Master Thesis

INTEGRATION OF A SMARTWATCH INTO INTELLIGENT WORK ENVIRONMENTS

accomplished at

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EHRENWÖRTLICHE ERKLÄRUNG

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DANKSAGUNG

Ich möchte mich an dieser Stelle ganz herzlich allen voran bei meiner Familie und meinen Freunden bedanken, welche mir in guten als auch schlechten Zeiten immer zur Seite standen und mir entsprechenden Rückhalt gaben.

Darüber hinaus gebührt Dank natürlich auch meinen Kollegen des Unternehmens LOGICDATA, durch welche ich entsprechende Unterstützung als auch Motivation erfahren durfte. Besonderer Dank gilt hierbei meinem Kollegen Hrn. Matthias Buch, welcher sich der Betreuung der Arbeit angenommen hat als auch meinem Vorgesetzten Hrn. Johannes Gradwohl, welcher eine Bereitstellung der benötigten Komponenten organisiert hat.

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KURZFASSUNG

Es ist hinlänglich bekannt, dass eine steigende Zahl an Personen einen Großteil ihres Lebens statisch sitzend an einem Büroarbeitsplatz verbringen. Darüber hinaus ist es mittlerweile deutlich erkennbar, dass dieses Verhalten zu gesundheitlichen Problemen wie Durchblutungsstörungen, Nackenschmerzen oder zu Problemen mit der Wirbelsäule führen kann. Aktuell werden immer mehr Arbeitsumfelder smart. Diese bieten die Möglichkeit in der Höhe verstellt zu werden und darüber hinaus eine Kopplung mit dem Benutzer zu erreichen. Personen, die an einem solchen Arbeitsplatz arbeiten, müssen sich erst an die Möglichkeiten und die damit in Verbindung stehenden positiven Nebeneffekte gewöhnen, generell besteht jedoch aktuell das akute Problem, dass es keine optimale Schnittstelle zwischen dem Nutzer und dem Arbeitsplatz gibt. Eine mögliche Lösung hierzu wird in sogenannten Smartwatches gesehen, welche vom Nutzer getragen werden und eine Interaktion mit dem Arbeitsplatz ermöglichen.

Der Zweck dieser Masterarbeit ist es, Möglichkeiten zur Integration solcher Smartwatches in solch smarte Arbeitsumfelder aufzuzeigen. Ein wichtiger Fokus dieser Arbeit ist, eine Basis für weitere Entwicklungen in diesem Feld zu schaffen.

Hierzu wird ein Zielsystem zusammen mit einer entsprechenden Architektur definiert. Dazu in Verbindung stehend wurden die Entwicklungswerkzeuge aufgesetzt und eine entsprechende beispielhafte Umsetzung durchgeführt. Diese Umsetzung wird in weiterer Folge auch von mehreren Probanden getestet.

Die beispielhafte Umsetzung zeigt, dass eine Integration von Smartwatches in solch smarte Arbeitsumfelder möglich ist. Darüber hinaus werden Tests hinsichtlich der Benutzbarkeit von Smartwatches durchgeführt. Die Umfrage zeigt, dass es durchaus noch Probleme hinsichtlich der genannten Benutzbarkeit gibt.

Es ist geplant die Entwicklungen auf dem Gebiet der Smartwatches und den damit in Verbindung stehenden Sensoren voranzutreiben, um am Ende des Tages einen echten Mehrwert für die Nutzer von smarten Arbeitsumfeldern zu generieren.

ABSTRACT

It is a known fact, that more and more people are spending a big part of their lifetime sitting at a static workplace. It is also known, that this leads to injuries like disturbed blood flow, neck pain or even damage of the spine. Currently a rising number of workplaces is getting smarter. They offer the ability to be adjusted in height and to get connected closer to the user. People working at such workplaces simply need to get used to that functionality and the positive effects on their personal health. The challenge is that currently there is no ideal interface between the user and the workplace. One idea to solve this issue is to use standard smartwatches, which are worn by the user and are able to interact with the intelligent work environment.

The aim of this thesis is to find ways, how standard smartwatches can be integrated into an intelligent office environment. The main focus of the thesis is to create a foundation for further developments in that field.

Therefore a target system is defined and a system architecture is built upon that. In correlation to the target system the toolchain is set up and the integration is realized through exemplary implementations. These implementations were also tested and verified by a defined group of people.

The exemplary implementations show, that an integration of smartwatches into intelligent work environments is possible from a technical standpoint. Next to that, a defined group of people conduct tests with the smartwatches. The survey, which has to be done by the group after the tests, showed that smartwatches bring many challenges in terms of haptics, usability and availability.

It is planned to continue the developments in the field of smartwatches and their sensors to finally create a real added value for users of intelligent work environments.

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1 INTRODUCTION

The overall aim of this master thesis is to find out whether it is possible to integrate smartwatches into intelligent work environments or not. Next to that the purpose of such an integration shall be worked out to get a better understanding on the needs and demands users have working in such environments.

1.1 Company Introduction

The company LOGICDATA is an Austrian based world class supplier for mechatronic solutions for adjustable furniture. The company was founded about 20 years ago by Mr. Walter Koch, who is still the owner and CEO of the company today. Beside him there are three more managing directors leading the company in Deutschlandsberg, who are Stefan Lukas, MD for R&D, Johannes Gradwohl, MD for Products & Markets and Jörg Schweiger, who is MD for Operations.

LOGICDATA is serving two big markets with its products – Firstly the home sector, which is basically dealing with adjustable recliners and adjustable beds and secondly the office sector, where the main application is the adjustment of desks and workstations in height. In any case the health of the human being is in the focus of the products.

In general the rate of products which are exported from Austria to other countries is constantly at 100%, since the big players in the furniture industry are located in northern Europe (Germany and the Scandinavian region) and in North America.

Throughout the last years LOGICDATA was in a leading position in terms of market shares but also in the field of innovations.

Today LOGICDATA has around 250 employees, which are working at four subsidiaries around the world:

- Deutschlandsberg, Austria: Headquarter, R&D
- Maribor, Slovenia: R&D
- Hong Kong, China: Supplier acquisition
- Michigan, USA: Sales and customer service

1.2 Initial Situation and Mission

As in the current days more and more people tend to spend an increasing amount of time at their workplace basically in a sitting position, one of the results is that an unknown but certainly growing number of people is suffering from that scenario. They suffer as the body is harmed by the static position, mostly the people tend to keep when sitting at a table. The consequences could be neck pain, back pain or even damages of the circular system.

The company LOGICDATA is highly motivated to create solutions, which support people in their daily life within an office environment. The goal is that the health of each individual is increased to the maximum. One key for that goal is that people are trained and motivated to utilize the existing components within the corresponding office environment in the best way possible, which means that for example a table and a chair is adjusted properly. Furthermore this also implies, that the focus of LOGICDATA is also widened up, since there are more components within an office environment, such as lamps, locking and authentication systems, climate controls, window blinds, etc.

Beside the user aspects the market is also going to be pushed into a new direction by such anapproach. This directional change will most likely allow LOGICDATA to stay in the position of the innovational leader in the market of office products.

Since this big visionary goal demands an intuitive and interoperable user interface one possible component could be a smartwatch. For that reason the main goal of this thesis is to obtain whether and how an smartwatch could be integrated into a currently existing system built from LOGICDATA components.

1.3 Scope of the Thesis and Objectives

The scope of the thesis is to prove whether and how an integration of a smartwatch into intelligent work environments is possible. According to that on one side the market perspective shall be evaluated to obtain possible use cases and on the other side one particular smartwatch shall be chosen, which is furthermore utilized for the integration.

The integration itself shall bring up a simple showcase, which shall be tested by a various number of people. With that tests knowhow shall be gained in the field of smartwatches, including possibilities in terms of sensors and connectivity and potential risks in terms of usability, haptics and availability.

The showcase shall incorporate products of the company LOGICDATA. In the end it is a non-objective, that anything sellable is a result of this thesis.

1.4 Research Design

In general the aim of this thesis is not only to integrate a smartwatch into an intelligent work environment – it furthermore shall deal with the question why this is needed and what the driver behind such demand is. To achieve such a status at the end the following steps shall be considered to be taken throughout this thesis:

- Creation of a clear picture in regards to the needs of the work environment and the users working there
    - Business insights (basically chapter 2 LOGICDATA Synthesis)
    - Theoretical insights (refers to chapter 3 Associated theoretical insights)

- Derivation of requirements according to the findings and draft definition of a system context
    - Definition of the final requirements (done in chapter 4 Definition of the target system)

- Preparation of a technological foundation
    - Gathering of insights into the Apple environment (as handled in 5 Preparative actions)

- Implementation and validation
    - Exemplary implementation (fully covered by chapter 6 Practical realization)

2 LOGICDATA SYNTHESIS

2.1 Introduction

One key element of this thesis is the evaluation of currently existing trends and changes in the market of work environments.

For approximately five years LOGICDATA has been working on a program called Synthesis. The focus of the program is put onto one main topic – how people are working tomorrow. To be able to come up with such a big prediction, the Synthesis group consists of different experts in different fields:

- Sales and product managers for market insights and actual trends
- Industrial designers for trend scouting and product design concepts
- Ergonomists for insights on demands and measures of human beings
- Consultants for market and business insights

2.2 The Vision

Actually the vision of LOGICDATA is that the intelligent work environment gets intelligent by the holistic integration of smart components. Following that vision the user shall be moved more into the center of the work environment and get more control over the components in terms of adjustability but also personalization.

At the end of the day the user shall receive the maximum level of support to increase its personal health to the best possible degree. To achieve that goal the following steps are currently taken:

- Creation of an communication hub for maximum connectivity (see chapter 2.4.2 LOGIClink for more information)
- Creation of a sensor or integration of further sensors to get closer to a holistic solution
- Collaboration with world class partners, such as ergonomists, scientists, doctors and engineers

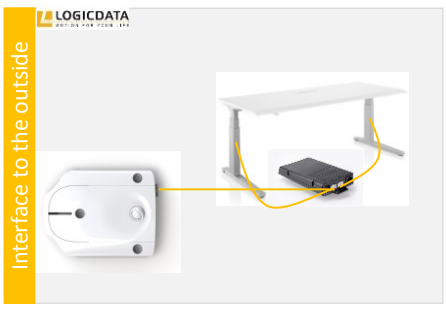


Fig. 1: Depiction of an intelligent work environment as envisioned by LOGICDATA. Source: own depiction

2.3 Trends and Developments in the Office Work Environment

As stated in the introduction to this chapter one core element of this thesis is the evaluation of currently existing market trends in the field of work environments. In the following subchapters the most important trends and developments are described in more detail to get a better understanding on what the demands from a market perspective are. Furthermore the possible functions for smartwatches are pointed out.

2.3.1 Activity Based Workplaces

One of the biggest and most impacting trend currently ongoing is the trend called Activity Based Workplaces.

Due to the fact that nowadays employees are more and more focusing on multiple tasks at the same time and collaborating with others the demand for a flexible work environment is steadily increasing. It is hard to tell when this trend was initiated originally and consciously, since for example lounge areas were already used for ad-hoc meetings for a long time. Still nowadays companies are pushing that trend due to its connected benefits for the organization.

The two basic principles for this trend are as following:

1. An employee is not owning a workplace anymore in the traditional way
2. There is a special workplace for any kind of need

Those principles might sound weird in the first place, but in general it simply means that an employee takes the workplace needed to fulfill a certain task in the most productive and efficient way. The workplaces from which an employee can choose from, are the following (according to the demands, also shown in figure 2):

- Silent work
    - Flexible desk, which can be moved around
    - Private office space
    - Quiet rooms
- Collaborative work
    - Meeting areas, which can be divided into warm-up and cool-down areas
    - Collaboration areas
    - Lounge areas
    - Atriums, stages

Fig. 2: Depiction of the Activity Based Workplace approach, showing the fragmentation of a facility into different workplaces. Source: Weblink http://intereum.com/about/living-office

In the general the basic aim behind that approach is that employees can choose how, where and with whom they want to work with to achieve the best results. The resulting huge flexibility furthermore allows that people can work in the way they work the best. Since all employees are still humans there is a big chance that one to another differs in his or her working style.

Furthermore all of these workplaces can either be used by simple appearance of the employee at the workplace or be booked in advance through a central system, but in the end the way of such handling relies onto the company, where this approach is applied.

For the introduction of such an impacting trend into an organization it has to be considered that such a change is not only affecting which furniture is placed within a facility, it's far more concerning the culture of the organization and therefore affecting each and every employee. To handle such a paradigm shift companies (including furniture manufacturers and retailers) started to offer consultancy for such change process.

Last but not least the monetary aspect of that trend has also to be pointed out. Since Investigations showed that workstations which are assigned to just one person, are used only for one third of the time throughout a day. This means that by achieving that the furniture and in a further case the workplaces are used for a long time also the investments into the facility (including furniture) could be optimized.

Fig. 3: Depiction of a combined area containing personal and collaborative workplaces. Source: Weblink http://www.hermanmiller.de/solutions/living-office.html

2.3.2 Rental Offices

Another big trend beside the Activity Based Workstations is the trend about rental offices.

In times where it is trending to create a startup, very small and young businesses search for safe options and possibilities to ensure their growth on a longer term. This also includes that especially in the beginning no big investments are put in things like a facility or furniture since in most cases (especially in the case of startups) the final success of an idea or a product cannot be guaranteed. Therefore the possibility of renting office space is a very attractive solution for that issue.

The whole topic about rental offices is not new – There has always been the possibility to rent at least meeting rooms (for example in hotels). Still this topic received special attention especially by the tremendous trend of startups, which is currently happening. As described before, the possibility to simply rent an office space is far less risky and causing much less overhead to the budget of such small and young organizations. Nevertheless this option is also interesting for normal sized companies, as not every company is either having a demand for a subsidiary at certain places or having the budget to build one at such place.

Besides the big advantages of not having financial overheads due to obligations and also not having long term contracts there is one more big gain by the utilization of rental offices. Being aware that in most cases a rental office is utilized by more than one organization at a time, the chance is quite high, that the organizations at such office space start to collaborate. This could simply be initiated whilst taking coffee breaks but end up in sharing ideas and learning from each other. That kind of synergy could be beneficial and important especially for startups and other small businesses.

Another boost for the popularity of rental offices is for sure the way how such offices can be booked. As shown in the figure below it is quite simple to book such an office space. Actually the look and feel of such webpages looks quite similar to webpages which are specialized on booking hotels.

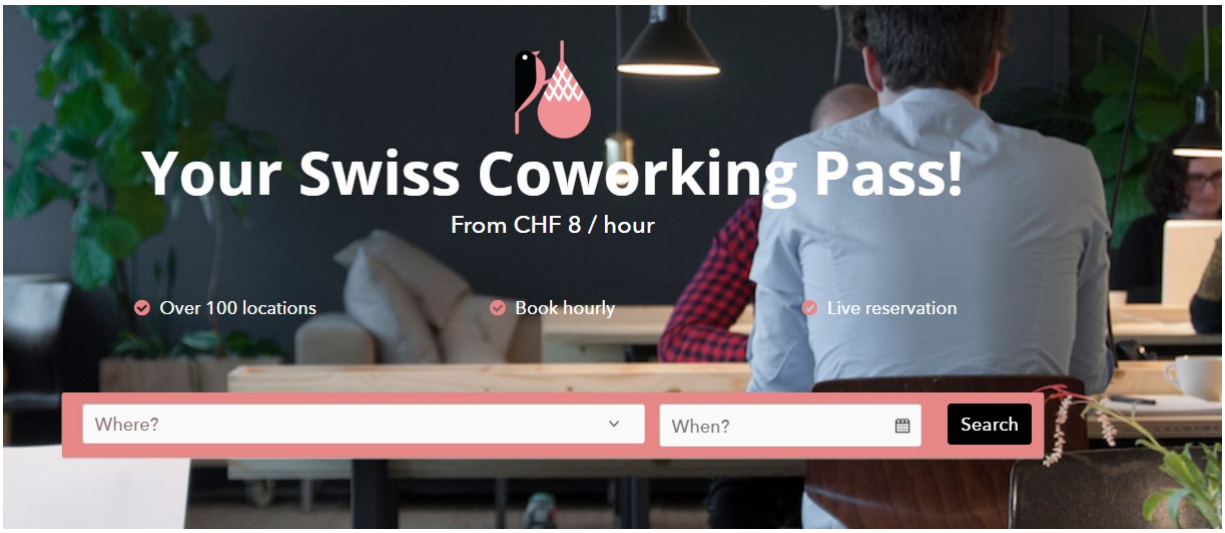


Fig. 4: Website for booking a rental office. Source: Weblink https://popupoffice.ch/

2.3.3 Analysis Tools

The next big trend beside renting office space and the special way of how it's furnished with appropriate furniture is the trend that deals with analysis tools.

As already noticed through the previous subchapters a very big topic around offices is dealing with the costs of a facility. Since nowadays the price for an office location which is in the best case in or at least around a big city, is increasing, companies are eager to utilize the available resources as good as possible.

Because of that there are different concepts and methods currently applied within the industry to deal with that topic:

The first approach follows the goal to get a clear picture on the utilization of the workplaces within a facility. Therefore the occupancy of each workstation is simply logged to a central system. This occupancy can be detected either by special sensors, which have to be attached to the workstations, or by using components which are already available within such a facility (for example network routers). The collected data is interpreted and illustrate in a final step.

Generally there are two main potentials, which could be gained with that method: Either there is space, which could be used differently (for example a meeting room could be used for workplaces, since it's barely used) or there is not enough space available.

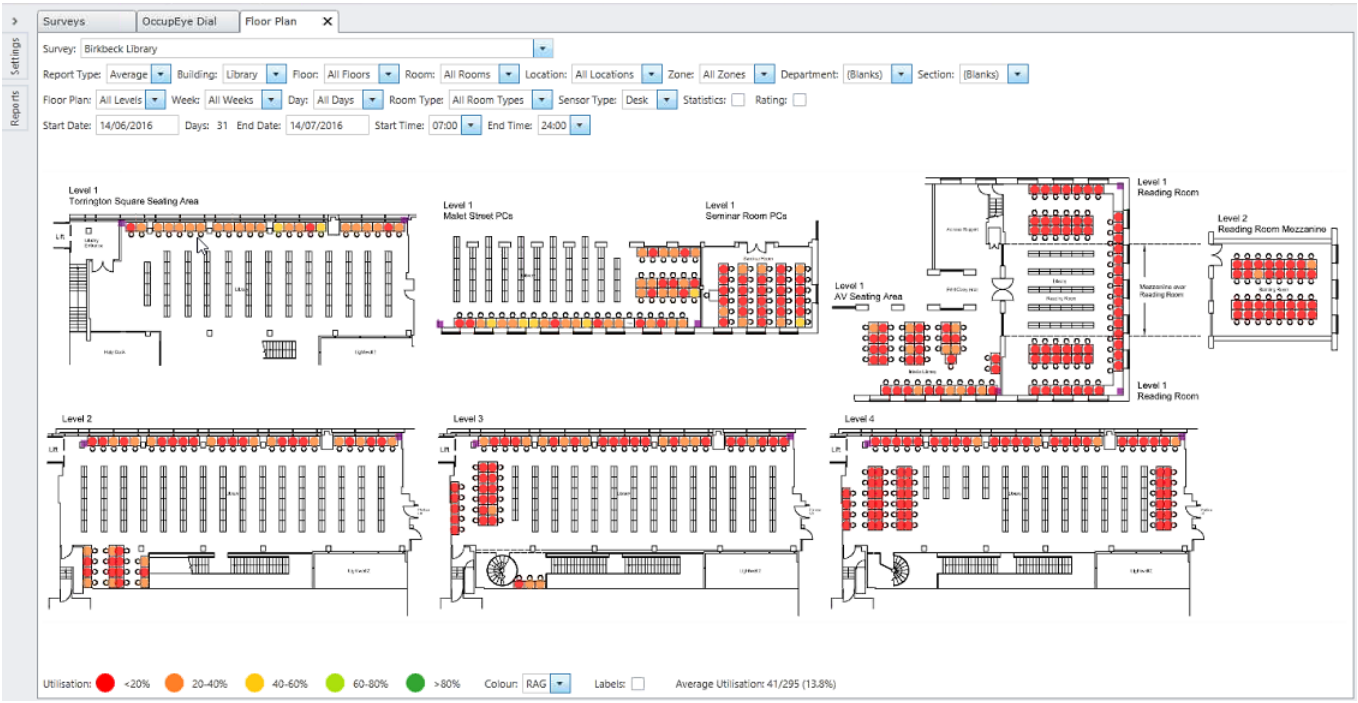


Fig. 5: Illustration of a heat-map showing the utilization of the workplaces within a facility, the darker the color the more a workplace is utilized. Source: Weblink http://www.occupeye.com/

The second approach is dealing with energy management within a facility. The overall goal hereby is to reduce the amount of energy needed by a facility. One exemplary realization for such an optimization has been done within the building *The Edge*, which is a facility located in Amsterdam, Netherlands. In that building, electrical systems including lighting, locking mechanisms, workstations, photovoltaic/solar systems, etc. are connected to a central system, which collects all possible data, interprets it and manages the whole facility based on that information. The result out of such a holistic approach is that this certain building produces more energy than it needs.[1]

The challenge with that approach is for sure, that as many electrical systems as possible need to have the ability to measure data, send it to a server and have the possibility to be changed in behavior (for example that a lamp can be turned off remotely). A sophisticated example from *The Edge* on that point is the following:

- An authentication system at the entrance detects which person enters the building
- The lighting system is able to detect where the person is going to through movement sensors
- All data is synchronized with the central system
- The central system is capable to find out the basic habits of a person regarding to when he or she is arriving, where the workplace is located within the facility and what is the common way to approach that workplace.
- From that the system is able to turn on the lights needed for a person to reach its workplace and therefore to reduce the overall waste of energy since all other lights could stay turned off.

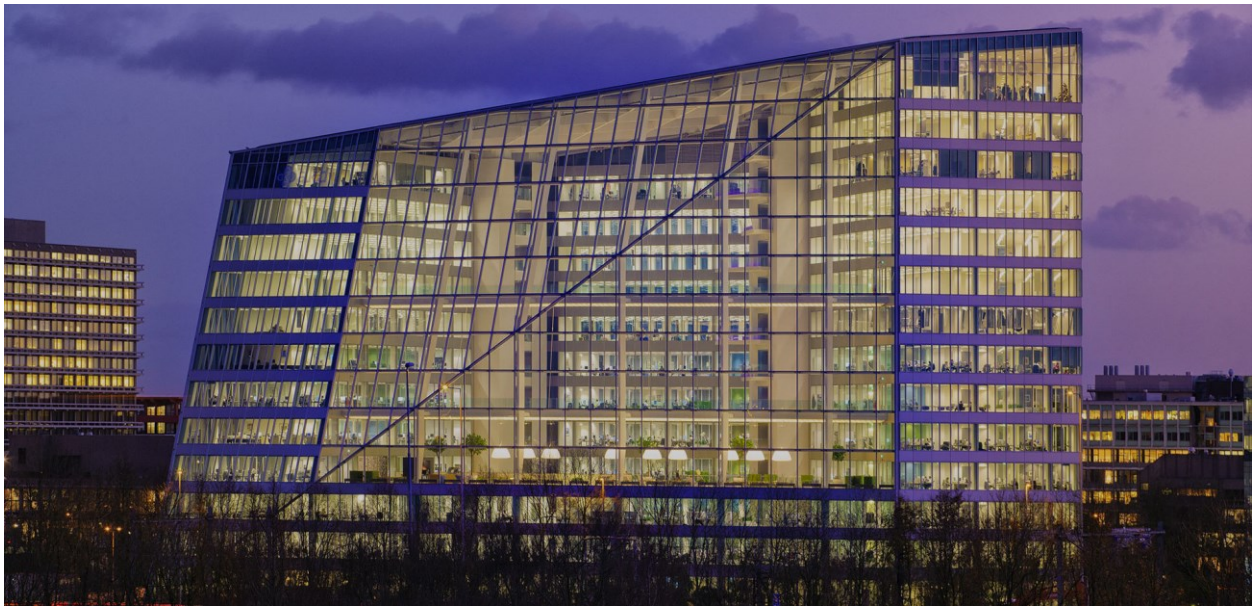


Fig. 6: The Edge, Amsterdam. Source: Weblink http://ovgrealestate.de/project-development/the-edge

[1] Cf. Andreae (2016), expert interview

2.3.4 Facility and Asset Management

The trend dealing with analysis tools (furtherly described in chapter 2.3.3) is extendable with the trend of facility and asset management.

As the general analysis tools have a focus on the whole facility as one holistic system, the facility and asset management tools add a certain amount of functions, which allow also employees to gain a benefit from such systems. Those functions basically allow employees to handle components within that facility (like furniture or rooms, etc.) and assets (like meeting infrastructure, printers, computers, etc.).

There are two quite popular approaches to that topic:

The first approach deals with reservation systems. The basic aim of reservation systems is that a user (regardless if it's an employee or just a guest) can reserve certain assets within the corresponding facility. This means for example, that an employee can book a certain room just for a meeting or a certain workplace for a day. It's up to the system to decide according to rules, whether the employee is able to reserve such an asset or not. Furthermore there are systems which even include interactive indicators like doorplates with displays or simple colored light indicators to show the status of the asset (booked, reserved, free). In the end, such systems are also able to do analytics on the data collected and therefore offer also the same abilities as the systems described in chapter 2.3.3 Analysis Tools.

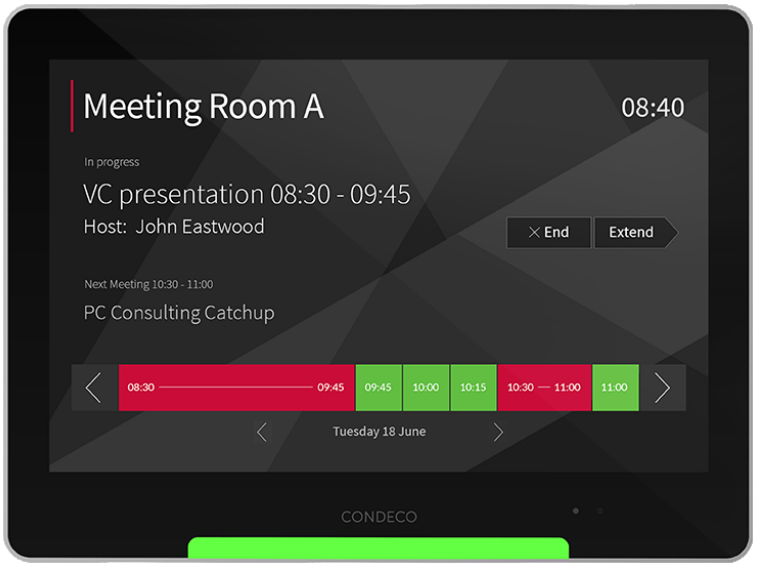


Fig. 7: Interactive doorplate. Source: Weblink http://www.condecosoftware.com/products/digital-signage/condeco-connect/

The second approach deals with indoor positioning. This approach combines the possibility to book assets like tables, rooms, printers etc. with the ability to track where each person is. Indoor tracking is basically realized with a special triangulation algorithm which allow to detect the real position of an employee within the building. In the end such systems allows an employee to search either for assets or also for colleagues on an interactive map visualized on any device like a smartphone, a tablet or a computer. Beside that the employee can also choose the option to be navigated to the asset it is looking for, which brings the huge advantage that people are not searching for things but simply are finding them.[2]

Fig. 8: Indoor positioning system. Source: Weblink http://flowscape.se/products/

[2] Cf. Reigo (2016), expert interview

2.3.5 Health Aspects

Another very important trend to be evaluated is dealing with health aspects in the work environment.

A general trend correlating to that topic is the self monitoring trend, which is currently occurring quite rapidly in communities all around. Here people tend to track all their activities by utilizing wearables as gadgets for gathering data. The most common data for such measurements are the heart rate and the step count. Mostly the motivation for self tracking is pushed by apps since people get reminded instantly when being offside their goals. The positive effect of that trend is that approximately half of the people which are using such wearable changed their overall approach to maintain their personal health[3].

Taking a step back, a brief look onto the general wearable market shows that due to this trend at least the shipment forecast and therefore the demand for such devices is steadily growing because of that application.[4] Such growing demand is also a good indicator that in near future the development for such devices is also going to be pushed further.

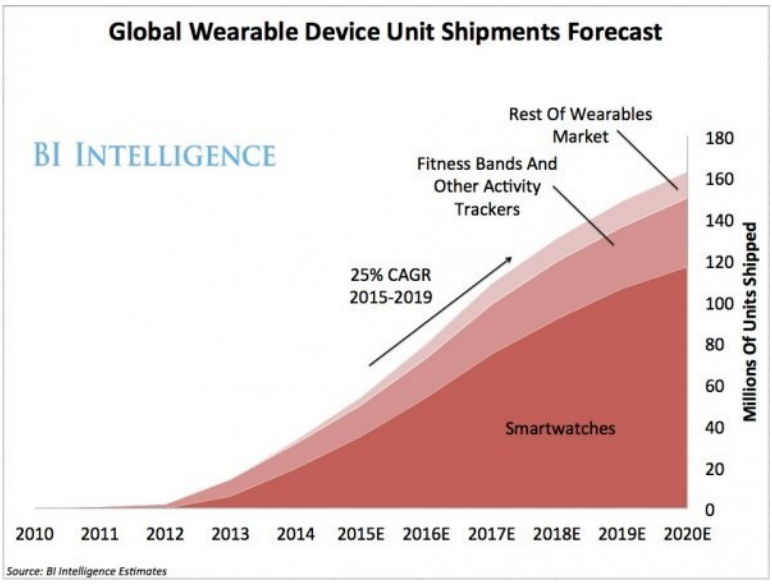


Fig. 9: Increase of shipment forecast for wearables. Source: Weblink http://www.businessinsider.de/the-wearables-in-the-healthcare-sector-report-how-emerging-consumer-and-professional-healthcare-trends-are-driving-interest-in-wearables-2015-10?r=US&IR=T

Coming back to the health topic in general, the tracking of personal data is one topic. The other subject which is correlating with the work environment is the fact that nowadays people are suffering from the way they have to do their daily work within such an environment.

[3] Cf. Paddock, How self-monitoring is transforming health, online source [04.12.2016]

[4] Cf. BI Intelligence, How emerging consumers and professional healthcare trends are driving interest in wearable devices, online source [04.12.2016]

The list of injuries, which are caused by sitting posture is as following:[5]

- Headache caused by blood flow disturbances
- Shoulder and arm pain
- Spine injuries including back pain and neck pain

The main problem with sitting is that the spine is under the same pressure as in a standing posture but which is applied in a bad way when sitting. Due to that the muscles in the back have to stabilize the upper body since the natural curve of the spine is distorted. Since it is exhausting to keep the posture upright people tend to slough around on the chair and at the workplace ending up in a static position, which finally leads to spinal problems.[6]

There are lots of different investigations on that topic, but the result is the same anytime: The best posture for the human body is not any static posture – it is far more the combination of different postures since it is highly important for the body to be in a constant movement. Due to such (micro-) movement the whole organism (and hereby especially the spine) is better supplied with blood which decreases the risk of any harm massively. Therefore it is highly important to motivate people to move their body, regardless whether they are sitting or standing.

Another topic which goes along to the trend described here is, that to a certain extent the risk of having employees on sick leave due to injuries caused by bad posture at the work environment will also force the employer sooner or later to change something.

Fig. 10: Back pain and neck pain. Source: Weblink http://truthnhealth.com/2011/11/banish-back-pain-with-natural-home-remedies-and-exercises/

[5] Cf. Not stated, Computer-related injuries, online source [04.12.2016]

[6] Cf. Pan, Why Sitting Too Much is Dangerous, online source [04.12.2016]

2.3.6 Personalization

Another important aspect with work environments deals with the personalization of the employees within their corresponding workplace.

As identified in earlier chapters the main trend currently ongoing tends to get away from the classic situation, that one workstation is assigned to one employee. People are more or less forced to choose their work space, where they want to work, but limited in time. Since human beings tend to mark their territories the demand for possible personalization will come more sooner than later.[7]

Due to that the employers have also to think about such scenarios since they want the people to stay within the organization. In general it is a quite divergent topic – on one side the company is normally anxious to share common values and a common picture especially to the outside, on the other side the company consists of individuals, which all have a different understanding of values and the picture they represent to the outer world.

2.3.7 Demographic change

In the end there is one subject which needs to be considered by all different trends and methods – the generations of the human population. Concerning that topic there are two extremely important things which need to be understood and considered for anything which is done in correlation with human beings.

Firstly the world population is undergoing a demographic change in terms of aging. Due to the fact that the life expectance is increasing the number of people being older than 65 is increasing dramatically in comparison to earlier years.[8]

[7] Cf. Shoemaker, The Importance of Personalized Workspaces, online source [04.12.2016]

[8] Cf. Not stated, Demographic Change in Germany and Europe, online source [04.12.2016]

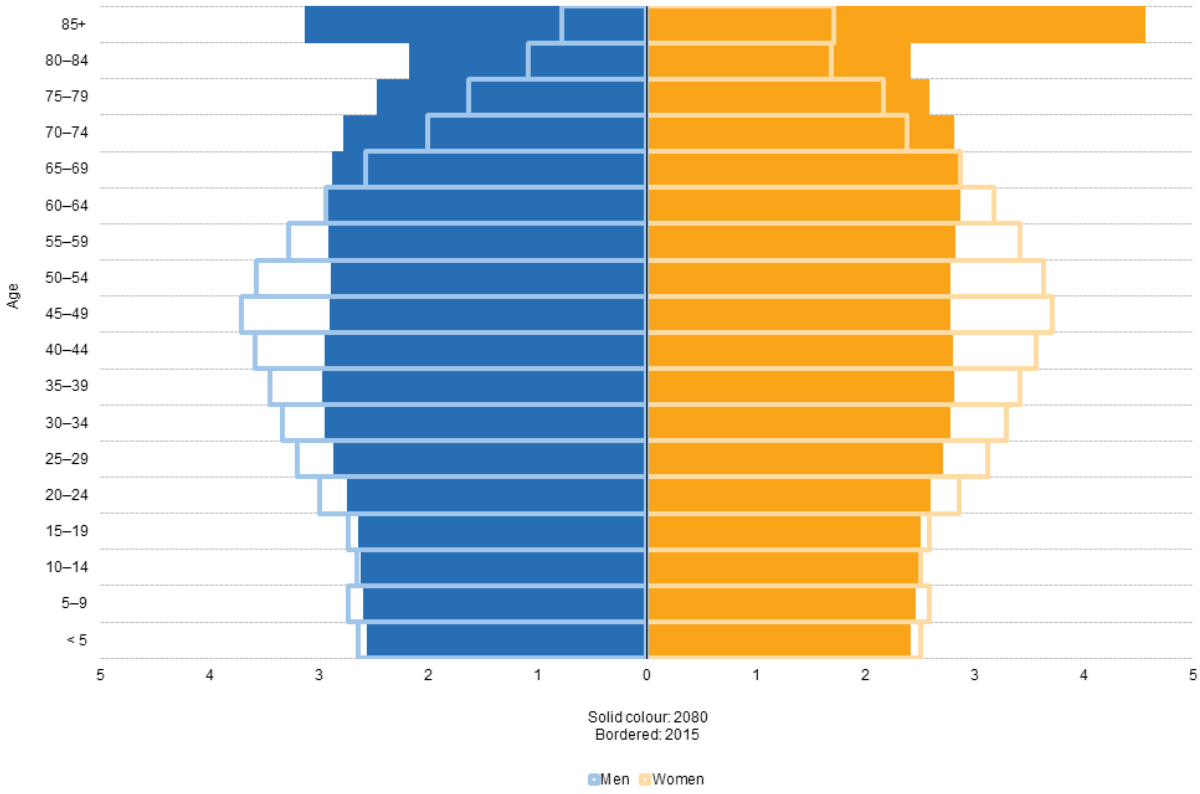


Fig. 11: Population Pyramid, showing the percentage share of age distribution. Bordered blocks indicate the portion for 2015, solid blocks the predicted portion for 2018. Source: Weblink http://ec.europa.eu/eurostat/statistics-explained/index.php/Population_structure_and_ageing

The figure above illustrates the ongoing change very well. The figure shows the

Whilst having a rather small percentage of people in the age area of 65 or older in the year 2015 this percentage is growing until the year 2080. Still the fertility rate seems stable since no change is visible for the population at the age of ten or less years.

Overall it has to be considered that due to an increased life expectance and a far higher percentage of old people this part of the population might also consider to work longer than to the age of 65. That might be a result of either the prediction that the upcoming generation of old people is better in shape at the same age and therefore still motivated and willing to work or that the currently existing retirement system is not able to handle such a big amount of people retiring.

The second big topic concerns the generations, which build up the overall population. To the current date the following generations are coexisting:[9]

Baby boomers

This includes people, who were born between 1946 and 1964. This generation is defined by being self-satisfied and self-centered, but also team-oriented to a certain extend. Besides that this generation tends also to be more positive about authority, hierarchical structures and traditions. This is going along with the motivation of changing common values for the good of all and not only for someone personally.

Generation X

That generation includes people, which were born between 1965 and 1980. This generation is defined as being entrepreneurial and very individualistic. It is the generation, which fell into the transition from written knowledge to digital knowledge since computers got introduced in schools and the daily life. People of that generation have the desire get the chance to learn, explore and make a contribution in the end. Mostly such people are self-absorbed and suspicious of all kind of organizations, which goes along with the motivation of being a survivor as individual. Lastly this generation can also be described as cautious, skeptical, unimpressed with authority and self-reliant.

Generation Y

This generation includes all individuals which were born between 1981 and 2000. This generation is known to respect authority and to schedule everything. Still, this generation is also feeling an enormous academic pressure. It was the first generation which grew up in a digital environment including computers and the internet. An interesting fact about this generation is that is not living to work but rather work to earn money which is spent to live the desired life.

[9] Cf. Novak, The Six Living Generations In America, online source [04.12.2016]

Generation Z

The last generation includes all children born after 2000. This quite young generation does not know a world without computers and cell phones. It is also the first generation which is totally technology driven and starts to interact with such devices already at a very low age. Still, since this generation is rather young to the current day there is not much known yet about it. One remarkable thing is that this generation is actually tired of hearing about the environment, which has to be saved, and all the political disasters ongoing.

As stated above each generation has its own characteristics which have to be considered for any planned interaction which concerns human individuals. Since the distribution of the generations is also slightly adjusting due to the demographic change described before, those characteristics are an essential piece in the puzzle of a successful product design.

2.3.8 Technological impacts

As a last methodology the general trend around technological impacts is being revised.

In general there are several technological developments and trends ongoing which interfere with the changes in the office environment. The basic trends here are as following:

Internet of Things which allows a higher level of integration of sensors and actuators. The main example hereby concerning the work environment is for sure the growing industry in regards to smart home appliances. This industry is basically trying to automate as much as possible within a building, like for example the lighting system, which is controllable through a smartphone.

The collaboration and interpretation of data fosters the second main trend correlating with the office environment. As already described in the previous chapters there is a big demand for analysis tools and options which allow to optimize systems and the utilization of either space or assets and to safe money at the end. This is correlating with the topic Big Data, which is furthermore handled in more detail in chapter 3.4.Along comes the fact, that nowadays it is not that hard anymore to setup a (cloud based) service for data collection since there are a lot of different service providers in the field.

Lastly the technological hurdles are getting smaller and smaller in general. In days, where programming languages are getting easier to learn and to use and developers do not heave to hesitate with abstraction layers of a microcontroller the barrier is quite low even for unexperienced people to at least prototype ideas with such technological environment. Furthermore as already described before, nowadays it is also quite easy to buy services (like for example cloud services) and therefore get rid of complex implementations.

2.4 System scope and products

The aim of this chapter is to give a rough overview on the products the company LOGICDATA is currently working on and which deal with the trends shown in the previous chapter.

2.4.1 Mechatronic package

The mechatronic package contains components which are needed to assemble a height adjustable work environment. This includes in general one or more actuators (depending on the workstation), a control system (either directly integrated into the actuators or decentrally organized as a separate control box), a handcontrol, a power supply and the needed cables.

The basic aim of this mechatronic package is to allow office furniture producers to bring adjustability to their products. Overall the system looks like following:

Fig. 12: Workstation incorporating a mechatronic package of LOGICDATA Source: own depiction

As illustrated in the figure above the mechatronic package is only focusing on the actuators and the correlating control system. All mechanical parts of the actuators including the gliding system, the metal housings and the metal frame are not part of the package of LOGICDATA.

2.4.2 LOGIClink

The LOGIClink is the very first central communication hub of the company LOGICDATA. This means, that this product consists of many different interfaces to achieve the best possible interactivity with the work environment.

The following interfaces are integrated into the device:

- Wireless interfaces: BLE for the connection of a smartdevice, active NFC to interact with NFC-capable devices (such as smartdevices or NFC-tags), WiFi for the connection to a corresponding network within a facility (if applicable)
- Wired interfaces: USB for the connection to a PC or a MAC, wired connection to the table control system
- Other interfaces: Bi color LEDs for the indication of statuses (like for example occupied, free, error), occupancy detection to detect whether a person is upfront the table or not, buttons for user interaction

It has to be mentioned that the device is capable of synchronizing information autonomously to a cloud service. This information includes data in regards to occupancy but also in regards to interface utilization. Furthermore statistical data of the control system is also shared, on one side to get feedback for future developments in the field of office products and on the other side for the purpose of predictive maintenance.

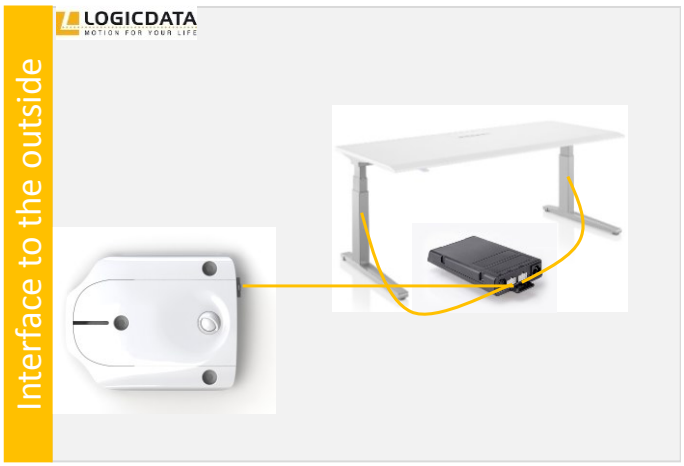


Fig. 13: LOGIClink integration to a work environment Source: own depiction

As shown in figure above the LOGIClink allows an integration of the work environment into a higher system. This brings the big advantage that classic adjustable workstations can be brought into such a system very easy by the simple attachment of a LOGIClink. In the end it is up to the final application to decide on how to interact with the workstation and what to do with the data gathered by the LOGIClink.

2.4.3 CHAIRsense

CHAIRsense describes a generic kit of sensors, which is easily integrate able into any existing office chair. The aim of that sensorkit is, that several measures can be achieved around an office chair. Those measures shall allow to track the posture of the person sitting on the chair and therefore to react appropriately in case this posture is not applicable or healthy for that person.

In the current status there are several challenges in correlation with that ambitious goal, which prohibits this concept to become a product, which is producible and sellable in high volumes. On one side it is not that easy to create a generic sensor-kit for a huge variety of existing office chairs. On the other side the final solution in regards to the supply of energy is still not settled, since the requirement is that the system is neither powered nor charged from the outside. To achieve such an autarkic system energy harvesting approaches are considered. For now this sensorkit is

Fig. 14: Office chair equipped with CHAIRsense sensor kit. Source: own depiction

The illustration above shows chair in a virtual environment. This chair incorporates the sensor kit and its basic interface to the outside of the system context. Basically it is intended to combine this sensor kit with a table which is equipped with a LOGIClink to achieve the maximum connectivity and interoperability. Furthermore by having the table and the chair combined there are far more possibilities to support the person working at such intelligent work environment.

3 ASSOCIATED THEORETICAL INSIGHTS

3.1 Introduction

Another key element of this thesis is the evaluation of further associated theoretical insights, which are basically trends and developments existent in other applications besides or around the work environment. The topics mentioned within that certain chapter mostly correlate with the trends investigated in chapter 2.3. Overall the chapters 2 and 3 build up the foundation of knowledge needed to understand the demands of the office furniture market to be able in the end to create products which serve the market and the user in the best possible way.

3.2 The Gartner Hype Cycle

The Gartner Hype Cycle is one of most popular tools to deliberate whether new technologies and applications are worth any further investigation or not. Therefore this method gives a view of how a technology or application will evolve over time. These predictions are based on the attention the technology or application gets from the public, including media interest, publications and simply stories about it. [10]

There are basically five phases within the evolution of new technologies and applications:

1. Technology Trigger

   The main basis for something new is a potential technology breakthrough. Initial proof of concept stories and first media interest lead to the first contact with the public domain. At that point a viable product is often far away.

2. Peak of Inflated Expectations

   The publicity leads to a number of both success and failure stories. Some companies start to take actions on the new technology, but in general many do not.

[10] Cf. Not stated, Gartner Hype Cycle, online source [04.12.2016]

3. Trough of Disillusionment

   That's one of the key phases within the evolution of a technology. As experiments and implementations fail also producers of the technology shake out or fail. Overall the investments only continue if the product is getting viable. This is the main point, where it is decided whether a new technology is a success or a fail.

4. Slope of Enlightenment

   The new technology becomes widely understood and more instances of how the technology can be applied crystallize. The next generations of products incorporating the new technology appear, which also lead to more public attention and to further funding by enterprises.

5. Plateau of Productivity

   The last phase in the evolution of a new technology is the mainstream adoption. Finally the market applicability and relevance of the new technology are paying off.

In summary this means, that such Hype Cycle shows the evolution of new technologies and applications and helps therefore organizations to separate the hype and bold promises of new technologies and applications. Out of that it is up to any company to decide whether to be actively investigating such new trend already from the beginning on or to start digging into such new trend not before is reached either the Slope of Enlightenment or the Plateau of Productivity. This decision is quite crucial, since it is always hard for a company to build up know how on some new technology or new application, where are other companies are already working since years.

Taking a closer look on the currently available Gartner Hype Cycle, which deals with Emerging Technologies (see depiction on the next page) the following trends have to be clearly marked out:

Phase: *Innovation Trigger*

Hereby the most important trends which correlate with the office furniture industry are as following:

- Personal Analytics
- Smart Workplace
- IoT Platform

Phase: *Peak of Inflated Expectations*

In that section the most essential trend is Connected Home.

This is the point where the overall topic in regards to intelligent work environments comes full circle. The trends currently ongoing in the office furniture market (as described in chapter 2.3 Trends and Developments in the Office Work Environment) are overlapping to a high degree with the general trends ongoing in the field of technology.

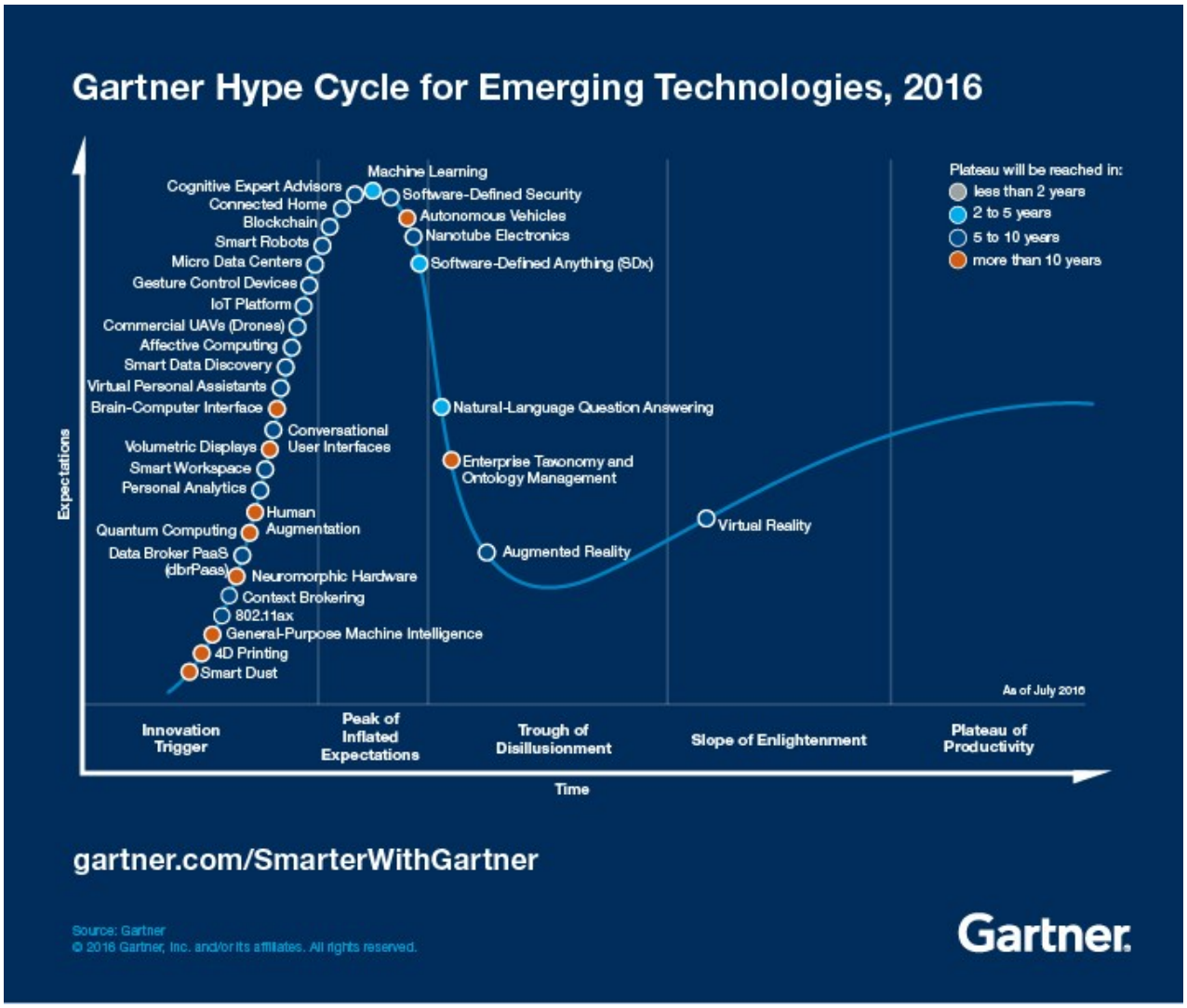


Fig. 15: Gartner Hype Cycle for Emerging Technologies. Source: Weblink http://www.gartner.com/smarterwithgartner/3-trends-appear-in-the-gartner-hype-cycle-for-emerging-technologies-2016/

3.3 Internet of things (IoT)

As being defined back in the year 1999 the terminology IoT, which is the abbreviation for Internet of Things, defines a network of connected objects, which are able collect and exchange data within the IoT ecosystem.[11] In general an IoT device consists of one or more embedded sensors and a network interface, which allows to be either monitored but also controlled from a remote location.[12]

Popular environments for IoT implementations, which are also in correlation with this thesis, are Connected home, Healthcare, Infrastructure and Smart buildings. Smartwatches are located basically in the Healthcare section, as they are mostly combining sensors with the ability to share measured data with an ecosystem (for example the Apple Watch forwards its measured data to the Apple Health health-tracking platform).

A key finding hereby is, that the field of Smart Offices respectively intelligent work environments is missing here as a core environment for IoT appliances. As shown upfront in chapter 2.4.2 LOGIClink and chapter 2.4.3 CHAIRsense LOGICDATA is currently working on devices, which follow the approach of IoT quite well – The devices are basically sensing information and forwarding such information to the ecosystem of LOGICDATA with the goal of being able to serve the user with the best support possible. The implementation of such new core environment might be interesting for LOGICDATA, since the motivation is anyway to be and to stay in the role of the innovational leader.

In general the driver for companies, which create appliances for IoT technologies, is based on two main expectations: The top value, which is expected by more than 47 % of the companies working on IoT technologies, is of course to grow revenue by either completely new or at least adopted sales channels. This expectation is mostly based on the estimation of devices, which are going to be sold and installed throughout the upcoming years (as illustrated in figure 16). The second value, which is at least expected by a fourth of the companies, is, that by such approach the customer experience could be increased.

[11] Cf. Not stated, The Internet of Things, online source [04.12.2016]

[12] Cf. Greenough/Camhi (2015), p. 3-4

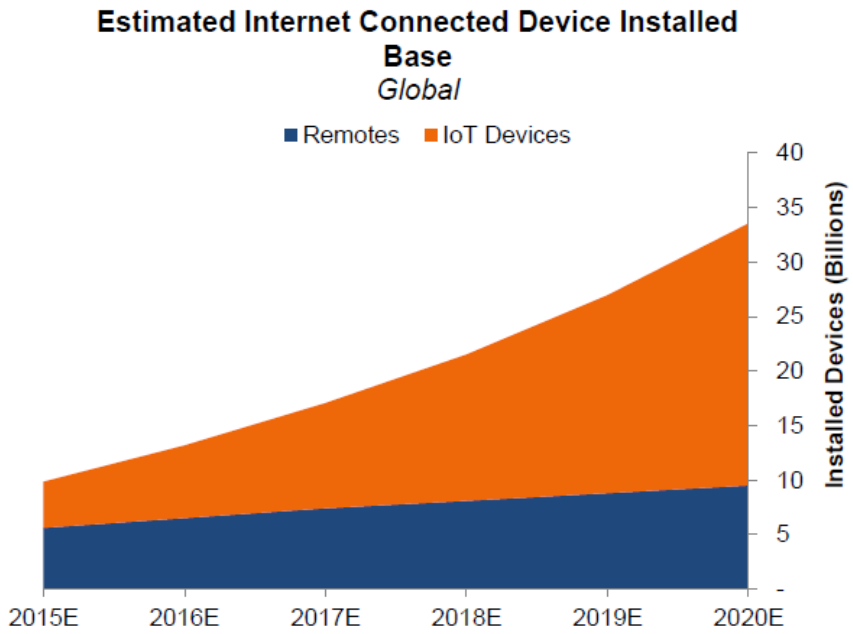


Fig. 16: Estimated Internet Connected Device Installed Base – All figures are just estimations (indicated by the 'E') Source: The Internet Of Things 2015 (2015), p. 32

Another good example for tremendous growth in the field of IoT is the environment around Connected Home appliances. This trend has currently more or less just been kicked off, since only isolated solutions are available from different brands, but no holistic integration is available yet. The figure 17 shows very well the growth which is expected to happen at least for connected LED light bulbs.

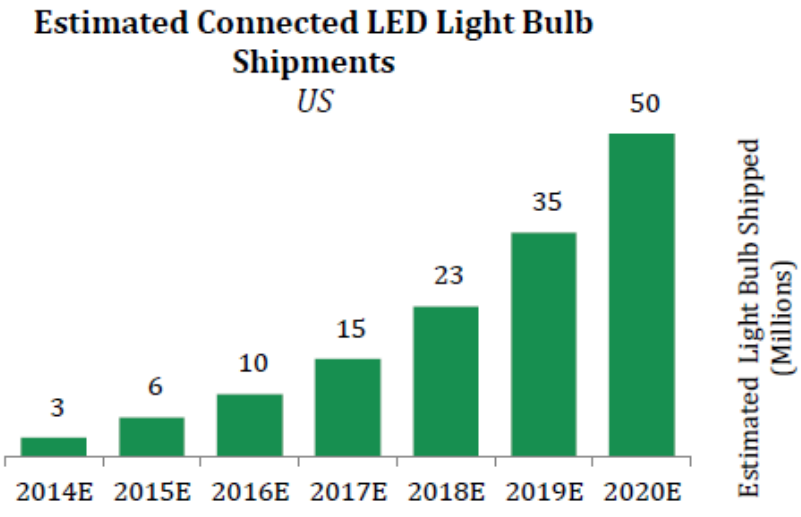


Fig. 17: Estimated Connected LED Light Bulb Shipments in the US – All figures are just estimations (indicated by the 'E') Source: The Internet Of Things 2015 (2015), p. 44

Such success is only possible, when the product is available for a reasonable price at the end of the day. Therefore also the estimated cost reduction needs to be considered when taking a look at such increasing sales figures (see illustration above).

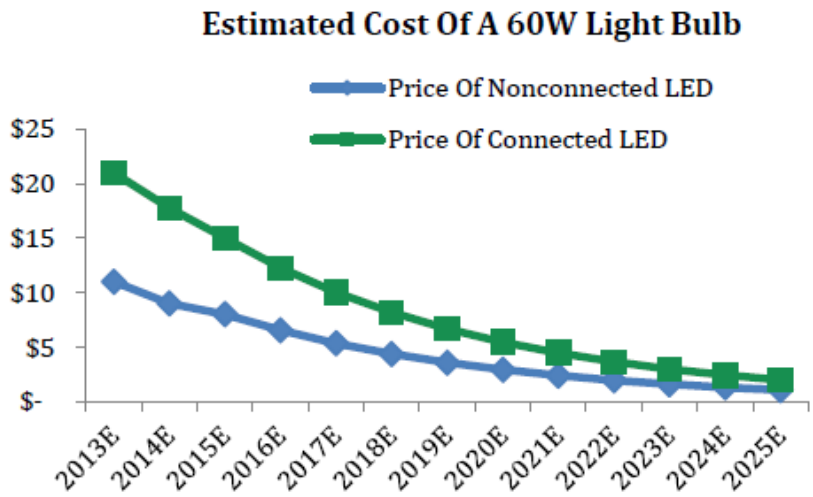


Fig. 18: Estimated Cost of a 60 W Light Bulb – All figures are just estimations (indicated by the 'E') Source: The Internet Of Things 2015 (2015), p. 44

Although the 60 W light bulb is not a relevant product for the European market anymore, the figure above shows the estimated development of the price of a technology, which is another key factor for the company LOGICDATA, since features are always considered to be important. Lastly regardless whether the solution contains IoT technology like smartwatches or even devices provided by LOGICDATA itself, the price has to be reasonable to guarantee the success of such an holistic system in the market.

3.4 Big data and data analysis

Next to IoT another correlating topic is concerning data storage and data handling. Since nowadays more and more device tend to synchronize data to cloud based services it is getting a huge trend to analyze big bunches of data and gain knowledge from such investigations.

In principal Big Data refers to data and data sets, which exceed the ability of traditional tools to manipulate it. Basically it can be described best by the 3 Vs, which represent the three parameters such a data set consists of:[13]

- ➔ Volume – defines the overall size of the data set
- ➔ Velocity – defines the rate at which the data is received and processed
- ➔ Variety – defines the range and type of data which is received and stored

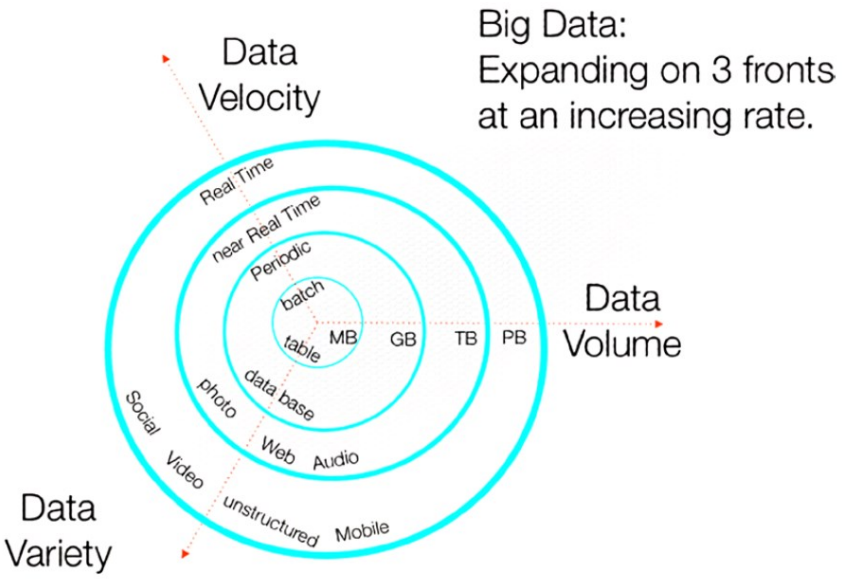


Fig. 19: Multidimensional 3 V diagram Source: Big Data Made Easy (2014), p. 7

As illustrated above big data is expanding in multiple dimensions over time. As such expansion is proportional to the size of the data set this also affects the handling of such data chunks. The derived basic principal requirements to a big data system are as following:

- ➔ A method for collection and categorization of data
- ➔ A storage system, which is distributable, scalable, offers redundancy and which is cost effective
- ➔ Parallel data processing
- ➔ The ability to monitor data trends in real time

[13] Cf. Frampton (2014), p. 6

But what can be results of such big data analysis?

One quite recent example is the following:

A popular American based insurance company is currently offering discounts for people which are willing to track their daily habits by wearing a fitness tracker. This fitness tracker is connected with the data system of the insurance company to ensure that they receive the data. The model is quite simple – The more physical activities or other healthy living activities the individual policyholder shows the more points can be earned, which can furthermore be used for rate discounts or other rewards.

This is just one example showing how such data conglomerates could lead to further knowledge. Other examples are car insurance companies, which simply track the driving habits of the driver and decide upon that the rate for the insurance.

Taking a step back to revise methods and trends, which are currently happening in the field of the office work environment, the following correlation can be found: All of the following trends and approaches follow the same principle as applied through big data:

- ➔ Analysis tools (chapter 2.3.3)
- ➔ Facility and asset management (chapter 2.3.4)
- ➔ LOGICDATA products (chapter 2.4)
- ➔ IoT, including the smartwatches (chapter 3.3)

Those appliances basically synchronize data with a service, which pushes the data into a storage for further handling. This handling implies processing and analyses on the data, whereas the exact analysis method and final interpretation of the data is up to the final application. In the end the goal is to gain knowledge out of existing data and bring that knowledge back into the application to achieve the best possible optimizations.

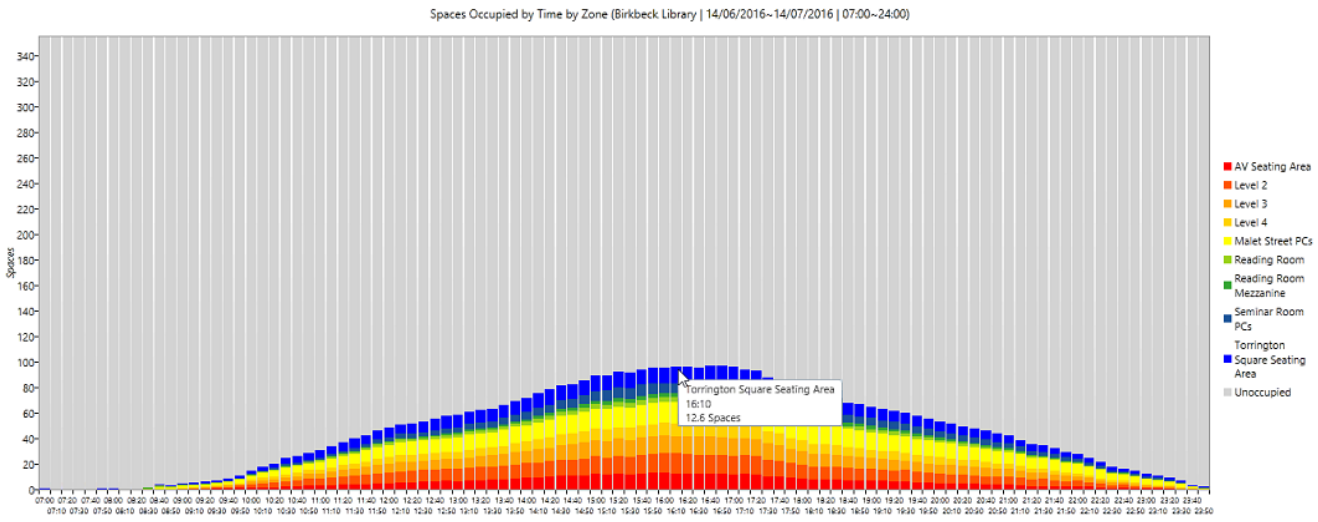


Fig. 20: Cumulated view of occupied spaces within a facility Source: Weblink http://www.occupeye.com/how-it-works-2/

3.5 Usability and User Experience

The next goes along very well to what was worked out already. Since the focus of IoT is, to create sensing devices, which synchronize their data with Big Data services, which also do an analysis on that data on a certain extend, an open subject is how the interaction with the user shall be realized.

Having the whole data gathering topics in mind another crucial fact which needs to be considered is the demographic change, especially affecting the age of the population and the correlating change of the generations. Since every generation has its special preference in how to work and how to interact with certain devices, this has to be for sure an input for the design and the implementation for user interfaces in general. Since the topic of this thesis is the integration of a smartwatch into an intelligent work environment this correlation fits pretty well in.

It is an important key fact that the target group or target groups for a product, regardless if it is an app for a smartwatch or a real hands on product, have to be defined beforehand. Due to that it is highly recommended to analyze the habits and preferences of the corresponding target groups to be able to design the human interface in an appropriate way. To achieve that there are several methods, which could be applied (like for example Design Thinking Method, Building Ideas) to get an insight on the customers needs and demands.

In general there are two important building blocks which need to be achieved to create a successful product:[14]

- ➔ Firstly the usability in general has to be assured. This implies, that a system is working properly and stable and that the functions needed by the customer are implemented in the right way.
- ➔ Secondly the joy of use is added on top of the usability. Hereby the focus shall be put on being delightful to create the best user experience possible.

[14] Cf. Jursa (2016), expert interview

Applying that to the well known Kano-model (see figure below) the result is that the general usability represents the basic needs on a product, whereas the joy of use acts as delighter on top.

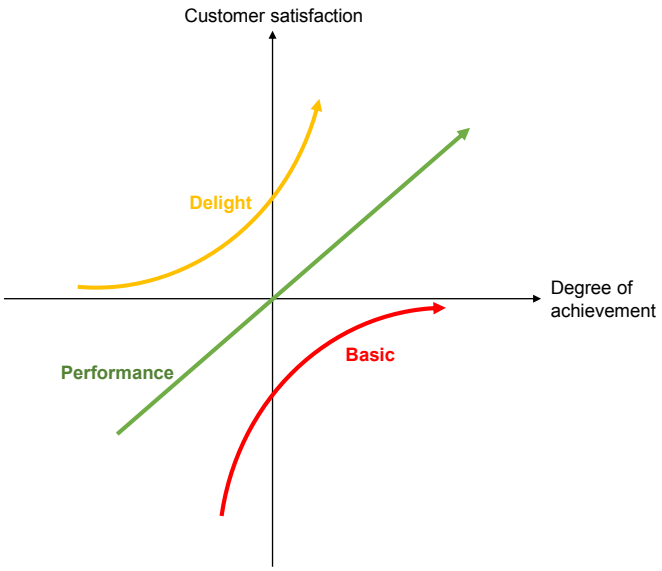


Fig. 21: Kano model. Source: Own depiction

3.6 Ergonomics

The last topic handled within that very broad chapter deals with ergonomics. This topic can be applied very general – still, since the focus of this thesis is the integration of a smartwatch into intelligent work environments the main focus shall also be on situations within a work environment.

In general the definition of ergonomics is as following:
Ergonomics (or human factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.[15]

Based on that, ergonomics simply define that products and systems shall be designed in a way, so that the human well-being and the overall system performance is optimized to the maximum. It is often a big misunderstanding when people think, that ergonomics deal just with the human body and the relating posture of such body including the handling of injuries like spine injuries etc.

[15] Cf. Not stated, Definition and Domains of Ergonomics, online source [04.12.2016]

As previously worked out in chapter 2.3.5 the main issue at a work environment is that people tend to stay in a static position which causes injuries for the body. By a simple comparison of the following two figures it is quite easy to see and to understand that the office industry has not changed dramatically throughout the last five decades in time. This opens up the general question whether the design of a table and the chair is the best for a human body or not, since the number of injuries is steadily growing.[16]

Fig. 22: office environment from past days. Source: Weblink https://pilgrimakimbo.wordpress.com/2011/01/27/tron-the-future-is-then-or-the-continuing-legacy-of-the-appropriated-action-office/

Fig. 23: office environment of today. Source: Weblink https://www.dezeen.com/2014/06/25/herman-miller-office-furniture-industrial-facility-yves-behar-fuseproject/

[16] Cf. Gregory (2015), expert interview

Next to the product design of tables and chairs, which might not be changed that soon, another big factor in terms of ergonomics is the motivation of the user. It is a highly important key finding, that users have to be intrinsically motivated to change something about a situation (for example due to having back pain or other spine injuries) or to stick to a certain procedure (for example doing changes of the posture periodically).[17]

The classical (and wrong) picture of the ergonomist is illustrated below. Here the ergonomist is simply reminding the person to sit upright, but as the ergonomist leaves the person it tends to slough again. Out of that it is highly recommended to design products in a way that people can see the benefit for the personal health or life situation by the utilization of the product or the system.

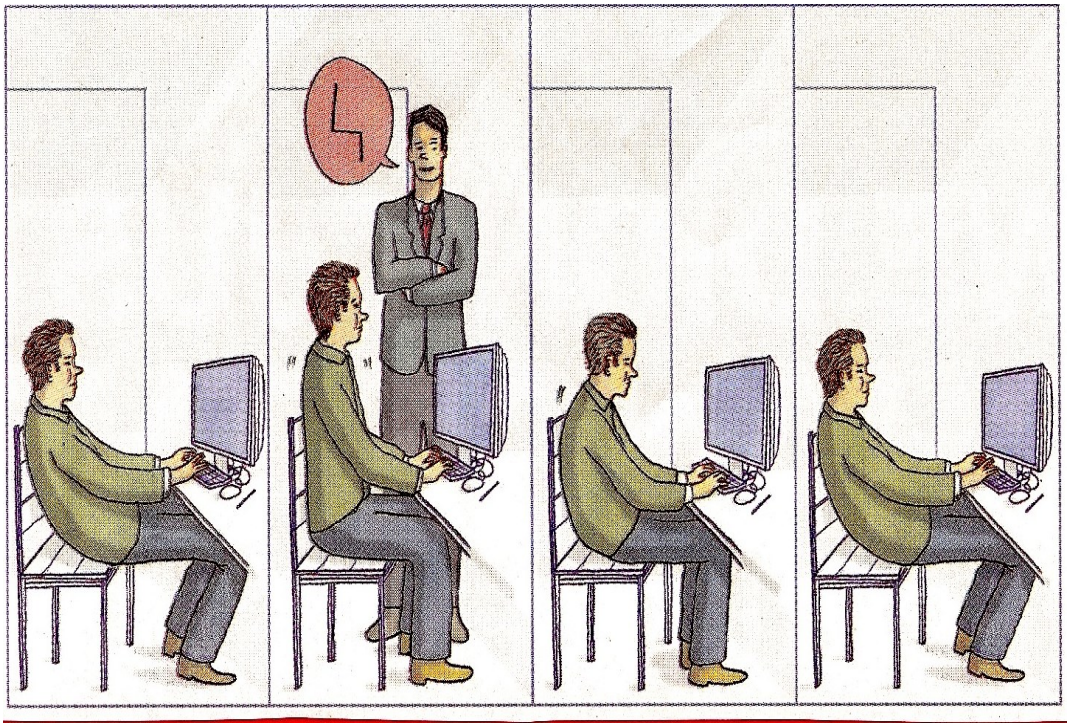


Fig. 24: Classical picture of an ergonomist Source: Depiction of Mr. Imada

[17] Cf. Imada (2015), expert interview

4 DEFINITION OF THE TARGET SYSTEM

4.1 Introduction

The aim of this chapter is to create an overview on the most popular existing smartwatches, an overview on the requirements to such smartwatches in correlation to the work environment and finally to decide which smartwatch is going to be used for an exemplary integration into an intelligent work environment. Finally the system context of the best case setup is illustrated and described in further detail.

4.2 Requirements and use cases for the system

The most basic requirement to the system is that existing LOGICDATA products shall be utilized. This includes basically actuators, the control system and the cables needed to connect all the parts. Due to that also LOGIClink shall be incorporated since it offers a big variety of interfaces, which might be helpful for the implementation of the integration.

Further requirements and use cases, which relate directly to the smartwatch, are derived from the trends and approaches described within the previous chapters:

2.3.1 Activity Based Workplaces:

Authentication at several workplaces (1)

Booking a workplace (2)

2.3.2 Rental Offices

Authentication at the office and / or at the workplace (1)

2.3.3 Analysis Tools

Activity tracking (3)

Communication with further systems (2)

2.3.4 Facility and Asset Management

Authentication at the workplace (1)

Booking a workplace (2)

Communication with further systems (2)

2.3.5 Health Aspects

Tracking of movement, including steps (3)

Determination of the posture of the person (4)

Differentiation between sitting and standing (4)

Vital metrics like heartrate (5)

2.3.6 Personalization

Options for personalization (6)

2.3.7 Demographic change

One device for different generations (6)

Easy look and feel and haptics (6)

3.4 Big data and data analysis

Being a source of further information in regards to the user (3, 4, 5)

3.5 Usability and User Experience

Easy look and feel and haptics (6)

Nice to present (6)

3.6 Ergonomics

Simplification (6)

As some of those requirements are falling into the same branch the requirements get a simple rating, which is represented by the numbers within the braces at the end of each requirement. By consolidating relating topics the following six main requirement can be defined as a foundation for further investigations:

1. Ability for authentication in general
2. Connectivity and interoperability with higher level systems
3. Basic activity tracking, including the tracking of movement and steps
4. Tracking of posture, including the differentiation between sitting and standing
5. Measurement of further vital metrics, including heart rate
6. Look and feel, including personalization, having one device for multiple generations and an easy and simple interaction

Those basic requirements will be considered for the selection criteria, by which the final smartwatch is going to be chosen. In the end the goal shall be that the technological package offers the best and most functions possible. Due to that the user experience shall also be on the best level possible. The final and consolidated selection criteria are summarized in chapter 4.6 Selection of the smartwatch.

4.3 Market analysis

Basically there are three main brands in the field of smartwatches nowadays, which are also in the scope for the choice on the target smartwatch for this thesis:

- Samsung
- Apple
- Pebble

Those three vendors are further being investigated in regards to technical capabilities in chapter 4.4 Evaluation of suitable devices. As illustrated in the table below Apple is the strongest manufacturer for smartwatches. If Apple would be compared directly with all Android Wear based smartwatches it still the stronger vendor, unless the Android Wear smartwatches are on the way to gain more and more market shares.

The category Others (including Pebble) is simply a container for all small vendors, which means that Pebble on its own is not a very strong competitor to Samsung or Apple.

Furthermore is has to be mentioned that all wearables which are not capable to run third party applications are not considered and therefore excluded from the table. Those devices are considered as Basic Wearables.

Market Share and Shipments of top smartwatch vendors
(Units in Millions)

Vendor	2015 Market Share	2015 Unit Shipments	2016 Market Share	2016 Unit Shipments
Apple	72%	3,6	47%	1,6
Samsung	7%	0,4	16%	0,6
Others (including Pebble)	11%	0,6	16%	0,6
Others (Android based)	9%	0,5	21%	0,7

Tab. 1: Market Share and Shipments of top smartwatch vendors (Units in Millions). Source: Own depiction.

As illustrated in the figure below the general forecast for smartwatches will steadily grow throughout the next years. Still one key fact hereby is, that consumers are still waiting and searching for the real functionality of such smartwatches. Furthermore it is also a matter of fact, that Apple will stay in the driver position of that market.[18]

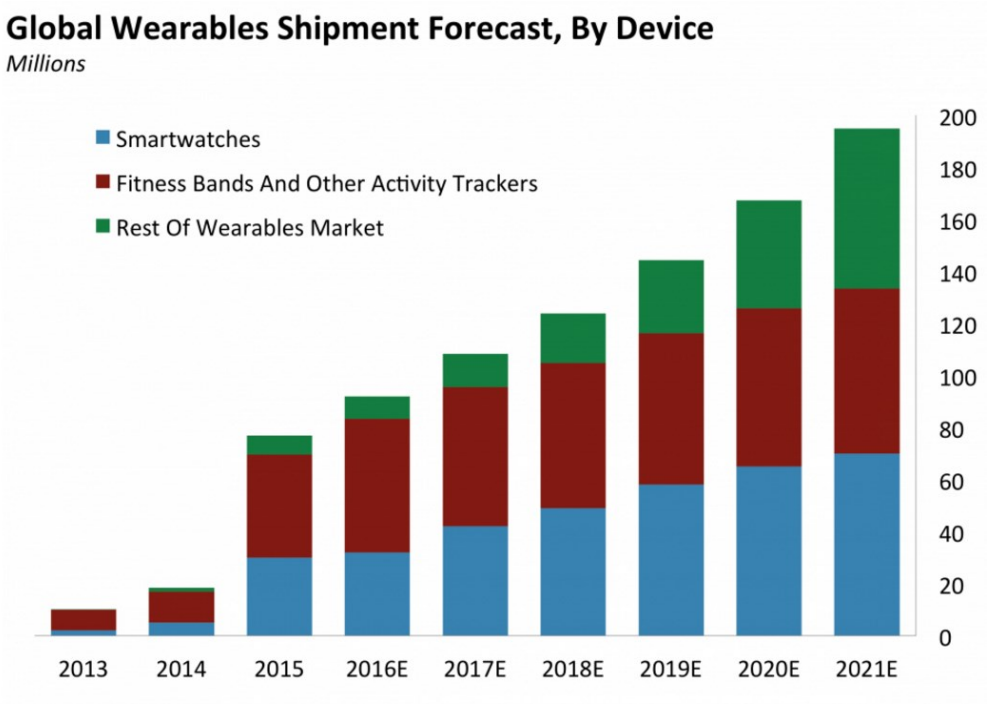


Fig. 25: Global Wearables Shipment Forecast– All figures are just estimations (indicated by the 'E') Source: Weblink http://www.businessinsider.de/smartwatch-and-wearables-research-forecasts-trends-market-use-cases-2016-9?r=US&IR=T

[18] Cf. Beaver, The Smartwatch Report, online source [04.12.2016]

4.4 Evaluation of suitable devices

The aim of this subchapter is to bring in as much information as possible for at least one smartwatch of each vendor of choice. These smartwatches are then going to be compared to each to finally end up with one single watch, which is going to be used for the exemplary implementation.

4.4.1 Samsung[19]

The model chosen from Samsung is the Gear S2, which is the currently available flagship model of the company. The biggest advantage of this smartwatch is that is looks like a normal watch, as it has a round display with a special resolution of 360 by 360 pixels.

By standard the smartwatch offers the interfaces WiFi, NFC and Bluetooth and incorporates an accelerometer, a barometer, a gyro sensor, a light sensor and a sensor for the measurement of heart rate of the person wearing the watch. Incorporating all mentioned hardware the smartwatch is capable to reach a theoretical battery lifetime of up to three days.

Samsung is restricting the interoperability for the smartwatch in a way that it can only be used in conjunction with Samsung smartphones.

4.4.2 Apple[20]

The Apple Watch is available in two generations, which mainly vary in their operating power capabilities and slightly in their interfaces. Compared to the Samsung smartwatch the Apple Watch features a rectangular display, which is available in two different sizes (272 by 340 pixels and 312 by 390 pixels).

The smartwatch features the interfaces WiFi and Bluetooth and incorporates an accelerometer, a gyro sensor, a light sensor and a sensor for the measurement of heart rate of the person wearing the watch. Next to that the latest version also features GPS as an additional sensor.

Apple is also restricting the interoperability like Samsung which means, that the Apple Watch smartwatches only work in conjunction with Apple smartphones. Overall the battery lifetime is theoretically predicted with 18 hours, which marks the lower bound of smartwatches available in the market.

[19] Cf. Not stated, Gear S2 classic, online source [04.12.2016]

[20] Cf. Not stated, Apple Watch Series 2, online source [04.12.2016]

4.4.3 Pebble[21]

The Pebble Time Steel is the current top of the line model of the vendor Pebble. The main advantage and differentiator to the smartwatches mentioned before is that the smartwatches from Pebble work with Apple and Android devices. It features like Apple a rectangular e-paper display with a resolution of 144 by 168 pixels, which is one of the worst resolutions applied for smartwatches.

Besides having the open interoperability to the big smartphone operating systems Pebble also relies to an open community. This brings the advantage, that more people are attracted to develop, improve and publish applications.

Due to the fact, that this watch incorporates no sensors it offers a battery lifetime of up to ten days in theory, which is another appealing aspect of this smartwatch.

4.5 Definition of selection criteria

This chapter describes the most important criteria which are applied in relation to the selection of the target system.

The main requirements in regards to the target applications can basically be derived from chapter 4.2 and are as following:

1. Ability for authentication in general
2. Connectivity and interoperability with higher level systems
3. Basic activity tracking, including the tracking of movement and steps
4. Tracking of posture, including the differentiation between sitting and standing
5. Measurement of further vital metrics, including heart rate
6. Look and feel, including personalization, having device for multiple generations and an easy and simple interaction

Further requirements, which were stated by the company LOGICDATA, are the following:

- Should work with apple devices if possible (very important for trade shows)
- Shall incorporate state of the art technology
- The device shall be recognized very easy, even by non experienced users and people – background is, that as many people as possible shall be attracted on a tradeshow

[21] Cf. Not stated, Pebble Time Steel, online source [04.12.2016]

4.6 Selection of the smartwatch

Within that chapter the final smartwatch is being chosen according to the requirements and findings out of the previous sections. The following table shows the most important information with regards to the general those information, which are in correlation to the possible target systems:

		Samsung Gear 2	Apple Watch	Pebble Time
general information	OS	Tizen	Watch OS	Pebble OS
	Hardware	1GHz Dual Core 512 MB Ram	Apple S1, Dual Core 512 MB Ram	100 MHz Coretx M4
	Sensors	accelerometer gyro sensor heartrate light sensor barometer	accelerometer gyro sensor heartrate light sensor	none
	Interfaces	Bluetooth WiFi NFC	Bluetooth WiFi	Bluetooth
	Battery lifetime	3 days	18 hours	10 days
	Compatibility	Samsung only	Apple only	Apple and Android
	Price	349	419	219
selection criteria	1.) Ability for authentication in general	by software by NFC	by software	by software
	2.) Connectivity and interoperability	yes	yes	yes
	3.) basic activity tracking	yes	yes	no
	4.) Tracking of posture	no	yes	no
	5.) Measurement of further vital metrics	yes, HR	yes, HR	no
	6.) Look and feel, etc.	~	yes Apple is known for its simple and intuitive user interfaces	No
	LD) Apple compliance	no	yes	yes
	LD) State of the art technology	yes	yes	no
	LD) recognition value	~	yes biggest market share	no
	Result	6	8,5	2,5

Tab. 2: Comparison of smartwatches according to the defined requirements. Green counts as 1 point, orange as 0,5 points and red as 0 points. Source: Own depiction.

As illustrated and summarized by the table above the Apple Watch is the clear winner and is therefore going to be the selected smartwatch for the integration into an intelligent work environment.

4.7 System context and boundaries

In this chapter the system context and its boundaries are shown and described in more detail. Important to mention is, that this certain system is also the basis for all furthermore ongoing exemplary developments for the integration of the chosen smartwatch into intelligent work environments.

4.7.1 System context

The following depiction shows the system context diagram of the related system, including the smartwatch, a smartphone and an intelligent work environment, which incorporates components of the company LOGICDATA:

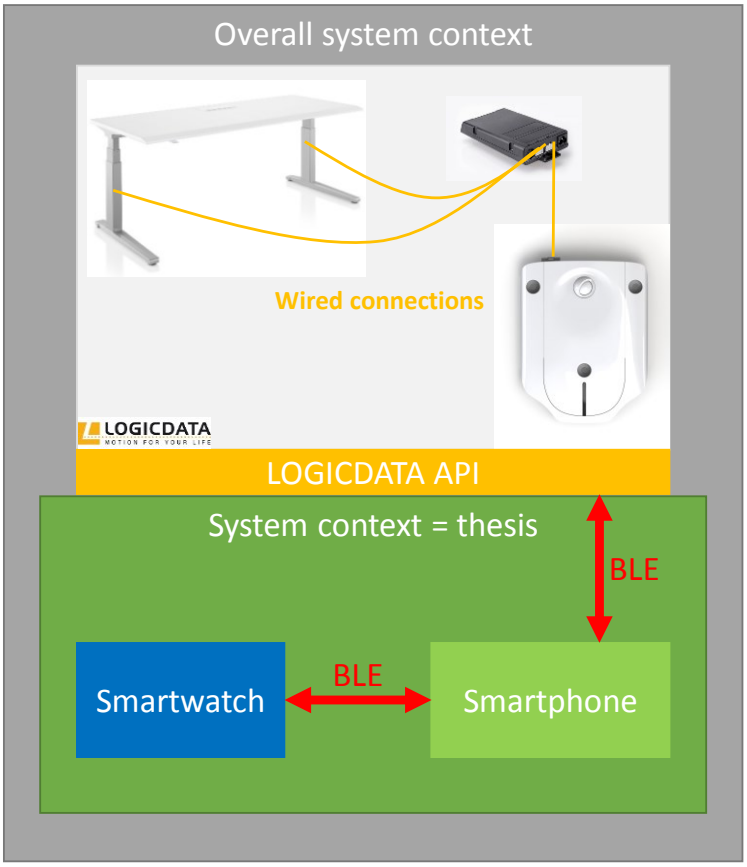


Fig. 26: System context diagram. Source: own depiction

In general the system in scope of this thesis simply consists of a smartwatch and a connected smartphone. Both devices are needed since a smartwatch is not able to communicate with other devices directly. The system context contains furthermore a table system, which is incorporating components of the company LOGICDATA. This system represents the best case setup for such application. Overall the boundary is strictly defined between the LOGICDATA-system and the smartphone/smartwatch-system.

4.7.2 Components

Referring to the depiction 25 following components build up the whole system:

Component	Purpose
Adjustable table	Work environment for a user
Control system and actuators	Mechatronic package, which enables the adjustment of the table
LOGIClink	Communication hub, which creates an intelligent work environment
LOGICDATA API	Generic programming interface, which abstracts the intelligent work environment
Smartphone	Connected to the intelligent work environment via Bluetooth the smartphone for this system is going be an Apple iPhone
Smartwatch	Device in main scope of this thesis, worn by the user, shall interact with the intelligent work environment the smartwatch for this system is going be an Apple Watch

Tab. 3: Components of the system. Source: Own depiction.

As already mentioned before this system configuration represents the simplest setup possible for such integration. In case any of the devices is missing (for example the LOGIClink) either the overall complexity increases by adding of other components or it simply does not work.

5 PREPARATIVE ACTIONS

5.1 Introduction

The main purpose of this chapter is to get a deeper understanding of the target environment, which consists of an Apple Watch and an Apple iPhone. For that reason this chapter simply deals with the technical foundation, which is defined by the operating system of each device and the related possibilities to develop custom applications.

5.2 Operating systems

As the target system includes an Apple Watch and an Apple iPhone the corresponding operating systems are under investigation to get a better understanding on what is possible and what not from a implementation perspective.

5.2.1 iOS

The operating system iOS, which is currently available in the 10th version, is the main operating system, which runs on several Apple smartdevices including smartphones, tablets and even multimedia-players.[22]

Taking a deeper look into the architecture it is clearly visible that the architecture in general consist of following layers:

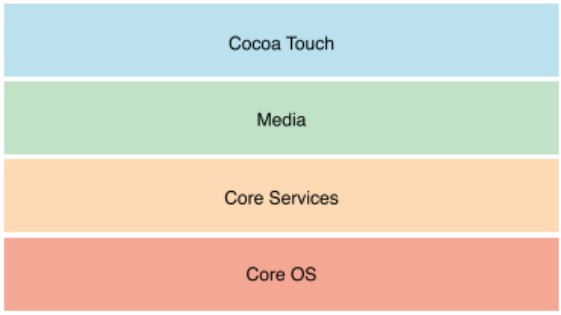


Fig. 27: iOS Architecture: Layers. Source: Weblink https://developer.apple.com/library/content/documentation/Miscellaneous/Conceptual/iPhoneOSTechOverview/Introduction/Introduction.html

Each of those layers contains fundamental services and technologies – In general the higher layers build upon the lower layers and provide more sophisticated services and technologies.[23]

[22] Cf. Not stated, iOS 10, online source [04.12.2016]

[23] Cf. Not stated, About the iOS Technologies, online source [04.12.2016]

Overall Apple is quite picky when it comes to app development. For that reason there are several rules consolidated and summed up in the so called App Programming Guide for iOS. The most crucial topics of that guide are as following:[24]

- Apps are expected to support key features: Every app has specific resources and configuration data, which has to be correct before an app could be submitted.
- Apps follow well-defined execution paths: The path from the launch of an app to the time it quits has to be well defined. This also includes transitions between foreground and background execution, termination and relaunch.
- Apps must run efficiently in a multitasking environment: There shall be a balance between battery life, performance, responsiveness and the user experience. Hereby it's highly interesting that Apple specifically puts focus on the battery lifetime in conjunction with multithreading.
- Communication between apps follows specific pathways: Due to security reasons, iOS apps run in a sandbox and have therefore limited interaction possibilities with other apps.
- Performance tuning is important for apps: Apple is once again pointing out the importance of having the battery life and the usability / performance of the app in a good balance.

[24] Cf. Not stated, About iOS App Architecture, online source [04.12.2016]

5.2.2 watchOS

The operating system for the Apple Watch is currently available in the latest release in version 3. This operating system runs specifically on the Apple Watch models Watch and Watch 2.

On that end it is highly interesting how the interconnection with the Apple iPhone is realized from a programming perspective. As shown in the figure below the smartwatch and the phone communicate through a channel, which is manifested within the main core operating system. Both sides simply use the existing frameworks to access that communication channel (for example to exchange data between the devices).[25]

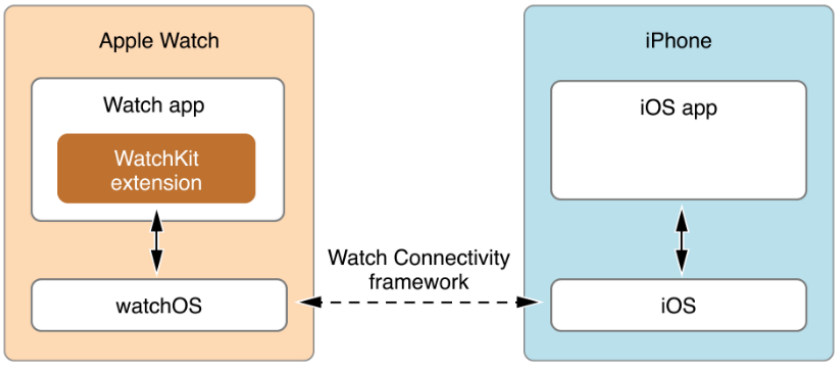


Fig. 28: Relationship between the Watch app interface, the WatchKit Extension and the iOS app: layers. Source: Weblink https://developer.apple.com/library/content/documentation/General/Conceptual/WatchKitProgrammingGuide/DesigningaWatchKitApp.html

Fhe App Programming Guide for iOS there is also an App Programming Guide for watchOS, which summarizes best practices regarding app development for that specific platform. Key points out of that are as following:

- All projects created for Apple Watches consist of two related bundles: a Watch app bundle and a WatchKit extension bundle. Both together collectively are known as Watch app. Next to that such Apple Watch projects are always including also the iOS part of the app, since in any case the Watch app is installed on the physical Apple Watch by the connected iPhone.
- Apple Complications: This neat kind of interface allows a user to place either a shortcut or a small indicator, which directly relates to the corresponding app at the watchface. This brings the big advantage, that the most important information could be shown through the main watchface, which makes the app more visible to the user in the end.

[25] Cf. Not stated, The Watch App Architecture, online source [04.12.2016]

- User Interfaces: In general it is intended, that the Apple Watch is simply an extension to an existing Apple iPhone and therefore not replacing or substituting the smartphone. Therefore the main goal for the smartwatch shall be, that information is displayed quickly and that the navigation and interaction facilitates fast. In the end the Watch app shall complement the experience of an iOS app.

Next to that another very interesting guideline is the Energy Efficiency Guide for iOS Apps, which also includes a separate section for the Apple Watch. This kind of information is highly valuable, since it is affecting the way of how an app is realized in the end. The most important key points out of that are:[26]

- Minimize Networking: The general data transfer requires system resources, such as radios, which lead to an increased energy consumption. Therefore there shall be two approaches considered dealing with such issue: Firstly the traffic shall be minimized between the Apple Watch and the iPhone, since such communication is affecting the battery lifetime on both ends. Secondly consider to reduce the overall network traffic by batching transactions and doing them at the best possible time (for example in the background).
- Optimize Graphics and Media: The app contents also directly influence the battery lifetime, therefore also here some approaches shall be considered: Unnecessary context updates shall be eliminated, whenever possible the background color of apps shall be black and generally combining rather dark colors and the media size of images and resources, which are downloaded and displayed by the Apple Watch shall be as small as possible to safe network and CPU resources.
- Reduce Work: Heavy work leads to a drain of the battery – since the battery lifetime is a factor affecting the user experience it is highly recommended to do less on the Apple Watch. If the app requires complex or lengthy operations the offload of such onto the iPhone shall be considered.

[26] Cf. Not stated, Apple Watch Best Practices, online source [04.12.2016]

5.3 Toolchain

5.3.1 Introduction to Xcode

It has been one of the main decisions next to the voting of the smartwatch, that the corresponding integrated development environment, short IDE, which is needed and used for the development of custom applications for the target platform, which is that case an Apple Watch and a connected Apple iPhone, shall be taken from the vendor if applicable.

In that certain case, since Apple is providing the so called Xcode IDE, this IDE has been chosen as main platform for all the development, which has to be done in conjunction with this thesis. Xcode was used in the versions 8.1, 8.1 beta and 8.2 beta. The final implementation has been done with version 8.2 beta (see also the figure below) in the programming language SWIFT (refer to chapter 5.3.3 SWIFT for further information).

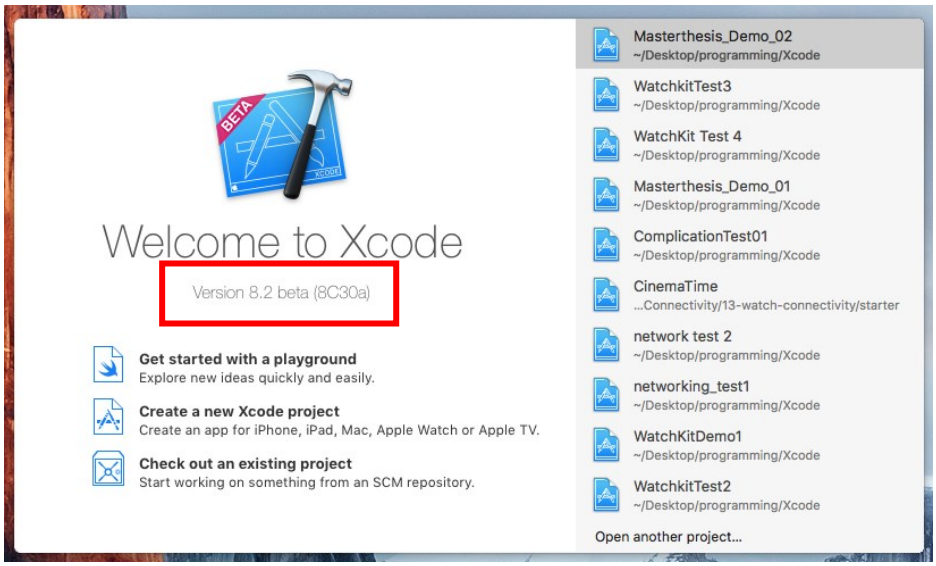


Fig. 29: Xcode version marked in red. Source: own depiction

The high variety of versions goes along with the availability of new updates or beta versions of the operating systems of the target platforms. Throughout the development phase of this thesis the Apple iPhone and the Apple Watch received each a major update (iOS to version 10, watchOS to version 3) plus several minor updates and beta releases.

The IDE can be downloaded from the Apple developer webpage https://developer.apple.com/xcode/ide/, but a developer account has to be created first. This developer account could simply be linked to an existing Apple ID (which is anyway needed to properly use the Apple devices) or a separate account.

Overall the IDE offers a broad range of features, which support the development process and foster the development experience.

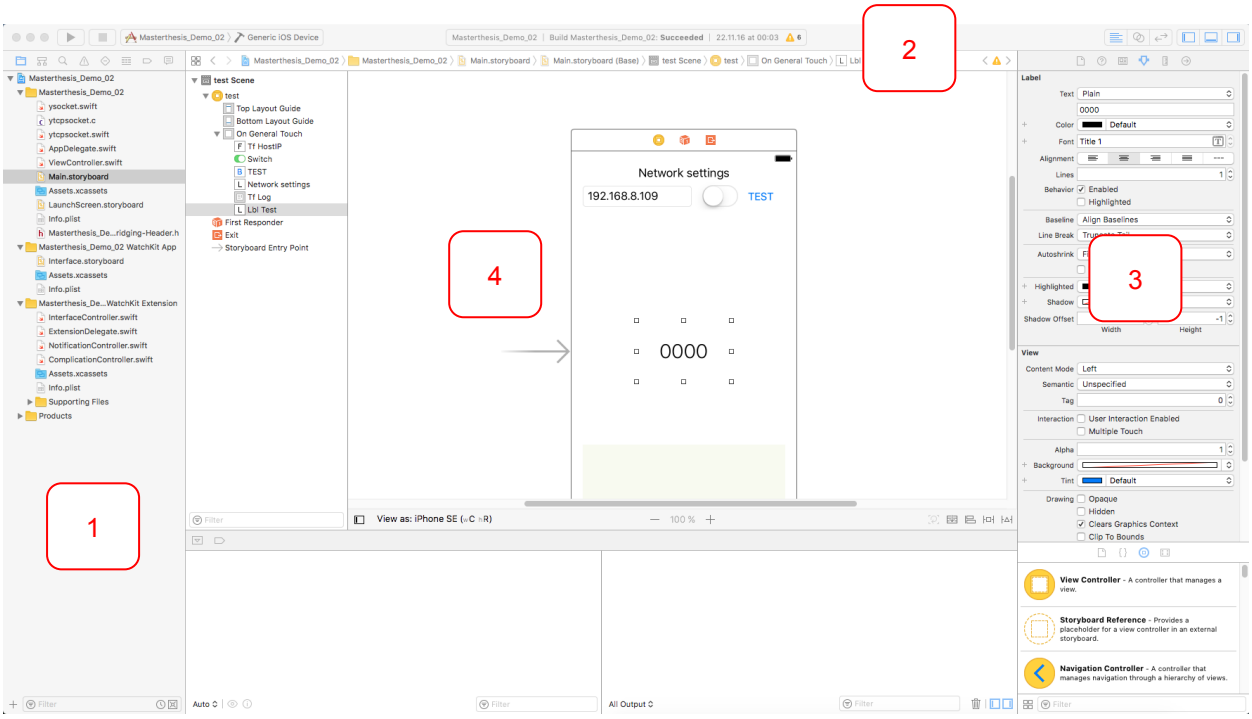


Fig. 30: Xcode IDE. Source: own depiction

Taking a closer look at the IDE following sections can be recognized:

1. Navigator area
2. Toolbar
3. Utility area
4. Editor area

Those areas are quite the same for different IDEs and toolchains, therefore no further details are going to be added hereby.

What is actually interesting is the possibility to debug not only applications for iOS but also the capability to debug watchOS apps, either on real hardware or in a simulator. Due to that the configuration simply needs to be set up and the application has to be started – that's all. Further examples on that are going to be shown within the implementation part of this thesis.

5.3.2 Apple Developer Program

Besides the normal Apple developer account there is the possibility to sign up for a special program called Apple Developer Program. By joining that program a big variety of features and possibilities is added to what's possible with the normal account.

There are basically four main branches, where advantages could be gained due to the membership of the program:

Software and Tools

By being member of this program the access to the latest beta OS releases is granted. Next to that also beta versions of development tools are included (like for Xcode beta versions).

This option is highly interesting especially for app developers, which need to be ahead of upcoming releases (including minor and major releases) with all their tests and verification processes.

Advances App Capabilities

Due to being member of the developer program access to the following Apple technologies is allowed and possible:

- CloudKit
- Game Center
- Wallet
- Apple Pay
- In-App Purchase
- Maps
- Keychain Sharing
- App Groups
- Data Protection
- HomeKit
- HealthKit
- Wireless Accessory Configuration
- Personal VPN
- Inter-App Audio
- Background Modes
- Associated Domains

Due to that, the possibilities for an app are nearly endless, but it also has to be mentioned that this technology is only usable when being member of the program.

Testing and Support

It is possible to invite up to 2000 external users for testing purposes when being a member of the developer program. Next to that code-level support is part of the program and guaranteed to enable quick and effective troubleshooting.

Distribution

In general this membership is needed to be able to distribute apps via the official App Store, which means by not having access to the developer program also no upload to the App Store is possible.To an extend this also includes further methods for distribution in the manner of testing.

The most important thing which needs to be mentioned in regards to the Apple Developer Progam is, that it is not for free – in general the price for such membership is 99 USD (incl. 20% VAT) per year. Due to the big advantages (access to beta versions, possibility of incorporation of further apple technologies) it has been decided for this master thesis to apply for such a membership.

5.3.3 SWIFT

Swift is a pretty young general-purpose programming language, which was mainly build using a modern approach to focus on safety, performance and software design patterns. For now this language is applicable for all Apple operating systems (including iOS, watchOS, macOS and even tvOS) and for Linux platforms. It is remarkable that the Swift-project is open source, which ends up being the first major release developed by Apple, which brings together a broad community of developers, both inside Apple as well as outside contributors.[27]

In principal Swift build on the best of C and objective C. Due to that the language and its connected syntax looks familiar in case that one or another stated languages are known. In any case it is recommended to get a deeper insight the changes in relation to the syntax before doing big projects with the new language, but that applies to every programming language.

Another thing which is remarkable and actually quite impressive, is the approach Apple follows to bring the new programming language out to the people. Since the last major update to iOS version 10 it is possible to take the first steps with Switft within the so called Swift Playgrounds-app, which runs on iPads. With that app it is very simple to get into the basics of the programming language and also to manifest the learned skills by doing further examples and projects within the app.

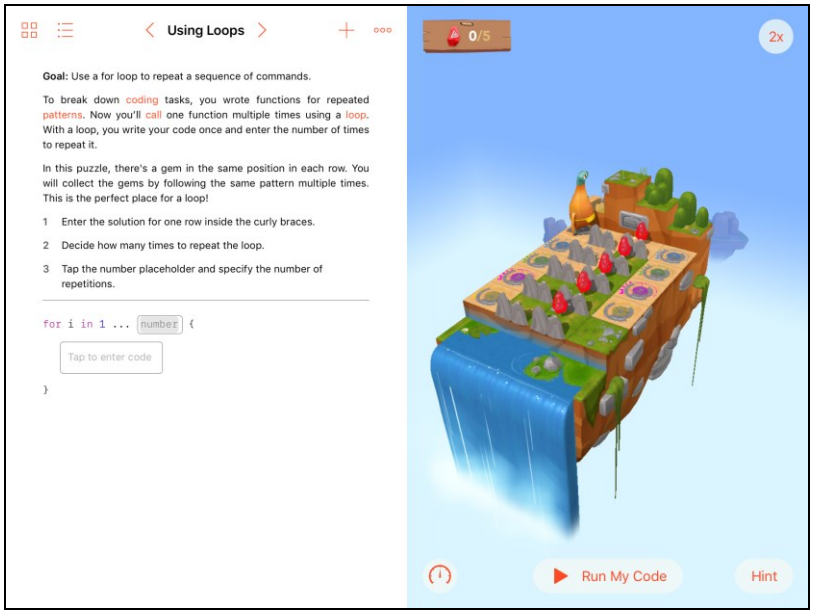


Fig. 31: Apple Playground. Source: own depiction

[27] Cf. Not stated, Swift.org and Open Source, online source [04.12.2016]

6 PRACTICAL REALIZATION

6.1 Introduction

The aim of this chapter is to realize an exemplary implementation for the integration of a smartwatch into an intelligent work environment. For that reason all gained knowledge in terms of requirements, insights but also in scope of the system and the correlating devices shall contribute to a holistic and broad solution as a final step. Next to the implementation also a validation is part of this chapter to furthermore gain knowledge in terms of smartwatches and their usability.

6.2 Definition of the concept

The aim of the concept and the relating exemplary implementation is to show, whether the integration of a smartwatch into an intelligent work environment is possible at all. Next to that the compiled list of requirements shall be evaluated according to their possible technical implementation and feasibility.

Out of that the most important targets for the concept are as following:

- Realization of a basic integration of a smartwatch into an intelligent work environment
- Basic communication between the smartwatch and the work environment (in particular the table system)
- Combination of data available within that ecosystem
- Incorporation of an Apple smartwatch (according to the selection done in chapter 4.6)
- Incorporation of LOGICDATA components

Furthermore the basic requirements, which were derived from the trends currently ongoing in the office furniture market (check chapter 4.2 Requirements and use cases for the system for further information on that), shall be considered at least for the architecture, but not for the actual implementation:

- Ability for authentication in general
- Connectivity and interoperability with higher level systems
- Basic activity tracking
- Tracking of posture
- Measurement of further vital metrics
- Look and feel

6.3 Architecture of the concept

As a result of the concept definition in chapter 6.2 the proposed architecture for the integration of the smartwatch looks like following:

Fig. 32: System Architecture: Best case. Source: own depiction

As the smartwatch is not able to communicate directly with any further device than the corresponding smartphone this resulting architecture is quite straight forward. Taking a look to the interfaces the interface between the smartwatch and the smartphone (1) is predefined with Bluetooth. For the communication between the smartphone and the intelligent work environment (2), consisting of an adjustable office desk in combination with a LOGIClink (check chapter 2.4.2 LOGIClink for further details), always Bluetooth is being considered as best option.

By the stated architecture the interoperability between the smartwatch and the intelligent work environment can be ensured as far as the smartphone, acting as man in the middle, is capable of forwarding commands. Going more into detail with the targets stated in the previous chapter this means following:

- Realization of a basic integration of a smartwatch into an intelligent work environment – Achievable
- Basic communication between the smartwatch and the work environment (in particular the table system) - Achievable
- Combination of data available within that ecosystem – Achievable, but needs to be done by the smartphone. This approach is recommended due to the Energy Efficiency Guide provided by Apple (check chapter 5.2.2 watchOS for further information)
- Incorporation of an Apple smartwatch (according to the selection done in chapter 4.6) – Achievable
- Incorporation of LOGICDATA components – Achievable

Furthermore the basic targets out of a more general scope shall also be evaluated:

- Ability for authentication in general – Can be realized via software the smartphone to which system it is paired to.
- Connectivity and interoperability with higher level systems – Achievable, but therefore the smartwatch simply needs to connect to such higher level system (for example share information with some cloud or utilize a special facility oriented application).
- Basic activity tracking – Achievable, that is anyway part of the Apple Watch and the Apple iPhone – the data is stored within Apple's health tracking platform Health. As mentioned in chapter 5.3.2 there are interfaces to this certain platform, which allow to synchronize data in both directions (in and out).
- Tracking of posture – Achievable, since Apple claims that they are capable to differentiate at least between sitting and standing posture of a person – this data is synchronized with Apple Health
- Measurement of further vital metrics – Achievable, the Apple Watch is capable to measure at least the heart rate of a person and synchronizes this data with Apple Health
- Look and feel – Depends mostly on the designer who is doing the app, therefore the target system is only capable to visualize the output of such designer.

To summarize the evaluation: The chosen architecture is capable to serve all use cases in the best way possible.

Note: Due to the fact, that the LOGIClink has not been capable to utilize the Bluetooth interface properly at the time the master thesis was worked out, the system architecture needs to be slightly reworked. This is needed to be able to implement the architecture also in a real life system approach.

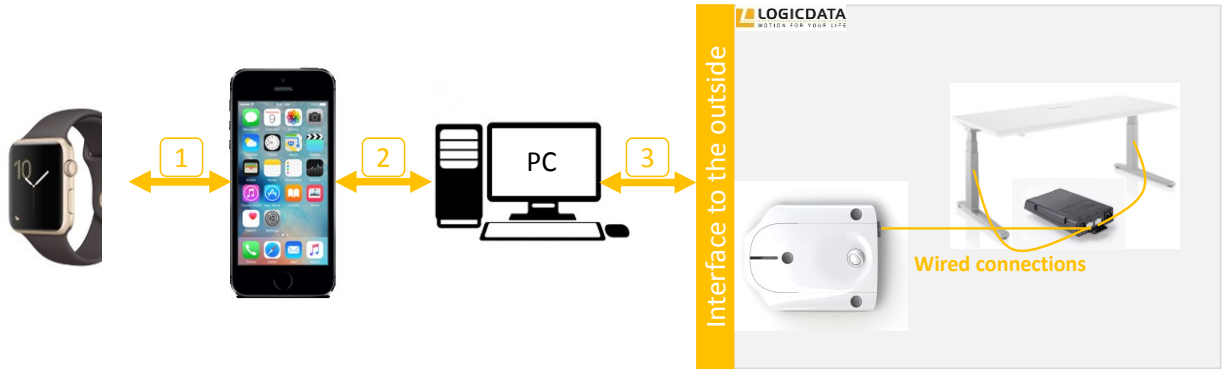


Fig. 33: System Architecture: Real case. Source: own depiction

As illustrated in the figure above due to fact, that the smartphone cannot communicate directly with the LOGIClink a PC was simply inserted as gateway. Out of the that, the smartphone is connected to the PC via WiFi (2), whereas the PC utilizes the USB interface to communicate with the LOGIClink (3).

As this change within the architecture is the smallest change possible and therefore not affecting the overall system performance the result of the evaluation before also applies for this architecture.

6.4 Implementation

Finally this is the chapter which deals with the actual exemplary implementation of the integration of a smartwatch into an intelligent work environment. The concept including the requirements to the system and the basic system architecture can be found in the previous chapters 6.2 and 6.3.

6.4.1 Data synchronization

Since the architecture features two main communication paths it is clearly defined that those paths are also going to be differentiated in terms of implementation.

6.4.1.1 Data synchronization between smartphone and smartwatch

This subchapter deals with the data synchronization between the smartphone and the smartwatch, which are part of the overall system. The devices are defined to be an Apple iPhone and an Apple Watch. For the implementation purpose the exact does not matter as long as the operating system version defined in 5.2.1 and 5.2.2 are capable to run on the devices.

In general the Apple ecosystem offers a quite neat set of functionality which allows to exchange data between an Apple Watch and a connected iPhone. The most important elements needed for the purpose of intercommunication are the WCSession class and the WCSessionDelegage protocol.

The WCSession class facilitates the communication between a WachtKit extension (basically the app side related to the Watch) and its related iOS app. Out of that both processes must create and configure an instance of this class. Having both session objects active the processes can communicate by sending messages back and forth. Next to that the object can be used to organize the handling of one or more watch objects from an iOS perspective.[28]

The WCSessionDelegate protocol is the counterpart for the messages send by using WCSession objects. This protocol defines methods, which are able to respond to messages send through such objects.[29]

[28] Cf. Not stated, WCSession, online source [04.12.2016]

[29] Cf. Not stated, WCSessionDelegate, online source [04.12.2016]

As illustrated in the figure below this results into the fact, that the WCSession object is simply used for sending data and the WCSessionDelegate method is simply used to collect / receive that data on the other end. The nice and comfortable thing to mention at this is, that the implementation works on both sides in the same way, which means that code could be even be reused.

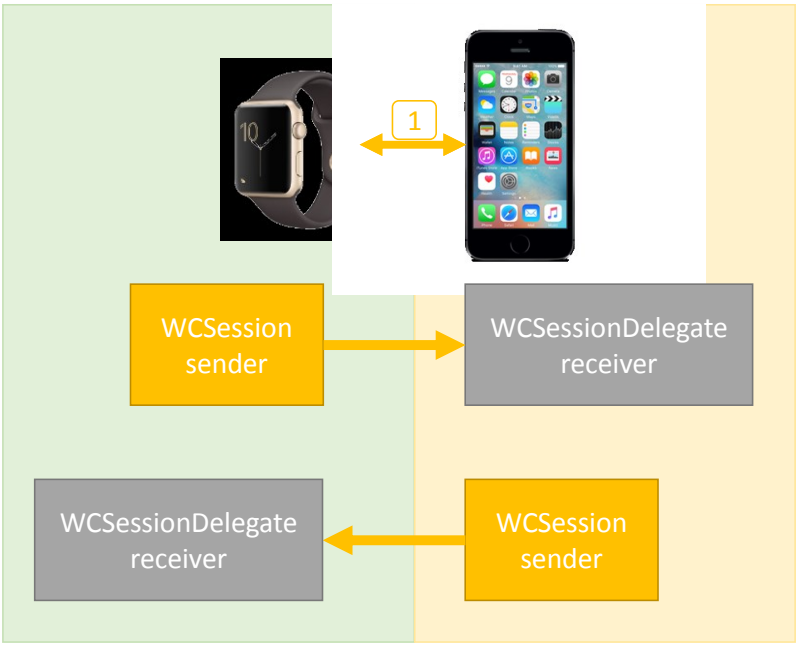


Fig. 34: Utilization of WCSession and WCSessionDelegate. Source: own depiction

Note: Next to all those implementation details it has to be mentioned that Xcode offers the ability to debug and run such scenarios either on the physical devices or within the simulator, which makes development far easier and simpler since working with breakpoints is also more applicable.

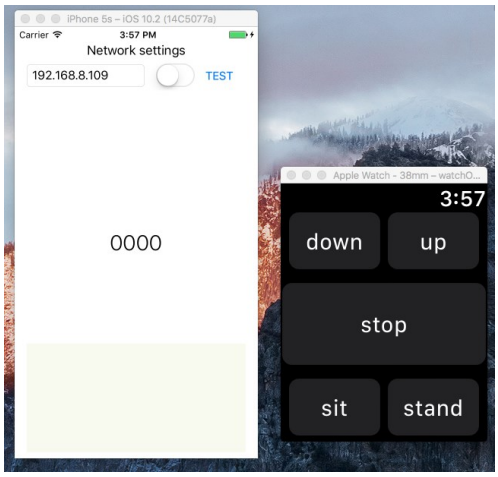


Fig. 35: Simulators in Xcode. Source: own depiction

6.4.1.2 Data synchronization between smartphone and PC

This subchapter handles the communication between the smartphone and the PC. As already stated before this communication is needed due to the fact, that the intelligent work environment is to the day not yet capable of having an interface ready for the iOS world.

Since the integration of the PC as a further element within the architecture is just an intermediate solution the motivation is to implement this certain communication path as simple as possible. Therefore it has been decided to go into the direction of using WiFi as a physical connection element and network sockets as a virtual counterpart.

Those network sockets are easily explained by taking a look onto following illustration:

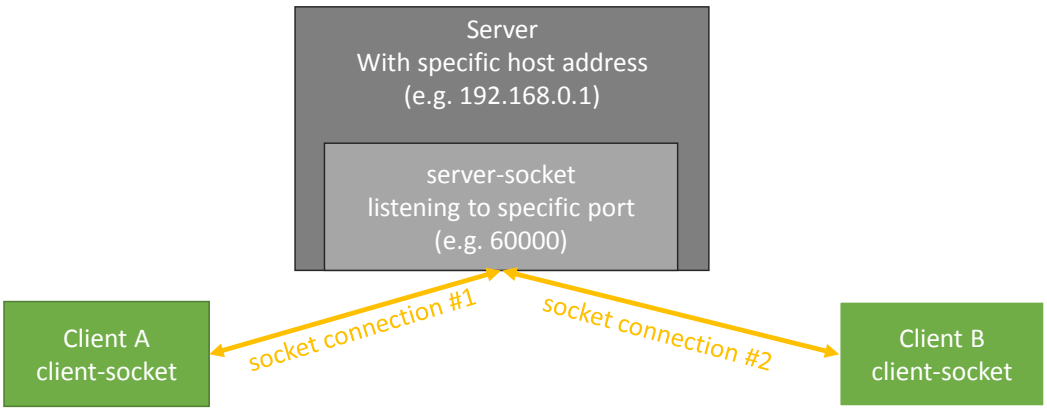


Fig. 36: Network sockets. Source: own depiction

The depiction above shows, that there are basically two roles defined in such ecosystem: Firstly there is the role of the server, which creates an unique access point, where all the clients can connect to. Due to that the server needs to be identifiable within a network, that is why it needs to have a specific network address (stated as host address within the depiction) and a specific port it is listening on for possible clients. Secondly there is the role of the client, which simply connects to the server through its unique identifiers. The server can differentiate several clients due to the ability of creating separate objects for each client.

Out of that the most important finding hereby is, that the server has to take care that all clients receive the information requested. Furthermore it is also a matter of fact, that clients cannot communicate directly within such topology.

Still, for the given architecture this is the most suitable and simple solution, since there is only going to be a point to point connection between the smartphone and the PC in case of this exemplary implementation.

To dig a little deeper into the actual implementation it has to be mentioned that for the PC side of the implementation the programming language C# has been chosen. With C# it is actually quite easy and simple to create an server socket instance due to having all needed methods available within the native library, but this applies also for other languages.

On the iOS end it has been a little bit more tricky. For this purpose, since network sockets are not supported natively by the iOS environment, a third party library[30] has been adducted to the overall implementation. The utilization of that library enabled the ability of an point to point communication between the smartwatch and the PC.

6.4.2 Interface utilization

The next chapter deals with the implementation and further utilization of the interface, which connects the smartwatch basically with the intelligent work environment. As the last communication hop in regards to the work environment and the actual system architecture is the PC, only this certain interface is being considered.

As already mentioned in chapter 2.4.2 the LOGIClink, which builds the bridge between a work environment and an intelligent work environment, will offer several APIs that could be used for the integration of such device into more holistic approaches and solutions (like also the approach of this thesis is). Nevertheless, since only the Windows version of that API was available at the time this master thesis has been implemented, the approach had to be adopted slightly.

Next to that it is a matter of fact, that the programming language for the PC software is defined with C#, since this language offers many capabilities in terms of server infrastructure, which is anyway needed for the interoperability for the smartphone (refer to chapter 6.4.1.2 Data synchronization between smartphone and PC for further information). As the API of the LOGIClink is DLL, which was written and compiled in C, the main issue in regards to the interface utilization was to incorporate such library.

In the end following abilities were obtained by the successful utilization of the API interface:

- Full control over the adjustable work environment (up, down, specific height)
- Height feedback from the adjustable work environment
- Full control over the LEDs of the LOGIClink
- Full access to the sensors of the LOGIClink (occupancy sensor mainly used)

[30] Cf. Not stated, SwiftSocket, online source [04.12.2016]

6.4.3 Data acquisition and interpretation

The aim of this chapter is to reflect the way data and information is exchanged within this small ecosystem and where and how this data is interpreted in further step. Finally the current situation is also evaluated in terms of reliability in taking further applications into consideration.

In principal the following illustration shows the data and information flow of the actual implementation:

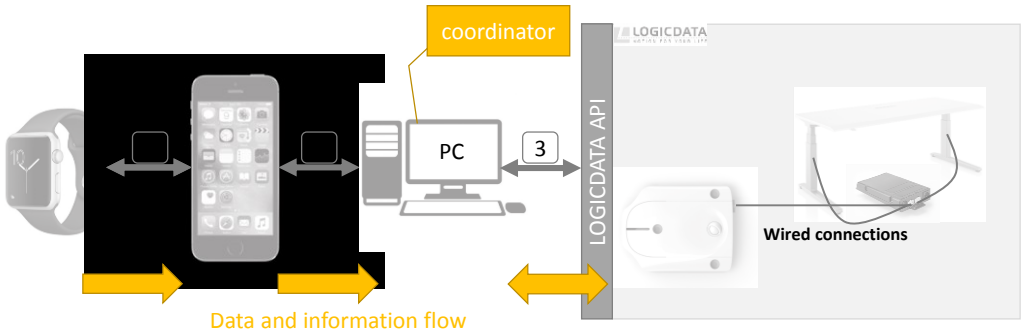


Fig. 37: Data and Information Flow: actual implementation. Source: own depiction

As visualized in the figure above, all data from the smartwatch and the smartphone is simply forwarded to the PC, which is gathering all the data and interpreting it and therefore acting as a coordinator. In that case all the logic is placed within the PC. Therefore it is up to the correlating implementation how the overall systems reacts to certain actions.

The big advantage of such approach is for sure, that it is very easy to implement and also easy to test and verify since errors and faulty behavior is mostly connected to the PC itself since for example movement commands are triggered from there.

Taking the general requirements, which shall be handled by such an system incorporating a smartwatch shall handle, into consideration, the following system approach would be much more appropriate:

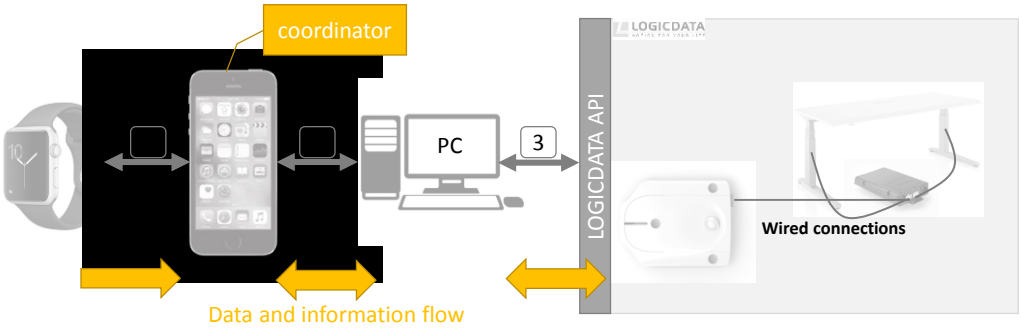


Fig. 38: Data and Information Flow: optimized approach. Source: own depiction

As illustrated above, the role of the coordinator is simply pushed into the smartdevice. This brings the big advantage, that the behavior of the overall system would be anytime the same from the user's perspective, since all the logic is contained in the smartdevice which is bound to the user.

Another advantage is, that it does not matter whether the connection to the intelligent work environment is realized by having a PC as a gateway or having a direct connection via for example Bluetooth.

The risk hereby is for sure the higher complexity in the implementation, since the logic needs to partly be spread between several different devices.

6.4.4 User interaction

The aim of this last chapter is to show the implemented user interfaces and the connected possibilities a user to interact with the system. For the reason of clarity the user interfaces of the three main devices are evaluated separately within the next upcoming subchapters.

6.4.4.1 User Interface of the PC-server

Starting with the user interface of the server application, which is running on the PC, the first interface shown is focusing mainly on the visualization of information. Since the main responsibility of the server application is to gather information and data from the smartphone and the connected smartwatch, the server has not to deal with any kind of direct user interaction.

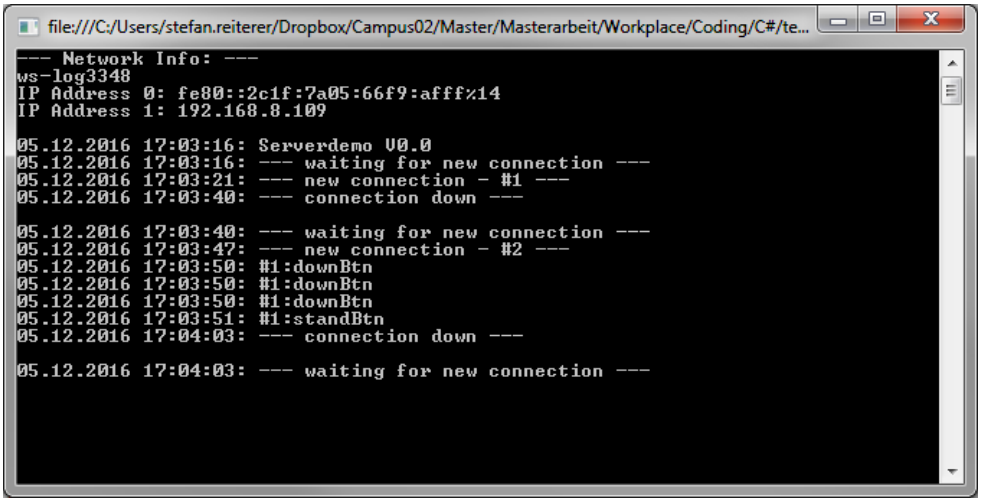


Fig. 39: User Interface of the PC-server. Source: own depiction

This approach is also clearly visualized by the actual implementation of the server application. As illustrated in the figure above, the actual interface is simply a terminal window, which adds a new line in case something with regards to the system is happening or ongoing. The user interface is very simply but at the same time very effective, since debugging is far more easy having the possibility to dig into raw data.

6.4.4.2 User Interface of the smartphone

This user interface of the smartdevice had slightly more requirements than the user interface of the server application. In that particular case the actual implemented user interface is capable of doing following:

- Setting up a connection to the server application manually, IP-address is changeable
- Certain test for that communication path
- General logging area, where all communication (incoming and outgoing) is documented and visualized for the user

Fig. 40: User Interface of the smartphone. Source: own depiction

Again, like it is also applied and used for the server application, hereby having the log of raw data in combination with a timestamp is simplifying the whole debugging and bug fixing procedure. Another thing to be mentioned at this place is, that this user interface is not in the main field of the user, since the main focus of this thesis is put onto the smartwatch and its correlated integration into intelligent work environments.

6.4.4.3 User Interface of the smartwatch

Finally the implementation of the user interface of the smartwatch is evaluated. This user interface is more in the main focus of the development since the main approach of the thesis is to integrate a smartwatch into the field of intelligent work environments.

As the main focus was set onto the illustration of the possible interoperation between the smartwatch and a possibly connected intelligent work environment the most basic elements for the user interface were defined to be simple buttons, which trigger a movement of the adjustable table, which is part of such intelligent work environment.

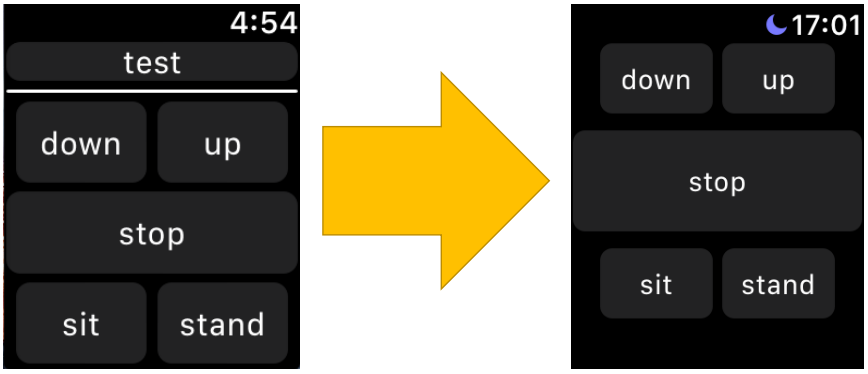


Fig. 41: Evolution of the user Interface of the smartwatch. Source: own depiction

The figure above shows mainly the evolution of this certain user interface. On the left there is the initial user interface, which included a test button for testing the network stability and availability. As it is easily remarkable the buttons were arranged very tight together, which brought up a very bad user experience. Due to that feedback the test button got kicked out (tests showed, that the network has no issue dealing with such communication) and the buttons were rearranged.

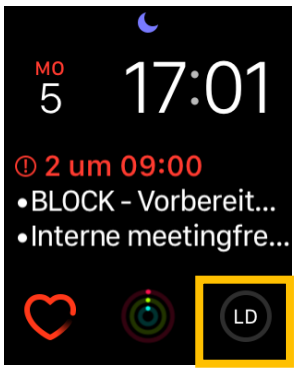


Fig. 42: Apple Watch Complication as part of the user interface. Source: own depiction

Another thing which should be mentioned is, that also a so called Complication has been created. By that it is possible to add a shortcut for the corresponding app to the main watchface. By that the user experience has also been improved further.

6.5 Tests and analysis

The final step which needs to taken is the test of the implemented system and the analysis of the results gained by those tests. Furthermore experience in the field of smartwatches and their usability in general shall be gained.

6.5.1 Definition of test procedures

Due to the experience in the field of product development it is highly important to bring in a good strategy on how the system shall be tested and how the group of participants for this test shall be organised.

Basically the overall approach is divided into two steps:

1. The first testing (phase 1) shall be done during development to cover mistakes, which could concern the design or the architecture of a product or a system.
2. The second phase defines the general test, which is done at the end of the development phase and incorporates also a broader range of people.

Out of the concept definition and the therefore connected requirements stated in chapter 6.2 following things shall be in scope of the tests:

- Overall functionality

  Are the devices interconnected?

  Is the communication working?

  Are the functions implemented properly? Is the adjustable table moving when a button is pressed?

- User experience

  How is the look and feel?

  What is good, what could be improved?

  Is this the right way to go?

  How shall an interaction with an intelligent work environment look like?

6.5.2 Definition of a group of individual test persons

The aim of this subchapter is to define a set of people for each step of tests which are done in correlation with this thesis. Based on the experience which has been gathered throughout the last years following composition is suggested to stick with when doing such tests:

Engineers

There is a high chance that an engineer asks the right question in regards to an architecture or in regards to how something is implemented and why

Non-technicians (including Sales, Accountants, Controllers)

Those people are especially important to gather feedback on the look and feel portion of the system.

Technology oriented people (including Productmanagers, Projectmanagers)

Those people most likely also tend to ask the right questions.

In general there is no limitation on how many or which people are brought to which phase, since it is for better that more than less people and individuals play around with a prototype or a product.

6.5.3 Phase 1: Ongoing tests

The first tests were done during the actual development of the overall system. Hereby uncertainly only a group of three people, consisting of two non-technicians and one technology oriented person, attended such tests.

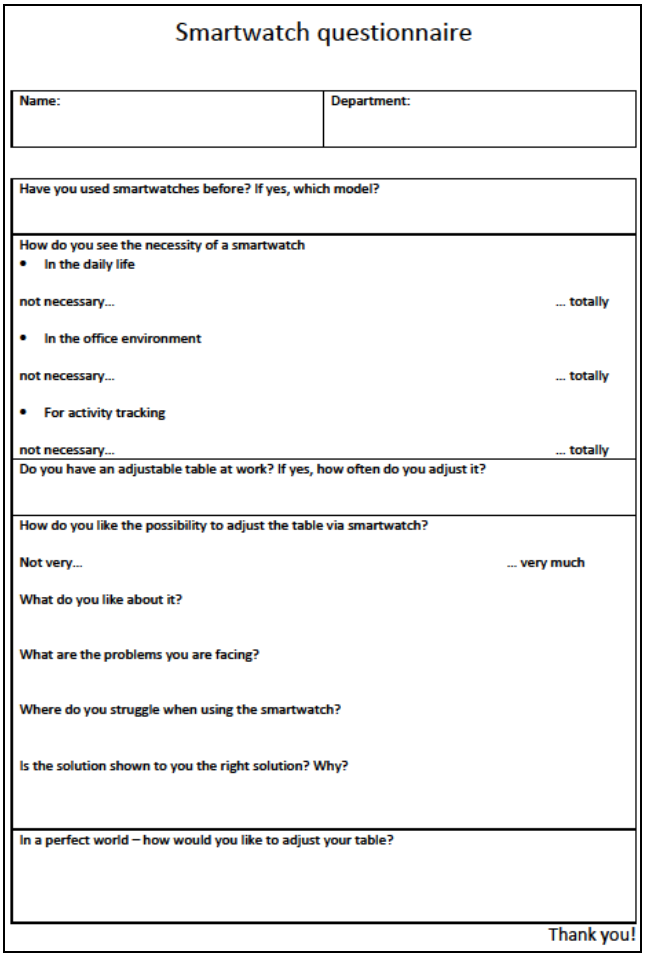
Luckily there was still feedback generated out of that test, which was as following:

- Smartwatch app is inconvenient to use, there is a high chance to hit the wrong button
- The idea is good, but the realization is not stable yet
- After an automatic movement any movement related button had to be pressed twice to initiate a new movement.

Due to that feedback, the system was adjusted accordingly (for example check out chapter 6.4.4.3 User Interface of the smartwatch) to get closer to a good user experience and a good system performance.

6.5.4 Phase 2: General test

For the second phase the approach is slightly changed. Hereby a questionnaire was created, which has to be filled out by the person, which is doing the test. This questionnaire contains different questions in regards to the system and to smartwatches as a technology (also taking the ideas from chapter 6.5.1 Definition of test procedures into consideration) and looks like following:



Smartwatch questionnaire

Name:	Department:

Have you used smartwatches before? If yes, which model?

How do you see the necessity of a smartwatch

- In the daily life

not necessary... ... totally

- In the office environment

not necessary... ... totally

- For activity tracking

not necessary... ... totally

Do you have an adjustable table at work? If yes, how often do you adjust it?

How do you like the possibility to adjust the table via smartwatch?

Not very... ... very much

What do you like about it?

What are the problems you are facing?

Where do you struggle when using the smartwatch?

Is the solution shown to you the right solution? Why?

In a perfect world – how would you like to adjust your table?

Thank you!

Fig. 43: Depiction of the questionnaire sheet. Source: own depiction

Luckily in the second phase of testing several people were willing to join and to also to openly give feedback on the system. The outcome is consolidated within the next chapter.

6.5.5 Analysis and results

In this certain chapter the results of the questionnaire, which was done with ten persons, are consolidated and reviewed. In the end the goal is to get a better understanding on smartwatches and how people tend to utilize them. A further goal is to verify the system approach and the related exemplary implementation in terms of reliability and completeness.

For that reason each question is going to be handled separately, whereas the responses are consolidated and filtered beforehand:

Q: Have you used smartwatches before? If yes, which model?

Only 25 % of the persons answered this question with yes. All the others have either some experience with fitness trackers or no experience with wearables at all.

Q: How do you see the necessity of a smartwatch

- **In the daily life**

The average value is around 35 % for this evaluation.

- **In the office environment**

Hereby the average is at approximately 40 %.

- **For activity tracking**

In that area the averaged value gets close to 70 %.

Q: Do you have an adjustable table at work? If yes, how often do you adjust it?

Here the answer was a clear yes, although the number of adjustment cylces varies quite a lot.

The absolutely lowest value is at 0 adjustments, whereas the person claimed, that a reminder function would be nice. Next to that there are several ranges and numbers, leading up to the absolut maximum number of adjustments which is 5 times per day.

Q: How do you like the possibility to adjust the table via smartwatch?

That question received quite positive feedback overall – The average value adds up to more than 80 %.

Q: What do you like about it?

Hereby the answers started to vary a bit. The most common reactions are:

- No need for further handcontrol at the table
- Fancy way to adjust the table
- New way of thinking

Q: What are the problems you are facing?

Again, the answers are aggregated due to similarities beyond the people doing the questionnaire:

- Reaction time, which lead to a bad (subjective) experience with the haptics of the system
- Reliability of the system
- Not everyone owns a smartwatch or an Apple iPhone
- Button is still more convenient
- No real value for the customer
- No direct feedback to user, might be dangerous

Q: Where do you struggle when using the smartwatch?

The most common answers are as following:

- Different approach than on a phone
- Receiving constant notifications – distraction
- (very) limited battery lifetime
- No real use case
- Small display
- No direct interaction

Q: Is the solution shown to you the right solution? Why?

Hereby the opinion of the people was quite streamlined and pointing the same direction throughout all participants. In general the approach seems right as it is a step into future, still the system showing the exemplary implementation is too far away from a serializable product.

In a perfect world – how would you like to adjust your table?

The highly interesting answers on that end are as following:

- Table shall recognize that the person is standing up / wants to stand up
- Table shall be smart enough to pair with the personal device
- Table shall be adjusted by simply grabbing the table plate and pushing it into the desired direction.

7 CONCLUSION

At the end of this thesis the whole procedure applied and the connected results shall be reflected once again. The big general question, which defined the aim of this master thesis was as following:

"Is it possible to integrate a smartwatch into intelligent work environments?"

By the execution of this thesis the answer to this question is a safe YES, but the overall efforts and actions taken have to be considered, as they were:

- Creation of a clear picture in regards to the needs of the work environment and the users working there
    - Business insights (basically chapter 2 LOGICDATA Synthesis)
    - Theoretical insights (refers to chapter 3 Associated theoretical insights)
- Derivation of requirements according to the findings and draft definition of a system context
    - Definition of the final requirements (done in chapter 4 Definition of the target system)
- Preparation of a technological foundation
    - Gathering of insights to the Apple environment (as handled in 5 Preparative actions)
- Implementation and validation
    - Exemplary implementation (fully covered by chapter 6 Practical realization)

In general this thesis solves not only the issue of integrating a smartdevice into an intelligent work environment – it furthermore clears up the question why this is needed and what the driver behind such demand is. Therefore this thesis is considerably important for people, which work in the business field of office furniture.

7.1 Achieved objectives

With the exemplary implementation, which is mostly stated and explained within chapter 6 following basic requirements (defined in 6.2) have been realized into a physical system, which is also usable for showcases:

Realization of a basic integration of a smartwatch into an intelligent work environment

This has been achieved successfully.

Basic communication between the smartwatch and the work environment

This has also been achieved fully – It is possible to adjust the table system via the smartwatch.

Combination of data available within that ecosystem

This has also been achieved – for that topic the occupancy data gets combined with the wish of the user to adjust the table – is the user standing upfront the table and therefore recognized by the system the table moves, otherwise it will refuse such movement commands.

Incorporation of an Apple smartwatch (according to the selection done in chapter 4.6)

Achieved.

Incorporation of LOGICDATA components

Yes, the system incorporates a LOGIClink and a LOGICDATA controlsystem

7.2 Recommendations

As a basis for further recommendations a simple look is taken at the results of the chapter 6.5.5 Analysis and results. As the results there show that most people have no experience with smartwatches at all and are therefore not used to its specific haptics and look and feel the question pops up, whether it makes sense today to follow this trend or whether it is still too early to do so.

Furthermore by that questionnaire people claim that the shown system is very fancy and nice to use, but also that there is no real value behind. This means that the missing link to success hereby is the final use case, which tremendously changes the life by the utilization of a smartwatch – and that cannot be only applied to the work environment, this also fits into the day to day story of smartwatches. Therefore the recommendation on that end is to simply find a real use case, which creates value to the user.

Lastly this questionnaire shows a very interesting fact. It seems people are actually used to the way a table is adjusted. If there is anything, which needs to be changed about it, then it is including, that the hand control disappears completely from the work surface since the table needs to get smart enough to find out, whether a person wants to work in a sitting or standing posture. Hereby the recommendation is to dig deeper into that topic, since such technology would open up new possibilities in the way tables are designed and used.

7.3 Next steps for LOGICDATA

Finally the next steps for the company LOGICDATA are already widely defined by the previous chapter:

- Question openly, whether the of smartwatches shall be followed or not.
- If yes, define a real use case which creates a value for the customer.
- Find new ways on how a table can be adjusted – at best the current hand controls are being substituted.

Another important step will be to setup a showcase system in the showroom of the company to simply gain further inputs and feedback throughout the year. For that the existing exemplary implementation could be reused immediately since it is working and functioning.

Next to that there is not much to add, besides arranging a defined hand over of the knowledge gained through this master thesis.

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expert interviews

Format: <name> ; <job title> ; <event/occasion, date and place of expert interview>

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Mr. Peter Reigo; CEO of Flowscape; Personal Meeting, 12.4.2016, Zurich

Mr. Jan Jursa; Information Architect; World Usability Congress, 18.10.2016, Graz

Mr. Andy Imada; Consultor for Human and Organizational Change, Macroergonomist; Personal meeting, 21.07.2015, Deutschlandsberg

Mr. Doug Gregory; Consultor for the office furniture industry; Personal Meeting, 21.07.2015, Deutschlandsberg

LIST OF ILLUSTRATIONS

LIST OF TABLES