DCM110 A DESIGNERLY PERSPECTIVE ON IOT; A GROWING SYSTEMS APPROACH

Designing a rich interactive system in growing IoT

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Abstract

Current Internet of Things (IoT) systems are mostly built upon screen-based or voice-controlled interactions. In the course "A Designerly Perspective on IoT" provided by the faculty of Industrial Design of the University of Technology Eindhoven, we were challenged to design for IoT systems while integrating literature from a variety of research fields including embodied, tangible and rich interaction. First, a design was made that included the core functionality of playing and sharing music in different areas of the house. Second, a core functionality of controlling media on the television was chosen and designed for, while also designing for emergent functionalities that live in between these core functionalities. This paper presents the exploratory design process of this challenge and and positions both the created designs and the authors within the presented literature and by means of that within the premise of the course.

***Figure 1**, IoT sound system*

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Introduction

Current Internet of Things (IoT) systems are mostly built upon screen-based or voice-controlled interactions. Take for example the systems from Google, Apple and Amazon. Google nest [1], Apple HomeKit [2] and Amazons system including the Echo speaker [3] make use of a smart home speaker that enables voice control. This speaker simultaneously acts as a smart home hub that can be controlled with screen-based interactions in the form of an application. In this application users can control and connect various IoT devices to create emergent functionalities that exist and live in between the core functionalities of these IoT devices. In the course “A Designerly Perspective on IoT” provided by the faculty of Industrial Design of the University of Technology Eindhoven, we were challenged to design for IoT systems while integrating literature from a variety of research fields including embodied [4], tangible [5] and rich interaction [6]. This paper presents the exploratory design process of this challenge and positions both the created designs and the authors within the presented literature and by means of that within the premise of the course: “there is a place for rich and embodied interaction in IoT systems” [7].

The design challenge included two separate assignments, assignment 2 & 3 of the course. In assignment 2 we had to choose a functionality of the home to design for, for an alternative reality in which the design would replace the typical screen-based input and output devices for IoT systems. Physicality and expressiveness where the way to go in this assignment and the theory as a base for this exploration thus included theory on ecological perception [8], embodied [4], tangible [5] and rich interaction [6], and ‘dematerialisation’ [9] as described by Lukas van Campenhout.

Within the group we quickly decided upon audio being the core functionality as a starting point of this assignment. We were inspired by the notion of dematerialization and thus motivated to design a rich interactive 'locus of interaction’ for audio that has been 'dematerialized’ as Van Campenhout described in his paper on Physical Interaction in a Dematerialized World [9]. Nowadays music mostly lives in, and is played or streamed from digital devices, saved in digital format. We saw opportunities to design rich interactions in the alternative reality for the current possibilities of sharing your music and creating a 'blend’ in the menu-based screen interactions on Spotify [10]. Moreover, as the assignment asked us to create a connected product in which something meaningful happens with this connectedness, we included to design for the existing possibility to bring your music along with you throughout your house. This is currently possible with Wi-Fi connected speakers that allow you to stream your music to different speakers throughout the house [11]. Since music itself is dematerialized, this form of playing music can also be seen as dematerialized, since in the old days you had to physically remove a CD or LP, bring it to a CD player or turntable in a different room and start enjoying your music in that room. We were mostly inspired by the third approach as presented by Van Campenhout [9] in which ‘the flexibility of the digital world and the richness of the physical environment’ are unified, which led to the creation of the music tokens and the belonging speaker (FIGURE). The upcoming section will dive deeper into the exploration and creation of these token-based interactions.

In assignment 3 the challenge was to take the design of assignment 2 as starting point for "systems design’. We had to choose a second core home functionality to add to our design, which would let the system 'grow’ and enables emergent functionalities to happen that live in between the two core functionalities. We iterated on the design of assignment 2, while including a new home functionality. This then led to a series of iterations on designing for emergent functionalities, by getting inspired through different approaches and theory on growing systems [12,13,14,15]

By filling in a core / emergent functionality matrix [15] we discussed the various options for a second core functionality to include and eventually chose for Video as our second core functionality. This was mainly because emergent functionalities existed in between them that could happen bi-directionally: From audio to video, and from video to audio. What these functionalities are and how we designed for them will be explained further in the corresponding section on the core and emergent functionalities in this paper.

After completing assignments 2 and 3, the final design is a rich interactive IoT sound system that enables the user to play, sync and share audio to multiple speakers in a variety of rooms in the house. It consists of a music speaker for playing music, and a tv speaker for playing video on the tv with corresponding audio coming from this speaker. The system comes with shape changing tokens that need to be placed on top of the speakers and enables the user to switch between music and video mode. By placing the token in music mode on the tv speaker, and the token in video mode on the music speakers, emergent functionalities arise.

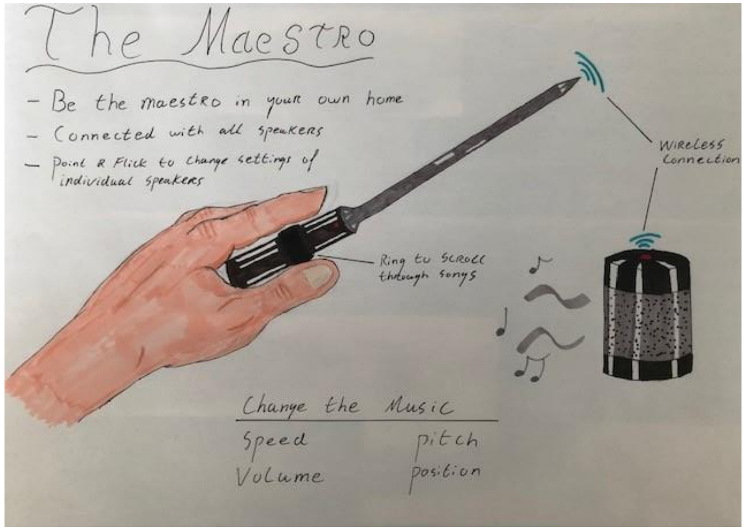
After this introduction that included the introduction to the course, the assignments, the chosen functionalities, our design goal and design, this paper continues with reflecting upon the exploratory design process by discussing and positing the designs within the literature. It moves on by discussing rich controls after which tangible and embodied interaction will be discussed. Next, our design in relation to the 4 approaches presented in [14] will be discussed, followed by a discussion on and placement from our designs within the centralized vs distributed dichotomy. It continues with a section that will dive into the core and emergent functionalities and lastly designing for growth will be discussed in which possibilities for growth in our design will be presented. The paper end with a conclusion on our explorative design process and position within the presented literature.

From remote control to rich controls

The goal of this design challenge was to develop a shared and growing IoT sound system that could replace the typical screen-based input and output devices for IoT systems, looking at physicality and expressiveness as a solution space. Whilst designing the rich interactions for our IoT sound system, one of the first major iterations from the design process towards our Physicalized Audio/Video Streaming System involved the realization that we should move away from the so called “remote controlled” interactions in order to achieve this more rich interaction set.

A remote, by its very nature, simplifies the interaction with a product to a single button press. The idea of the very first remote control (developed by Zenith) was innovative. The ability to manage the audio of your television without having to stand up and walk over to the device itself was a delight to many [16]. Yet, the use of a remote control nowadays can get very complicated. This is due to a couple of reasons. First of all, more and more functions are added to the remote, which also resulted in extra buttons. Eventually, you would get a remote that is completely filled with buttons [16][17]. This goes well with the discussion of Djajadiningrat et al. on Gibson’s Theory of Affordances, where they discussed how the increasing amount of functions packed in a single housing would leave less space for the controls. Eventually you would even end up with buttons on a remote that were capable of controlling multiple types of on-screen menu’s based on what mode the system was on. So the overall function-to-control ratio has increased severely [18]. Next, there is little meaning between interaction and function when pressing a button. Although most controls have a button for almost every function (brightness, volume etc.), the fact remains that these functions are just interchangeable. This is also what Frens hints towards in his article about rich interaction, where he says there is no fixed coupling between control and function [6]. One button can do A at one point, but might as well be made to do B instead. There is no logical reasoning why a button should perform task A instead of B, besides the icons that are printed on them during production (product semantics). And even with icons, the right option is not always intuitive [19]. This is true regardless of the amount of buttons a remote has. In fact, it is even true for (almost) buttonless remotes, as the touchpad of the Apple Siri Remote could also perform different tasks depending on the mode. However, there were usability complaints as users had difficulty determining what the touchpad controlled at what moment [16].

These issues could be seen to some degree in the first array of concept sketches (figures 2 - 4). We aimed towards a IoT sound system that would allow users to play, sync and share audio to speakers throughout the house, looking for physicality and expressiveness in the process. Most of these initial concepts revolved around a certain action performed from a distance to direct the speaker. One example is the concept dubbed “The Maestro”, which was a wand that was wirelessly connected to the speakers and could switch them on/ff and change their volumes with upward and downward flicks. Although this interaction fitted well thematically, the fact remained that the coupling between the control and function was somewhat lacking. For these concepts it was also true that the control could easily be used to direct a different function. So even though there were no buttons on “The Maestro”, the flicking had little meaning to changing the volume and could be used for a song-skipping function instead. The same could be said about the other concepts shown in the sketches, as they worked in a similar fashion. Therefore, we looked more at Tangible and Embodied interaction in order to create interactions that made more sense between their controls and functions. These will be explained in the next section.



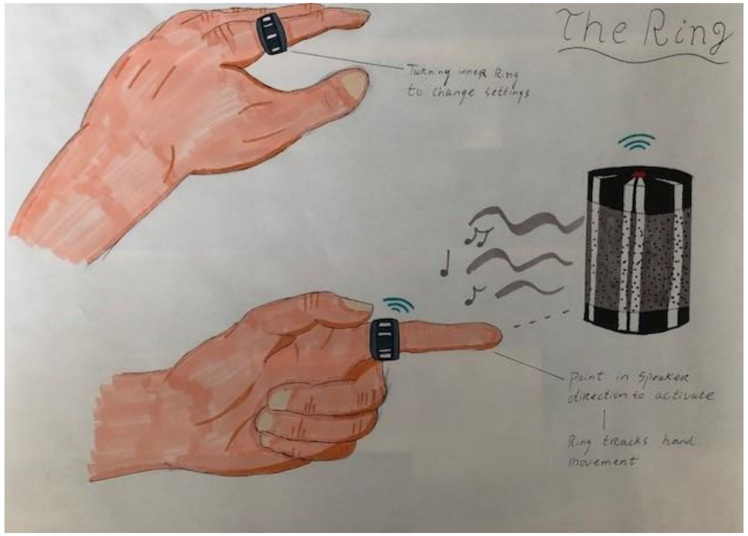


Figure 2 (top)*, Meastro Wand concept sketch &* ***Figure 3 (bottom)****, Magic Ring concept sketch*

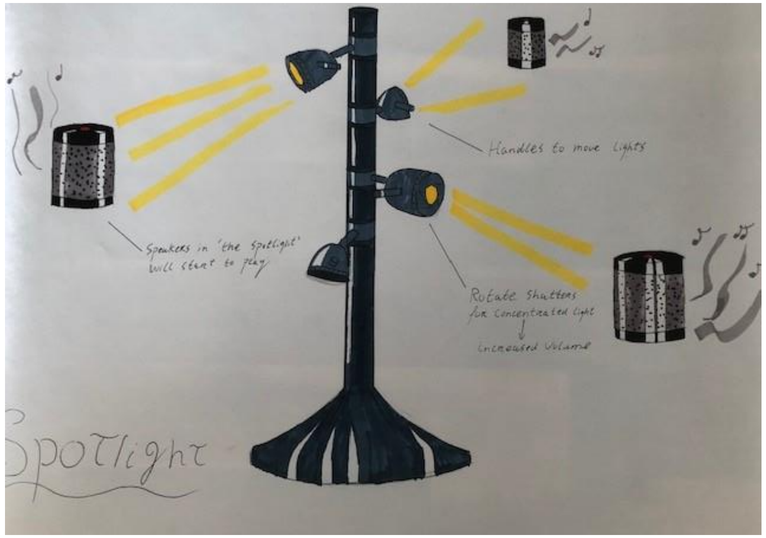


Figure 4*, Spotlight concept sketch*

Of course, the argument can be made that it is simply “easier” to use a remote, both for the user and the designer. The designer can freely put all its designed function on the remote of the product without worry and the user can just grab the remote while remaining seated to control the device. But we believe, based on what we discussed during this course, that this can also be seen as “the easy way” and is not the most fitting mindset within the context of this course. Based on what we learned about affordances, we believe that the interactions with a device should be clear and logical instead of needing a manual to figure out.

Tangible & Embodied Interaction

Academic design is often based on theoretical frameworks such as embodied, tangible, and rich – interaction. Designing within one of these theoretical frameworks cannot be done by using a recipe that formulates how design can be performed in a stepwise plan. On the contrary, designing needs more of a mindset. Design depends on different ideological starting points. On one hand, one can set the priority to function and efficiency at the starting point of design, while utilizing your body and using your body as a manual (embodied interaction) can be at the starting point as well. However, exploring the middle ground between these two ideological starting points of design may bring interesting and innovative solutions to design challenges.

Overbeeke argues that the ideological starting point of setting the priority to function and efficiency often results in poor experiences with little respect for users in designing electronic products. According to him, to achieve rich experiences, design should respect all of man's skills, including his perceptual-motor and emotional skills, instead of focusing only on his cognitive skills [20]. Klemmer, Hartmann, and Takayama also describe that the physical bodies of human users play a central role in shaping human experience in the world, understanding of the world, and interactions in the world [21].

While designing the IoT sound system, the middle ground between the two ideological starting points has been explored. The purpose of exploring this middle ground was to create rich experiences while interacting with a music audio and video audio streaming device, while functionality and efficiency were not compromised. The IoT sound system is a tangible and embodied interactive audio streamer that focuses on physicality and emphasizes affordance, action, and functionality. According to Frens, Interactive products have three properties: form, interaction, and function. Key to this model is the notion that these three aspects are related to each other, for form invites one to interact and in this interaction, functionality is reached [6]. Thus, an attempt has been made to make the cycle of "Function – Action – Form" (figure 5) more complete by emphasizing affordance, action, and functionality.

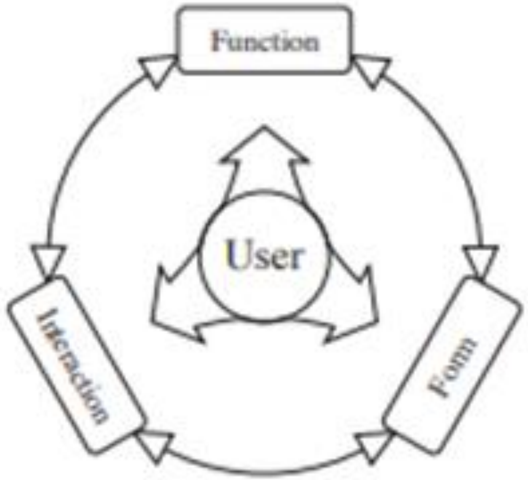


***Figure 5**, Function – Action – Form framework*

Affordance is mostly related to form in the "Function – Action – From" cycle as most interpretations see affordances as 'inviting the user to the right action' [22]. Within the design of the IoT sound system, users are invited to the right action on the physical product by its form. These right actions lead the users to the appropriate functions. The IoT sound system has three main interaction possibilities: Placing the tokens on the streaming devices; selecting a song or video sound; and reshaping the tokens. Designing for embodied and rich interaction had the priority while designing these main interaction possibilities. The cycle of “Function – Action – Form” has been unified by using embodied and rich interaction as engaged and meaningful interaction with the artifact is created by iterating on its form.

***Figure 6**, Round and rectangular token with holes in the middle*

<u>Placing the tokens on the streaming devices</u>

The tokens and the streaming devices are designed in such a way that it invites the user to place the tokens on the streaming device. The tokens, both the round ones and the rectangular ones, have holes in the middle (figure 6), while the first iteration of the tokens had a whole opening (figure 9). The form of the first iteration of the tokens did not have a meaningful relation with the interaction as it was not clear where this opening stood for. The streaming devices both have a protruding pin on the top of their physical bodies (figure 7). The holes in the tokens and the pins on the streaming devices have the exact size that the tokens can be neatly slid onto the streaming devices. The form of the tokens and the form of the streaming devices affords the users to interact with them in the proper way. This proper interaction, in its turn, opens the function of “start streaming”. On top of that, the grooves and ridges on the top and bottom of the token respectively allow users to place multiple token on top of each other. This opens up the possibility to share media with each other, as the speakers will be able to play songs from the playlists on every token and/or analyzes watchlists to pick the perfect movies/series for everyone to give an example. The design of the tokens and the streaming devices ask for embodied and rich interaction as engaged and meaningful interaction with the artifact is created.

***Figure 7**, Both streaming devices with protruding pin on the top of their physical bodies.*

There are two streaming devices. One device allows users to stream audio and has a round shape. The second device has a rectangular shape and allows users to stream video sound. The shape of the devices affords the users to place the right token on top of the device. The round-shaped audio tokens are made to be placed on the round audio streaming device, while the rectangular-shaped video tokens are made to be placed on the rectangular video streaming device. The first iteration of the device on the other hand was singular rectangular speaker with a round shutter at the front that could open and close to manage the volume of the speaker as well as a display on top to bring information over to the user (figure 8).

***Figure 8**, First iteration speaker*

***Figure 9**, First iteration token with whole opening*

To open emergent functionalities, the appearance of the screens on the streaming devices changes. A dotted line indicates what kind of streaming token is expected and prompts to open a particular function. The shape of this dotted line affords the user to place the corresponding token on the streaming device (figure 10). By integrating these screens into the designs of the streaming devices, the hybrid approach is adopted. The screens are designed according to the “Function – Action – Form” cycle. The form of the animation shown on the screen affords the right action, which subsequently reaches functionality.

Figure 10, *Displays with dotted line to indicate token shape*

Selecting a song / video sound

A slider is mounted on the top of each token (figure 11). This design invites users to slide the slider around. The form of the tokens with their sliders affords the users to have the right interaction, which is sliding the slider around. The proper interaction with the sliders opens the function of choosing a song on the music streaming device or choosing a video streaming sound on the video sound streaming device. By having the slider on top of the tokens, unlike having the slider on the side of the tokens as in the first iteration (figure 12), the slider stands more out. This enhances the affordance to interact with theslider.

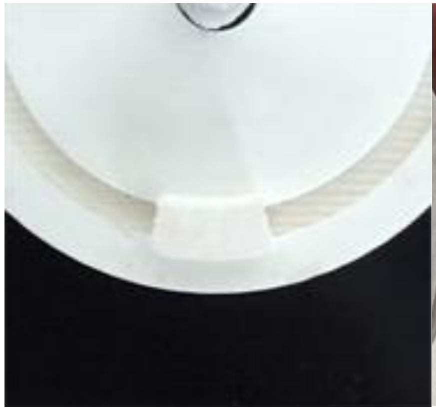


Figure 11 (left), *Top-side slider on token &* ***Figure 12 (right)***, *First iteration slider on the side of the token*

Reshaping the tokens

The IoT sound system makes users able to stream music and to stream video by using the same token(s). However, these tokens need to be reshaped in order to get from one streaming option to the other one. In this way, the shape change approach of growing is adopted. The shape change approach is self-contained and changes shape under computational control: an interactive node could present new, rich action possibilities in response to “growth” of the systems [14]. The first shape wherein the tokens can occur is a round shape (figure 13). This round shape metaphorically stands for a CD or LP, that can be placed on a music player. This also makes the round version of the tokens the one that allows users to stream music. The tokens are rotatable. The sides of the tokens have a wrinkly design which affords the user to rotate them.

By the rotating interaction, users can reach the new functionality which is streaming video sound. The rotation on the tokens reshapes the tokens from a round shape to a rectangular one (figure 13).

The rectangular shape metaphorically stands for a videotape that can be placed in a video player. The wrinkly design of the rotation knob is still visible on the rectangular tokens which afford the user to reshape the tokens to the round version at any time.

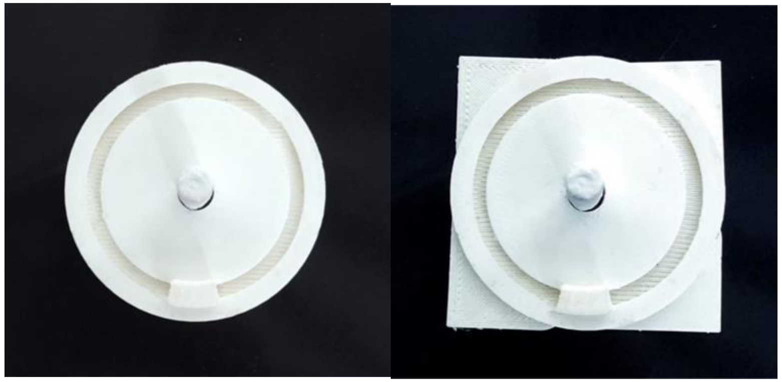


***Figure 13**, Token shapes: Round & Rectangular*

View on Modular & Service approach

The tokens have been designed with the definition of Holmquist in mind [23]. They define tokens as “a tangible that is permanently tied to the information it represents”. For us, this information depends on the transfiguration the token is in (square/circle). As each of the different modes has a different catalogue of data or music. This made it even more important to allow for the shape changing approach to differentiate between these two aspects.

Using this shape changing approach defined as, “The shape change approach is self-contained and changes shape under computational control: an interactive node could present new, rich action possibilities in response to “growth” of the systems” [14]. We could show the different main functionality between audio and video. The difficult part of designing for “growing” systems with this shape changing approach is that when you do have a shape changing device it is hard to leave room for another future additional functionality. Now this project focuses on two core functionalities, but it left us with the question about how one would design for possibilities as you are limited by the current mechanical solutions as discussed by Frens in Designing for Embodied and Rich Interaction in Home IoT [14]. This design also encountered this problem as the prototype is heavily dependent on the mechanical solution as seen in figure 14 .

In this case we just focused on the two main core functionalities.

If we look at the definition that is presented in this paper as, “shape changing controls can be designed that do offer changing forms to express changing functionality and accommodate changing interactions” [14]. We can conclude that this design comes close to this definition.

One could argue that the tokens could be defined as containers. “The container is a tangible to which digital information can be coupled and decoupled. Its nature is generic: It can be associated with any type of information” [23]. However the information on this token will always be one of two types. Video and audio. This is why we had to make the tokens iconic to make each type of information different using metaphors. As discussed in the previous chapter, differentiating between these two functionalities had to be done in different shapes to allow for the shape changing approach. Using metaphors could help a user identify the different functions for audio and video. The round shape was based on the LP’s and CD’s and the square shape of the video functionality was based on the square shapes of television screens and video tapes. These shapes are then also translated to the speakers and tv modules around the room.

The design has a very modular approach as a response to the growing system requirement of this exercise. Each of the devices were interconnectable through the tokens which allowed the system and the tokens to grow. By adding new components in the form of different speakers and modules, our system can grow naturally with the size and layout of the house. The paper of Frens on designing for embodied interaction in growing IoT [14] presents a problem where “a modular approach makes it difficult to grasp emergent functionality”. The design tackles the problem by making the tokens link different IoT devices and allowing emergent functionality to arise between them. For example, when linking the tv module with an audio speaker as a “host” you get the emergent functionality of karaoke.

The interaction with the screen also changes a bit depending on the device the token is linked to. With this hybrid approach we are able keep the same mechanical layout but still have different functionalities depending on the mode the token is in.

In conclusion this hybrid approach of the tokens really supports the modular approach of the speakers. As it allows for the system to expanded without updating the interaction of functionality of the devices.

Our design also tried to materialize the internet of things connection by having the user physically make the connection between the devices. Van Campenhout [9], gives an example about having the user move music albums from one place to another. To make this interaction meaningful this music must be some form of matter or physical metaphor. This is in our case done via your token that you physically must manipulate to see all the songs on the speaker for example. This materialization, of an otherwise invisible aspect of the data, visualizes for the user and makes them aware which devices around his house are linked and communicate with each other. This is simply achieved by forcing the user to set up their own network around the house.

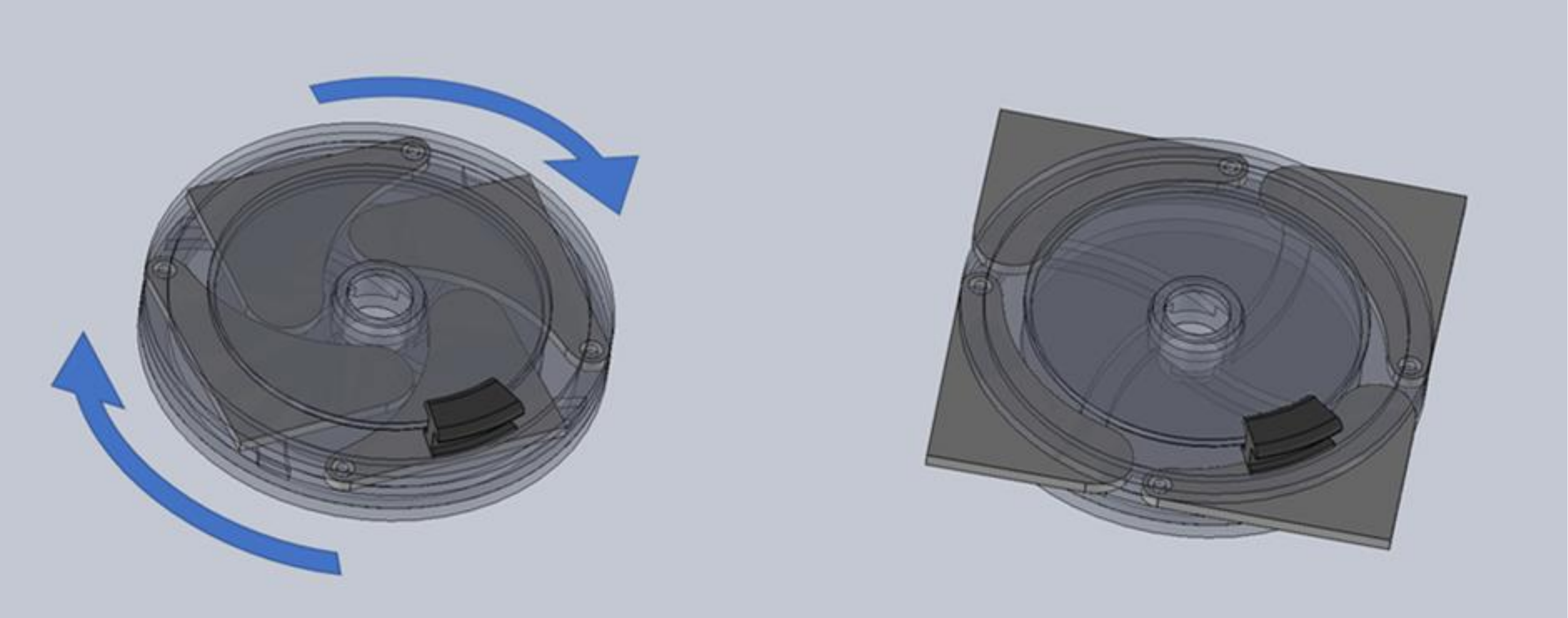


Figure 14*, Shape changing token mechanics*

Centralized and Distributed system

When further designing the initial concept for growth, keeping the physicalization of the loci of interaction in mind, multiple design decisions need to consider how to shape the growing system. When considering the new devices added to the concept, the question arises if it is more fitting for this new concept to be designed for a distributed or centralized system[14]. The biggest benefit of using a centralized system is to be able to show the user all of the various functions in a central place. The user sees the integrated system in a central location, making it more understandable to see the full system as an integrated system. The drawbacks of using a centralized system may occur with expanding the existing system with more emergent functionalities. This new system still needs to show the connection and growth of the system logically without the need of distributing the functions to another device. For example, when using the shape-changing approach, as described by Frens [14], a limitation could occur on the number of shapes chosen for the concept limiting the system's growth. The other approach, designing a distributed system, may help solve this problem. The benefit of using a distributed system is the ease of letting the concept grow with the growing system. Each object in the system determines if it should be included in the result of the system, as used by Emre et al. [24]. A good example of this is the Modular approach as described in the tilted remote example by Frens[14]. However, the distributed system also has its shortcomings in dealing with emergent functionalities. For the user, it could become unrecognizable which component of the concept is used for which function and what the system is capable of when trying to hide the computer from the user [25].

Reflecting on the design of our concept, multiple physical tokens are used for the human-computer interaction between the speaker(s) and the user(s). The tokens communicate the user's desire to the speaker, where the speakers and the television show the result of the action by using a screen and/or making a sound (figure 15). The user can communicate to not only one speaker but also to a system built up out of multiple speakers.

***Figure 15**, Music mode displays (top) & video mode displays (bottom).*

To begin with, the tokens themselves are modular and take the shape-changing approach. These tokens themselves can be used on multiple speakers throughout the room. With the tokens, the user can communicate his preference of wanting to play music or watching television to the speakers and tv. Also, the user may re-map the parameters of use from the speakers with the token on the speaker. The speakers are included in the (sound) system when a token is placed on top. This token, therefore, supports a distributed system, where every token makes its own decision. This automatization of connecting the speakers also leads to the redundancy of the original technology parameters. The behaviour of the full systems depends on the behaviour of the individual tokens. The music speakers in the concept can be placed in different spots, making the place of use of the token variable throughout time. Using the emergent functionalities of this new system, the distribution side of the system steps forward. However, when looking at the user case of using a single speaker where the emergent functionalities of the concept are neglected, it is concluded that the system shifts to work more like a centralized system. The speaker directs the user's actions by displaying the action on the speaker itself by showing what the user has done. Every time the user wants to execute the desired action, he must go to the speaker's location. This is especially the case when using the television speaker, which has a fixed location. Now the user needs to go repeatedly to the fixed location for adjustments to the parameters of use.

Learning about Emergent Functionalities

In order to make our rich interactive Locus of Interaction we had developed by the end of the second assignment capable of growth and turning it into a shared and connected IoT system, we had to think about what other core functionalities would go well with the current functionality. With the current functionality, the user was able to play, share and move their music within their homes.

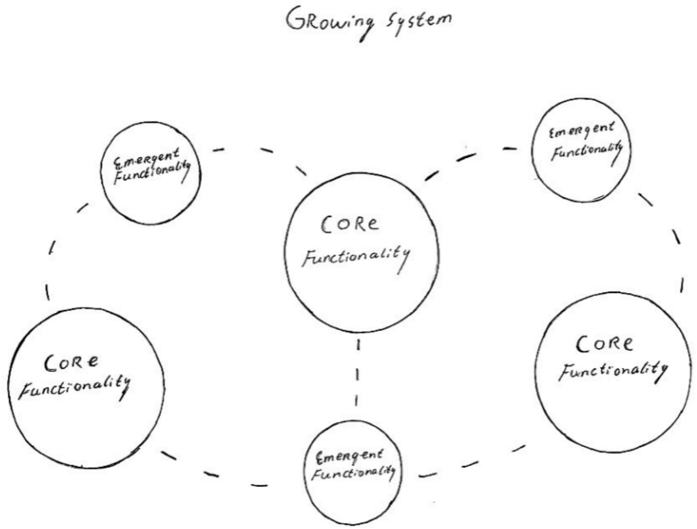


Figure 16, *Growing systems network drawing*

Trying to combine this with other functionalities proved troublesome however. Mainly because many extra functionalities could be achieved without designing an actual interaction. To combine sound with time for example, it was possible to add a timer function to the speaker and call it a day. But this would not add to the rich interactions of the system. So we wondered how one would design for an emergent functionality that does not require an interaction, if this was even necessary at all? This led to some interesting in-class discussions, which revealed that these “clashes” between functionalities were a result of us treating each core functionality as a separate part. Instead of trying to have the system switch between the two core functionalities, keeping them very much intact and separate by doing so, we should look what functionalities would “emerge” if we were to combine them. As was said during the discussion, the functionalities of a shared connected system are not just that black-white. There is some grey area in between the two core functionalities, which creates these emerging functionalities we are looking for (figure 16). Eventually, we based our emergent functionalities on this grey area principle, where we could link audio to video and video to audio. So if one were to put an music token on the tv speaker, the music would be displayed on the TV in the form of lyrics. Similarly, if a video token would be placed on the music speaker, the video sound would be played from these music speakers. This worked well with the hybrid approach we already had going, as the physical token would allow the user to move and shift modes, while the displays would provide information on what modes were active.

Design for (Limited) Growth?

One of the final discussion points of this design process was about how to make our system capable of growing/expanding. Of course, it fits the area of the Internet of Things very nicely, as it could lead to a network of connected systems all working as one. However, in the context of this course this caused some confliction thoughts. As the focus for this design process also lied on the physicalizing of the Loci of Interaction, we were conflicted about how far the system should be able to grow and to what degree the Loci of Interaction should grow along with the system. Should it be capable of indefinite growth? This also led to an interesting in-class discussion on the growth of physical and digital systems. Because the fact remains that when you have a physical control system (the Loci of Interaction) it will eventually need to grow in size to make space for all the extra controls you need for the extra functionalities within the growing system. This will eventually lead to an inconveniently sized control system. This is a constraint that the fully digital systems simply do not have, because you can simply add another app for the new functionality. However, this does not mean the physical systems are incapable of growing. As we also looked back at the given literature, we also came to realize that a shared systems is of course more than just the sum of all individual systems, as mentioned by Frens & Overbeeke in his article on Growing Systems [13]. It also states that a system can adapt to the wishes and needs of the user in current time, and that is what makes a system truly intelligent [13]. So, in this case, removing or replacing functionalities could also be considered growth, which is a great example of how the ‘modular’ approach could work. Other work also shows how systems can grow without necessarily adding a completely new physical component, for the data a system provides can already help steer a different existing system in the house [26]. For example, the thermostat can receive information from the active lights on what rooms need heating. This adds a new functionality to the connected system without adding a new physical component. These insights eventually helped us look at the possible future steps of our growing system. We believe that we can reach many more functionalities with exploring the shape-changing qualities of the token. For example, we could add the option to make the token fully round and place it on a socket on the wall to act as a thermostat or placed on a calendar to represent a timeslot (see figure 17). Just as explained in the literature, this adds new functionalities without adding totally new physical elements to the control system or Loci of Interaction.

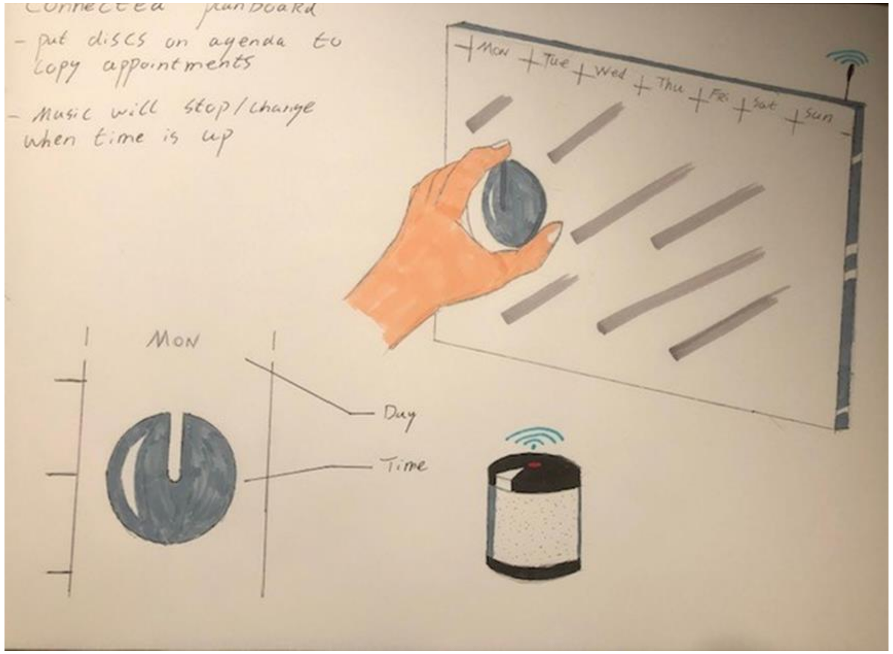


***Figure 17**, Calendar core functionality concept sketch*

Conclusion

The design process of our rich interactive system for a shared and growing IoT environment did not go without its challenges. Since pretty much all our group members were very efficiency oriented, it was sometimes troublesome to come up with both a rich and meaningful interaction. This was a big discussion point during most of the course in fact, as we often compared the value of rich, tangible and embodied interactions to a purely screen-based interaction, which seems simply more efficient at first glance. This consideration lingered for the better part of the first half of the design challenge (assignment 2), which led to an initial design that was still very function oriented. By doing so, we placed a lot of different controls on the disc tokens and made the interactions with the system very confusing, chaotic and actually less efficient in the process. After taking another critical look at the provided literature and combining multiple approaches offered in this course (hybrid, service and shape changing) we managed to reduce the amount of controls and bring back this desired efficiency. In the end, we believe we managed to design a rich interactive system for growing IoT that fulfils our expectations of a meaningful/useful rich embodied interaction. Looking back at our original goal of designing for the ongoing dematerialization of music and video, we aimed for shaping more value in the act of playing, sharing and moving music in the homes. We managed to rematerialize the music in the shape of a token, which adds value to the experience by allowing the user to easily access the emergent functionalities. Being able to put music on the TV(video) speaker and a video token on the music speaker allows for the combining of two core functionalities and more options to shape the playing of music and video in one's home. We could say that our design also manages to materialize the internet of things connection to some degree by having the user physically make the connection between the devices, which is further amplified by having the speaker distributed through the house while having the control/information displays centralized on top of each individual speaker. Finally, the shape changing qualities of the tokens allow us to bypass the physical constraints for growth up to a certain height by changing the functionalities without adding totally new elements. This interchanging of functionalities based on the current needs of the user can be argued to define a truly intelligent system.

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Personal Reflections

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I am interested in a connected future in which I think the Internet of Things (IoT) will become more prominently present in the form of connected products. A Designerly Perspective on IoT focusses on this phenomenon and includes one of the expertise areas I want to focus on in my master (Technology and Realization). The choice for this elective was easily made. I was eager to realize a connected prototype for this course.

However, I soon realized the focus of the course was rather aimed towards creating embodied, tangible, or rich interactions in an IoT product and being able to bring these concepts into that of a growing system. I was familiar with these concepts but had been sceptical towards them. I appreciate efficiency more in design and rich interaction often means a loss of functions. Nevertheless, as was communicated in the first lecture, I temporarily dropped my opinion, stood open for the premise of the course and learned about the integration of these concepts in IoT systems.

While doing the latter, it was hard to let go of efficiency, and rather think about creating value by making a unit between form, function, and interaction [1]. While trying to do so, I learned that rich interaction can also be beneficial on a usability term when it creates this unity. The notion of "dematerialization" [2] inspired me to create more value for dematerialized music by integrating rich interaction, while keeping the flexibility of the digital world. While bringing this forward into the 'growth' of our design in assignment 3, and thereby taking a hybrid approach [3], I struggled with how to integrate the theory into our design. This was mainly due to the theory and presented concepts being brought forwards as a mindset, rather than a recipe. The structure of the course helped me to cope with these struggles. The open discussions on the literature, actively participating and asking critical questions helped making the mindset clearer. Moreover, by having these discussions on and talking about the concepts, I realized that as a designer we do not have to agree with nor adopt academic writing, thinking it is the right way to go. In that sense, after having followed the course, I can now state I have formed my own stance towards the mindset and premise of this course.

I agree with that there is a place for rich interaction in IoT systems. It has been a great learning experience to get familiar with the mindset and exploring the integration of theory in the assignments. But the key question for me was the one Sander Bogers asked during the final presentations: "What is the added value of a certain embodied, tangible or rich interaction against a screen-based interaction?" (Personal Communication, April 7, 2022). Only when a certain interaction has more value than the screen-based interaction, I think there is a place for rich interaction. If I do not see this added value, I am not a designer who is likely to make use of the mindset in my designs.

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