Towards Preventive Healthcare through the Use of Smart Mobile Devices

Rebecca Kunze
Atos Information Technology
Munich, Germany
rebecca_ku@web.de

Dominik Klomann
Boehringer Ingelheim
Ingelheim, Germany
dominik-klomann@live.de

Meike Bremmer
Boehringer Ingelheim
Ingelheim, Germany
meikebremmer@web.de

***Abstract*—Through the digital transformation, we experience massive changes in all areas of our lives including the health sector. The trend of smart mobile devices such as smartwatches has experienced strong growth in recent years. This paper takes advantage of their technology and shows an idea of how smart mobile devices can be used in the healthcare sector by evaluating opportunities and risks.**

***Index Terms*—mHealth, eHealth, smart mobile devices**

I. Introduction

Through the fitness movement, smartwatches, life trackers and wearables have undergone rapid development [1]. Reasons for this are an increasing health awareness of the population and the increasing digitisation of society [2]. Thereby smart mobile devices serve a growing need: building an ecosystem in which one's data can be monitored permanently and everywhere.

By combining the advantages of the smartphone, such as the transmission of messages, Bluetooth, GPS and the internet with the recording of health-related data, data-gathering devices like smartwatches become more attractive. Moreover, it allows data to be collected, but also to be further evaluated, processed and compared. This leads to the fact that their development is constantly being pushed forward [3]. As already indicated by Schobel et al. [4], using smart mobile devices can avoid the setbacks of paper-based methods like surveys or queries. In addition to the term eHealth, the term mHealth, mobile eHealth (solutions) [1] became established dealing with portable electronic devices (see figure 1). These terms stand for several expectations that have to be met by digitisation in the health care system to create simpler, faster and improved care and to simplify documentation and communication between different stakeholders.

MHealth creates opportunities to develop solutions individually adapted to each patient. But one of the biggest challenges is it to develop applications and platforms that can adapt to the constant development of new technologies and at the same time face their challenges.

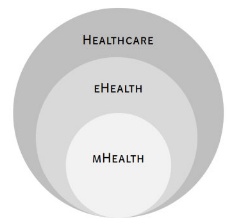

Fig. 1. healthcare, eHealth and mHealth

II. State of the Art

The idea of using smart mobile devices like smartphones to collect health-relevant data is becoming more attractive. In a case study of the Swiss University [5], a smartphone application was developed which can be used to obtain health-relevant data in tropical and subtropical locations during travel. Gaggioli et al. [6] already developed a phone platform with which they could collect users' psychological, physiological, and activity information for mental health research. The user receives daily self-report questionnaires to answer. Information was collected via wireless electrocardiogram heart rate and activity. Another example shows Mimi [7], which is an app that uses a quick test to determine whether a hearing loss is present. The product is CE-certified as a medical device in the EU. Besides, the app Preventicus can check the heart rhythm via smartphone rather quickly, reliably and accurately [7]. IEpi, an app developed by Knowles et al. [8], based on simple extension and reuse of subcomponents, allows flexible adaptation for different purposes, for example, for recording activities to investigate their impact on health outcomes.

Nevertheless, all approaches mentioned so far as well as the gaps that already existed beyond them are left open. What Blobel and Holena [9] describe in their 1997 report is now to be developed namely via an app. That development requires improved communication and cooperation of different organisations, institutions, and persons involved in healthcare as care providers. The solution proposed is an application and platform for the reliable, secure and trustworthy collection, analysis and provision of health-relevant data to selected stakeholders. An application that can integrate into any smart device leads to the opportunity to analyse collected data and appropriate responses communicated to selected stakeholders by building a sharing network. Moreover, early detection of risks of diseases and dangerous medical conditions is possible with preventive and interventive measures.

III. Proposed Approach

A. General Idea

The transition from generalised to personalised healthcare as well as the goal of focusing on preventive measures rather than the treatment of medical conditions [3], requires a massive amount of qualitative data to be collected, stored, analysed and shared with selected stakeholders.

As a result a framework for reliable, secure and trustworthy collection, analysis and provision of health data to selected stakeholders is needed. It shall mainly make use of the advancements in mobile data collection [4] through the rise of smart mobile devices. It is therefore proposed to use such devices to enable a channel of continuous health data provision. Further, such data shall be used to continuously evaluate medical conditions, identify risks early and share information with dedicated stakeholders, thus allowing preventive measures. Hence the use of Artificial Intelligence (AI) technologies is suggested.

In addition, forming powerful partnerships with technology or healthcare institutions is highly recommended due to the high complexity of healthcare itself. Further, Setbacks of paper-based methods (e.g. surveys, queries, etc.) [8] are to be eliminated step-by-step.

B. Involving Continuous Engineering Practices

Apart from a continuous data provision the application of *continuous engineering practices* [10] is key to the approach stated. Future development must at least consider a subset of these practices in order to be able to allow further adoption.

Firstly, the healthcare environment is constantly undergoing changes in legal, regulatory and technical matters. This requires the practice of *continuous planning* to be established in order to ensure adaptability and constant communication with all stakeholders (e.g. patients, medical practices, hospitals, etc.) involved. In consequence quick and appropriate responses to impacting changes are enabled.

Secondly, the practices of *continuous run-time Monitoring* and *continuous testing* shall find application. It is crucial to constantly enhance and optimise techniques for reliable data collection and analysis to allow appropriate diagnosis and their respective responses. Moreover faults and errors must be identified as soon as possible when dealing with health-relevant data. Therefore medical professionals and scientists shall be collaborating to constantly improve diagnosis methods and preventive measures or indications.

Furthermore, the practices of *continuous security* as well as *continuous trust* must be considered. As processing of health-relevant data is highly sensitive, appropriate information protection is key to creating a trustworthy handling of such. Further, the use of the proposed framework is highly dependent on the trust of all stakeholders involved, especially patients' trust. Therefore it is crucial continuously renew and strengthen the trust by involving the evaluation of (data) security matters in all steps of development and operation. Nevertheless certain risks are to be taken into account and will be further evaluated within the discussion.

IV. Proposed Architecture

A modern, future-oriented, upgradeable and extendable architecture builds the basis for the successful application of the proposed approach. Nevertheless it is vital to build a foundation by orienting on well-established concepts (e.g. client-server, cloud concepts, Artificial Intelligence) that allow further extension in the future. Therefore the proposed architecture (see figure 2) combines both proven and new elements to allow further adoption and evolution.

A. Data Sources

As most of the predictions and enhancements in healthcare rely on data, it must be ensured that as many data sources as possible are integrated into the architecture. The following data sources are proposed.

*1) **Smart Mobile Devices**:* Based on the ongoing rise of smart mobile devices [1] such as smartphones, tablets, wearables etc. and their respective data caption capabilities [1] it is essential to include them as major data collectors. Their ability to monitor different parameters (e.g. heart rate, blood pressure, activity levels, usage behaviour, GPS position, etc.) offers a window of opportunity for a recurrent data collection and comparison. In addition, multiple methods such as photoplethysmography or AAl support systems can be used to acquire different parameters of health.

*2) **Webbrowser & Manual Inputs**:* Nonetheless there still are factors and additional information that (yet) cannot be captured reliably with digital devices or sensors (e.g. feelings, allergies, etc.). Therefore it is necessary to allow manual triggered inputs within a Web Interface and a respective mobile App. This information shall help complementing the automatically captured data.

*3) **Medical Records & Medical Practice Connectors**:* Medical history and historical data is key to further evolution in terms of treatment or prevention of medical conditions. Thus it is necessary to provide and use connectors to existing medical practice software as well as manual inputs for questionnaires that broaden the medical records.

Fig. 2. Proposed Architecture

*4) **Existing & Future Scientific Data**:* Partnerships and cooperation with scientific institutions represents a major aspect of the proposed architecture. As further enhancements and extensions of Artificial Intelligence (AI) requires as much qualitative and quantitative input as possible, the partnership with scientific institutions is considered a major aspect.

*5) **Health Insurances**:* Apart from medical practices and the patients themselves, health insurances play an essential role in most health care systems. Health insurances can be both data provider and data accessor and must therefore be included in the architecture.

B. Cloud Architecture & Access Controller

As it is for many cloud architectures, it is crucial to work with a number of distributed and interconnected servers serving as the "cloud". Those servers shall process, combine and join data from the aforementioned data sources and shall be monitored closely by operations.

*1) **AI Component**:* Artificial Intelligence (AI) is a crucial factor in future healthcare [1]. Hence it is inevitable to include an AI component. The entire component shall not be limited to relying on a single form of AI, but rather be made of a combination of AI technologies (e.g. machine learning, neuronal network, etc.) to achieve optimal results. However, it is crucial ensure that quality as well as compliance is always being monitored closely by medical and scientific professionals. Despite that AI technology is very resource consuming and expensive to create and maintain. Thus it is to be considered a major architectural driver.

*2) **Backup Storage**:* Despite all efforts for using modern technologies and apply agility, it is essential to obey the rules of proper data management. This involves the use of appropriate and secure backup storage. As the amount of data is most likely to soar throughout time, extendability must be ensured.

*3) **Access Controller**:* Dealing with health-relevant, highly personalised and sensitive data requires high-level security as identified earlier. Required by law as well as for providing trust to patients themselves, it must be ensured that access to data is conditioned on proper authorisation. The access controller is the central element for controlling which of the stakeholders is allowed to see a defined amount of (anonymised) data. It shall mainly allow the patient to configure Access rights.

V. Discussion

The idea of eHealth, which is the root of mHealth as well, came up for the first time more than 20 years ago and it is not without a reason that it has not established as the common health system up to now. Back then, technical frontiers have been a main reason to a limitation of use. With the further development of mobile and medical-technical devices, the cloud established as well and the idea of electronic support in the healthcare sector became theoretically feasible. But at the same time, legal restrictions concerning data protection have become stricter and data collection, especially this highly sensitive health-related data, is connected to high safety measures. For that reason, the architecture of this framework still leaves room for ideas that cannot be realised for the protection of personal data.

The described access control can be seen as a opportunity, but also as a problem. Since highly sensitive data is involved, the handling must always be secure and traceable. For these reasons, the patient needs to approve the assignment of access rights regularly. Nevertheless, the assignment of access rights is difficult and, in case of doubt, depends on the specific case. Additionally, the number of mobile subscribers needs to be considered as well. Although the usage of smartphones and other mobile devices has increased significantly until now, even in 2025 not everybody will have a mobile device available. Yet, the number of 5.8 billion mobile subscribers [11] gives a hint of how the progress is going.

It must of course be borne in mind that care must also be fully guaranteed for patients without access to digital healthcare. This particularly concerns elderly people. Nevertheless, communication with patients must be designed in such a way that everyone, regardless of age or origin, can take advantage of the digital change in terms of their health. A user-friendly interface with easy to learn and intuitive operation might facilitate handling. At that point it needs to be very clear that the suggested platform can and does not replace a doctor or an ambulance, but the doctor's access to medical data can accelerate the process of getting well and especially in the field of prevention of illness, the generation of a digital image of the patient can lead to big steps in terms of early recognition.

A. Challenges

A challenge yet to be overcome is the dependence on manufacturers. This leads to barriers when it comes to compatibility because some manufacturing companies construct their devices not to be compatible with other manufacturer's devices. This also concerns the quality of measured values. Pedometers, for example, can easily be deceived which leads to inaccuracy of calorie combustion. Incorrect data can have negative effects on the evaluation and falsify it. For that reason, it is unavoidable to reduce inaccuracy of measurement before the data can be meaningful about the health status of a person. The rapidity of development of mobile devices is also a problem for the user who is forced to buy a new version of his device regularly if he intends to use the newest technology.

B. Opportunities

On the other hand, mobile health offers many possibilities with regards to the future. The rapid development of the medical and pharmaceutical industry as well as technical progress of sensors promise fast improvement of measurement accuracy. Furthermore, cost savings are expected due to multiple reasons: A health-conscious lifestyle results in a decreasing susceptibility to disease and in consequence to less cost for medicine. Additionally, the need for care for elderly will decrease in the long term. Patient-oriented communication coupled with a quickly accessible platform on which health data can be read is a major and important step in the healthcare system for the benefit of users.

Ultimately, the desired goal is preventing diseases instead of treating them [3].The permanent monitoring of patients makes it possible to detect any deterioration in their health at an early stage and to better interpret and treat symptoms in the future.

VI. Conclusion

The mobile health sector is continually growing with a high potential on the market [12] as it supports what is consolidated in our primary instinct since the beginning of evolution: Being healthy. The development profits from growing interest and promises a future-oriented development of the health sector within the next years. It is recommended to further investigate an appropriate assignment of access rights as this represents a vital issue in healthcare. Although the above-mentioned risks need to be considered, the industry has great potential to embrace the latest technology and use it for the benefit of patients worldwide.

References

[1] D. Bienhaus, "Smartwatch and Wearables im Gesundheitsbereich: Grundlagen und Anwendungen", Gesellschaft für Informatik, Bonn, 2016.

[2] D. Matusiewicz and L. Kaiser, Digitales Betriebliches Gesundheitsmanagement. Springer Gabler, Wiesbaden, 2018.

[3] R. Moses, B. Hurley and Nairita Gangopadhyay, "Forces of change - The future of health", in Deloitte Insights, the Deloitte Center for Health Solutions, 2019.

[4] J. Schobel, R. Pryss, M. Schickler and M. Reichert, "Towards Flexibly Mobile Data Collection in Healthcare", in IEEE's 29th International Symposium on Computer-Based Medical Systems, IEEE Computer Society, 2016.

[5] A. Farnham, U. Blanke, E. Stone, M. A. Puhan and C. Hatz, "Travel medicine and mHealth technology: a study using smartphones to collect health data during travel", Journel of Travel Medicine, International Society of Travel Medicine, 2016.

[6] A. Gaggiolio, G. Pioggia, G. Tartarisco, G. Baldus, D. Corda, P. Cipresso and G. Riva, "A mobile data collection platform for mental health research", Springer-Verlag, London, 2011.

[7] C. Bauer, W. Gründiger, T. Hauk, E. Kendziorra, M. Kisser, R. Köhler, J. Meiser, J. Scheider, N. Wohlgemuth and C. Wrobel, "Mobile Health im Faktencheck - Oft gehört, gern geglaubt: Antworten auf Mythen und Halbwahrheiten zu digitaler Gesundheit", Bundesverband Digitale Wirtschaft (BVDW) e.V., Düsseldorf, 2016.

[8] D. L. Knowles, K. G. Stanley and N. D. Osgood, "A Field-Validated Architecture for the Collection of Health-Relevant Behavioural Data", IEEE International Conference on Healthcare Informatics, IEEE Computer Society, 2014.

[9] B. Blobel and M. Holena, "Comparing middleware concepts for advanced healthcare architectures", International Journal of Medical Informatics, vol. 46, Elsevier, 1997.

[10] B. Fitzgerald and K.J. Stol, "Continuous software engineering: A roadmap and agenda", in The Journal of Systems and Software 123, Science Direct, 2017.

[11] J. Stryjak and M. Sivakumaran, "The Mobile Economy 2019", GSM Association, 2019.

[12] A. Author, "Digital and Disrupted: All Change for Healthcare" by Roland Berger GmbH, 2016.