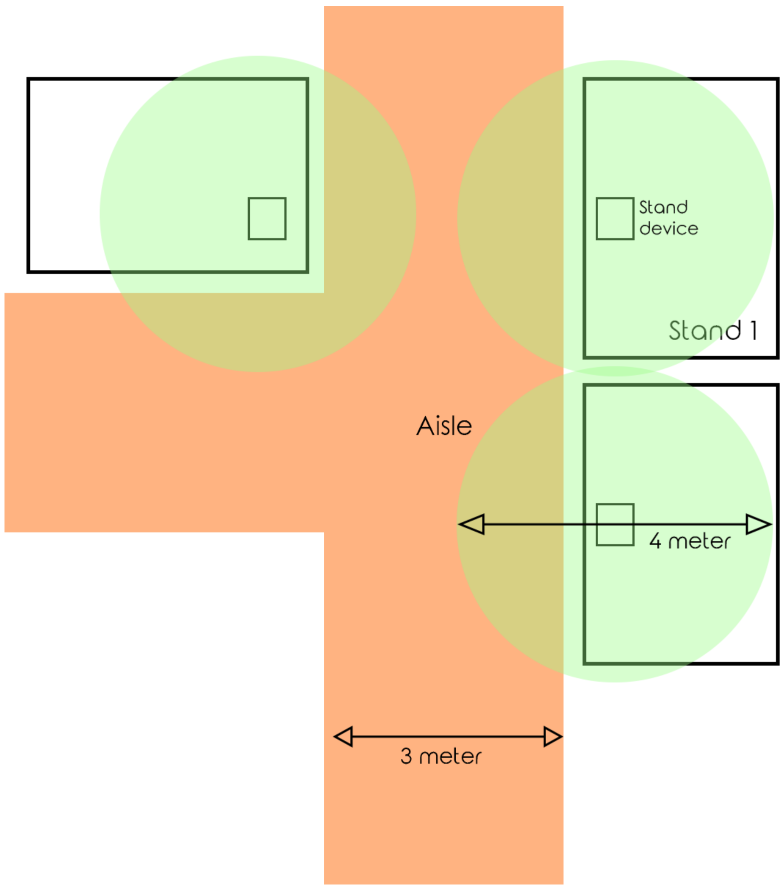


Figure 33: The role played by a stand device's transmitting range

Judgement of visitors

As mentioned, stand devices will have the task of collecting the visitor profiles from visitors who found its exhibitor interesting. The way the system will determine whether or not visitors are genuinely interested in certain stands has already been discussed in this report, and the method that has ultimately been chosen for this important action is partly based on the Easyfairs Smart Badge which was described earlier (Appendix 20).

Visitors will deposit their digital pheromones when they scan their personal device at the device found in each stand. While this can be seen as an active confirmation method by visitors, which was not found to be very reliable, its success will lie in the fact that this action is disguised by another one. Visitors will be informed that they will be able to scan their devices when they are interested in an exhibitor because it will automatically cause them to leave their contact information which will allow them to receive more information and set up a follow-up meeting. While this is also true, the hidden purpose of this scan is that it collects the data of the visitor's profile and processes it to be used in the system.

Scanning of visitor badges for this reason is already being done at some fairs. In these cases, however, exhibitors take control in this by scanning visitors by hand (Scan2Lead, 2017) (figure 34). This system intends to prevent exhibitors from manipulating the system this way by shifting the initiative to the visitors.

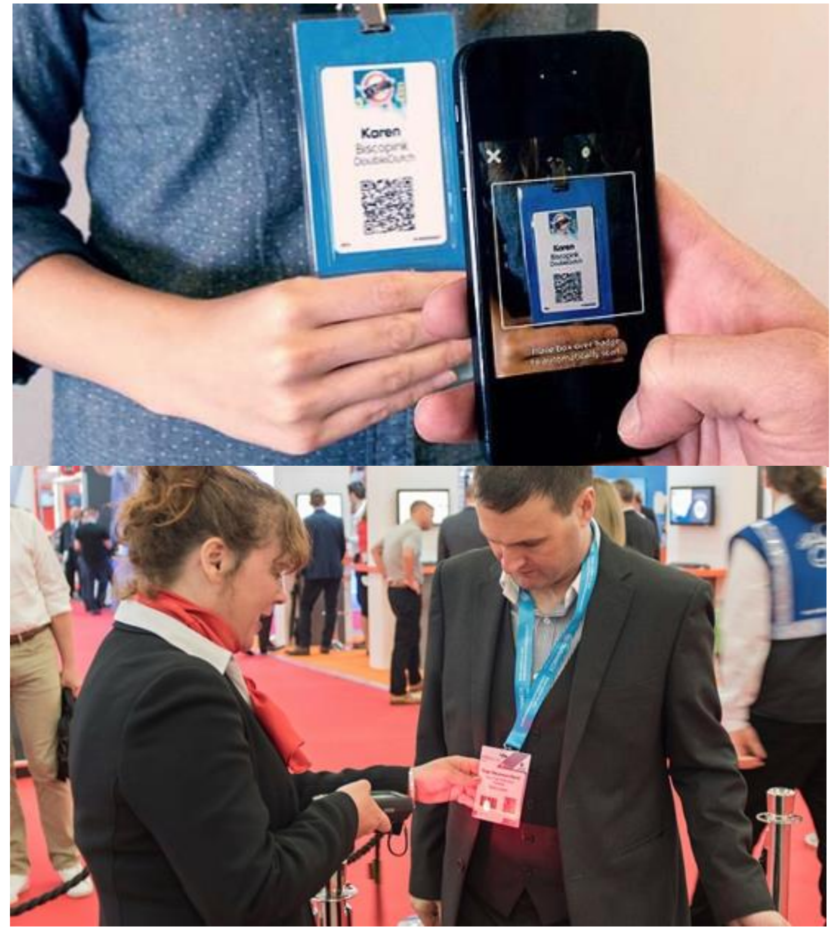


Figure 34: Current exhibitor-controlled visitor badge scanning methods

Scanning percentage

An extra functionality for the stand device that was not yet considered in the conceptualization phase is to register the amount of unique personal devices that passed its stand in close proximity. This data would then be compared with the amount of unique devices that were scanned at the stand device, and be used to calculate an 'attraction percentage': the ratio between visitors that were close enough to interact with the stand and visitors that found the stand to be interesting. This percentage could be used for the following purposes:

- To provide equal matching opportunities to stands in less favourable locations by lowering the matching threshold for those with fewer visitors passing by.
- To provide exhibitors with extra feedback on their performance, either during or after the event.
- To provide the organizer with information on the walking patterns of visitors, which can be used to evaluate the lay-out of the trade fair.

This additional feature would require the personal device to transmit a signal to stand devices through which it can be identified. It is crucial that each personal device is only registered once.

In conclusion, by adding this relatively simple function to the system it becomes able to increase the quality of matches and offer extra services with high value to both exhibitors and organizers. It is for these reasons that it has been included in the design on the conditions of being technologically and economically feasible.

Enabling technology

This chapter will describe all the technologies that have been selected to enable the features of the design that have been explained so far, and explain why these have been deemed to be the optimal choices. These technologies include the communication protocols by which the system's data is transferred, and the hardware that enables visitors to interact with this data. The way all hardware has ultimately been connected can be found in Appendix 30.

System

The first step in designing and selecting the technological components of either two products is to compose a definitive system architecture. A first draft of this was constructed while described the first two conceptual designs, and will be used as a starting point here (Appendix 14). While the previous diagram takes into account all actors in the system, the new one focuses on its technological components (figure 35). It provides more precise and detailed information about the flows of information within the system, and information enters the system in the first place.

As far as the longer-range communication (stand device to personal device) is concerned, several options were considered (Appendix 26). Ultimately, the choice was made to give the stand device an active role in the matching process by having it transmit its collected data to nearby personal devices. These personal device would then only have to receive this data and compare it with its stored data to determine a possible match. This choice was made because it removes the need for a transmitting component in the personal device which would have been a major consumer of power in a device that can only contain a small battery. 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.

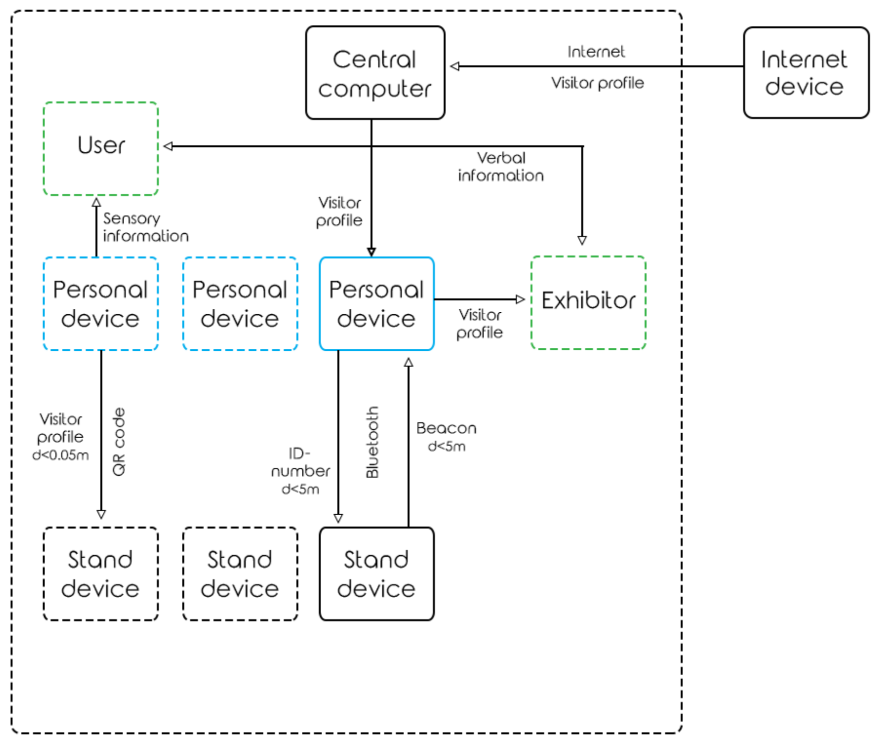


Figure 35: The EvAnt Matchmaker's system diagram

Communication methods

To enable the communication paths visualized in the system diagram (figure 35), choices for specific technologies were made.

Beacon transmission

In order for stand devices to be able to communicate their visitor data to nearby personal devices, a medium-range communication method is needed. Bluetooth Low Energy (BLE) has been deemed the most suitable communication protocol for this purpose because of its lower power consumption, versatile range, and the option of a peripheral chip with a transceiving functionality. This last feature allows the personal devices to also transmit an ID-number back to the stand device, which allows for the aforementioned calculation of scanning percentage. Stand devices will be equipped with a transceiver chip (nRF51822), which also has the processing capabilities to create the data strings which it transmits. Personal devices will contain the cheaper nRF8001 chip, which has no processing capabilities and only acts as a transceiver. More information can be found in Appendix 27.

Uploading of profiles

When a visitors receive their personal device at the start of an event, their personal profile will have to be uploaded onto it to allow the device to compare their profile with incoming data strings. The choice has been made to use a wired micro-USB connection between the reception desk's computer and the personal device for this. This method offers more precision than wireless channels, which is needed in this situation.

Scanning personal devices

The best way for visitors to leave their profile data at a stand has been deemed to be a close-proximity scan of the personal device by the stand device. QR-codes will be used to enable this, because they can simply be printed on the personal devices' badges, as is already being done on most trade fairs. Another reason why this method was chosen over an easier scanning method (NFC) is that the extra precision that comes with QR (required distance and orientation) prevents badges from being scanned by accident and polluting the system's data. Lastly, QR-codes have been around since 2000 and enjoy a lot of familiarty among the population (figure 36): the vast majority of the western population have at least seen them (eMarketer, 2011). They are even used on many current visitor badges. One can therefore expect that visitors will instinctively know what to use them for. More information can be found in Appendix 27.

Figure 36: QR-code scanning has become a familiar communication method

Central communication

Stand devices will need to transmit their collected data to the event's central computer so that it can afterwards be used to by the organization and exhibitors to evaluate their performance. The preliminary method that has been chosen for this is to use the stand devices BLE modules to send this data, and have them act as range-extending repeaters when certain units are not in Bluetooth-range of the central computer. No official reports on the viability of this can be found, however. This is why an alternative option of mobile network-enabled cloud storage has also been considered. More information can be found in Appendix 27.

Additional hardware

Processing power

Both devices require a technological component that processes the data collected by their sensory and receiving components (QR code scanner, antenna). The personal device needs this component to store a visitor profile and compare it with incoming visitor data. The stand device needs this component's calculating power to combine all incoming data entries into a comprehensible data string to be transmitted to nearby personal devices (figure #), as well as its memory to store these data entries for further use.

As far as the stand device is concerned, these functions can be fulfilled by the BLE module with which it will be equipped. This component has a processor with the required specifications for the relatively low-complexity calculations required in this product (Appendix 28). The module used in the personal device, however, does not appear to have any internal memory to store the user's visitor profile with. This device will therefore require an additional microcontroller with which to store and process this data. This microcontroller will only require 4 pins, enough flash memory to be able to store a visitor profile, and enough RAM to calculate the presence of a match. Based on these general requirements, a module was chosen (Appendix 28).

Power supply

Both the personal and the stand devices will be equipped with a battery to supply it with power (figure 37). These batteries will be replaceable rather than rechargeable in order to avoid the investment cost for chargers, and because these devices will most likely initially only be used for ca. 16 days a year which means that replacement battery costs will be low.

Because of limited room in its casing (figure 40) and its low power consumption, the personal device has been equipped with a standard 2032 3V coin cell battery with a capacity of 235 mAh. With its current components, this battery enables each device to last for an effective 5,5 days of continuous trade fair visit (Appendix 29). The stand device, which has no space restrictions and will consume significantly more power, has been equipped with two standard AA batteries. More information can be found in Appendix 28.

Alongside with these batteries, both devices will be equipped by two complementary components: a battery power feedback LED and a power switch.. These components allow trade fair employees to power the device off after being used and see when a battery needs to be replaced. The personal device's switch is hidden, and can only be accessed with a needle-like tool. This prevents visitors from (accidentally) switching their device off.

Badge holder & Retractable lanyard

The two remaining store-bought components are a transparent badge holder and a retractable lanyard (figure 38) which will be used in the personal device to, respectively, contain its paper badge and to allow visitors to wear the device around their necks. The motivation behind the choice for a lanyard that is specifically retractable, is that visitors of all sizes will need to be able to insert their badge into a stand device without having to adjust their posture (figure 29).

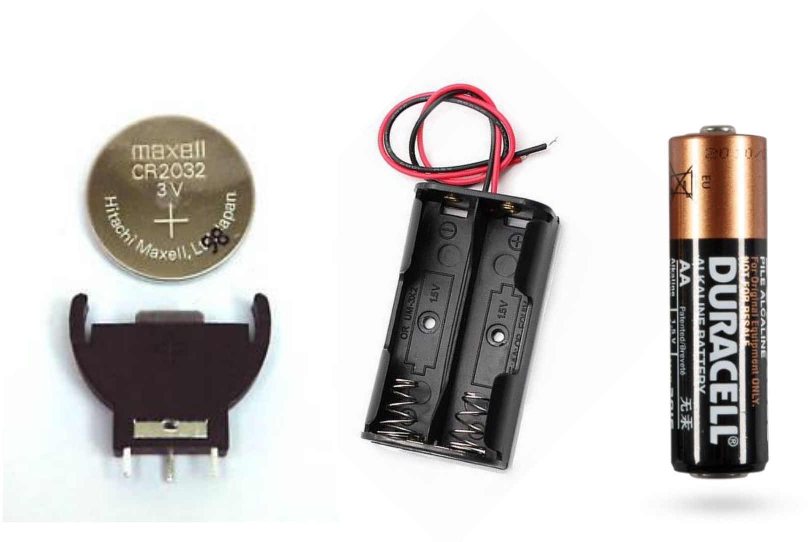


Figure 37: The coin cell battery and its holder, and the AA battery and its holder

Figure 38: Retractable lanyard (left), and a standard badge holder (right)

Casings

The only custom-designed parts of these two devices are their casings, of which the design has already been shown and explained. Because of the large difference in required amount, these casings will be produced with two different methods. The personal device, of which several thousands will need to be made, will be produced by injection molding. The design of their casing has been adjusted to this method (figure 39). Dividing the casing into two halves as such also allows for a fast and easy assembly process (figure 40 &41).

The stand device's casing will most likely be produced the company Formit, which specializes in a sheet-plastic production method. Not only does the shape of this part lend itself for this method, it is also a cost-efficient choice for a part with a low number of required units to be produced. This last argument has been confirmed by a personal quotation from Formit (Appendix 34). This part will be produced out of HIPS. Technical drawings for both parts can be found in Appendix 31. Both casings will require a small complementary clear-plastic part to cover the holes through which the LED-light will shine.

Figure 39: Two halves of the personal device's casing

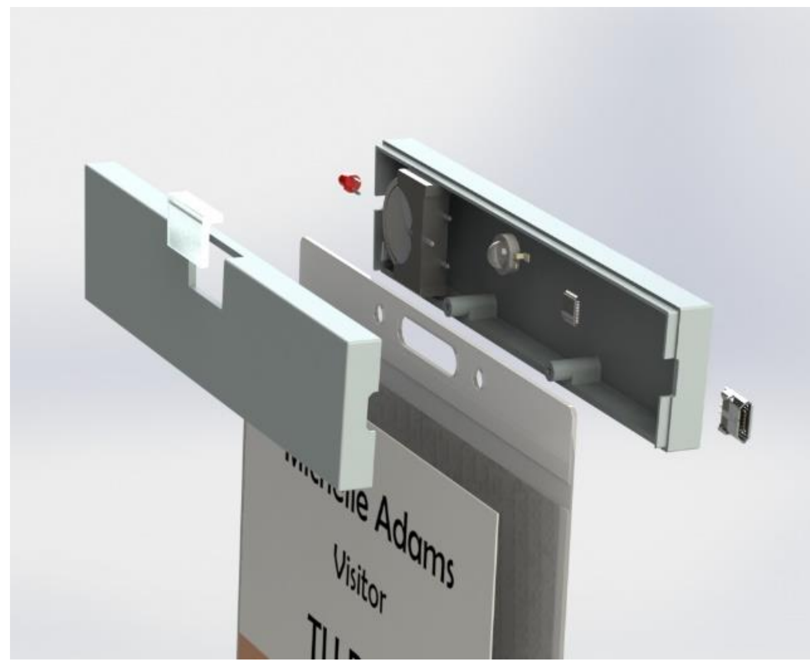


Figure 40: The sandwich-like assembly method of the personal device

Optional components

During the creation of this and other conceptual solutions, several interesting ideas were generated which were not incorporated into the final concept design but which may prove to be useful additions to it in certain situations. While they were not initially incorporated in the final design because of various reasons, their advantages have too much potential to completely ignore. The choice was therefore made to briefly elaborate on these additional features and to suggest them as optional system components. This matches with the chosen rent-based business model, as customers (trade fair organizers) can rent the components which best benefit their event.

Smartphone app

The first one of these is based on the Alex posture tracker and the smartphone concept, and has already been briefly discussed in its analysis. A smartphone application would in this case be developed to provide a visitor with feedback on his/her visit, specifically about the stands they have visited. Its features would, to start with, be:

- To remind its user which stands they found interesting, and to provide them with more information about these exhibitors.
- To allow its user to access additional information about an exhibitor when examining its stand. This not only benefits the user itself, but also increases the quality of the data in the system because badges are being scanned by better informed visitors.
- To track their user's route and inform them on which areas they have yet to visit.

Since this component is not vital to the success of the system it is described as an optional component to it. However, once developed, this application will be available for all people that visit a trade fair which uses this system unless the organizer chooses not to (e.g. to discourage the use of smartphones). Visitors will simply be able to download the app, and will be informed of this option even before arrival. Because of the choice to use QR codes as the personal devices' scanning method, these apps can easily be linked to a visitor profile by scanning these QR codes with the smartphone (figure 41).

Figure 41: An example of how a smartphone app would scan a QR code

Interactive map

A second additional feature could be the interactive map which was discussed in the ideation phase (Appendix 13). This map would be displayed on a screen at strategic spots at a trade fair.

Because this extra component mainly focuses on wayfinding, it will be more suited to appear at certain trade fairs over others. The events at which it will prove especially useful are those who primarily attract goal-oriented business(wo)men. As mentioned earlier in this report, this visitor type often arrives at a trade fair well-prepared and on a schedule, and therefore benefits from clear directional cues. The interactive map plays into this need by offering these cues, while at the same time subtly attempting to influence these visitors by displaying the stands that match with their visitor profile more clearly (figure 42).

To enable this, the device that displays the interactive map will be equipped with a QR code scanner. Scanning a visitor badge at it will activate the map, as well as calculate the existence of match for all exhibitors at the fair. This functionality is made possible by the aforementioned central computer sending its data concerning the scanning of personal devices at stand devices to this interactive map. This last device will then use the same process as the personal devices to determine with which exhibitors a visitor matches, and adapt its interactive map accordingly.

Figure 42: An example of how the interactive map will look like

Costs & Business model

The ideal choice of business model for this design appears to be a rental model. Because of the few times a certain trade fair takes place (once a year), an organizer will not buy a product like this because it is simply not economically viable. The product will have to be produced and attached to a company from which trade fair organizers can rent it and use it at their event. Because of the amount of trade fairs in the Netherlands, and their tendency not to be organized at the same dates, very few product sets* will actually have to be produced to comply with the demand of the entire market. A complete overview of the basic business model to be used can be found in Appendix 32.

*A product set is defined as the amount of both devices required to apply the system to a trade fair. This amount will be more accurately defined later in this report

An interesting additional option could be to reach out to existing companies who already provide products or services to trade fair organizers. They would make an excellent intermediary party because of their existing contacts and infrastructure (storage and transport). Examples of such companies are the aforementioned EasyFairs and Shake-On, although their products can be seen as direct competitors of this system. Such a company could:

- Invest in the production of the system's devices.
- Store the devices and transport them to the events.
- Communicate with organizers and make deals with them.

Costs

A criterion that was used multiple times during the conceptualization phase is the implementation threshold of the design. A defining feature of this criterion are the development costs of the system, which directly relates to the amount of money trade fair organizers will have to pay to rent it for their events. These development costs can be divided into the following elements:

- Production costs
    - Purchasing of electronic components (Appendix 34)
    - Production of custom parts
    - Assembly
- Logistics
    - Distribution
    - Storage
- Software development

Amount of devices

An important factor in determining the production costs of the system's components is the amount that will have to be (initially) produced. A larger batch size naturally increases the total production costs, but is also expected to decrease the production costs of each individual device. This is due to suppliers offering discounts for bulk orders, and production process investments (molds, machines) being distributable over a larger number of units.

This initially required batch size differs for both types of devices, since there are always more visitors than exhibitors at a trade fair. To arrive at a realistic estimation of these numbers, the amount of visitors and exhibitors of a sample of six trade fairs in The Netherlands and Belgium has been analyzed (Appendix 33). The ratio between visitors and exhibitors at two-day trade fairs has been determined to be 42 on average (visitors per exhibitor). The average amount of visitors at these trade fairs is 3,650, with an average number of 106 exhibitors. These quantities have been used in the calculation of the cost price of each device.

Production cost prices

Using these aforementioned quantities, a price for each individual component has been determined and added up to one approximate production cost price for each of the two devices (Appendix 34). Producing a stand device will cost €94.66, while producing a personal device will cost €10.87.

Software development

Estimating the costs involved in the creation of a system's software is a complicated endeavor, even with the help of (online) quotations. That is why, for this estimation, the price that OGZ paid for the development of software of a comparable size and complexity is used. This amount was roughly €70,000.

Return on investment

Now that a realistic estimation of the required investment can been made, the next step is to determine how much organizers will have to pay to rent this system for their event in order to get a return-on-investment in a certain number of years. In the case of a business deal with OGZ, the system could be rented to their 12 yearly events. In this scenario, the amount of devices that will have to be produced depend on the largest of the 12 events. However, a distinction can and should be made in this regard. OGZ's educationally themed events have a significantly larger visitor/exhibitor ratio than their (and all) other trade fairs, meaning that they require a lot more personal devices to be produced.

An option to deal with this problem is to initially disregard the educationally themed trade fairs, and produce enough personal devices to be able to cater to all other events. 8000 devices would suffice in this scenario. The system could still be used in the four events with more than 8000 visitors, as long as it makes a selection on which people will opt out of using it. This measure would not be permanent. It is only intended to keep the initial investment low to be able to test the system and evaluate its effect. More personal devices could then be produced to meet the demand of the remaining trade fairs. This option was agreed upon by Han Bosman.

Another insight gained was that the total number of people that visit a two-day event does not necessarily equal the required amount of personal devices. Apparently, only 4 to 8% of these visitors will attend both days of such an event. This means that the remaining 92 to 96% of visitors can be divided over two days, which would result into a required amount of (((8000x0.92)/2)+(8000x0.08)) 4,320 visitors. This amount will be raised to 4,500 to account for a possible unequal distribution of visitors over these two days. Regardless of the educationally themed events, a 110 stand devices will have to be produced to be able to cater to all of OGZ's trade fairs.

Device	Amount	Cost per unit	Total investment
Stand device	110	€94.66	€10,413
Personal device	4,500	€10.87	€48,915
Total			€59,328

Table 3: The EvAnt Matchmaker's investment costs

With these investment costs as a starting point, a return-on-investment calculation was made for three possible 10-year scenarios ranging from optimistic to pessimistic (Appendix 35). In the optimistic scenario, the system is rented to all eight of OGZ's trade fairs in its first year, after which it is rented to 4 additional events every subsequent year. After a peak at the 4th year, this trend reverses. In the second scenario, the system is rented to all eight events for each year. In the pessimistic scenario, the system is rented to just one event in the first year, with one additional event every subsequent year with a maximum of eight (Appendix 33). The conclusion to be drawn from these calculations is that the product is economically viable in all three scenario's depending on the renting fees for the personal devices, which would have to be 1, 2, and 5 euros respectively. The organizer of these events could choose to pay for these renting costs itself, or choose to add them to the fee it is currently charging exhibitors to participate.

Prototyping

A key step in any design process is to evaluate the key choices that were made with a functional prototype. Ideally, such a prototype would be identical to the current state of the design and embody all of its intended functions so that their combined effects can be observed. However, due to limited resources, this prototype will focus on only a part of the design's functionality. Its focus will lie on the way the personal device interacts with its user after having received and having matched with a signal from a stand device. These functions have been chosen because they are hardest to evaluate with theory alone.

Objectives

Resulting from this prototype's focus, a set of specific goals have been formulated in the form of research questions, which the user test will aim to answer:

- How does the user respond to a vibrational and subsequent light signal from a device worn around their neck.
    - What is the required strength of the nudge's signals to be effective?
    - Have the right nudging methods been chosen?

- Can users use the signal to identify its source?
    - Does their position on the aisle influence their decision in this regard?
    - Does their walking speed and/or direction influence this decision?

Embodiment

In order to be able to answer these questions, a two-part prototype has been constructed; one part to act as the stand device and one part to act as the personal device (figure 44). The stand device solely acts as a transmitter, and consists only of an Arduino Uno microcontroller, 433 MHz RF-transmitter, and 6V battery pack. The personal device acts as a receiver as well as an actuator. It consists of an 433 MHz RF-receiver, Arduino Micro microcontroller, LED, vibrational motor, and 6V battery pack. Radio-frequency communication has been chosen over BLE for this prototype because of its simplicity and lower cost, since only one-way communication is required. More details on the electronics that were used and the code that was written can be found in Appendix 36. The personal device's components were placed into a plastic container to which a lanyard was connected (figure 43). This allowed participants to wear it in the way the final design will be worn, since this is an important variable in the way the device nudges its user.

The main challenge in the construction of these prototypes lied in the reduction of the RF-communication modules' range. This was done by supplying a minimal voltage to both components, as well as by removing their antennas. An effective range of ca. 5 meters was achieved.

Figure 43: Personal device as worn by participants

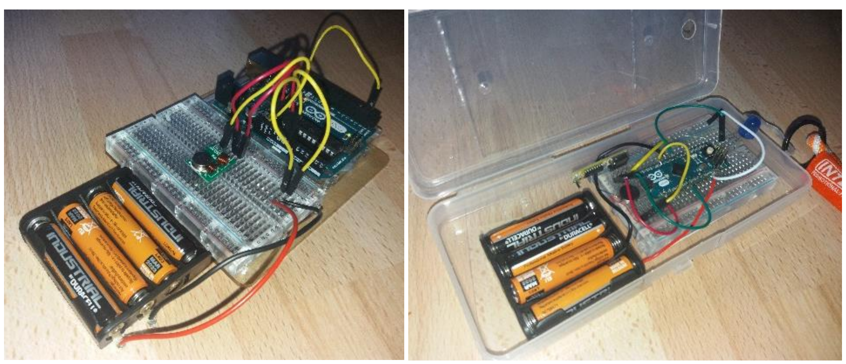


Figure 44: Prototypes of the stand device (left) and personal device (right)

Scenario

Since the goal of the prototype is to gain the best possible insights on the effects of the personal device's nudge, the test would benefit from a scenario that is similar to the scenario of a trade fair. This is why the prototype was tested at an actual trade fair (OGZ's Big Data Expo) rather than in a more controlled environment (figure 45).

The initial plan was to place the transmitter in the back of a to-be-determined stand. Participants would then wear the personal device and be asked to walk through the aisle in which the stand was located, making it easy to verify if the participant linked the nudge to the correct location. Unfortunately, the RF-link between both devices turned out to be subject to too much interference at this event, making it unreliable and unfit for user testing. This is why an alternative testing scenario was improvised.

The personal device was programmed to send a signal to a participant 35 seconds after being activated. Participants were then asked to wear the device around their neck and walk down an aisle in a certain direction. Although the personal device no longer responded to a transmitter, it still sent its wearer a signal which could be evaluated. The participants were also asked to which stand they felt like the device was trying to guide them. Information regarding the link between signal and source could still be obtained this way (based on the participants' position on the aisle as well as their walking direction) even without an actual source.

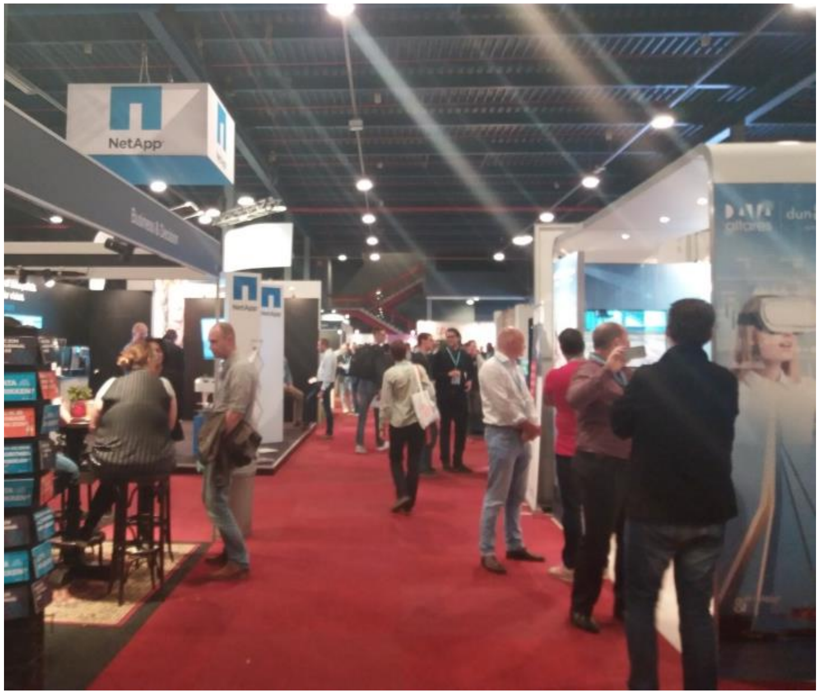


Figure 45: OGZ's Big Data Expo

Results

In the end, 8 visitors of the Big Data Expo participated in this user test. Despite of this relatively small amount of participants, some valuable insights were gained. First of all, 4 out of 8 participants did not notice the nudge to begin with. This tells us that either the vibration signal was not strong enough or that the device did not make sufficient contact with the participants' bodies in order to convey the signal. Seeing as this signal is very noticeable in an environment without other stimuli, this confirms the added value of testing the prototype at an actual trade fair. It also confirms that the light-based signal alone is not sufficient to draw the attention of the wearer. Interestingly, one participant did feel the vibration signal, but felt it via the lanyard which he wore underneath his collar. This led to the realization that this part of the personal device is often in closest contact with the body of its wearer, while the casing itself could be separated by several layers of clothing. The personal device's nudge could therefore perhaps be improved by moving the source of the vibration signal to the chord with which visitors wear it.

Out of the 3 participants who did sense the nudge, 2 specifically stated that they first felt the vibrational signal, after which they looked down and saw the LED burning.

Redesign

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 (Appendix 37).

Two measures were ultimately decided upon: an upgraded vibration motor which is able to deliver a stronger signal at the same voltage, and the direct connection of the lanyard to this motor (figure 46). This motor comes with two small constraints: its higher power consumption and its size (length). This increase in power consumption can be countered with the choice for a more efficient LED (Appendix 29). Its length can be nullified by orienting the motor at an angle.

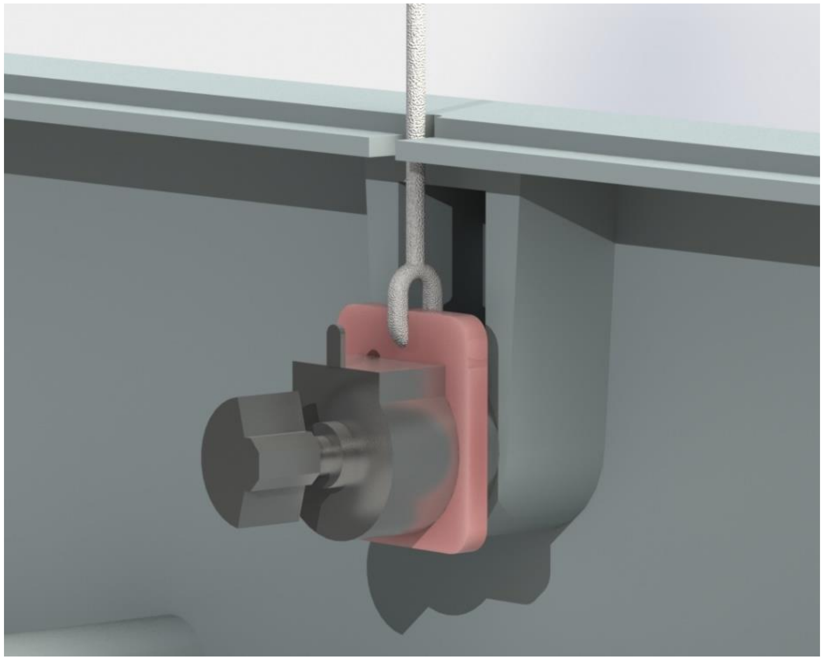


Figure 46: The conceptual connection of the lanyard to the vibration motor

Evaluation

Now that the design has been fully elaborated on, an evaluation can be made in regards to its compliance to the natural model as well as to the degree in which it solves the constraints of trade fair visitors and exhibitors.

Trade fairs

When looking back to constraints that visitors and exhibitors are currently facing at trade fairs and the project goal that was formulated based on these, one can conclude that the final design does exactly that: it increases the chance that visitors find the right stands based their content and the opinions and objectives of the visitors. The only remark here is that the content of stands is only indirectly included in this matching process; only in the form of visitors' opinions about this content.

The concept choice criteria that were created earlier in the project (Appendix 11) are also a good reference point for the evaluation of this design. The main conclusion to be drawn from this is that the design meets these criteria quite well. User participation effort is slightly higher than intended because visitors need to actively scan their devices. Furthermore, the nudges they receive are not on a subconscious level, requiring the visitors to put some cognitive effort into following them correctly. While the implementation threshold is very low, some measures will have to be taken. For example, receptionists will have to learn how to prepare the devices and exhibitors will have to learn how to read the badges. As with any matchmaking system, the people who benefit most from it are those who are less sure about what they want or need. In this case, these are the orienting visitor types. This design, however, is believed to be able to trigger an interest and subsequent behavior change in goal-oriented visitors as well.

Another evaluation method has been to make an inventory of all the information that the three parties would want to know after an event (with the help of Han Bosman), and to see which pieces of information can be provided with the help of this system (Appendix 38). The conclusion drawn from this is that, in this regard, this system mainly caters to exhibitors and the organizer of the event. Especially valuable is the qualitative information gained by exhibitors. They can now not only know which visitors were interested in their stand, but also what kind of visitors they were.

Natural model

The natural model was closely followed via the Biomimicry method, and was applied after being abstracted. As intended, this abstraction process did not change the core of the communication method but only the way it manifests itself in this particular scenario. A major challenge in this process has been to identify the differences between ants and humans and the environments they operate in (nature and trade fairs). The nature of these differences made it necessary to change certain aspects of the natural model or to discard them entirely. This has been the reason that the aspect of wayfinding is much less prevalent in the final design than it is in the natural model (or in the road signs concept).

Biomimicry

While most steps of the aforementioned Biomimicry design method were successfully used in this project, there is one element that has proved to be more challenging to integrate: Life's Principles. While these principles should ideally be used to aid in the concept development phase by helping the designer learn from nature in a more general sense (rather than just the natural model), they have mostly been used as an evaluation tool for the final design (Appendix 4). In its essence, Biomimicry is a design method that aims to mimic nature with the purpose of arriving at a sustainability-focused design. Life Principles can be seen as guidelines on how to achieve this. While an evaluation of the final design by these principles pointed out that this design follows them rather well, the conclusion can be drawn that the field of application did not lend itself well for sustainable innovation. The process that was ultimately used could perhaps better be described as Biomimetics. This is, as an expert at TU Delft pointed out, the process in which nature is mimicked for technological rather than sustainable advancement.

The main ways in which the final design follows Life's Principles are through its use of readily available resources (visitor badges, registration process, visitor scans)

Future development

While this project has resulted into a promising, feasible, and detailed design, a few additional development steps are still required. The main step will be to develop the software that will be used by the stand and personal devices. The defining characteristics of this software have of course been described, but have not yet been written in programming code for the reason that the skillset of the designer did not allow this to be done time-efficiently enough. The second development step is in regards to the aforementioned redesigned nudge given by the personal device. Although this will have to be tested more extensively for a definitive answer, it can be said with some confidence that the redesigned nudge is now strong enough to be noticed by visitors in all trade-fair situations.

Other applications

While the field of application was chosen at the very start of this project, the basis of the final design can still be applied in various situations other than trade fairs. Depending on the situation, certain changes will have to be made to it. A field of application that was considered were festivals (and similarly; theme parks). Since the areas on which these events take place are significantly larger and less organized than trade fairs, the concept would have to more focused on wayfinding since festival visitors can not be expected to walk all the way up to a stage before receiving a nudge. Seeing as road signs are already often being used at festivals, the aforementioned road signs concept might have been the best chosen in this scenario. Nevertheless, the final design could be applied to festivals on the conditions that the nudge has a wayfinding component to it. This nudge would also have to be given through a device other than a badge since these have no affiliation with this type of event. A bracelet would be anonymous and easy to use, although expensive to produce for the larger events (ca. 60,000 visitors). Using a smartphone would be more practical in this regard, but has the aforementioned disadvantage of requiring users to install a special application.

Another considered field of application were museums. While these appear to be more similar to trade fairs at first glance, there is a large difference in the way visitors approach it. Since they often pay for their visit and see it as a recreational event, visitors have more of an intrinsic motivation to spend time at every artwork. This reduces the value of a system that helps them find the "best" piece of art, because they will most likely find it themselves eventually. Artworks can also be considered to more objective than trade fair exhibitors, and that peoples' opinions about them are so personal that the value of the opinions of others is a lot less valuable.

To conclude, the choice to apply the natural model at trade fairs at the very beginning of the project appears to have been the optimal one. Its viability mostly lies in the fact that it was not just similar to the natural model (like museums and festivals) but that there turned out to be a genuine demand for such a matchmaking system, instead of it turning out to be just an entertaining gimmick to attract visitors.

Risk analysis

A risk analysis has been made to identify (all) possible constraints in the designed system, and to think of possible solutions to them. To help with this analysis, a detailed user scenario was first made . This scenario supplied an inventory of all possible situations, which lied at the basis of the risk analysis (Appendix 38).

Several important conclusions have been drawn from this risk analysis. One of the main insights is that a lot of the strain of this system is placed on the trade fair employees who welcome visitors and supply them with their personal devices. An extra use scenario has been made to gain additional insights into this process (Appendix 38). While some degree of automation or self-service element could be applied here, the best way to deal with this is to train these employees appropriately.

The second main insight is that this system would greatly benefit from a helpdesk at the trade fair. This special stand would have to clearly identifiable and placed at a central location. Visitors can come here if their device is broken, is out of power (although this should be prevented), or when they have lost their device. Trade fair employees will be instructed to bring any abandoned devices to this desk.

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