5-24-2013

Context Aware Mobile Knowledge Management System in Healthcare

Sandeep Lakkaraju
Dakota State University, slakkaraju@pluto.dsu.edu

Context Aware Mobile Knowledge Management System in Healthcare

Sandeep Lakkaraju
Doctoral Student, Dakota State University
slakkaraju@pluto.dsu.edu

ABSTRACT

Clinical practitioners need to have the right information, at the right time, at the right place; which is possible by mobile healthcare. It is not only important for them to have the right information, but they have to manage this right information with proper knowledge, which requires the skills for efficient knowledge management in a mobile healthcare setting. Utilization of mobile devices in healthcare to share knowledge may not only improve the decision taking time, but also reduces the medical errors and costs involved. Need for this information sharing may often be required across various hospital staff that play variety of roles (as practitioners, nurses, administrative staff etc.) and works in multiple schedules (work shifts: night, day etc.), resulting in need for proper 'context aware' knowledge. This research paper is an attempt to develop a context aware model which can help the healthcare organizations in efficiently practicing the knowledge management in a context based mobile healthcare setting.

Keywords

Context awareness in healthcare, mobile devices in healthcare, knowledge management in healthcare

1. INTRODUCTION

According to a report by the Institute of Medicine (IOM) in 2000, 'about 98,000 people are dying in the United States of America just because of medical errors' (Kohn, Corrigan, & Donaldson, 2000). With the use of proper alert mechanisms in the healthcare organizations, these medical errors can be prevented (Dawes & Sampson, 2003; Orzano, Mcinerney, Scharf, Tallia, & Crabtree, 2008). Studies on mobile knowledge management (MKM) exist that focus only on issues of mobile learning and context oriented mobile knowledge management (Balfanz, Grimm, Tazari, & Datenverarbeitung, 2000; Räisänen, Oinas-Kukkonen, Leiviskä, Seppänen, & Kallio, 2010; Zuga, Slaidins, Kapenieks, & Strazds, 2006), however there exists limited focus on application of context aware MKM (CAMKM) in healthcare.

Over the years, researchers working on mobile device application in healthcare have concentrated more on addressing technical issues neglecting the 'user-centered' aspect (Chevrollier & Golmie, 2005; Prestigiacomo, 2011; Vawdrey, Hall, Knutson, & Archibald, 2003; Waegemann & Tessier, 2002). There are many research studies on knowledge management in healthcare (Dawes & Sampson, 2003; Hsia, Lin, Wu, & Tsai, 2006; Orzano, Mcinerney, Scharf, Tallia, & Crabtree, 2008), and various other studies on mobile healthcare management (Mathur, Ramachandran, Cutrell, & Balakrishnan, 2011; Ondash, 2004; Vawdrey et al., 2003; Waegemann & Tessier, 2002), and other studies on mobile knowledge management (Balfanz et al., 2000; Derballa, 2006; Grimm, Tazari, & Balfanz, 2002; Thiele, Knapp, Schader, & Prat, 2006). Although research exists on application of mobile knowledge management in healthcare, there is need for proper context aware models for knowledge sharing across a healthcare organization (Alonso, Tapia, García, Sancho, & Sánchez, 2011; Silva & Arsenio, 2011; Viswanathan, Chen, & Pompili, 2012).

Medical errors and costs can be reduced by sharing knowledge and using innovative technologies (such as mobile devices). There is need for proper 'context aware' knowledge to be available for healthcare personnel (ex: practitioners, nurses, administrative staff etc.) who works in multiple shifts (work shifts: night, day etc.), (Bossen, 2002; Reddy & Dourish, 2002). This research paper consists of literature review of context awareness in healthcare, mobile device application in healthcare, and knowledge management in healthcare setting, followed by identifying the system perceptions and requirements for this current context aware model, and the research paper will be concluded by the discussion on the developed model. The research idea is shown in *figure 1*.

1.1 Research Methodology

In the process of executing this research, author has applied design science research methodology. Design science research focuses on developing artifact or model or method (Hevner, March, Park, & Ram, 2004). Design science involves developing new artifacts based on the business needs (Hevner et al., 2004). Design science helps in finding a way to accomplish human goals (March & Smith, 1995). A design science uses mostly artificial phenomena (such as hypothesis) and artifacts, and the artifacts/methods/instantiations developed through design science will themselves be considered as contributions to the body of knowledge (March & Smith, 1995). A problem requires the researcher to demonstrate the need for that model, which will be motivated by problem centered initiation (Cole, Purao, Rossi, & Sein, 2005; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007).

This research paper is divided as follows: in *section 2*, literature review on context awareness in healthcare *(section 2.1)*, mobile device application in healthcare *(section 2.2)*, and knowledge management in healthcare *(section 2.3)* are discussed; in *section 3*, the proposed literature oriented perceptions and system requirements are discussed; and in *section 4*, the context aware mobile knowledge management model is proposed and the constructs of the model are explained.

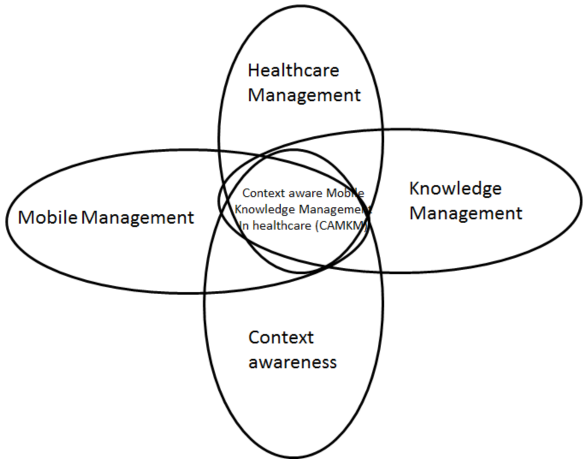

Figure 1: Research idea

2. CONTEXT AWARE MOBILE KNOWLEDGE MANAGEMENT IN HEALTHCARE

Objectives of a solution design and development includes the need to identify a better artifact, which is motivated by objective centered solution (Eekels & Roozenburg, 1991; Hevner et al., 2004; Peffers et al., 2007). This step can act as literature review on the need for the context aware mobile knowledge management in healthcare. Context awareness, mobile device application, and knowledge management in healthcare will be focused in this particular section.

2.1. Context awareness in healthcare

Though there exists various definitions for the term ‘context’ by various researchers (Brown, Bovey, & Chen, 1997; Ryan, Pascoe, & Morse, 1998), definition by Dey, Abowd, & Salber (2001) is considered to be ‘more appropriate’ (Debes, Lewandowska, & Seitz, 2005), which is “any information that can be used to characterize the situation of entities (i.e. whether a person, place or object) that are considered relevant to the interaction between a user and an application, including the user and the application themselves. Context is typically the location identity and state of people, groups and computational and physical objects” (Dey et al., 2001, pg 11). ‘Context’ can be applied in three types: (i) to demonstrate context information, (ii) to execute a service, and (iii) to label and store context oriented information for future reference. Whereas, context aware computing can be defined as “an application’s ability to adapt to changing circumstances and respond according to the context of use” (Kjeldskov & Skov, 2004, pg 5). Some of the existing context aware applications in healthcare may include: Mobile ward: mobile electronic patient record, Denmark (Kjeldskov & Skov, 2004); context aware mobile communications: Mexico (Munoz, Rodriguez, Favela, Martinez-Garcia, & Gonzalez, 2003), etc. Bricon-Souf & Newman (2007) indicates that though there exists research on context awareness in healthcare, most of the papers are based on the ideas and models proposed in the computer science research where healthcare is only used as a means for testing those proposed models.

Based on this discussion, it can be understood that for a CAMKM model to accommodate context awareness in healthcare, model should identify: (i) the role of the healthcare staff (whether it is a nurse, or a physician, or an administrative staff, or pharmacist, or emergency department, or a patient), (ii) the type of information they are trying to access, (iii) the requirement to execute certain service, and (iv) record the context in which the users are requesting the service.

2.2 Mobile device application in healthcare

Because of their multiple capabilities (large memories, robust processes, performance speed, etc), latest smartphones are being considered as powerful hand-held computers rather than just mobile phones (Boulos, Wheeler, Tavares, & Jones, 2011; Crilly & Muthukkumarasamy, 2010; Ivanov, Gueorguiev, Bodurski, & Trifonov, 2010). Mobile technology will help in solving multiple health problems located world wide (Waegemann & Tessier, 2002). According to June 2012 statistics, United States of America (USA) has a population of about 310 million people, and there are about 327.5 million wireless subscriber connections, i.e. about 102.4% of wireless users across USA (CTIA, 2012). This rapid growth in mobile users every year will stand as a proof that mobile technology has a lot to offer to the healthcare industry. Many nations across the world have identified the usefulness of these mobile devices, and have applied in various general and emergency cares (Ammenwerth, Gräber, Herrmann, Bürkle, & König, 2003; Haux, 2006). Research indicates that mobile devices are being used to educate healthcare professionals (Lindquist, Johansson, Petersson, Saveman, & Nilsson, 2008), to offer distant care in developing countries (Kaplan, 2006; Martinez, Phillips, Carrilho, & Thomas, 2008), using location based technologies to offer care (Boulos, Anastasiou, Bekiaris, & Panou, 2011; Versel, 2011), application of text messaging in delivering care (Fjeldsoe, Marshall, & Miller, 2009; Lim, Hocking, Hellard, & Aitken, 2008), and usage of mobile health records (Lane, Heddle, Arnold, & Walker, 2006). As of February 2010, Apple app store has more than 4000 healthcare related apps targeting patients (Boulos, Wheeler, et al., 2011). Though the role of smart mobile devices (like mobile phones, iPads, tablet PCs etc.) is increasing, they have some limitations with respect to screen size, connectivity, data transmission, memory and screen resolution issues, operating system issues (like Android OS, iOS, etc.) (Free et al., 2010). Mobile devices can be complex to use for some patients and hospital staff, troubleshooting simple issues like resource overloading or device locks can be a hassle for some of the users (Wu, Li, & Fu, 2011). To overcome this, mobile devices can be designed with a simpler user Interface. Not all mobile devices come with built in support for encrypting the data that should be transmitted. Mobile devices are susceptible to attack on sensitive data. Including highly efficient encryption algorithms can make the devices slower and inefficient.

Based on this discussion, it can be understood that for a CAMKM model to accommodate mobile devices in healthcare, the model should identify: (i) the type of mobile device (ii) optimize the output information, (iii) evaluate the speeds of the internet and (iv) optimize the display resolution and determine the size of output data to be sent.

2.3 Knowledge Management in healthcare

Research indicates that though there is a certain distinction between the fundamental concepts of data, information and knowledge; data and information, and information and knowledge, are often used interchangeably creating some confusion (Fahey & Prusak, 1998; Horton, 1979; Kock, McQueen, & Baker, 1996). According to Alavi & Leidner (2001), data can be any facts or raw numbers; and information can be considered as 'processed data' which is richer than the data itself; whereas knowledge can be considered as processed information with direction. Knowledge management is being considered as a crucial element in the process of decision making by the organizations to support their staff, and to improve their organizational success. The concept of knowledge management mainly follows a 'user-centered' approach which helps in efficiently organizing and processing the data, thereby allowing the user to utilize this processed data in the process of taking decisions (Balfanz et al., 2000).

According to Derballa & Pousttchi (2004), knowledge management can be classified into five classifiers: virtual teamwork: which may represent distant workers, expert finder: which may involve obtaining an expert opinion through utilization of expert systems, maintaining databases: which may allow to create, edit, delete, save, and retrieval of information whenever necessary, virtual/augmented reality: which may allow processing request across internet, and case based reasoning: which may validate the current situation based on any past occurrence of a similar situation. Derballa & Pousttchi (2004) also indicates that 'possible benefits of KM are restricted because of the inadequacy to facilitate ubiquitous access to knowledge'…which is possible by 'including mobile aspects'. When knowledge management is expected to be applied in a rapidly changing mobile environment (especially in healthcare), there is every need to include 'context' and analyze the situation based on the context and there by manage the knowledge. 'Context and Knowledge Management is a very important feature of a service platform, particularly where services are expected to behave intelligently, learn, exhibit awareness of their surroundings and react to changes' (Mullins, TSSG, & Daidalos Project, 2008, pg 3).

Based on this discussion, it can be understood that for a CAMKM model to accommodate knowledge management in healthcare, the model should (i) accommodate knowledge management across virtual teams, (ii) identify and provide expert solutions for efficient knowledge management, (iii) maintain database to store and retrieve information for future knowledge management, (iv) allow internet search for efficient and supportive information, and (v) provide case based storage of information which may allow users (such as practitioners) to re-visit and validate the current situation based on any past occurrence of that type of situation.

3. LITERATURE ORIENTED PERCEPTIONS AND SYSTEM REQUIREMENTS

Based on the above literature oriented discussion in section 2 (on mobile device application, and knowledge management application, and context awareness in healthcare), possible literature oriented perceptions are identified and are shown in the *table 1*.

Literature Oriented Perceptions		
Literature Oriented Perceptions (LOP)	**Description of LOP**	**References for LOP**
LOP 1	Identifying the role of the hospital personnel (patient, physician, nurse, administrative staff, emergency staff, pharmacy staff)	Context awareness (Brown et al., 1997; Debes et al., 2005; Dey et al., 2001; Ryan et al., 1998)
LOP 2	a healthcare personnel's need to access certain type of information	
LOP 3	A healthcare personnel may require to execute a service	
LOP 4	A healthcare personnel may store context oriented information for future reference	
LOP 5	Optimizing the display (of information) based on mobile device screen size, resolution, operating system, etc.	Mobile device compatibility (Adipat & Zhang, 2005; Free et al., 2010; Gururajan & Murugesan, 2005; Ondash, 2004; Vawdrey et al., 2003; Wu et al., 2011)
LOP 6	Optimizing the information based on the internet connectivity issues and the internet speeds	
LOP 7	Requirement of knowledge management across virtual teams	Knowledge management (Balfanz et al., 2000; Dawes & Sampson, 2003; Derballa & Pousttchi, 2004; Hsia et al., 2006; Orzano et al., 2008)
LOP 8	Identify expert solutions for efficient knowledge management	
LOP 9	Maintaining database to store and retrieve information whenever and wherever necessary	
LOP 10	Perform the search (support) request across internet for efficient and supportive information (Virtual reality)	
LOP 11	Case based storage of information which may allow healthcare personnel (such as practitioners) to re-visit and validate the current situation based on any past occurrence of that type of situation	

Table 1: Literature Oriented Perceptions

4. CONTEXT AWARE MOBILE KNOWLEDGE MANAGEMENT MODEL (CAMKM) FOR HEALTHCARE

Based on the perceptions discussed in the section 2 and section 3 which are shown in the table 1, possible system requirements are identified and obtained by combining one or more LOPs. LOP 1 through LOP 4 yields context awareness oriented requirements, similarly, LOP 5 and LOP 6 yields the mobile device oriented requirements, and LOP 7 through LOP 11 yields the knowledge oriented requirements. Based on these system requirements, author has proposed CAMKM model for healthcare which is shown in the *figure 2*. CAMKM system architecture consists of seven components which include: user, mobile device (input/output device), database, context based optimizer, query parser, knowledge management optimizer, and output optimizer; each of which is discussed below in detail.

4.1 User:

A user can be any of the participants of a regular hospital process who can be mainly divided into six categories: physicians, nurse, administrative staff, emergency staff, pharmaceutical staff, and patient. Each of these participants may be issued with a role-id based on their category (i.e. administrative staff, patient, physician, nurse, emergency staff, and pharmaceutical staff) and these users may have to use a health record as common means of source for reference. If they are using a paper based record, it would be a cumbersome process to store, update the record, retrieve, and search for information in the health record, and also to carry it between each department (Krogh, Rough, & Thomley, 2008).

4.2. Mobile device:

Each of these above mentioned activities can be easily performed with an electronic health record, and for this particular paper, authors have considered the electronic health record usage through mobile devices as medium. These devices can be any of the PDAs, laptops, computers on wheels, mobile phones, notepads, etc.

4.3 Database:

Database will help in storing information for future use. Queries from mobile device will be taken as input into the database, and the context will be analyzed using context based optimizer, and knowledge management optimizer will help in identifying the knowledge classifier. Each action which involves user details, mobile device details, context details, knowledge details, and queries will be recorded into the database.

4.3 Context based optimizer:

Based on the definition of the context given by Dey et al. (2001), one of the tasks of this model is to identify the person, place, and object. Based on this, the context based optimizer is mainly divided into three categories as shown in the *figure 2*: role identifier, place identifier, and object identifier. This notifies the importance to identify whether the person requesting the information is a practitioner, or a nurse, or emergency department personnel, or a pharmacist, or a patient, and from where is he requesting the information, and through which device. The role identifier task can be accomplished by issuing a role id for each of the users based on their category (i.e. practitioner, nurse, pharmacist, etc.) If the person is requesting the data from a bedside ward, or an emergency ward, or from the pharmacy, or from their home, etc., their position can be recorded using global positioning services (GPS), indoor positioning services, RFID chips (Edwards, 2009; Halamka, 2007; Versel, 2011).

These RFID chips contains a 16 digit encrypted code which can be linked to a record residing on a secured website that records a particular patient's information (in this case, a user's movements and positioning) (Halamka, 2007). RFID chips records each of the user's movements, notifying real time updates about user's to the concerned CAMKM system thereby allowing to record the context in which the information has been requested. These implanted RFID chips can also be used for identification purposes (Campbell, 2011). The object from which the information is being requested can be acknowledged by using any of the mobile devices detecting software's (example 55degrees.mobi). By analyzing the object (type of mobile device) which is being used to request the information, the output will be optimized according to the features of that particular mobile device (i.e. screen size, resolution, etc.). Hence the context based optimizer will be able to identify the person, place, and object. Based on the context, the type of privileges will be provided to that particular document for that particular person in that particular context.

4.4 Query parser:

The query parser will validate the request for information based on the context, and will further sends the request for information into the knowledge based optimizer which would further process the request.

4.5 Knowledge management optimizer:

As discussed above and shown in the *figure 2*, knowledge management can be classified into five classifiers: virtual teamwork, expert finder, maintaining databases, virtual/augmented reality, and case based reasoning. Once the context is identified, the query parser will identify the need for which a particular request is being requested, and based on which the query parser will analyze the knowledge classifier from the knowledge management optimizer. If the query requested by the user resembles any existence of similar cases, 'case based reasoning' will be considered and based on existing case experiences, the output will be provided. If there is need for discussion about the requests, virtual teamwork will allow the users to discuss with distant workers. The queries which demand more skilled suggestions, expert systems will be used in obtaining an expert opinion.

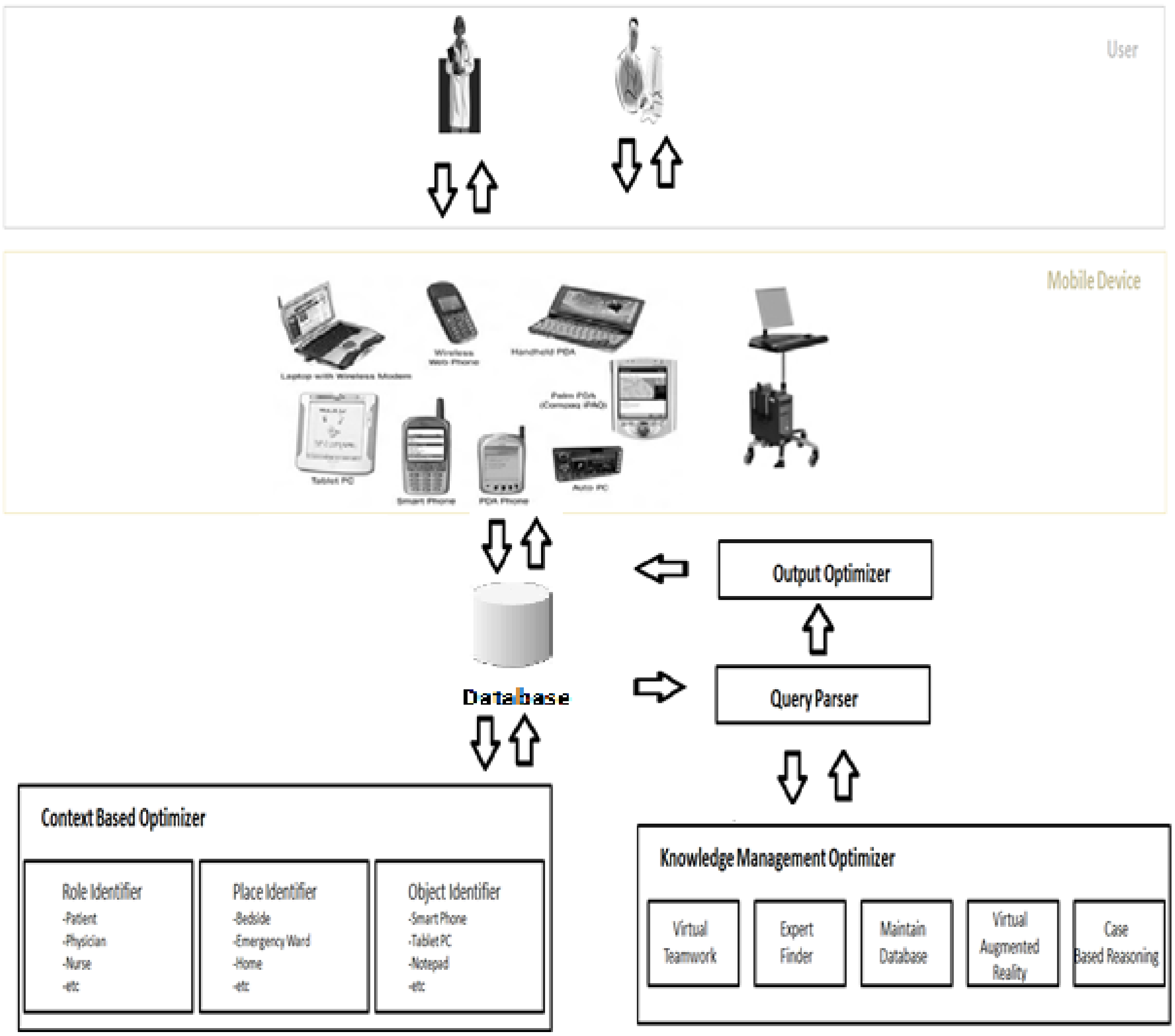

Figure 2: CAMKM system architecture

Based on the privilege provided to the user, the knowledge based optimizer may allow to record, delete, and retrieve information from the databases whenever necessary. Once the context is determined and the query is analyzed, the system will search for any existence of similar cases, and will suggest based on the existing case based reasoning, and this process involves validating the current situation based on any past occurrence of a similar situation. Based on the analysis and search for any past occurrences, the system may process the request across internet and provide with the suggestions.

4.6 Output Optimizer:

This output will be optimized based on the screen size, resolution, and network connection speed of the mobile device which (was previously categorized by object identifier in the context based optimizer) requested the information.

5. CONCLUSION AND FUTURE WORK

In this research paper, author has conducted a thorough literature review on context awareness in healthcare, mobile device application in healthcare, and knowledge management in healthcare, following which the system perceptions and requirements to develop the context aware system are discussed, and the context aware mobile knowledge management model is proposed and the constructs of the model are explained. Developing a real world working model and testing the model are our near future tasks on hand. Author intends to use attribute based access control and extensible access control markup language (XACML) to address role identifier, place identifier, and object identifier. XACML can efficiently handle the role attributes, environment (place) attributes, resource (object) attributes, and context attributes (Identifier, 2005). Author intends to demonstrate and evaluate the current model as near future steps. Demonstration is the process in which the developed artifact will be implemented and this step requires an appropriate context or a client where the artifact can be implemented (Peffers et al., 2007).

ACKNOWLEDGEMENT

I would like to thank Dr. Surendra Sarnikar for his valuable and timely comments, and all the reviewers for their valuable feedback.

REFERENCES

Adipat, B., & Zhang, D. (2005). Developing Adaptive and Personalized Mobile Applications : A Framework and Design Issues. *the Eleventh Americas Conference on Information Systems* (pp. 1862–1868).

Alavi, M., & Leidner, D. E. (2001). Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. (I. Nonaka, Ed.)*MIS Quarterly*, *25*(1), 107–136.

Alonso, R. S., Tapia, D. I., García, Ó., Sancho, D., & Sánchez, M. (2011). Improving Context-Awareness in a Healthcare Multi-Agent System. *Trends in Practical Applications of Agents and Multiagent Systems*, 1–8.

Ammenwerth, E., Gräber, S., Herrmann, G., Bürkle, T., & König, J. (2003). Evaluation of health information systems—problems and challenges. *International Journal of Medical Informatics*, *71*(2-3), 125–135. doi:10.1016/S1386-5056(03)00131-X

Balfanz, D., Grimm, M., Tazari, M., & Datenverarbeitung, G. (2000). A Reference Architecture for Mobile Knowledge Management. *Intelligence*, 1–9.

Bossen, C. (2002). The parameters of common information spaces:: the heterogeneity of cooperative work at a hospital ward. *Proceedings of the 2002 ACM conference on Computer supported cooperative work* (Vol. 176, pp. 176–185). ACM. doi:10.1145/587078.587104

Boulos, M. N. K., Anastasiou, A., Bekiaris, E., & Panou, M. (2011). Geo-enabled technologies for independent living: examples from four European projects. *Technology and Disability*, *23*(1), 7–17.

Boulos, M. N. K., Wheeler, S., Tavares, C., & Jones, R. (2011). How smartphones are changing the face of mobile and participatory healthcare: an overview, with example from eCAALYX. *BioMedical Engineering Online*, *10*(1), 24.

Bricon-Souf, N., & Newman, C. R. (2007). Context awareness in health care: a review. *International Journal of Medical Informatics*, *76*(1), 2–12.

Brown, P. J., Bovey, J. D., & Chen, X. (1997). Context-aware Applications: from the Laboratory to the Marketplace. *Ieee Personal Communications*, *4*(5), 58–64.

Campbell, S. (2011). XECAN and Trimble Partner to Deliver ThingMagic Powered RFID Oncology Solution Providing Direct Interface to EMR. *EMR Daily News*. Retrieved from http://emrdailynews.com/2011/09/28/xecan-and-trimble-partner-to-deliver-thingmagic-powered-rfid-oncology-solution-providing-direct-interface-to-emr/

Chevrollier, N., & Golmie, N. (2005). On the Use of Wireless Network Technologies in Healthcare Environments. *Simulation*, 1–6.

Cole, R., Purao, S., Rossi, M., & Sein, M. K. (2005). Being proactive: where action research meets design research. *Proceedings of the TwentySixth International Conference on Information Systems* (pp. 1–21). Association for Information Systems.

Crilly, P., & Muthukkumarasamy, V. (2010). Using smart phones and body sensors to deliver pervasive mobile personal healthcare. *2010 Sixth International Conference on Intelligent Sensors Sensor Networks and Information Processing*, 291–296. doi:10.1109/ISSNIP.2010.5706767

CTIA. (2012). U.S. Wireless Quick Facts. *CTIA - The Wireless Association*. Retrieved from http://www.ctia.org/consumer_info/index.cfm/AID/10323

Dawes, M., & Sampson, U. (2003). Knowledge management in clinical practice: a systematic review of information seeking behavior in physicians. *International Journal of Medical Informatics*, *71*(1), 9–15. doi:10.1016/S1386-5056(03)00023-6

Debes, M., Lewandowska, A., & Seitz, J. (2005). Definition and Implementation of Context Information. *Joint second Workshop on Positioning Navigation and Communication*, 63–68.

Derballa, V. (2006). Mobile Technology for Knowledge Management. *Group*, 651–656.

Derballa, V., & Pousttchi, K. (2004). Extending knowledge management to mobile workplaces. *Proceedings of the 6th international conference on Electronic commerce ICEC 04* (pp. 583–590). ACM Press. doi:10.1145/1052220.1052294

Dey, A., Abowd, G., & Salber, D. (2001). A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications. *Human-Computer Interaction*, *16*(2), 97–166. doi:10.1207/S15327051HCI16234_02

Edwards, J. (2009). PositiveID Deal Advances Use of Micrchip Implants in Florida Health System. *CBS News*. Retrieved from http://www.cbsnews.com/8301-505123_162-42843647/positiveid-deal-advances-use-of-microchip-implants-in-florida-health-system/

Eekels, J., & Roozenburg, N. F. M. (1991). A methodological comparison of the structures of scientific research and engineering design: their similarities and differences. *Design Studies*, *12*(4), 197–203. doi:10.1016/0142-694X(91)90031-Q

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review*, *40*(3), 265.

Fjeldsoe, B. S., Marshall, A. L., & Miller, Y. D. (2009). Behavior change interventions delivered by mobile telephone short-message service. *American Journal of Preventive Medicine*, *36*(2), 165–173.

Free, C., Phillips, G., Felix, L., Galli, L., Patel, V., & Edwards, P. (2010). The effectiveness of M-health technologies for improving health and health services: a systematic review protocol. *BMC research notes*, *3*(1), 250.

Grimm, M., Tazari, M. R., & Balfanz, D. (2002). Towards a framework for mobile knowledge management. *Practical Aspects of Knowledge Management*, *2*(2), 326–338.

Gururajan, R., & Murugesan, S. (2005). Wireless Solutions Developed for the Australian Healthcare: A Review. *ICMB*, 472.

Halamka, J. D. (2007). A Chip in My Shoulder. *Life as a Healthcare CIO*. Retrieved from http://geekdoctor.blogspot.com/2007/12/chip-in-my-shoulder.html

Haux, R. (2006). Health information systems - past, present, future. *International Journal of Medical Informatics*, *75*(3-4), 268–281.

Hevner, A. R., March, S. T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, *28*(1), 75–105. doi:10.2307/249422

Horton, F. W. (1979). Knowledge, Information and Data. *Information resources management concept and cases*. Association for Systems Management.

Hsia, T., Lin, L., Wu, J., & Tsai, H. (2006). A Framework for Designing Nursing Knowledge Management Systems. *Management*, *1*, 138–143.

Identifier, D. (2005). eXtensible Access Control Markup Language OASIS Standard , 1 Feb 2005. (T. Moses, Ed.)*Oasis Standard*, *200502*(February), 23.

Ivanov, I. E., Gueorguiev, V., Bodurski, V., & Trifonov, V. (2010). *Telemedicine and Smart Phones as Medical Peripheral Devices (Computational Approaches)*. *2010 Developments in Esystems Engineering* (pp. 3–6). IEEE. doi:10.1109/DeSE.2010.7

Kaplan, W. A. (2006). Can the ubiquitous power of mobile phones be used to improve health outcomes in developing countries? *Globalization and Health*, *2*(9), 9.

Kjeldskov, J., & Skov, M. B. (2004). Supporting Work Activities in Healthcare by Mobile Electronic Patient Records. (M. Masoodian, S. Jones, & B. Rogers, Eds.)*Computer Human Interaction*. Springer. doi:10.1007/978-3-540-27795-8_20

Kock, N. F. J., McQueen, R. J., & Baker, M. (1996). Learning and Process Improvement in Knowledge Organisations : A Critical Analysis of Four Contemporary Myths. *Knowledge Creation Diffusion Utilization*, *3*(1), 31 –41. doi:10.1108/09696479610106790

Kohn, L. T., Corrigan, J., & Donaldson, M. S. (2000). *To Err Is Human: Building a Safer Health System*. (Linda T Kohn, J. M. Corrigan, & M. S. Donaldson, Eds.)*Medicine* (Vol. 6, p. 287). National Academy Press. doi:10.1017/S095026880100509X

Krogh, P. R., Rough, S., & Thomley, S. (2008). Comparison of two personal-computer-based mobile devices to support pharmacists' clinical documentation. *American journal of healthsystem pharmacy AJHP official journal of the American Society of HealthSystem Pharmacists*, *65*(2), 154–157.

Lane, S. J., Heddle, N. M., Arnold, E., & Walker, I. (2006). A review of randomized controlled trials comparing the effectiveness of hand held computers with paper methods for data collection. *BMC Medical Informatics and Decision Making*, *6*(1), 23.

Lim, M. S. C., Hocking, J. S., Hellard, M. E., & Aitken, C. K. (2008). REVIEW SMS STI : a review of the uses of mobile phone text messaging in sexual health. *International Journal of STD AIDS*, *19*(5), 287–290. doi:10.1258/ijsa.2007.007264.

Lindquist, A. M., Johansson, P. E., Petersson, G. I., Saveman, B.-I., & Nilsson, G. C. (2008). The Use of the Personal Digital Assistant (PDA) Among Personnel and Students in Health Care: A Review. (G. Eysenbach, Ed.)*Journal of Medical Internet Research*, *10*(4), e31.

March, S. T., & Smith, G. F. (1995). Design and natural science research on information technology. (A. Baranzini, J. Ramirez, C. Schaerer, & P. Thalmann, Eds.)*Decision Support Systems*, *15*(4), 251–266. doi:10.1016/0167-9236(94)00041-2

Martinez, A., Phillips, S., Carrilho, E., & Thomas, S. (2008). Simple Telemedicine for Developing Regions: Camera Phones and Paper-Based Microfluidic Devices for. *Analytical Chemistry*.

Mathur, A., Ramachandran, D., Cutrell, E., & Balakrishnan, R. (2011). An Exploratory Study on the Use of Camera Phones and Pico Projectors in Rural India. *Camera*, 347–356. doi:10.1145/2037373.2037426

Mullins, R., TSSG, & Daidalos Project. (2008). Mobile Service Platforms Cluster: White Paper: Context and Knowledge Management. *European Commission: Information Society and Media*.

Munoz, M. A., Rodriguez, M., Favela, J., Martinez-Garcia, A. I., & Gonzalez, V. M. Context-aware mobile communication in hospitals. , 36 Computer 38–46 (2003). IEEE Computer Society Press. doi:10.1109/MC.2003.1231193

Ondash, E. (2004). Nurses Choose PDAs Over Other Mobile Information Technologies. *AMN Healthcare, Inc*. Retrieved from http://www.nursezone.com/nursing-news-events/devices-and-technology/Nurses-Choose-PDAs-Over-Other-Mobile-Information-Technologies_24474.aspx

Orzano, A. J., Mcinerney, C. R., Scharf, D., Tallia, A. F., & Crabtree, B. F. (2008). A Knowledge Management Model : Implications for Enhancing Quality in Health Care. *Journal of the American Society for Information Science*, *59*(December 2007), 489–505. doi:10.1002/asi

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A Design Science Research Methodology for Information Systems Research. *Journal of Management Information Systems*, *24*(3), 45–77. doi:10.2753/MIS0742-1222240302

Prestigiacomo, J. (2011). Mobile healthcare anywhere. A proliferation of mobile devices means specific wireless challenges for healthcare organizations. *Healthcare informatics the business magazine for information and communication systems*, *28*(3), 34, 36.

Räisänen, T., Oinas-Kukkonen, H., Leiviskä, K., Seppänen, M., & Kallio, M. (2010). Managing Mobile Healthcare Knowledge: Physicians' Perceptions on Knowledge Creation and Reuse. *Health Information Systems: Concepts, Methodologies, Tools, and Applications* (pp. 733–749).

Reddy, M., & Dourish, P. (2002). A finger on the pulse: temporal rhythms and information seeking in medical work. *Proc Conf on ComputerSupported Collaborative Work CSCW*, *Proceeding*(7105), 344–353. doi:10.1145/587078.587126

Ryan, N. S., Pascoe, J., & Morse, D. R. (1998). Enhanced Reality Fieldwork: the Context-aware Archaeological Assistant. (V. Gaffney, M. Van Leusen, & S. Exxon, Eds.)*Computer Applications in Archaeology 1997*, 269–274.

Silva, J. C., & Arsenio, A. M. (2011). Context-Awareness for Mobility Management A Systems Survey for Healthcare Monitoring. *Communications*, 18–23.

Thiele, O., Knapp, H., Schader, M., & Prat, N. (2006). A Context-Aware Architecture for Mobile Knowledge Management. *Information Systems Journal*, *9*(200), 219–226.

Vawdrey, D. K., Hall, E. S., Knutson, C. D., & Archibald, J. K. (2003). A self-adapting healthcare information infrastructure using mobile computing devices. *Proceedings 18th IEEE International Symposium on Defect and Fault Tolerance in VLSI Systems*, (SN -), 91–97. doi:10.1109/HEALTH.2003.1218725

Versel, N. (2011). Emergency Room Patients Tracked With RFID Tags. *Information Week Healthcare*. Retrieved from http://www.informationweek.com/news/healthcare/EMR/231901224

Viswanathan, H., Chen, B., & Pompili, D. (2012). Research challenges in computation, communication, and context awareness for ubiquitous healthcare. *IEEE Communications Magazine*, *50*(5), 92–99. doi:10.1109/MCOM.2012.6194388

Waegemann, C. P., & Tessier, C. (2002). Documentation goes wireless: a look at mobile healthcare computing devices. *Journal of AHIMA American Health Information Management Association*, *73*(8), 36–39; quiz 41–42.

Wu, I.-L., Li, J.-Y., & Fu, C.-Y. (2011). The adoption of mobile healthcare by hospital's professionals: An integrative perspective. *Decision Support Systems*, *51*(3), 587–596. doi:10.1016/j.dss.2011.03.003

Zuga, B., Slaidins, I., Kapenieks, A., & Strazds, A. (2006). M-learning and Mobile Knowledge Management : Similarities and Differences. *Information Sciences*, *4*(2), 58 – 62.