Intelligent Mobile User Interface

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Intelligence in interface design can cover anything from the embodied conversational agents to the reason for introducing new achievements. It can be referred to as the process or vehicle to achieve something innovative that is possible with the given tools and knowledge. Generally, the term intelligence is used to describe the observable fact where a certain natural or artificial system can learn from or adapt to the environment.

This thesis defines the current mobile design commonalities and capabilities of detecting the context and sensing the user behaviour. It presents a high level information framework that is needed to achieve more intelligent mobile devices. These are then used as the basics for presenting example concepts that can create the next revolution in mobile design.

Keywords and terms: intelligence, mobile, interface

Contents

1. Introduction

In 1997 at GSM World Conference the Nokia 9000 Communicator received an award in innovation category. The judges found that the introduced product encompassed everything that was unprecedented in mobile communications. It featured a combination of voice and data services in one single unit. Nokia's Communicator opened a brand-new product category and expanded the product range for the cellular industry as a whole. [Nokia]

Nokia Communicator 9000 was a revolutionary product at the time of its public release in 1996, as well as the preceding IBM Simon that was released to public in 1993. They both were combining phone and functionality that was at that time only available in mobile environment in personal digital assistants (PDA) and laptops. Applications included address book, world clock, calculator, notepad, e-mail client, set of games and the ability to send and receive faxes. In addition, with Communicator 9000 users were able to browse text based Internet.

In mid 1990's the smart phones created a new category for mobile computing that had relied to laptops and PDAs earlier. The era of smart phones had started. Laptops had existed for over a decade before releasing the first devices that we can call smart phones. Laptops are mobile devices as well, but they are usually not carried and kept close 24 hours a day, seven days a week, as is common with smart phones. It is also more common that there is more than one user for a laptop, opposite to smart phones that are generally personal. Recently, a new member has entered between these two mobile form factors. Tablet form factor was started by Nokia internet tablets in 2005, but iPad from Apple made the breakthrough in 2010. Before the recent progress in this category, there have been different tryouts, mainly using PC operating systems. These early devices have not been successful products and have not reached public audience as have the new tablets that are utilizing mobile operating systems. Tablets are better for some use cases than smart phones, such applications can be browsing or visual media consumption, mainly due to convenience factor of larger display. Still, it can be assumed that tablets are not as personal devices as mobile phones, largely due to their size. Currently there are no multipart devices that would combine some of these existing form factors. Taking all this into account, the smart phones along with feature phones are the only devices which the user is likely to carry in their pockets or bags around the clock.

How a smart phone is used greatly depends on the capabilities of the interface. Smart phone and its interface is a tool for its user and usefulness of that tool will be defined by its characteristics and how well it serves its purpose. Smart phones can be expected to work, for example as an extension for users normal communication capabilities and assist in daily planning. The general definition of a tool is that it can be used to produce an item or to achieve a task, but it is not consumed in the process. It should be noted that the word tool is a bit misleading for a mobile device as they also work as your downtime entertainment, fashion statement and ego-booster. All these factors need to be taken into account when designing the interface and its visual appearance, and for the product design overall.

In interaction design for mobile devices it is important to understand the situation where the device is used, what does this mean from users' perspective and how the device can assist in that specific setting. There is a difference in how the device should behave, for example, when a user is sitting on a park bench to while a user is driving a car. This situation dependent and time relevant environment can be called as the 'context'. Discussions of the mobile context often only take into account what can be studied through microphone, accelerometer, camera or other onboard system capable of detecting surrounding physical environment. This can be referred to as 'physical context'. To really understand the context the system should know a lot more. The system should know what is the status of services available in the Internet or any other connected service and understand the meaning of remaining battery life. It should take into account how the user uses the device, what applications have been used and how, the availability and location of friends and family. Generally the content that can be accessed via Internet access point can be referred to as 'the cloud'. All these and more play a part when trying to understand the person owning the device and how to serve that person best.

The topics inside intelligent design are not new. Sukaviriya and Foley [1993] first presented adaptive interfaces in 1993. This was continued by M. Maybury and W. Wahlster [1998] by introducing intelligent user interfaces where they further explained the benefits of adaptive interfaces. At the same time Reeves & Nass [1996] studied how people collaborate with media and devices, setting an example of human expectations for interface design. Multimodal interface studies are an important piece of bringing intelligent design into existence. Studies by Raisamo [1999] and Ronkainen [2010] support and give guidance how modality can be utilized in interaction design.

Recent evolution in mobile technology has offered the possibility for intelligent UIs to take a step further, with Apple iPhone 4S and Ipad 2, Nokias' N9 running Meego and Lumia with Microsoft Windows, Android based devices with Samsung Galaxy II being examples. Intelligent interface should feel similar to what you are used to. In a perfect world there would be no need to understand how to operate the interface, instead things should feel natural. The common services in the Internet need to be naturally fitted to mobile use. Certain elements of intelligence will be built through a long lasting evolution, like common sense library [MIT Media Lab], but they do not prevent introducing intelligent solutions today. The devices mentioned above have taught users a new way of using mobile devices. Interface with touch, voice, gestures -

in addition to the early solutions on haptic feedback - offer more natural interaction. Higher display resolutions and network capabilities enable the Internet to get all the time closer to mobile environment, not forgetting the technological advances in graphics and information processing, energy consumption and design tools. All these are needed to create an environment and framework where the device can offer intelligent assistance for users.

However, as a side effect of this development an even more complex system environment is created with unlimited amount of information available all the time. In current smart phones the software typically is ignorant of the context related to device status. Factors such as available information, user behaviour, surrounding environment and events are left unnoticed, even though there is no actual restriction for this in current day software and hardware development. The device carries multiple sensors that can easily gather information from the surrounding environment (i.e., haptics sensors, audio sensors, and lighting conditions. In addition the current performance and calculation power already enables the system to gather and study the internal states. The difficulty is to understand what is relevant and when. Current mobile platforms seem to offer enablers for technological achievements more than actually behave as natural companions for users. Understanding the user should not be the task only in designers' head in some design office, but a constant process while the user is actually using the device. Only so we gain more intelligent aids for everyday life.

Known and clearly visible problems in present day mobile interfaces are that interfaces are not flexible and therefore not related to user behaviour and context. Often design is feature-driven and as a result fairly complex and unnatural. Mobile devices do not understand each other; this behaviour could be utilised, for example between devices that are owned by family members or friends. The services accessed online from the mobile environment do not share information with each other and do not understand the mobile context.

An interactive interface requires the device to detect changes in the surrounding environment and to return the status through a feedback mechanism, while in reactive the state is changed only through specific input. As an opposite to this the intelligent interface can learn from the context and adapt based on the perceived factors. As mentioned before, the context means the available local and external information and as well as changes in internal system processes.

In this thesis I will focus on smart phones and defining the next revolution in interface design, although the intelligent design mindset can be carried over to other computer form factors as well. I will focus on near future possibilities in designing interfaces, especially for mobile use scenarios. The target is to understand how the UI could be enhanced with no or little additional requirements for currently available technology. I will introduce basics of intelligent design framework and explain how new concepts are created with included example designs. I will also analyze the factors that needed to be taken into account when introducing these new ideas within the company organization and in public space. And eventually conclude with a prediction of future in mobile phone interaction design.

2. Definition of intelligent UI

As stated by Maybury and Wahlster [1998], intelligent interfaces provide a number of additional benefits to users, including adaptivity, context sensitivity, and task assistance. These categories are rather vague and can be extended to cover a more human approach to intelligence when in pursuit of the next interface generation:

1. *Natural.* Instead of trying to mimic a user or human, the tool is supposed to support a user in areas which can be enhanced by technology. There should be no learning curve when taking the device into use and when exploring its capabilities. Task flow should be natural and it should work in a way you expect. The Turing test [Turing, 1950] requires the tool to behave as a human. Instead we should consider how to test the feasibility of the tool in task where it is supposed to provide assistance in. For example, when the purpose of the device is to extend memory capacity for remembering the important information gathered during a workday. Or to a more complete extent, how efficient the tool is in assisting the user on daily tasks, in planning the future and in reaching short term and long term goals. Human characteristics, such as perception, learning, memory, expectations and sensory system, should be taken into account when designing the discussion framework with the device.
2. *Safe.* The device should inform user why certain decisions (recommendations) were made, this can be done by literally explaining the reasons, or the device behaviour should be logical and evident enough for user to create the connection between the original and the resulting states. In addition, users should be able to change the factors that resulted to the recommended function or information. This can be done for example by providing the tools for teaching, where the users supply information on what are the factors they want to be taken into account. Collecting user behaviour information automatically should occur so that the users can trust the system while it gathers information of their daily activities and life overall.
3. *Learning and Adapting.* Sukaviriya and Foley [1993] stated that developing an adaptive interface requires a user interface, which can be adapted, a user model, and an adaptation strategy. Recommendation services and associating pieces of information require this ability. These abilities cannot be created without understanding the user and the capability to adapt related to the gathered information.
4. *Sensing*. Ability to see, hear, smell, taste and feel. Moreover, to understand, recognize, value or react to something. These listed senses produce so much information of surrounding context that an ability to detect what is relevant is

needed. Detecting contextual information through one of these natural senses offer already valuable information. However, the capability to understand and use information from all channels would provide full consciousness of surrounding physical context.

5. *Irrational & Playful*. It is evident that to give pleasure the device needs a wink of an eye and a smile. Reeves and Nass [1996] proved this through numerous psychological studies that led them to the conclusion that people treat computers, television and new media as real people and places. The UI solution should harness this power. This could be utilized efficiently for example in content discovery. For example, providing additional information for the user through a meaningful channel while they are listening to music.
6. *Social.* Cross device and cross multiple devices. Your family, friends and public community should change the information and recommendations that you receive, as in real life. The device is able to discuss with other devices, services, as well as the capability to seek and access local and online information. Recommendation services are enhanced through comparing the collected user data with that of other users.

These categories can be more effectively used to understand an intelligent interface. The main difference towards the definition by Maybury and Wahlster is that these partly new, partly reformed topics take a step closer towards communicating with the user in more natural way. Feeling safe, sensing in social environment as well as irrational behaviour, along with other before mentioned categories can be used as heuristics in intelligent design tasks, whether the need is to compare interfaces or to create requirements for a new design model.

3. Mobile device restrictions and capabilities

A mobile user is continuously in a rush, impatient, and unable to wait [Ramsay and Nielsen, 2000]. Multimodal interfaces combine many simultaneous input modalities and may present the information using synergistic representation of many different output modalities [Raisamo, 1999]. The system is often restricted by the performance and energy consumption requirements to accommodate the long battery life. The low power versions of all hardware elements are constantly developed, for example, Bluetooth for close proximity connections, OLED displays for low power consumption. Designers need to take the found restrictions into account when designing the interface. However, increased battery life is eaten up by constantly growing connectivity and graphics performance needs [Carroll and Heiser, 2010].

Understanding the restrictions and on the opposite side using the capabilities of existing components in new ways is the groundwork in inventing behaviour of intelligent interface. The following chapter includes hardware features that are expected from a current day smart phone, and as well these topics gather together the elements what is regarded as a smart phone in this thesis.

3.1. Sensory system

In an interactive system, the device gathers information from the environment with a sensory mechanism. To understand the possibilities of a haptic system it is important to recognize what the device is able to detect from the context and what is required to read this information. The energy consumption limitations are essential for sensory system included in the mobile device. The system must be optimized for battery consumption. This usually means that the sensor cannot be on all the time. Also the combined physical size of all the sensors is a constraint towards the size and mobility of the device.

1. **Accelerometers.** An electromechanical device that measures acceleration forces. Forces may be static (gravity), or they can be dynamic caused by moving or vibrating the accelerometer [Dimension Engineering]. Accelerometers can also detect the orientation or tilt of the device [Hinckley et al., 2000]. Different accelerometers and the way the sensor have been set up within the device affect the data which they can read:
    - *Number of axis.* 3-D positioning requires a 3 axis accelerometer, or a pair of 2 axis accelerometers mounted at right angles.
    - *Maximum swing.* Affects the amount of g-forces detectable.
    - *Sensitivity*. Affects the detected size of the change in acceleration

- *Bandwidth.* Amount of times per second you can take a reliable acceleration reading.

The motion and orientation can be recognized with the help of an accelerometer, but they are not currently utilized effectively. This often causes a situation where the natural "gestures" of the user are missed [Ronkainen, 2010]. In addition to offering the knowledge of user movement the sensor can be used to, for example, stop the hard drive before the impact if the device is dropped, or for the camera stabilization.

2. **Gyroscope.** A device for measuring or maintaining the orientation, based on the principles of conservation of angular momentum [Wikipedia]. Whereas accelerometers measure linear motion against the pull of gravity, gyroscopes measure angular momentum in a motion that is independent of gravity. A gyroscope can detect 2-D and 3-D movement in space. This information offers a natural and more universal interface tool as well as a more enjoyable user experience for gesture recognition or detected body motion. Other possible applications are image stabilization in cameras, enhancing navigational systems and remote-pointing applications such as Wii Remote [Nintendo].
3. **Vector Magnetometer** can detect the orientation of magnetic moment and its magnitude. It is important for the mobile phone that the magnetic force can be detected regardless of the device orientation. This sensor can then be used for applications such as compass. The knowledge of magnetic poles can further be used to provide information such as in which direction the camera is pointed. This is often used in Augmented reality (i.e., LAYAR [Layar Ltd.])
4. **Camera** component can provide a constant stream of visual data. Camera component quality and resolution dictates the amount of information that can be gathered. Camera can be used to detect simple environmental factors such as lighting conditions. In more intelligent applications it can combine detected view with knowledge of history data resulting in face recognition (to detect the name of the person in view). Currently mobile devices already use face detection (i.e., Nokia N9) to detect that there is a person or people in the photo and using that information in focus placement
5. **ALS**. An automatic light sensor can detect the lighting conditions. This information is currently used for changing the screen illumination. Other use cases are to utilize the information in turning on the flash light when taking photos.
6. **Mobile radios** (Wi-Fi, GSM, CDMA, BT, NFC, LTE etc.). Currently the radios are used mainly for data transfer and rough location detection. The range varies between different radio technologies (Figure 1) and therefore it is

common that one smart phone carries multiple radios. Radios can also provide information on the location of the user or other radios that are located nearby.

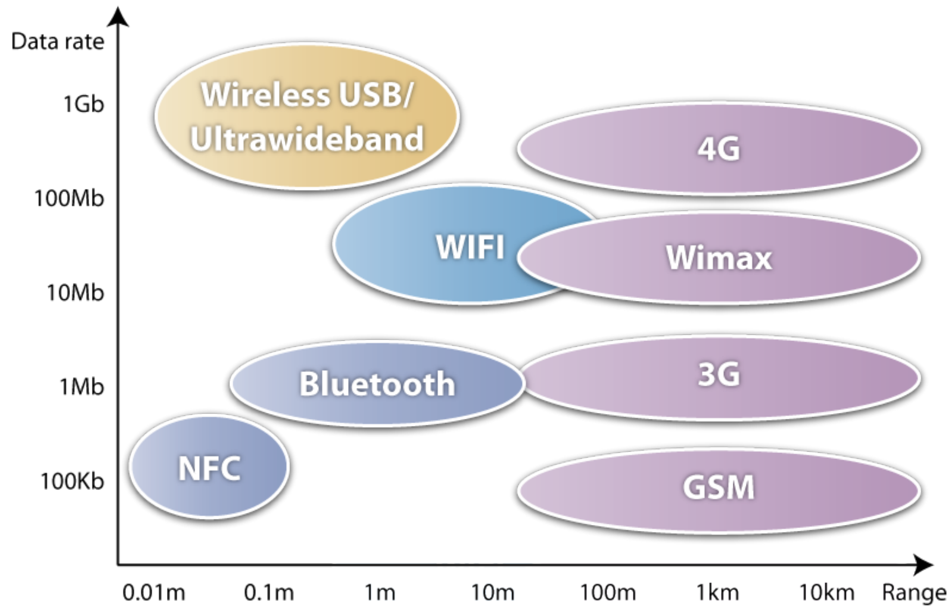

Figure 1: Range and Data speed of different radio technologies

7. **Connectors.** There can be different kinds of connectors on a device, such as the USB for charging or headset plugin. The common 3.5mm A/V plugin can be used to detect whether there is a wired headset or video cable available. If headset is detected it can feed the information to the sound system, which in its part can then alter the sound volume to the assumed level. For example, when the device volume is set to maximum and a headset is plugged the volume is automatically turned down, this is done in order to protect the ears of the user.
8. **Microphone**. Used in sound detection and loudness detection. Works also outside human hearing capabilities (ultra low and high bandwidth). For example Shopkick uses ultrahigh sound encoding in location detection [Shopkick Ltd.].
9. **Proximity sensor** is used to detect a specific proximity to an object and if the functionality of the sensor is based on optical detection, it can also recognize the ambient light conditions. The sensitivity and calculation of the actual distance varies between different components. The sensor may be optical, or a combination of a photocell and LED or laser. It may employ a magnet and a Hall effect device. Sensors currently used in mobile devices (i.e., Apple iPhone) are mainly based on optical detection. A proximity sensor can provide

information whether the device should record a touch event or not, or how a touch is sensed within the given context (touch lock). The sensor can also provide added information on where the device is currently located and how it is used. For example, if in ongoing call and the discussion is played through device loudspeaker, in this case, if the user decides to move the phone to ear the sound can be automatically changed to device earpiece.

10. **Touch detection.** Multitouch technology is becoming a standard in touch sensing. This can be enhanced with force sensing, detecting hovering (gestures) or off screen touch, as the touch detection area can exceed the bounds of the display area. Touching is a complex activity where there are several forces and factors that need to be recorded to provide natural interaction. The system needs to detect the closeness of the input device and the pressure used towards the display, what is the size of the area that is touched and whether there are multiple touch points. It needs to understand if the item touching the display should have an effect or not, for example, while a finger is dragged on top of the display.

    The touch sensor is a sensor which is used to detect the finger or a stylus. There are two main types of touch screen technologies used in mobile devices, capacitive and resistive. However, the use of resistive technology in smart phone development is decreasing rapidly. These technologies are explained in the following chapters. The third technology would be to combine these two mentioned. This would possibly provide a solution that could take the advantages of both. In addition, there are several other touch sensor technologies that can be used in environments that do not have the same development restrictions than mobile environment (battery lifetime, size, weight). These technologies are not handled in this thesis. Currently available smart phones offer touch detection only exactly on top of the display area. It is important to realize that the touch sensitiveness should not be limited for the display area only. It is rather safe to make an assumption that touch detection will include also other areas on device surface than only display area in near future. This can be used, for example, in a situation where holding the device in hand would turn off the display lock [Hinckley et al., 2000] or for providing controls outside the display area to applications that would benefit from removing the controls from view, such as games. The main touch screen technologies can be described as follows:

    a. Resistive touch screen is composed of electrically conductive and resistive layers separated by thin space. When some object touches this kind of touch panel, the layers are connected at certain point; the panel then electrically acts similar to two voltage dividers with connected outputs. This causes a change in the electrical current, which is registered as a touch event and sent to the controller for processing. Layer can also measure press force when using force dependent resistors. [Wikipedia]

b. Capacitive touch screen panel is coated typically with material that conducts a continuous electrical current across the sensor. The sensor exhibits a precisely controlled field of stored electrons in both the horizontal and vertical axes. While resistive touch detection works with all kinds of objects, the capacitive sensors can be operated only with a bare finger or with a conductive device being held by a bare hand. Capacitive touch provides usually higher visual clarity than resistive. [Wikipedia]

New technological achievements and innovations are constantly introduced for mobile devices to enhance the sensory system. The downfall is the way they are usually presented to users. The information a sensor can provide is essential for designer to understand. With this knowledge the designer has a better capability to understand what is the meaning of the gathered information from users' perspective. Showing whether a wired headset is connected may not be too valuable for the user as such, but adjusting the device sounds related to connected headset is. In addition, studying the information gathered by all the sensors as a whole can provide results that will bring clear and meaningful benefits for users. Using the GSM cell information along with GPS in location detection is one of the best combinations that are already used. Location detection can be also a combination of other technologies as well, like ultrasound and GSM cell or Bluetooth and GSM cell.

3.2. Feedback system

The smart phone output components are introduced in the following list. There are no mobile mass-market solutions available that would provide feedback with taste or smell. Audio, visual and touch modalities have output technology available. Nevertheless, all these feedback modalities need to be synchronized to provide a meaningful result from the users' perspective. This means that the actuators that provide touch feedback need to be optimized to work in co-operation with the visual and audio feedback. The given output should also be dependent of the current context. Haptic feedback on the current mobile devices is fairly limited. Current smart phones are using only vibrotactile feedback. There are no mass market solutions available to provide haptic feedback, for example, for texture, slippage or temperature. Nevertheless, design of feedback should undoubtedly follow the rules of what feels natural and logical for the humans. By studying and understanding what is perceived as natural, the design will achieve a lower learning curve when moving between different haptic devices. The main components that are used to provide feedback on mobile devices are:

1. **Display**. There are several types of displays. Currently the display component leads the energy consumption along with GSM module [Carroll and Heiser, 2010]. While in GSM module there can be little development on reducing the used energy (if optimizing the network traffic is not taken into account), the display seem to offer a lot of new possibilities. OLED (OLED, OLED pentile, AMOLED) is a low power display that do not need separate backlight as LCD, therefore it is consuming much less energy. Although, selected color scheme for graphics in OLED may work the opposite way, for example, blue and white colors consume lot of energy. Therefore it is necessary to use, for example, yellow tints, especially in low contrast situations [Chuang et al., 2009]. Variant of OLED, the Active-matrix OLED (AMOLED) enables low power mode to display subset of colors all the time as in Nokia N9 when displaying notifications and time while device is locked. Innovations in display technologies, especially for mobile products seem to move fast. Products with flexible display are targeted to be launched during 2011 according to Samsung [Samsung Ltd.]. Samsung has also introduced transparent AMOLED.
2. **Vibro-tactile actuator**. The force of the feedback the vibrating component is able to provide is dependent of the size of the actuator, the used voltage and the location of the actuator in the device. Other variables that need to be taken into account for vibro-tactile devices are 1) Depending on the used technology the actuators can produce disturbing and unwanted sound. 2) The latency time starting and stopping the actuator need to be precise to have effective feedback. 3) Wave shape, duration, strength and frequency can provide extended haptic feedback if used cautiously, so that user can distinguish the selected variations.
   Humans can recognize differing vibra waveforms fairly efficiently, better than differing frequencies, or amplitude modulation. A vibration can feel rough or smooth depending on the used shape of the electrical current. Smooth vibration is created using a sine wave, rough vibration by using a saw tooth wave. [Hoggan and Brewster, 2007]
3. **Piezoelectric**. Piezoelectricity is the ability of some materials (notably crystals and certain ceramics) to generate an electric potential in response to applied mechanical stress [Wikipedia]. This enables the use of piezoelectric material to provide mechanical feedback when the electrical current in the piezo element is altered. The size of the element can be so small that it does not affect the mobility of the device. Although the amount of physical movement is also really

small and therefore affects the amount of tactile feedback available from the component. The recent development in Piezo Film development is an enabling transducer technology with unique capabilities. Piezo Film's stress constant (voltage output per stress input) is about 10 times higher than other piezoelectric materials such as ceramics and quartz. It makes a highly reliable vibration sensor, accelerometer and dynamic switch element [Measurement Specialities]. These Piezo films are reducing the size of the Piezo element and possibly enable the attachment to the display component.

4. **Loudspeaker**. Current smart phones have two loudspeakers to provide audio feedback for user. One is meant for playing sound when user is using the device on ear (i.e., when having a private phone conversation), the other can be used for more public occasions that require powerful audio repetition (i.e., teleconference or playing games). These can be bypassed with a wired or wireless headset. Creating rules for which audio feedback is played to which available loudspeaker in all different interaction scenarios is a rather difficult task. Audio routing definition needs a holistic understanding of the interaction model and the audio routing capability of the system.

The development in display technology has provided all the time more cost effective, low energy, high-resolution components that conform also to the mobile requirements for size. Despite the rapid development in displays and touch technologies the tactile feedback technology has been lacking behind. Vibra actuator can be used for feedback, but often the quality and resolution do not match the needs of design. For example Apple iPhone models and Nokia N9 are using the vibra only for most critical interactions, like input and alerts. Recently signed patents by Nokia for Tactile touch screen [WO2008037275, 2008] and Apple for Multi-touch display screen with localized tactile feedback [20090167704, 2009] show that there may be announcements shortly in this area.

3.3. Memory

Current growth in the amount of memory available on smart phones will likely make sure that there is enough memory space for majority of users and use cases. The difficulty comes from understanding what is in that memory space. The memory needs to be indexed to optimise the access to files and to assign them to available applications. Indexing effort for tens or hundreds of gigabytes consumes battery life, time and processing power. Indexing may prevent user to access the transferred information. For this reason the memory needs to be indexed immediately after a sync or a data transfer to understand what new items where copied to the device. Smart phone developers have recently introduced cloud services. A cloud may in future offer the needed capacity to index the data on users' device more efficiently. This could be done so that while syncing or transferring information to the device, the cloud is updated and, therefore, it can also be aware of the content. After cloud has indexed the information the index could be pushed to the device.

Clouds can also act as the link between other information sources. It can optimize the information available in the Internet to be used on the smart phone, and at the same time the information feed can go towards cloud to create more information from the current mobile environment, this may be of use when combined with other sources in the Internet. The information gathered from multiple sources gives a better and stronger understanding of the studied factor than a single feed.

4. Process to design intelligent UI's

Design development has been more or less a straightforward process to invent how to exploit new technological breakthroughs. Often the design is created with tight schedule, without really having the possibility or capability to understand how this would enhance the users' daily activities best. One of the main ideas behind intelligent interfaces is that they adapt and morph over time creating an opportunity to use all the information that can be collected during or after the device is launched for public use. As a result it also provides the possibility for a designer to move out from the mental model of needing to design a solution where "one size fits all".

Current smart phone designs are too often created in silos, meaning they are not integrated well into the holistic system. For example, there can be an application for maps with navigation capabilities, but it does not provide well-organized help to remind and guide the user for an appointment on the other side of the town. Instead, the user usually has to navigate between maps, calendar and communication tools in order to accomplish the task. This kind of silo design can be considered as vertical design approach where a user dives deep in one app space for accomplishing one dedicated task. The opposite of this is horizontal design where tasks can be accomplished without manually transferring information between applications. Likely the simplest example of this kind of task could be the copy-paste functionality. The question is how to create a process which helps designers more efficiently design for these horizontal use cases, rather than for one application at a time.

UI Design Phase	*Description*
Ul architecture	Defining the Ul at a gross level, defining the key design direction
UI detail design	Defining the UI at a level detailed enough to serve as instructions for the programmers
Ul design change management & verification	Design rework to address issues that arise after the UI design freeze; also includes work to verify that the UI was implemented as specified

Table 1: Stages of UI design according to McInerney and Sobiesiak [2000]

Process where design precedes software development is called a waterfall process. This process has been studied (see Table 1 and Table 2) and found useful. However, the tools that are used in software development and interface design are getting better, the amount of information that can be handled is increasing, the quality and visualization of concepts is getting more appropriate, iteration rounds are faster and more effective with better communication and collaboration tools, this all means that the waterfall process can be updated. The best result is not achieved when the work is handed over from designer to software developer after design concept is finished, but through joint effort when going through the development from beginning to end. In addition, the waterfall process would no be suitable for creating intelligent UI solution as the understanding of users and their changing behaviour related to the new interface is built parallel to actual SW development.

UI Design Phase	*Description*
Analysis	During this initial phase, the UI team learns about the application domain via various techniques such as interviews, reviews of current products, study of documents, task analysis, and similar. The team develops a good understanding of the various user types to be supported, the key user tasks and flows, the target working environment, and the characteristics of the data that the UI will collect and display. At the end of this phase, the team would normally have a starting set of design knowledge and requirements that should guide the rest of the phases.
Conceptualization	Through creative activities directed by the analysis results, the UI team will produce a conceptual vision of the UI. A UI concept may include elements such as the architecture, organization, layout, navigation schema, and graphical templates. Using, for example, storyboards the concept will be illustrated by depicting how key user tasks will be accomplished using the new UI. The concept typically undergoes a number of revisions and refinements until it is approved.
Prototyping	Starting with the conceptual design, the UI team creates a mock-up, or prototype, of the UI using a suitable technology, in many cases simply HTML and JavaScript. The prototype will typically cover most of the screens in the UI and serves as a vehicle to complete the detailed design of the screens in the UI. Once completed and revised, the prototype is ready to be transferred

Table 2: Stages of UI design according to Puerta and Hu [2009]

McInerney and Sobiesiak discussed how design should be taken into account in SW development (Table 1). They covered the basic principles of one design cycle with a maintenance phase to control the changes. Puerta and Hu further developed the early design definition process (Table 2) emphasizing the importance of concepts and prototyping. These conclusions can be used as a basis for design process in current day design process. However, it is necessary that these ideas are developed further.

4.1. Design phases in Intelligent UI

Understanding the user behaviour is very significant in all design efforts. Often designers refer to a common use case when they explain selected solutions. The problem is that it is very difficult to identify the one and only fixed solution that all people expect. Common use cases are usually identified through focus groups, heuristics [Nielsen and Molich, 1990, Lewis and Rieman, 1994], personas [Blomquist and Arvola, 2002] and other tools [Jeffries et al., 1991] that enlighten information of user behaviour. All these tools provide valuable information. Overall understanding of users and their goals are critical for designers and developers creating the system. The mentioned tools vary in difficulty, for example, using the persona method is arguable as it is very complex. Considering the solutions through persona is difficult, especially if the designer or developer was not involved in persona creation [Blomquist and Arvola, 2002]. Gathering information should not focus only at the beginning of the design process and development iteration. It is very important that validation work is continued throughout the lifecycle, also during the time when the solution is in users' hands. Over time all new solutions taken into use change the behaviour of people using them. Understanding these behavioral changes adds to the required time. Only after this point the device can adapt to the new situation. Nevertheless, exaggerated simplicity is necessary at the beginning, but after user has learned the basics, more can be provided. When user has learned to efficiently operate the interface solution the device can offer more advanced options.

While the processes presented in Table 1 and 2 are common approaches for developing interfaces, they are not optimized for building complex and intelligent interfaces. In complicated environments the knowledge and understanding of the interface logic increases still when it is actually taken into use. The development and design iteration of the solution is continued throughout the product lifecycle (Figure 2). Designers and developers themselves should be the first everyday users of the solution. Iteration cycles, validation of behaviour and knowledge building are key elements in design process. This can be started already in concept level. Pixel perfect visualizations of the intended design increase the awareness of needed functionality and build common agreement to achieve the wanted target. The visualizations can easily be turned to animated demos that even more increase the understanding. Usability testing and other information gathering methods should be used to explore how the approach changes user behaviour over period of time, and how the users expect the interface to adapt to their environment.

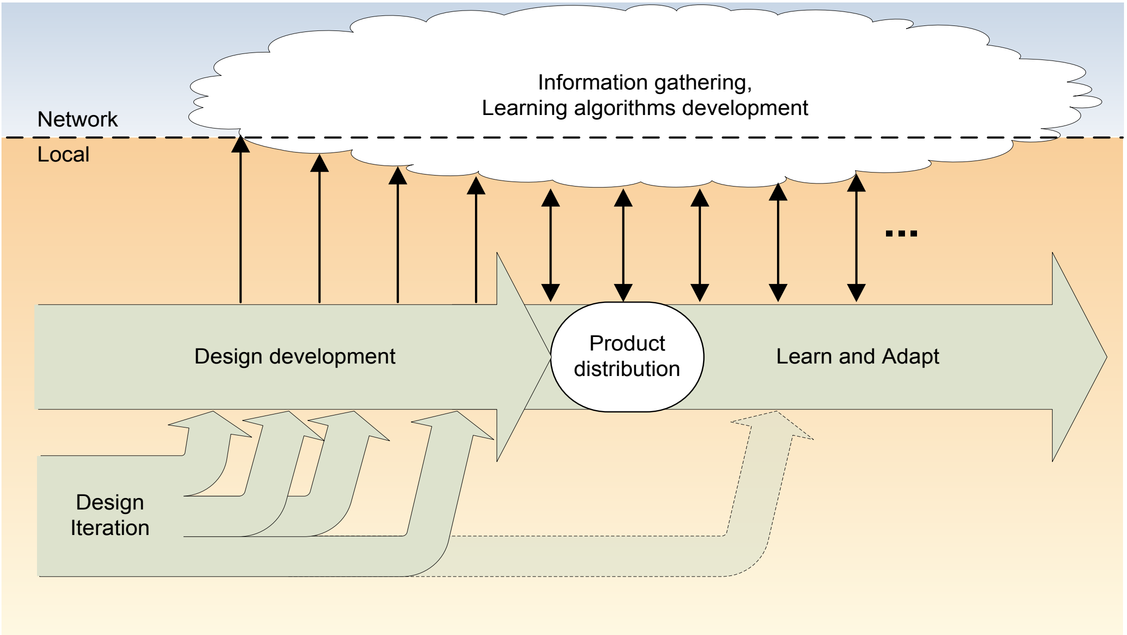

Figure 2: Intelligent UI design process lifecycle

Agile manifesto [Beck et al., 2001] was created for environment where requirements are constantly adjusted and modified. Although it is arguable whether this method is suitable as such for very complex interface development with multiple dependencies and high demand for user centered approach. Still the main objective of the process is valid for design approach. The main benefit is the mindset where solution can be constantly iterated and environment is optimized for changes. Human centric design approach can be fitted to agile software process. To create and maintain alternate design solutions in changing environment requires two or more separate development paths. While the current best understanding is maintained, detailed and matured in the development path the iterated solutions and new ideas are studied on parallel paths. Agile development mainly focuses on small sprints that lead to a certain goal. In design the knowledge gathering, concepts, design, iteration and validation may take long periods. These long lead-time improvements are brought in to the development path when they are ready and verified.

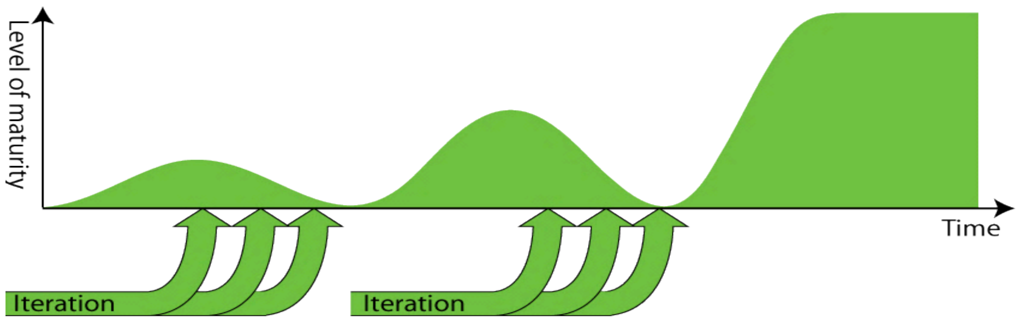

Figure 3: Design iteration in Agile environment

In Agile development the parallel development and design activity need to be spread into phases of iteration and maturity (Figure 3), where the system may be unusable and unstable during iteration round or in rare cases these activities can be done on fully parallel path while maintaining the integrity of the currently used system. During these design and development cycles it is necessary that after iteration cycle the quality of the system is raised high for validation purposes. This enables the designers to gather information of how the available system is used by users. The length of the iteration and maturation cycle is dependent of the complexity of the system. Design validation, testing and iteration require time, as well as the maturation depending on the level of changes proposed.

4.2. Design development

Memmel et al. [2007] studied the integration of agile software processes and concluded the work in defining the overall development to five different phases (Figure 4). In all cases the communication of the design is the key. Memmel et al.'s CRUISER model expects the design to be finished and static at the end of production phase. To support intelligent UI idea the best the design and development should not end at that point. Instead, the end of production phase should only mean that the software quality has achieved a level where a distribution to users can be initiated. In addition, CRUISER model is lacking a very important headline. During design and development process it is fairly easy to add something that was missed on the way. Reasons for the need of additional features can vary from misunderstanding between developer and designer, to wrong interpretation of user needs. The additional features will cause priority changes in interaction model and overcrowding of information. Therefore, it is necessary to constantly simplify and optimize the interfaces for its purpose. The iteration cycles should take into account the whole interface and not only the new required feature. Designer needs to consider continuously whether something could be removed.

Designers need to build and update the understanding of problems by studying

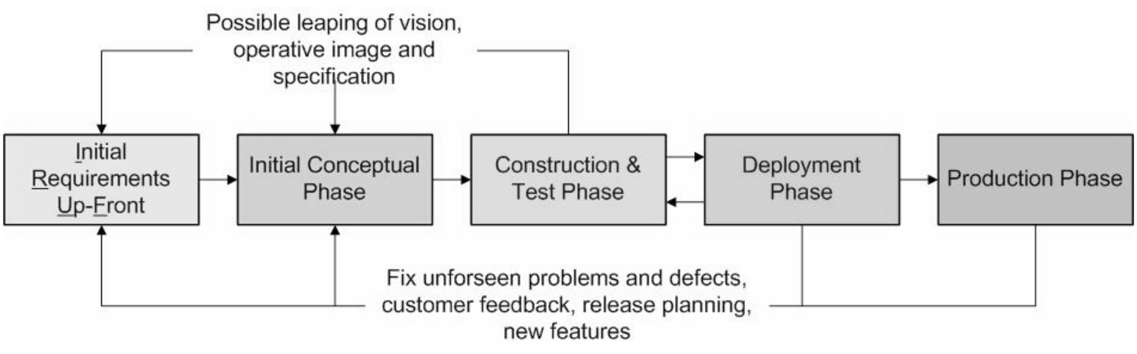

Figure 4: Overall phases of CRUISES model [Memmel et al., 2007]

environment and related tasks. Maintaining the target to enhance or create new solutions to improve the task execution or the environment to achieve users' goal. The design should be validated and tested with selected heuristics. The designers should also use the system themselves, not only study subjects using it. This can be roughly compared to writing a book without reading it yourself. Complex, and can be done, but often better results are accomplished by actually running through the predefined tasks yourself. Designer needs to understand the needs and purpose of the tool. This can be achieved by learning from using existing systems. The best design can be gained when there is enough knowledge in the specific area.

During the different design and development phases there are certain set of human centric design tools that are most efficient. These include design cards, sketching, wireframes, low and high fidelity demos. In every case - picture, video or demo always tells more than textual description of the interface. Pixel perfect presentations are needed to really understand the desired result and to communicate with it. This can be optimally achieved through prototyping tools, or static layout visualization.

When the developed solution achieves the quality target, the distribution to selected audience or public can be started. To accomplish shorter learning curve for users towards new interaction methods and visualizations, the distribution should be well thought. Instructions and use scenarios should be promoted through channels that are often used and available to all to increase users understanding. When taking the solution into use the users should have the possibility to guide and teach the system so that the interface can adapt faster to provide more exact recommendations and to be more correct on the created relevancies.

4.3. Learn and Adapt

Creating algorithms that detect commonalities in user behaviour, context detection and relevancies in content requires constant updates and maintenance of the database containing and storing this information. This can be considered to be the core of enabling interface to be intelligent. These databases can exist locally in device memory, in network or both. Network refers to all outside information that a device can connect to as 'the Cloud'. These connections can be established via the mobile device connectivity (i.e., WLAN or Bluetooth) and can reside in near surroundings, in intranet or the Internet or any other network that the device can access.

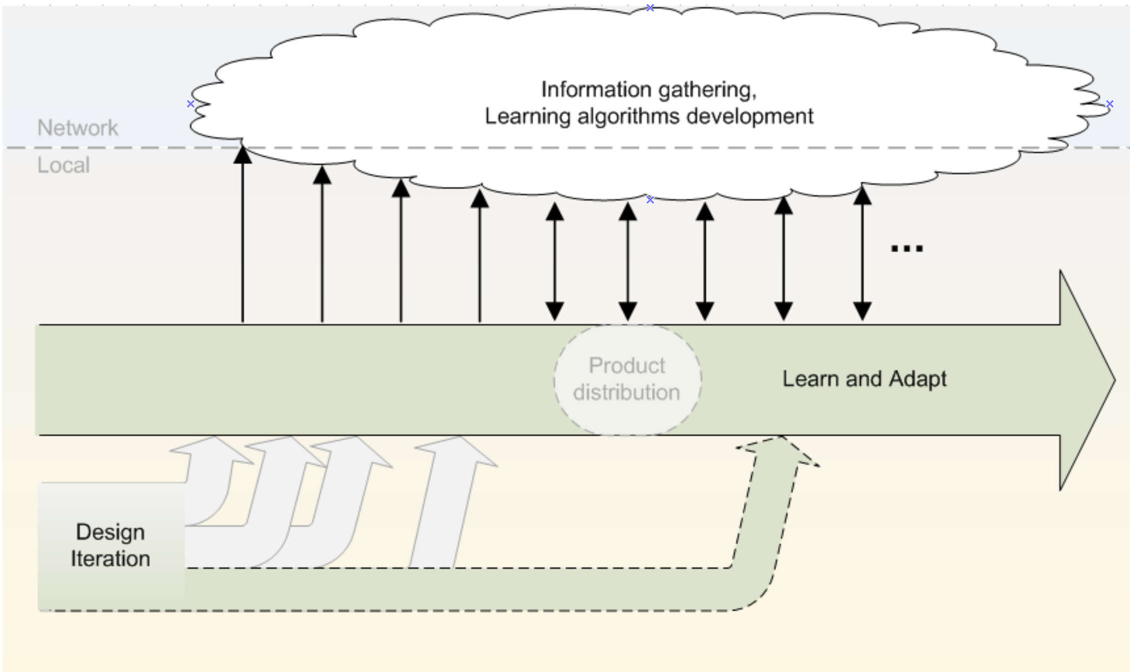

Figure 5: Learn and adapt phase

Gathering the information is a process that usually is longer than lifetime of one interface solution. An example of this kind of database is the common sense library maintained by the MIT Media lab [MIT Media Lab] where information collection was started already in 1999. These kinds of databases are not useful until there is an algorithm that connects the random facts together to provides an answer. Another example is the Open Street Maps [Open Street Map Foundation] that provide a tool to access information gathered by a public community. The cloud can also maintain the information of the users' mobile device content and learned behaviour. Once the user wants to upgrade the existing device, the new gadget can be prepared with already gained information of user characteristics and needs.

The interface can adapt to support users' activities better based on the gained information or more efficient algorithms. In optimal environment these changes are taken into account by the interface naturally when the information is available (Figure 5). In certain situations this is not enough and publishing a new software update to the device is needed.

5. Intelligence Framework

In computer science, and specifically in the branches of knowledge engineering and artificial intelligence, an inference engine is a computer program that tries to derive answers from a knowledge base. It is the 'brain' that expert systems use to reason about the information from the gathered knowledge for the ultimate purpose of formulating new predictions. Inference engines are considered to be a special case of reasoning engines, which can use more general methods of reasoning. [Wikipedia]

Inference is a prediction reached on the basis of evidence and reasoning. To build intelligent interfaces the inference engine concept should be expanded to contain the capability to store and maintain the information derived from the environment and user behaviour, if reference to brain is kept this could be called the 'memory' (Figure 6). Naturally, the neural network of the brain also maintains the links and the values of how these pieces of memory are tied to each other and how the current context affect these links (relevancy).

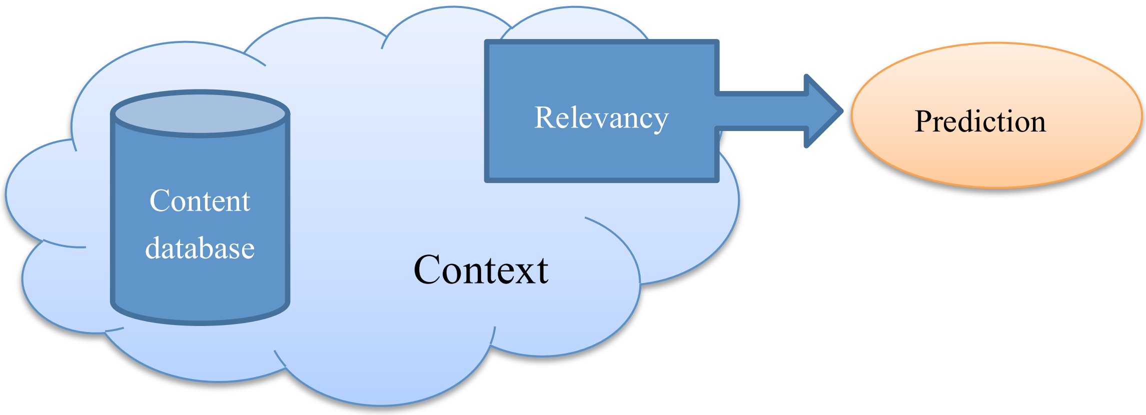

Figure 6: Inference engine

The problem of this system is that it may not have all the information to make the correct logical prediction. Simplified example:

1. Electricity can be extremely dangerous
2. The Internet requires electricity to function
3. Therefore, The Internet can be extremely dangerous.

Gathering all necessary information to create an adapting relevancy engine is crucial for the success of an intelligent application. By assumption, correct prediction requires infinite amount of information, the intelligence machine that can handle and collect this information is immeasurable complex, and still we could only talk about a prediction. Regardless, this kind of system is not needed to create valuable new information for users. As stated, the prediction will be always a prediction. The information is presented to a user who will make the final decision whether to use the presented information or not.

5.1. Content

The content database contains a collection of raw information that can be stored locally or in the cloud. For example, the Microsoft's Mail for Exchange server provides capability to maintain contact information in many locations. The user created database commonly is located on the mobile device and company provided databases usually in the cloud. The interface can offer search results from both of these locations. The database can contain huge amount of information, which implies that it is necessary that the search algorithm is efficient. The algorithm needs to understand what information is in the database, as it may be fairly time consuming task to go through all the files when search command is given. Opening a file is a time consuming process with the currently available mobile computing power. A file can be opened in different ways, the metadata usually stores information that is relevant to understand what is in the file. Reading the metadata of a file does not open the whole file to the memory. The metadata information as well as the content of different files is usually indexed to a single optimized file that is used for conducting the search commands. Collecting the data requires time and the more there is data, the more time is needed to optimize the data for usage. Involving the cloud to gather and interpret the information can help to shorten the time for the system to be functional and so on beneficial for the user. There is a lot of information in the Internet, created by the participants online. This information can be harnessed and great projects like Photosynth [Snavely et al., 2006] are utilizing this already by using online photos and videos taken by common people. The information of a single photo can be exceeded multiple times, when it is combined with thousands photos of the same location, either over time or on a single moment. Other examples of similar database collections are Openmaps [Open Street Map Foundation], Common sense library [MIT Media Lab] and Wikipedia [Wikipedia]. In addition, the knowledge of two or more of these kinds of databases can be put together to form one place that combines the information. These combinations are called mashups or web application hybrids, example of this would be the Woozor [Woozor] that combines Google Maps [Google Maps] and Weather Channel [The Weather Channel].

Resolving what is relevant for the user within the content is an area where devices could be more intelligent. How to index or search, for example, the songs or photos? It may be that the date, name or location of a photo is not relevant for user, instead the colours or objects in the picture may be. For songs the user may be interested in what is the beats per minute ratio (bpm) or the songs that have female singer.

5.2. Context

The context is usually explained as things surrounding the user. This can be easily mistaken as something that happens in the real physical environment, like whether the user is inside a building or outside, whether the ambiance is loud or silent. Of course, this information is relevant to understand the full context. But the real meaning of context should cover everything that is relevant from users' perspective. This means the state of users preferred Internet sites, the remaining battery life of mobile phone, the calendar invitations, the loudness of played music, and so on. The context lives in the digital world as well as in the physical world. Users' family, friends and public changes the information and received recommendations. The system needs to understand what contextual information can be received from the different domains. This information does not need to be calculated and indexed by the mobile device. Instead the algorithm to understand the contextual information can be stored and maintained by the cloud, which may then provide and follow the needed information and act accordingly. So, for example, if the user is listening to a song, the device can offer immediate news of the band and its members, or of the upcoming concert. The cloud can provide this information when it receives information on users activity.

5.3. Relevancy

Relevancy is the condition of being relevant, or connected with the matter at hand. An algorithm that is trying to answer the question what is relevant for the user at the moment, and what is irrelevant. When the user presents a question or performs an action, the relevancy engine is set to work to provide additional information that may help the users' decision or behaviour. There are several elements that are needed to create the assumption. These elements can be shared between the mentioned categories, the content and context. The content provides the information database, the context provides the factors that may result that some content is more important than other. The decision of whether a certain information is more relevant than other is the basis of the algorithm that can be called as the relevancy engine. Underneath is a list of steps to approach ultimate relevancy engine in order from simple to more complex systems:

1. **Manual** adjustment of the relevancy. The users' create their own personality, through answering a set of questions or by giving examples of their behaviour in the predetermined situations. Recommendation services like the MovieLens [GroupLens Research Lab] uses this kind of a system, where the users grade movies that they have seen. Based on the prior grading and comparing the results to the grades from people with similar

interests the system recommends relevant options that may appeal for the user.

2. **Automated** recommendation. The device studies the users' personality through behaviour and actions, and the behaviour of others to create the prediction. The common Internet search engines and bots may already provide this kind of behaviour. The search engines measure how accurately a particular website or a web page matches the question. For example, a query on a 'mobile phone' would list pages that included the text 'mobile phone' above pages that were just about 'a phone', because the pages containing the 'mobile phone' would assumedly be more relevant. In addition, the resulting list can be ordered with the knowledge of how many users have visited a certain page after giving the same or similar search criteria.
3. **Context driven** system uses the context to determine the factors that alter the general personal character of the user. This kind of a system can provide an assumption of the events user may be interested of. The context usually is also closely tied to time. Something may be relevant now, but it may or may not be relevant anymore in 5 seconds, or in the following day. If the user lives in Tampere, and is visiting currently in Helsinki, an event in Helsinki is likely more important than a corresponding in Tampere. Whether the system keeps promoting the events from Helsinki after the user returns back to Tampere should be dependent on how often the user has visited Helsinki previously. Some of the instances may be very important even though they happen only once a year, like the birthdays. On the other hand, some of the instances may not be important even though they have happened previously daily, like the information of university events after the graduation.
4. **Association** is the connection or relation of ideas, feelings, sensations, etc. correlation of elements of perception, reasoning, or the like [Dictionary]. Highest level of understanding is the relevancy. Answering question whether a user associates the apple to computers, fruits, to Beatles or perhaps to a garden in Spain is something that can not be easily understood by any current technology. The association usually creates more problems in the system, than helps solving them. Consider a music recommendation system as an example. If the user is currently listening to a hard rock band, can the system answer if this is because of the current mood, current activity, having friends around (location) or the fact that the user read an article of the singer? The system can recommend similar music, but can not predict whether the user wants to listen to a next song

from the same band or music that is from the same genre. The music recommendation systems like LastFM [LastFM] or Pandora [Pandora] are enhanced radios where a user accepts these limitations.

The relevancy is always something that can be understood only by studying the subject. The study period can be short or long. Short being, for example, a set of questions to which the user gives answers for. While solely following the users actions and behaviour can be a long process. Utilizing both of these methods at the same time is likely to bring the best results. The complexity of relevancy gathering is closely related to the technological capabilities of the system at hand.

5.4. Prediction

The result of the relevancy engine algorithm is not a conclusion, it is a prediction in which the user may be interested of. In some occasions the system can give exactly the correct answer, for example, when asking what was the famous book from J.D. Salinger. The obvious answer would, of course, be the 'Catcher in the Rye', but then again, this may not have been the book the user was looking for, even though 'he kind of remembered that it may have been'. Based on the available information the relevancy engine provides the best guess, or the list of best guesses. Whatever the result is the user needs to trust that all meaningful information was shared and there are no underlying solutions that would be better. The user needs also to trust that the privacy was maintained during the process.

6. Example applications

The following examples in intelligent design are in the order of complexity perceived by the user, and likely also from the development perspective. Starting from basic and simple intelligent design concepts, moving towards more complex context and content framework dependent applications requiring a system that can learn from user behaviour. These require relevancy calculations and complicated algorithms. All of the examples should be applicable for development for current smart phones.

6.1. Intelligent vibra

The smart phones usually carry a vibra actuator to boost notifications or other information defined by the feedback framework. When the vibra is playing the whole device moves. The user senses the motion as extended feedback. The vibration can also be detected, for example, from a purse or a back bag. Nevertheless, it can be assumed that in certain situations the vibra motion does not provide the wanted result. When the phone is located on a hard surface and the vibra is played, the device seems to cause a lot of noise when literally jumping on the platform. The user is likely to perceive this behaviour as not wanted or poor design. Using the motion sensors on board in combination with the sound detection to detect the setting could solve this. In this scenario the vibra could behave in different way than in the normal condition. The vibra could be turned off or a different vibra pattern could be used to better suit the conditions.

6.2. Intelligent sharing

The NFC technology is making a breakthrough after six years since the first NFC product launch, the Nokia 6131 in 2006 [Nokia]. The design of how to share with the NFC is not yet as it should be. Nevertheless, the NFC technology is already removing the difficult initiation process of the Bluetooth connection. Still sharing the phone number, web page or any other information included in the NFC protocols could be optimized and simplified. Example cases of current design problems are the following:

1. If the user wants to share a contact card from the NFC capable phone to another, the user needs to select the contact card, then select share, and select sending method as NFC.
2. The web page contains a phone number to which the user wants to call to. Currently the user has the choice of opening a phone application and then typing the phone number manually via the dial pad.

All in all, the sharing requires rather extensive steps, even though the NFC technology is already optimizing the behaviour to correct direction, these rather easy steps could be still simplified. For example, if the data that is included in the NFC protocol (i.e., contact card, phone number, web address.) is selected and the device detects another NFC device the sharing could be started immediately by asking the user whether the sharing is the next wanted action. Getting two NFC devices within the contact distance of under 10cm requires already a decisive action. This would leave out the complex user action to select a sharing action and then method, as it is fairly obvious that the sharing through NFC is the wanted action and method. The following procedures can solve the problems mentioned:

1. If the user selects a contact card and after that the device detects an NFC device close. The originating device could ask whether the sharing is the wanted action (Figure 7).

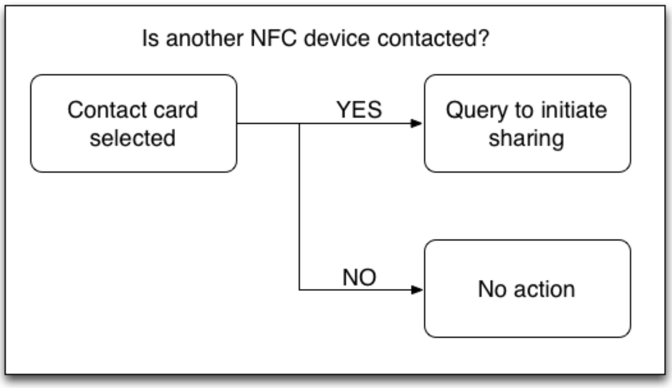

Figure 7: NFC contact sharing between two mobile devices

2. If the user paints a phone number from a web browser or from a message content on an NFC capable laptop and then the laptop detects an NFC capable phone nearby. The laptop could present a question whether the phone number or link should be transferred to the phone (Figure 8).

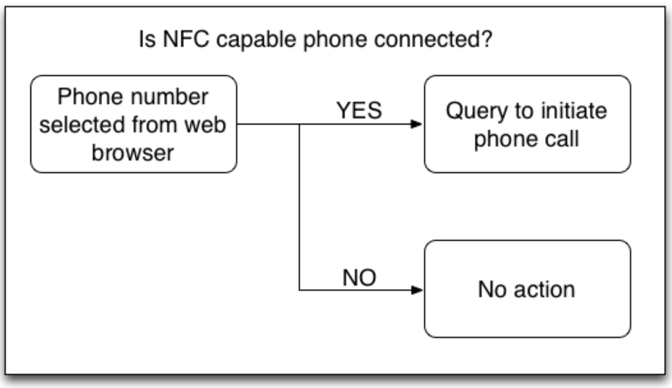

Figure 8: NFC phone call initiation when browsing on computer

6.3. Intelligent alarm clock

Creating a 'one way fits all' design almost always includes compromises. The users' need to select from the applications or devices that would suit the best for their behaviour and usage. For example, when concepting a clock application the designer may ask the users to define a snooze time that would suit them best. The common result is likely to vary between 5-30 minutes. As a result the presumable time which the designer selects is from somewhere between those limits. Alarm clock solutions and calendar reminders in the mobile world usually have a 10-15 minute pre-selected snooze time.

What if the designer would not have to select this, but actually the device would learn the behaviour of the user. At the beginning the device would provide all snooze variations. Normally this would not be good solution, as when waking up it is better to have larger buttons to be able to make the correct selection. After a certain period of use the view would change so that the snooze buttons would adjust in size to make it easier for the user to make the selection (Figure 9). This kind of behaviour of enlarging the most common elements is already in use in tag clouds by LastFM [LastFM].

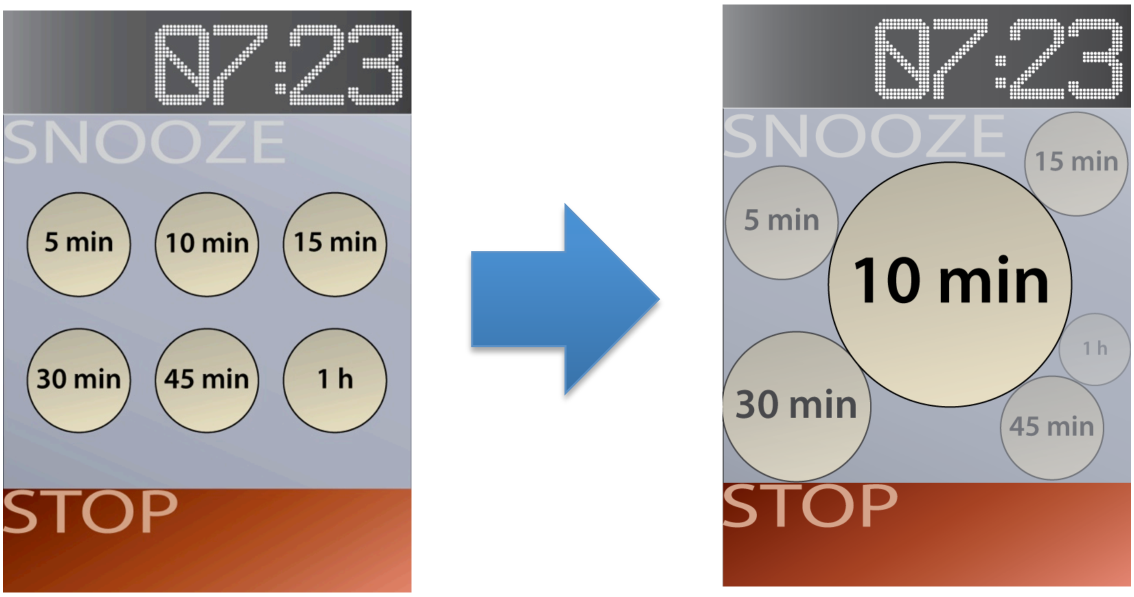

Figure 9: Alarm clock morph example

6.4. Intelligent Phonebook

A contacts list can be optimized to support calling, messaging or social networking. It can not be optimised for all of these at the same time. The result is a design compromise where it needs to be decided will there be one common single list, or several lists each optimized for one of the previously mentioned actions. The Nokia N9, iPhone 4 and Android have a phonebook (optimized for creating calls) and a different list to cover all contacts, taking into account all communication methods and information storing (home addresses etc.). Basic functionality of phonebook includes 1) the call log that gives easy and fast access to recent calls, the users usually remember to who they have been in contact recently, 2) the dialler for inserting a new unknown phone number and 3) optimized contacts list with a search to find the wanted contact.

There are several ways how this list could be enhanced (Figure 10). The phonebook can have links to other means of communicating, with, say, a presence status used in Internet communication channels. This can act as an initiative for a phone call as it would be easier to detect when a person is available.

Figure 10: Visual example of Intelligent phonebook

6.4.1. Discussion incentive

The discussion incentives have two different kinds of purposes, one being the guidance for when it is best time to call (presence information), and the second to work as content for the discussion. The presence information in social networking has become a standard, people express their current status by present, away and busy in most of the used services (i.e., Google, Facebook, Skype and Exchange). Though it can be debated whether the away status is meaningful from the mobile device perspective, unless it can be detected whether the user is really away from the location where the device is situated. When device is in user's pocket the likely status is present or busy. This common way of showing the presence can be enhanced by displaying the available status message. The status message can be the latest information the user have made available in the Internet in any of the available services. This information would also work as the content for the discussion. Other ways of sharing the discussion initiatives could be sharing the time, weather and location of the other participant. This may vary from person to person, as could also the amount of information visible on the list. The list could have more space reserved for the contacts that are common and close (family).

6.4.2. Smart list

Predicting the next likely contact to which user is going to use is essential. These categories presented in the following subsections are all needed at the same time. For example, the most often created call could be made to the closest family member (spouse), but also calls to one's relatives may follow a pattern occurring at a certain time of a week, month or a year. Recognizing a pattern is difficult and error prone. Certain patterns may exist during the on-going week, but disappears on the following week. It is therefore necessary to optimise the screen use for these categories so that for most of the users this would provide the answer, but at the same time it would provide easy access to the others, if the optimized list do not provide the wanted behaviour.

6.4.2.1 Most often used

The simple alphabetical list of contacts can be enhanced with data gathering. Collecting statistics for calling and messaging for a single contact can provide a prediction of who are the most often used entries. Current solutions usually offer the possibility to manually mark some of the contacts as favorite. But having the prediction of 3-5 most used contacts would likely provide automatically the similar results. It can be argued whether this will replace the manual favorite setting, as the user may want to have the possibility of inserting a favorite even though it is not often used, for example, an emergency number. The system needs to have enough intelligence to understand if a certain number is used only in messaging and it should not be offered in phonebook for calling.

6.4.2.2 Currently relevant

Further extension in predicting the wanted contact would be to understand which is the currently relevant contact. This is time dependent prediction, which means that at the present moment a certain contact may have higher relevancy than another. This functionality should not duplicate the information given in the previous category (most often used), even though some of the contacts may be often used and at the same time currently relevant. The relevancy would be predicted based on the information that is available on the device and in the cloud. Example cases that would likely provide a meaningful result from user's perspective include the following:

- An appointment with a person that is also available in the device phonebook, or a conference phone number that was attached to the calendar invitation.
- A friend has a birthday that is announced in the social networking service.
- A social cast news, say, an upcoming party.
- A published location in the social networking service.
- If a family member that is allowed to see the users location happens to be nearby.
- A missed call.
- Combination of users, if the user tends to call certain contacts one after each other. For example, based on previous behaviour the user has called first to the golf center, then to a golf buddy. Or when the user has received a call from his child he may be likely calling his wife next.

The time is the essential value for predicting the currently relevant contact. When will a contact start to be relevant, and when will it become again irrelevant? It is obvious that predicting the relevant contact for all previously presented examples may be very difficult and require a rather complex algorithm. Nevertheless, the system could already predict fairly simple situations, like listing a contact from which the user recently received a text message.

6.4.2.3 Recently used

Recently used category is already in use in most of the mobile phones. This is the call log. It provides the solution, for example, in cases where the user is following up on a previously occurred call, or it can enable the user to call back if the line broke during the call. It can separate information between the inbound and outbound conversations. The call log, as mentioned above is common functionality and expected feature when purchasing a phone from the current markets.

6.5. Intelligent energy consumption

As the energy is the most critical resource of a mobile device it is necessary to create a system that would save as much of the battery life as possible. There are several settings and algorithms that are already in use on the devices, trying to predict, say, when it is ok to dim the display based on what the user is currently doing. Often the selected behaviour is that during navigation task or while playing a video the display dimming does not occur, while reading a web page the brightness period may last longer. Detecting and recording the user behaviour during a longer period and more extensively may provide further results, and bring up differences between the users.

When optimizing the energy consumption of a device, the safest selection for behaviour change of the interface is the knowledge whether the device is connected to an outlet or not. If the device is connected and the charging has been completed, it can be assumed that the device has unlimited energy to consume. This would mean that device can be online and updating the databases as much as needed.

It would provide valuable information to detect the current location and movement and match the battery usage to these values. If the user is static, it is more likely that there is a possibility to charge the device. On the other hand, if user is on the move it is less likely that he would interact with the device. We can make a common prediction which services are meaningful while driving a car and which operations can be reduced, for example, email synchronization, RSS feed updates, social networking updates and Wifi network search cycles. This system would be error prone if it would not be able to study the pattern of behaviour. Can the system detect whether the user is driving a car, or sitting on the passenger seat? The user could be often travelling with bus, and actually would need the RSS feed updates, as that is his main interest during the trip. Or being static on a boat while fishing does not usually mean that there is a possibility to charge. Setting the presence status automatically to assume the user to be at sleep always from 10pm to 8am would also create many angry customers who work on three work shifts.

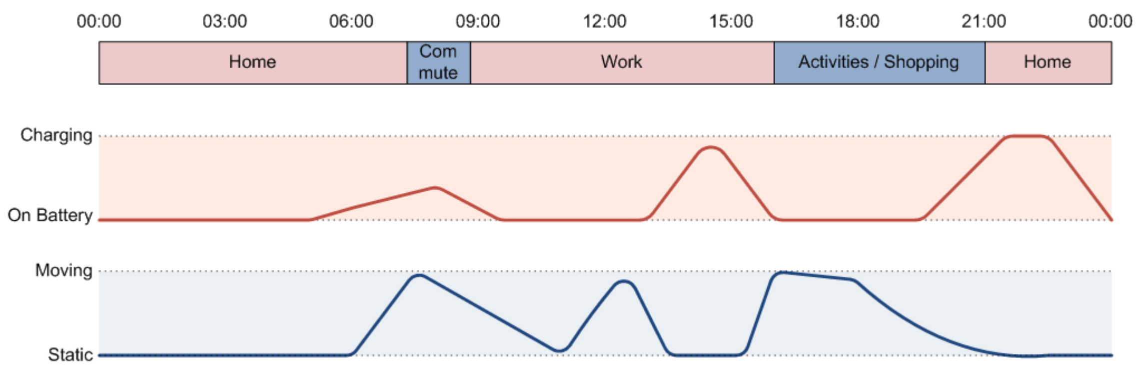

Figure 11: Pattern detection in energy consumption and charging

Knowing the patterns will provide better predictions. If the user behaviour is not within a previously detected pattern, the device should fall back to a default acting mode. A pattern would help in situations like reminding the user of charging in meaningful situations, for example before the user goes to sleep or during afternoons at work (Figure 11). The online presence could be turned off in case a sleeping pattern is detected and the device static, and not plugged in to a charger.

7. Acceptance of new solutions

The smart phone penetration statistics shows that the majority of people are not carrying devices that contain the enablers described in this thesis. The smart phone platforms are separated from the feature phones by, surprisingly, their features. The smart phone usually contains a camera and a GPS navigation unit, a high-resolution touchscreen and a web browser for viewing standard web pages, a high-speed data access via Wi-Fi and a mobile broadband. In addition, as they are platform based with a public API list, they have the possibility to run 3rd party applications.

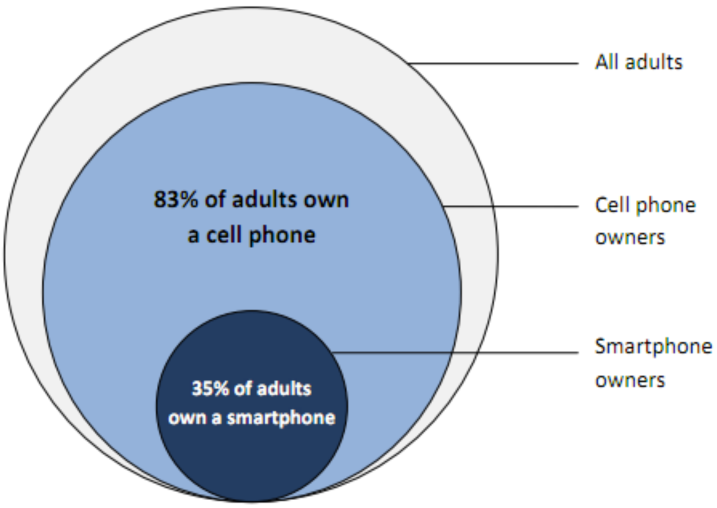

Figure 12: The Pew Research Center's Internet & American Life Project, 2011. n=2,277 adults ages 18 and older. Interviews were conducted in English and Spanish, by landline and cell phone.

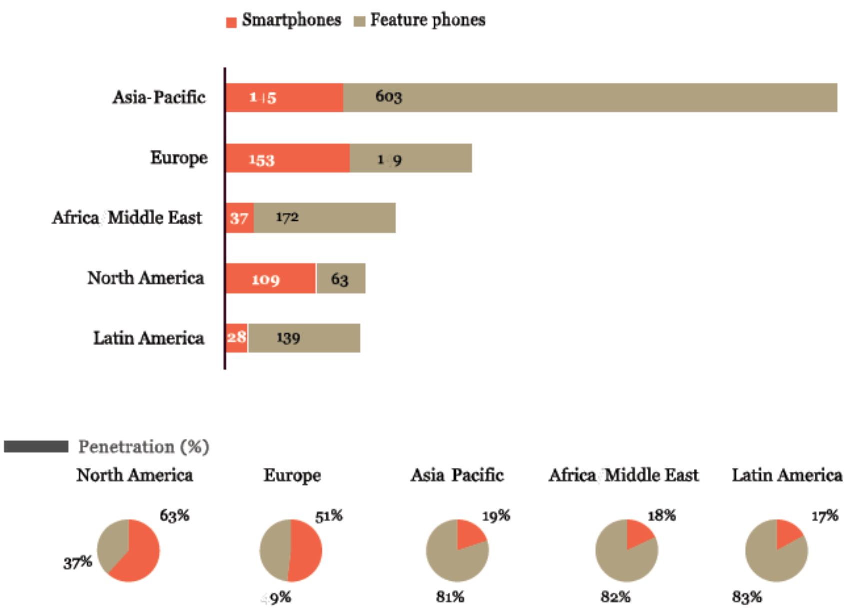

Figure 13: Smart phone penetration in different market areas [Vision Mobile Ltd.]

Pew research center studied the American phone penetration (Figure 12) with the result that 83% of all American adults ages 18 and older own a cell phone. Of these cell phone owners, 42% own a smart phone, which translates to 35% of all adults. Almost six in ten (58%) of these smart phone owners use a geosocial or a location-based information service of some kind.

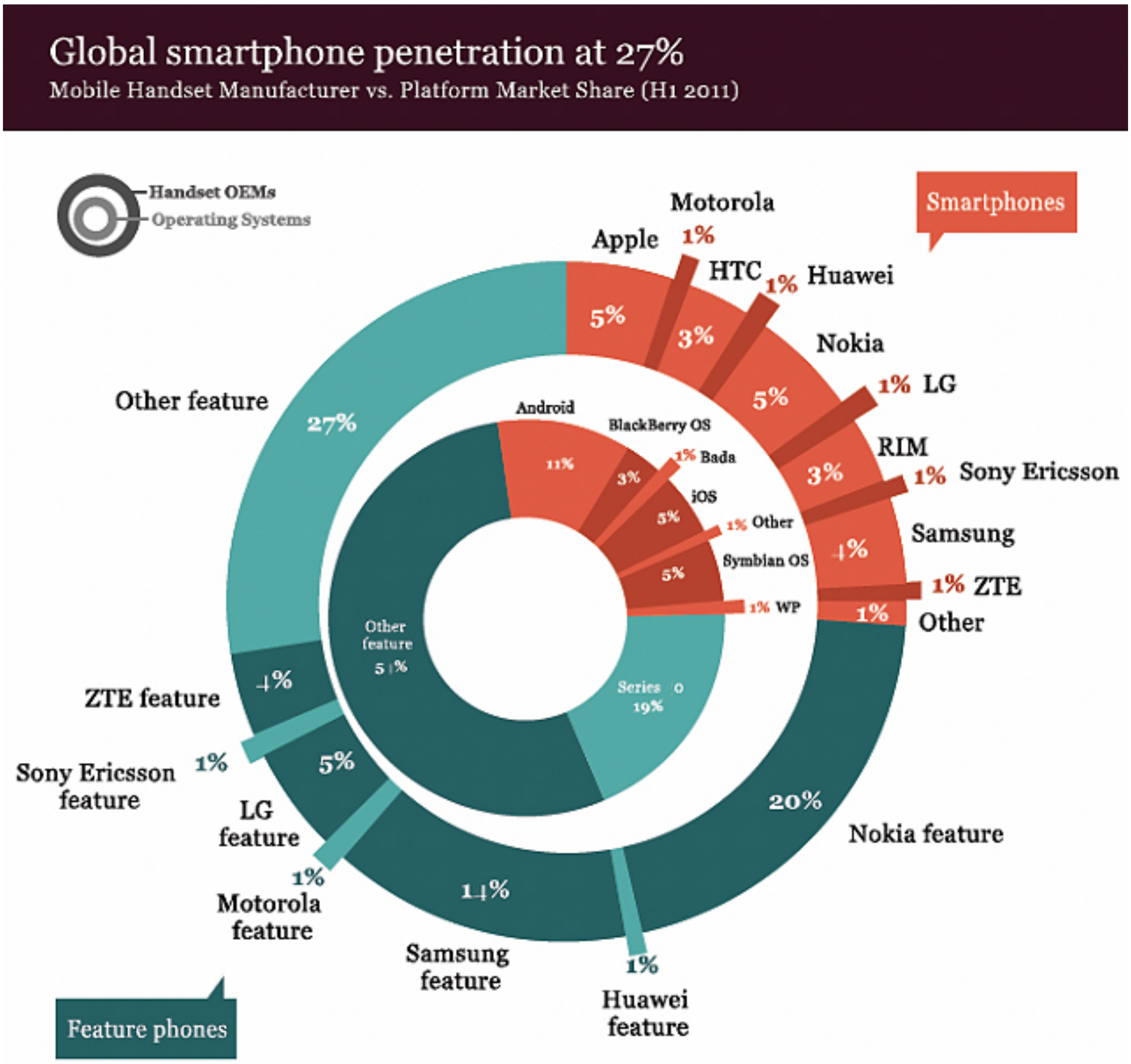

Figure 14: Global smart phone penetration 2011 [Vision Mobile Ltd.]

These smart phone penetration figures are from December 2011; in 2008 the penetration was still globally 11% according to the Vision mobile study [Vision Mobile Ltd.]. The growth to global 27% penetration is rather recent (Figure 13 and Figure 14). The growth is even faster in certain areas, looking only at the North American markets the smart phone penetration grew from 10% 2008 to the current 40% (Figure 15). In North America this assumedly correlates with the success of the iPhone (released 2007) and Android (released 2008) devices.

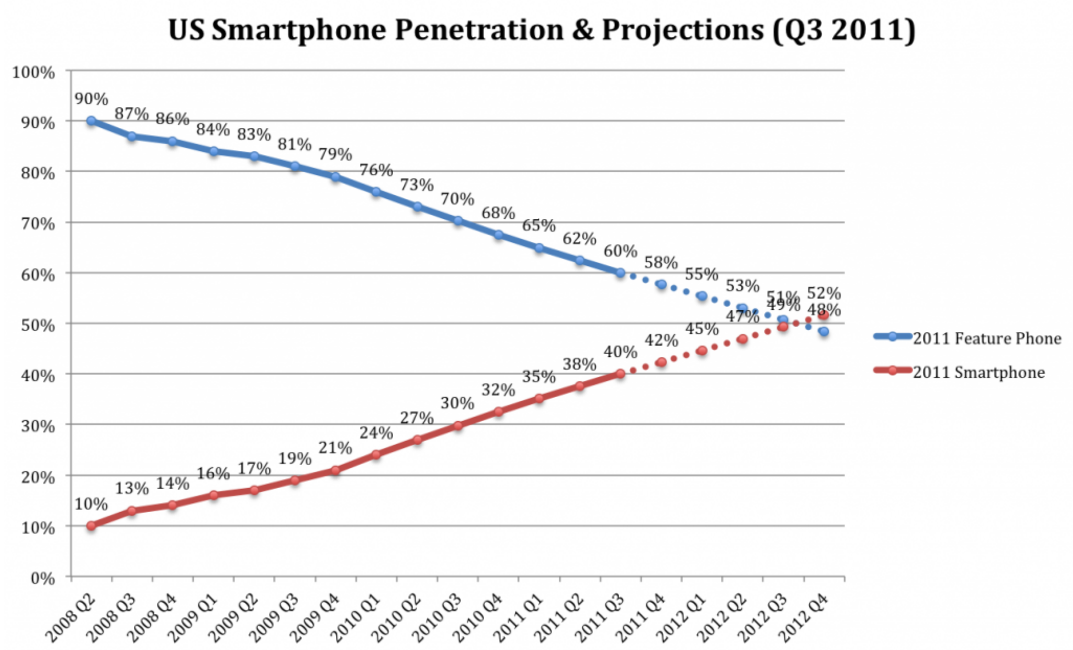

Figure 15: Phone penetration in US. Dotted line shows prediction. [The Nielsen Company]

The low penetration has a clear implication to the geosocial and collaborative applications, for location-based services and mobile gaming. The less people there are co-located or sharing the information in the same forum, the less meaningful content there is to maintain interest. The Internet collaboration tools (i.e., Microsoft live and Skype) and social applications (i.e, Google+ and Facebook) are still rarely optimized for the mobile environment. The sharing and collaboration is much different in situation when the user is browsing on a home computer, than when in mobile environment. The gaming industry is usually one of the firsts to explore new ideas and technology, but only recently the mobile gaming has been developing to a direction that takes the mobility and its possibilities into account. The glance of new possibilities when the smart phone penetration reaches higher marks can be seen in products: The Shadow cities, a game combining the location detection and social environment [Grey Area Ltd], Foursquare with business, promotions are gained when virtually logging into a shop [Foursquare Labs, Inc.], digital coupon services like Shopkick with the automatic recognition when user has entered to a shop or an area within a shop [Shopkick Ltd.]. Based on a study by Comscore mobile social networking audience grew 44% over the past year (2010) in EU [Comscore Inc.].

The fairly low penetration of smart devices during past years has a cultural impact in introducing the intelligent design overall. In large scale, understanding the new mental models and the acceptance of new design metaphors and interaction solutions materializes slowly. Introducing new interaction model to an existing platform may result to a rather vocal push back. When Facebook launched its new interface, over 1.5 million members signed in for Facebook group: “We Hate The New Facebook, so

STOP CHANGING IT!!!" [Facebook Inc.]. On the other hand, new market entries can create fast changes. The iPhone launch in 2007 set immediately a new standard for the mobile interfaces. Some people are more adaptable to change, embracing anything new and exciting. For others new things can be equally exciting, but the re-learning process comes at a cost. The association of learning is met with difficulty and the need to re-learn something can bring up regressive feelings. When a radical change is made to something 'already useful', but does not fundamentally change the experience, people rebel. Overall new technology makes people feel insecure. People pick their brands and hold them close to their chest. Just as the users like to explore new things, they are just as cautious as they have ever been, seeing most new things as a threat to long-term stability. Due to this all existing platforms are tied to evolution and new market entries can easier cause revolutions.

The public push back effect is only the tip of the iceberg - as the saying goes. The innovation acceptance within a company organisation has fairly similar structure as what we see in public. The innovation can start as a perfect idea on a designer's desk, or in a design group's whiteboard. From there it needs to enter the dungeon of acceptance in the company management. I would argue that the most marketing and selling of the new models happen inside the company. After the management is convinced to explore the idea more, the whole organisation needs to be convinced that the solution at hand is the wanted direction. While at the same time the original designer or design group can't lose their own trust on the innovation. In some cases the found restrictions on the way may alter the original design so that it is barely recognisable, but with enough perseverance, internal marketing and investments in the future the design can excel from the first step to the last. To better tackle the beasts in this kind of environment, it is obvious that at the beginning of an innovative product creation the organisation needs to consist of people that are willing to think in new ways. Also the less there are people working on the first versions, the easier it is to agree on the common target. At the later phase it is important to also convince the remaining audience in the organisation, including those who are not so willing to adopt into the new way of thinking. They usually try to challenge the ideas more and therefore help to find and solve every detail that is not yet recognized in the presented solution. Throughout the whole innovation and acceptance process it is necessary to produce material that explains the target design and interaction as clearly as possible. The pixel perfect visualisations, demos and prototypes that were created during the design process (Section 4.1) help efficiently in the internal marketing as well.

8. Discussion

The purpose of this thesis was to focus on near future possibilities when designing interfaces in mobile use scenarios. The current enablers in mobile phone technology, the enlarging smart phone penetration and the existing interaction models offer a solid ground to develop the next generation of interfaces in mobile environment. The recent figures in smart phone usage seem to be comparable to the diffusion of innovation curve [Rogers, 2003]. This can be taken as a evidence that the smart phones start to interest the late adopter segment. People need to get used to smart phones and current use concepts, such as the behaviour of touch screen controls, or feeling secure when managing the information of what users share to public, such as location. Deeper analysis on privacy concerns was left out from this thesis. The privacy overall is possibly the slowest moving particle in accepting new solutions. The trust is gained only by common understanding that a certain way is safe and no misuse has occurred. The privacy concerns should be taken into account when productising new solutions to ensure that they will not prevent or slow the adoption progress.

Through changing this mind-set and by building the trust, the more possibilities the designers will have to introduce new revolutionary solutions. The social environment is the current day's user guide. The more there is information that needs to be learned or understood, the more people rely on their social network for guidance.

The deepest pitfall in intelligent design is how to avoid annoyance, as the predictions need to provide assistance. It will be unpleasant for the user if the device keeps on guessing wrong or behave in unexpected way. Adaptation of interface should not disable or deny access to a service or option that has been there before. Some features like the intelligent vibra (Section 6.1), sharing (Section 6.2) and clock application (Section 6.3) are fairly safe solutions and will not cause confusion. By defining the levels of relevancy development (Section 5.3) we can set milestones for understanding the context and relevancy. To some degree it is possible to use these elements to create for example the phonebook application (Section 6.4) and as well the energy consumption feature (Section 6.5). To increase the intelligence of the interaction design even further it would be necessary to study the forgetting algorithms for recommendation systems. There is very little information available on how to handle the large databases so that the system could better understand what is relevant today.

What will be the impact of smart phones coming so popular? How will this change our behaviour and expectations? In 1997 Internet penetration reached 10% in developed world, by 2002 it reached 42% [Wikipedia], this is comparable to the smart phone penetration development from 2008 to the present. How we use the Internet has changed significantly after 2002. The next years will show what we really gain from having this much computing power in our pockets.

9. Conclusion

By the information presented in this thesis and the examples given, it is fair to conclude that intelligent design is at present possible, and it can provide assistance in everyday life. How this will be brought into users hands remains as the question mark. Creating revolutions in design requires determination and risk taking. This thesis was written to diminish that risk and help to understand that this is the obvious and clear path for the next generation of interfaces. As explained through examples, the intelligence can be brought into design with rather small steps. The static interfaces that are purely controlled by the user without any prediction, assistance or context awareness is ready to be left in pages of history. As people are getting familiar with the multimodal interfaces and their behaviour it reduces the learning curve which is needed to accept and understand the interfaces that adapt over time.

Creating a design revolution should happen in larger scale, in one big front and with a clear message. The intelligent design needs to be visible from hardware to software, throughout the whole device. It is for granted that the devices become more intelligent, acting as true companions for users. The revolution can start today.

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