

Possible Breakthrough Applications and Markets

Smartphones in Home Automation

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1 Abstract

This document is a technical essay which shows the possibilities of smartphones in home automation and assisted living.

2 Introduction

In the last few years, smartphones have become much more than a normal phone you use to call a friend or to send short messages. They are small gadgets, almost every person possesses at least one and they are increasingly powerful. So what is a smartphone and how can it be used?

A smartphone is a mobile phone offering advanced capabilities beyond a typical mobile phone, often with PC-like functionality. Smartphones run a complete operating system like Symbian OS and provide a standardized interface and platform for software developers. This platform offers developers as well as users to add any application for enhanced data processing, connectivity or entertainment. The difference to a conventional mobile phone like the Nokia series 40 is that these phones only support sandboxed applications in general. They are only capable of running applications like JAVA games or other platform dependent software tools. The major disadvantage of a platform dependent respectively JAVA based application is, that it is much slower than a Symbian application. Software may be developed by any software developer that has the knowledge to do so. Developers may be the manufacturer of the device that provides device specific software or the network operator, which offers third-party software to provide network specific tools like *assisted GPS*. In general any person that would like to program a tool to control any external hardware using the phone's technology and features or any person that would like to develop software for entertainment or any other commercial or non-commercial use case has the possibility to do so, since the operating system is open.

Concerning features, most of the *state-of-the-art* smartphones completely support full featured email capabilities and offer the functionality of an adequate modern personal organizer. Additionally, smartphones partially feature an extra interface such as a miniature QWERTY keyboard, touch screen, a built-in camera, contact manager, acceleration sensors or build-in navigation hardware just to give a few examples. Most of the devices are also able to open business documents in a variety of formats such as PDF or Microsoft Office. Smartphones which are based on a *Windows Mobile* operating system hardly differ in functionality to a conventional personal computer. Some smartphones are already powerful enough to play high quality computer games in 3D or broadcast TV on their well-resolved displays. As notebooks, also many smartphones are equipped with *wireless LAN* and have a pre-installed version of an Internet browser on the phone's memory. BlackBerry for example even offers secure access to company mail although many big companies such as IBM block this feature.

All this enabling technology lays the foundation for the use of smartphones

to simplify life. So how could these high tech gadgets be used to contribute to daily life and assist living?

3 Smartphones for Assisted Living

Assisted living and home automation is a field within building automation. It deals with automation techniques of private homes for the comfort and security of its residents. This chapter discusses the possibilities and prospects but also the constraints of smartphones in terms of home automation and assisted living.

4 Home Automation and Sensor Networks

The target of home automation is not only to control the environment using a remote control, but also making the environment more intelligent so it can react to a person's presence. Therefore miscellaneous sensors might be used to collect data from the environment such as temperature, volume and brightness. Instead of installing high-tech home automation computers, a smartphone, which in some cases already has the corresponding software to evaluate test results from these sensors or even are equipped with sensors on its own, can act as the brain of a home automation system and moreover coordinate subsystems over network connection. The smartphone can sense that it is carried into the house and tell the building that it is occupied and to automatically start the heating. The other way round, the house could sense, that the mobile phone has left the house and set the heating or air conditioning to an energy saving mode.



Figure 1: NFC-Hardware used for the protection of a ski.

More sophisticated systems can maintain an inventory of products, recording their usage through an NFC tag, send the data to the mobile phone and prepare a shopping list. The user just needs to confirm the proposed order and the

mobile phone might order the products at a online store featuring suppliers that deliver the goods directly home. Especially handicapped persons may profit from such a sensor network. Smartphones that monitor particular states of health such as blood pressure, heart frequency or blood sugar already exist. In combination with additional sensors, elderly people that depend on home care might regain a certain amount of autonomy. The smartphone can detect a collapse respectively a downfall and alert the nurse or call the ambulance or also transmit blood test results every now and then. Furthermore, wheel chairs equipped with acceleration sensors might also indicate a downfall and send a report to the mobile phone which alerts the nurse. With *radio frequency identification (RFID)* the nurse might check the medicine chest at the office and bring fresh supply if required.

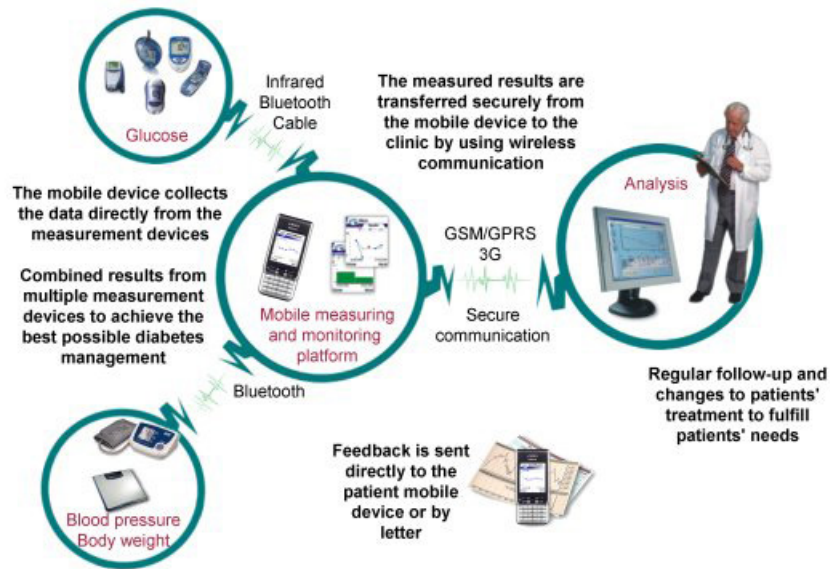


Figure 2: Smartphone model for health care issues.

The whole coordination may be handled with a single small gadget in combination with an electronic environment. The smartphone might assure autonomy for handicapped persons and simply the work for the nursing auxiliary. In case of an accident emergency aid may administered much faster to casualties or even immediately. It follows from the above that a smartphone might increase the anticipated average life of handicapped or elder persons. Moreover it might be cost-efficient because smartphones are equipped with these sensors anyhow and software is not the problem.

4.1 The Jungle of Remote Controls

In a modern household, many electronic devices like TV, the radio or any other home entertainment system are ubiquitous. To control these devices, a person needs loads of bulky and unhandy remote controls, which look similar to each other and for the user it is prevalently complicated to distinguish between the remote control for the TV and any other device. This is where the smartphones come into play.

As already mentioned in the introduction, more and more smartphones feature touch screens and large displays. Moreover they are equipped with radio technology such as *infrared*, *bluetooth* or *wireless local area network*. Some of these technologies like *bluetooth* or *infrared* are used by conventional remote controls to control the appropriate entertainment systems. Simple software tools for smartphones can displace these old fashioned and unhandy remote controls. Instead of loads of plastic remote controls one single smartphone with a diversity of small software tools may be enough to control every single gadget within the entire household.



Figure 3: Smartphone as remote control.

As to home automation in general, a smartphone might also provide additional information and event driven tool tips on the display, which a conventional remote control cannot offer because they are normally not equipped with a display. In this case, the user has to read the manual and he does not get any information tailored to particular tasks. Concerning the remote control issue smartphones might provide functionality a standard home automation

system perhaps could not. A light system that provides just a single function for switching the light on and off might profit from the use of a smartphone as controller. The software running on a smartphone can be enhanced or modified at discretion. This fact opens manufacturer independent developers the doors for *open source* projects and individual remote controlling systems. In terms of the example named above, the software for the control of the light might offer functions that are more sophisticated such as a timer function, which turns the lights on or off at a certain time or a function that is event-driven and reacts to the presence of the mobile phone for example. The roller blind may close itself because the mobile phone "*knows*" when it is getting late or realizes when the user wants to watch a DVD in his home cinema.



Figure 4: Interaction with TV set.

The example above is the proof that event oriented features are not only possible or science fiction, they are already possible nowadays. The smartphone might just make it once more easier for the user to interact in a natural way with his environment. The smartphone might be responsive to its environment and automatically turn down the volume of the radio or pause the DVD on an incoming call or any other event that occurred within the home automation network. Smartphones equipped with sensors for heat may regulate the room ambient temperature without the need to bother the user. Not only in this case smartphones, being sensor networks themselves, interact with another sensor network. The smartphone in connection with network technology might use all registered sensors to cooperatively monitor physical or environmental conditions including temperature, sound volume or other environmental impulses mentioned above.

4.2 Near Field Communication

Near Field Communication (NFC) is a short-range wireless communication technology. Some mobile phones like the *Nokia 6131 NFC Edition* already feature NFC readers and allow the exchange of data between the mobile phone and any interface that is equipped with an external NFC reader. The equipment is not very expensive and affordable for nearly everybody. There is not a large market

at the moment but the capabilities are widespread.

4.2.1 Comfort Issues

As already mentioned before, *Near Field Communication (NFC)* and *Radio Frequency Identification (RFID)* are both state-of-the-art technologies that have a hand in home automation either in security relevant topics or in comfort issues.

Passive NFC tags might contain any information. These tags may contain specific information about rooms or devices. NFC capable smartphones have the possibility to interact with NFC tags and with the appropriate software it is able to understand and interpret them and to be responsive events for instance. Small NFC tags affixed to a door frame could store proper information for this room. This information can be used to boot automatically remote control software on the mobile phone by touch. Additionally, guideline values for any of the smartphone's sensors which shall be active in this room may be downloaded.

Besides the just given example, the only appropriateness of remote controls is not just to enable or disable a device. Certainly, a DVD recorder provides functions for recording a DVD. Therefore time, date and a channel needs to be entered manually. NFC technology could ease this procedure. Passive NFC tags may be integrated into the TV guide storing information of movies and TV series. A smartphone might be used for programming any DVD recorder by just touching the right tag in the TV guide. In the future movies will not be stored on DVDs or any other disks. Enormous hard drives will replace them and probably store hundreds of movies on the disk. Instead of going down such a list step by step, the smartphone might use NFC tags to load the desired movie.

4.2.2 Security Issues

NFC technology also opens the door for security relevant topics. Instead of a common door lock, a NFC based terminal might provide access control for any building. Presumably, this is not a complete new thought. But probably new is that not a key card is the key for the door but a smartphone. If a conventional key of a standard front door nearly every person have in their houses is lost, the lock and all corresponding keys must be replaced. The labour time of the service man, the keys and the lock sample money and the whole changing process is getting expensive. If the smartphone is lost, a new access key can be applied to it easily preconditioned the user has the rights to do so. By dint of the right software the system administrator that is normally the owner of the house might handle this situation on his own at a minimum of complexity. There is no need to go for a service man or spend money for any equipment.

As already mentioned NFC technology is not widespread so far although they are not very expensive. Within a few years an electronically controlled door lock might be as cheap as a conventional one. Moreover, features like temporary access may be possible side effects of this outstanding technology. There is no longer the need for giving the door key to the cleaning woman. With a smartphone the option of limited access is provided. Access to the

house might be just granted on a certain day over a certain period of time. At the same time, this technology enables access monitoring. The owner of the house might receive an short message when the cleaning woman enters the house and another one when she leaves.



Figure 5: Possible connection to any hardware or remote system.

Because the entry system would be a subsystem of the home automation system, it might be connected to the alarm system, which is also a subsystem of the home automation system. If the entry system is manipulated or damaged, the system might inform the owner via short message and automatically call the police. The faster the police is called the better the chances to catch the intruder. From this it follows that smartphones in connection with home automation systems might be appropriate to time critical applications.

5 Beyond Home Automation

Smartphones combine the scope of supply and services with the functionality of a *Personal Digital Assistant (PDA)*. Because they are small, these devices are always carried around by their owners. From that it follows that home automation is not the end of the technical evolution. Carrying the mobile phone around makes a computer always available, a computer that is able to communicate via sensors with its environment. This goes by the name of *ubiquitous computing*. Users are able to benefit from the advantages a smartphone may also provide for home automation.

Every second household already possesses at least two cars. For each car the owner gets two keys. But sometimes there are more people in a household which like to drive the car and they need to borrow a key. If the owner forgets the key in his jacket and takes it with him to work, the other people that would like to drive the car simply cannot because the key is not available. At that point smartphones may help. Instead of using conventional keys, which are partly already electronically controlled, a smartphone might adopt this job.

A NFC capable smartphone might be equipped with the key for the car. The car would need a RFID reader to perceive the mobile phone close to itself. This technology is not new at all. Renault for example already uses tiny plastic cards which interact with radio technology with the car. It is not even necessary to put the key into the ignition of the car. It is enough for the car that the card is within it. Instead of using this plastic keys, smartphones might be used. The big advantage smartphones can offer is advanced information and functionality because of the display and an interface that makes it possible to communicate with the device. If a conventional key is lost or stolen, a thief simply may use it to also steal the car. If the smartphone containing the key for the car is stolen with intent to also steal the car, the owner might just delete the key on the smartphone due to any external software on a personal computer that is able to create an uplink to the smartphone's car control tool. Also a subsystem in the car could be integrated which bars thieves from starting the engines of a car. This subsystem may be activated via smartphone and send information about the car's location to the next police station.

Moreover, the smartphone may serve as external communicator between the board computer and an external person which could be the administrator of a forwarding company. The smartphone might transmit information about mileage, actual position and also calculate whether the transport is in time or not. A car renting agency might loan temporary keys for their keys in form of an electronic certificate. For a thief it would be useless to steal a car which is controlled by a key that is merely valid within a certain period of time.



Figure 6: TDS-S system prototype.

In connection with NFC technology smartphones can be used for nearly all security relevant issues, providing loads of functions for every single scope. With the project Theft-Deterrent System for Skis we showed, that a mobile phone can be used to program skis directly on slopes and to secure them electronically from being stolen. A smartphone is able to extract a unique serial number which is stored in the users ski. This serial number can be transmitted to the binding

of the ski. Before the mobile phone transmits the serial number, it ciphers the information so it is immune against manipulation by thirds. Moreover, the smart phone is able to control an alarm function, which is integrated directly into the binding of the ski. In the near future the smartphone will be able to notify its user about any theft of the skis. In combination with acceleration sensors the ski is more intelligent. It is able to transmit acceleration to the smartphone and the smartphone decides whether the ski is carried away or just falls to the ground.

This technology might also be used for a completely different topic. Professional skiers could use the acceleration sensors in combination with the smartphone for training methods. The mobile phone uses the data received by the ski and either evaluate the information directly or send it via GPRS or UTMS to any server that is able to interpret it. Subsequently the interpreted outcomes might be send back to the skiers smartphone. Additionally, a centrally located smartphone, for instance the coach's one, could use the racers' smartphones as slaves and download the test results.



Figure 7: Configuring a ski using a smartphone.

6 Conclusion

At the moment, all these technologies may not be fully developed but the only constraint is the developer's imagination. Maybe the major challenge concerning this scope is the linkage between every single system, the requirement to combine various subnetworks in order to create one big one. For a simple user it is necessary that he has the feeling of communicating with an intelligent being rather than hammering commands into a brainless machine. Neuronal networks and artificial intelligence which are partly required for sophisticated and complex applications are computationally intensive. Although many of present-day smartphones are fast and feature enormously big memories, this will not suffice

at all.

Many of the devices or technologies needed for some of the examples mentioned above are technically mature and already exist in parts. All those masterminds, developers and contrivances just have to go on in what they are already doing: Writing down new ideas and trying to implement them.

In many of the given examples, also security plays a big role. These systems must be resistant against manipulation and hacking by any individuals. Without security, the whole system is not worth a cent. Customers of such a system want to feel safe within their own four walls, thus a system that has security lacks will not sell quite well. It is up to any developer to invent completely new concepts for home automation and ubiquitous and it will not take long until people interact with smartphones using human body interfaces, which are microprocessors directly implemented into a person's skin. What has been sheer lunacy a few years ago is already reality at this stage. There are undreamed-of possibilities within the field of mobile computing and the very thought of an invention may change the world.