

SHARING MEDICAL PROFILES FOR INTERNATIONAL STUDENT IN UUM

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**SHARING MEDICAL PROFILES FOR INTERNATIONAL
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ABSTRACT

One of the most common information technology activities is improvement of healthcare and clinical management systems including personal healthcare records. Personal healthcare records have the potential to help individuals to do a more active role in their health care. It plays a main key in medical diagnosis and therapy. International students in UUM do not have personal healthcare records, which can be shared among medical centers. The aim of this study is to develop a prototype for sharing medical profiles; the prototype is developed by using C# language, and the research design based on general methodology. The evaluation was based on user perception through the use of System Usability Scale (SUS), and the prototype was assessed through a sample questionnaire that consists of thirty-three respondents and the results have been positive.

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TABLE OF CONTENTS

ABSTRACT	IV
ACKNOWLEDGEMENT	V
TABLE OF CONTENTS	VI
LIST OF TABLES	IX
LIST OF FIGURES	X

CHAPTER ONE:INTRODUCTION

1.1 Background	1
1.2 Problem Statement	4
1.3 Research Questions	5
1.4 Research Objectives	5
1.5 Research Scope	6
1.6 Research Signification	7
1.7 Organization of the Project	7

CHAPTER TWO:LITERATURE REVIEW

2.1 Healthcare Information System	9
2.1.1 <i>Architecture of the Healthcare Information System</i>	11
2.2 Electronic Medical Records	16
2.3 Personal Health Record.....	20
2.3.1 <i>Personal Health Record Model</i>	22
2.4 Health information exchange	23
2.5 SUMMARY.....	26

CHAPTER THREE:METHODOLOGY

3.1 Research Methodology	27
3.2 Research Methodology Phases	29

3.2.1 Awareness of Problem.....	29
3.2.2 Suggestion.....	30
3.2.3 Development.....	30
3.2.4 Evaluation.....	31
3.2.5 Conclusion.....	31
3.3 Summary.....	31

CHAPTER FOUR:ANALYSIS & DESIGN

4.1 SYSTEM REQUIREMENTS.....	32
4.1.1 Functional Requirements.....	32
4.1.2 Non Functional Requirements.....	34
4.2 Use Case.....	35
4.3 Activity Diagram.....	37
4.4 Use Case Specification.....	38
4.5 Sequence and Collaboration Diagram.....	38
4.6 CLASS DIAGRAM.....	50
4.7 System Interface.....	51
4.8 SUMMARY.....	57

CHAPTER FIVE:EVALUATION & RESULTS

5.1 General Information.....	58
5.2 Evaluation of User.....	62
5.3 Summary.....	75

CHAPTER SIX:CONCLUSIONS

6.1 Discussion.....	76
6.2 Contribution.....	77
6.3 Future Work.....	78
6.4 Conclusion.....	78

REFERENCES.....80
APPENDIX A91

LIST OF TABLES

Table 2. 1: Basic comparison between two types of PHRs	21
Table 4. 1: List of Functional Requirements	33
Table 4. 2 List of Non-Functional Requirements	34
Table 5. 1 : Distribution of Respondents Based on Gender	59
Table 5. 2 :Distribution of respondents based on age	60
Table 5. 3: Distribution of Respondents' Occupation	61
Table 5. 4 : Statistics for All Elements	62
Table 5. 5: Q1 Using SMP helps me to be more effective.....	63
Table 5. 6: Q2 Using SMP helps me to be more productive	64
Table 5. 7: Q3 Using SMP saves my time when I use it.	65
Table 5. 8: Q4 I Using SMP would enhance my effectiveness.	66
Table 5. 9: Q5: Using SMP would make it easier to do my tasks	67
Table 5. 10 Q6: SMP was everything I would expect it to do.	68
Table 5. 11 Q7: SMP is simple to use.....	69
Table 5. 12 Q8: SMP is very friendly to use.....	70
Table 5. 13 Q9: It requires the fewest steps possible to accomplish what I want to do with it	71
Table 5. 14 Q10: I can use it without written instructions.....	72
Table 5. 15:Q11: I don't notice any inconsistencies as I use SMP	73
Table 5. 16 Q12: I can use SMP successfully every time.....	74

LIST OF FIGURES

Figure 1. 1 : The prototype process.....	6
Figure 2. 1: Health-care information system architecture.....	12
Figure 2. 2: medical information system interoperable	15
Figure 2. 3: Personal Health Record Model.....	Error! Bookmark not defined.
Figure 3.1 : Research Design Methodology	28
Figure 4. 1: Use Case Diagram of SMP.....	36
Figure 4. 2: Description the activity diagram for SMP.....	37
Figure 4.3: Login Sequence Diagram	39
Figure 4. 4: Login Collaboration Diagram.....	40
Figure 4. 5: Search Patient Info Sequence Diagram	41
Figure 4. 6: Search Patient Info Collaboration Diagram	42
Figure 4. 7: Views patient information Sequence Diagram.....	43
Figure 4. 8: Views patient information Collaboration Diagram	44
Figure 4. 9: add patient statues Sequence Diagram	45
Figure 4. 10: add patient statues collaboration diagram	46
Figure 4. 11: Print Patient Info Sequence Diagram	47
Figure 4. 12: Print Patient Info Collaboration Diagram.....	48
Figure 4. 13: Logout Sequence Diagram	49
Figure 4. 14: Logout Collaboration Diagram.....	49
Figure 4. 15: Class Diagram for SMP.....	50
Figure 4. 16: Homepage Interface.....	51
Figure 4. 17: Login Interface	52
Figure 4. 18: Search Patient Info Interface	53
Figure 4. 19 : Views Patient Info Interface.....	54
Figure 4. 20: Add Patient Statues Interface	55
Figure 4. 21: Printout Patient files Interface	56
Figure 5. 1: Distribution of Respondents Based on Gender	59
Figure 5. 2: Distribution of respondents based on age.....	60

Figure 5. 3: Distribution of respondents' occupation 61

Figure 5. 4: Statistics for Question One..... 63

Figure 5. 5: Statistics for Question Two 64

Figure 5. 6:Statistics for Question Three 65

Figure 5. 7: Statistics for Question Four 66

Figure 5. 8: Statistics for Question Five 67

Figure 5. 9: Statistics for Question Six 68

Figure 5. 10: Statistics for Question Seven..... 69

Figure 5. 11: Statistics for Question Eight..... 70

Figure 5. 12: Statistics for Question Nine..... 71

Figure 5. 13: Statistics for Question Ten 72

Figure 5.14 : Statistics for Question Eleven 73

Figure 5. 15: Statistics for Question Twelve 74

CHAPTER ONE

INTRODUCTION

1.1 Background

In past years, the world had witnessed rapid technological developments in services such as cellular technologies and internet that have led to the emergence of novel ways of organization information (Sood, et al., 2008). Healthcare applied on information technology is a main global issue that has triggered a marked amount of research. Implications of information technology for healthcare reform command much speculation (Suh, 2006). Though health information technology promises benefits to healthcare, many problems exist. Despite years of research in the area of information technology, the progression in adaptation remains low (Baoli, 2009).

Specifically for healthcare, the need for portability and instant communication has transformed the use of the electronic medical record. The electronic medical record has been augmented by a component that utilizes current technological developments such as internet technology to create a more complete source of healthcare data management. The personal health record is such a unit. Together, these technologies have the potential to transform aspects

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REFERENCES

- Adler-Milstein, J., & Bates, D. W. (2010). Paperless healthcare: Progress and challenges of an IT-enabled healthcare system. *Business Horizons*, 53(2), 119-130.
- Adler-Milstein, J., Bates, D. W., & Jha, A. K. (2009). US Regional health information organizations: progress and challenges. *Health Affairs*, 28(2), 483-492.
- Agarwal, R., & Angst, C. M. (2006). technology-enabled transformations in US health care. *Human-computer interaction and management information systems: applications*, 6, 357.
- Aichholzer, G., & Westholm, H. (2009). Evaluating eParticipation projects: practical examples and outline of an evaluation framework. *European Journal of ePractice*, 7, 27-44.
- Alawneh, R., El Sheikh, A., & Kanaan, R. (2011). Development of Embedded Personal Health Care Record System. *iBusiness*, 3.
- Alter, S. (2008). Defining information systems as work systems: implications for the IS field. *European Journal of Information Systems*, 17(5), 448-469.
- Arbona, A., Benkner, S., Engelbrecht, G., Fingberg, J., Hofmann, M., Kumpf, K., et al. (2007). A service-oriented grid infrastructure for biomedical data and compute services. *NanoBioscience, IEEE Transactions on*, 6(2), 136-141.
- Baker, M. J., Webb, C. T., Stroud, D. A., Palmer, C. S., Frazier, A. E., Guiard, B., et al. (2009). Structural and functional requirements for activity of the Tim9–Tim10 complex in mitochondrial protein import. *Molecular biology of the cell*, 20(3), 769-779.

- Bangor, A., Kortum, P. T., & Miller, J. T. (2008). An empirical evaluation of the system usability scale. *International Journal of Human-Computer Interaction, 24*(6), 574-594.
- Baoli, Q. (2009). The Construction of Electronic Health Records in Regional Informatization [J]. *Journal of Medical Informatics, 4*, 13-15.
- Berry, G. R. (2006). Can computer-mediated asynchronous communication improve team processes and decision making? Learning from the management literature. *Journal of Business Communication, 43*(4), 344.
- Cabot, J., Clarisó, R., & Riera, D. (2008). *Verification of UML/OCL class diagrams using constraint programming*. Paper presented at the IEEE International Conference on Software Testing Verification and Validation Workshop, ICSTW '08, Lillehammer
- Cahill, V. (2008). *Customisable model transformations based on non-functional requirements*. Paper presented at the IEEE Congress on Services, Honolulu, HI.
- Chen, L. P., Zeng, Y., Chai, Y. X., Qin, Z. X., Gong, Y., & Wang, Y. L. (2009). UML-based approach to generate testing sequence of polymorphic software. *Journal of Computer Applications, 3*.
- Chung, L., & do Prado Leite, J. (2009). On non-functional requirements in software engineering. *Conceptual modeling: Foundations and applications, 363-379*.
- Comito, C., Gounaris, A., Sakellariou, R., & Talia, D. (2009). A service-oriented system for distributed data querying and integration on Grids. *Future Generation Computer Systems, 25*(5), 511-524.

- Connor, P. E., & Becker, B. W. (2003). Personal value systems and decision-making styles of public managers. *Public Personnel Management, 32*(1), 155-180.
- Cronin, C. (2006). Personal health records: an overview of what is available to the public: AARP Public Policy Institute.
- Denzin, N. (2009). *The research act: A theoretical introduction to sociological methods*: Aldine De Gruyter.
- Denzin, N. (2009). *The research act: A theoretical introduction to sociological methods*: Aldine De Gruyter.
- DesRoches, C. M., Campbell, E. G., Rao, S. R., Donelan, K., Ferris, T. G., Jha, A., et al. (2008). Electronic health records in ambulatory care—a national survey of physicians. *New England Journal of Medicine, 359*(1), 50-60.
- Dogac, A., Kabak, Y., Namli, T., & Okcan, A. (2008). Collaborative Business Process Support in eHealth: Integrating IHE Profiles through ebXML Business Process Specification Language. *Information Technology in Biomedicine, IEEE Transactions on, 12*(6), 754-762.
- Elliott, J., Heesterbeek, S., Lukensmeyer, C., & Slocum, N. (2005). Participatory methods toolkit: A practitioner's manual. *King Baudouin Foundation and the Flemish Institute for Science and Technology Assessment (viWTA)*.
- Enjo, H., Tanabu, M., & Iijima, J. (2009). *A step toward foundation of class diagram algebra for enterprise service systems*. Paper presented at the Fourth International Conference on Computer Sciences and Convergence Information Technology, ICCIT '09, Seoul.

- Fraser, H. S. F., Biondich, P., Moodley, D., Choi, S., Mamlin, B. W., & Szolovits, P. (2005). Implementing electronic medical record systems in developing countries. *Informatics in Primary Care, 13*(2), 83-96.
- Griffin, R. W., & Moorhead, G. (2011). *Organizational behavior*. USA: South-Western Pub.
- Grossman, J. M., Kushner, K. L., & November, E. A. (2008). *Creating sustainable local health information exchanges: can barriers to stakeholder participation be overcome?* : Center for Studying Health System Change Washington, DC.
- Hamelburg, M. (2009). EHR and HIT incentives in the American Recovery and Reinvestment Act. *Intellect Prop Technol Law J, 21*(6), 7-13.
- Hasling, B., Goetz, H., & Beetz, K. (2008). *Model based testing of system requirements using UML use case models*. Paper presented at the 1st International Conference on Software Testing, Verification, and Validation Lillehammer.
- Herrera-Viedma, E., Alonso, S., Chiclana, F., & Herrera, F. (2007). A consensus model for group decision making with incomplete fuzzy preference relations. *Fuzzy Systems, IEEE Transactions on, 15*(5), 863-877.
- Hillestad, R., Bigelow, J., Bower, A., Girosi, F., Meili, R., Scoville, R., et al. (2005). Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. *Health Affairs, 24*(5), 1103-1117.
- Huang, E. W., & Liou, D. M. (2007). Performance analysis of a medical record exchanges model. *Information Technology in Biomedicine, IEEE Transactions on, 11*(2), 153-160.

- Ibrahim, N., Ibrahim, R., Saringat, M., Mansor, D., & Herawan, T. (2010). On well-formedness rules for UML use case diagram. *Web Information Systems and Mining*, 432-439.
- Ishak, I., & Alias, R. (2005). Designing a strategic information systems planning methodology for Malaysian institutes of higher learning. *Issues in Information Systems*, 6 (1).
- Islam, M. S. (2008). Towards a sustainable e-Participation implementation model. *European Journal of ePractice*, 5(10).
- Jamal, A., McKenzie, K., & Clark, M. (2009). The impact of health information technology on the quality of medical and health care: a systematic review. *HIM J*, 38(3), 26-37.
- Jin, Y., Deyu, T., & Xianrong, Z. (2011). *Research on the distributed electronic medical records storage model*. Paper presented at the International Symposium on IT in Medicine and Education (ITME), Cuangzhou.
- Jones, O. (2003). The persistence of autocratic management in small firms: TCS and organisational change. *International Journal of Entrepreneurial Behaviour & Research*, 9(6), 245-267.
- Jost, T. S. (2010). Health Exchanges and the Affordable Care Act: Eight Difficult Issues. The Commonwealth Fund. September.
- Kang, S., Kim, H., Baik, J., Choi, H., & Keum, C. (2010). *Transformation Rules for Synthesis of UML Activity Diagram from Scenario-Based Specification*. Paper presented at the IEEE 34th Annual on Computer Software and Applications Conference (COMPSAC), Seoul.
- Kaufman, J., Adams, J., Bakalar, J., & Mounib, E. (2008). Healthcare 2015 and Personal Health Records: A Standards Framework: IHIC.

- Keyhani, S., Hebert, P. L., Ross, J. S., Federman, A., Zhu, C. W., & Siu, A. L. (2008). Electronic health record components and the quality of care. *Medical care*, 46(12), 1267.
- Kim, M. I., & Johnson, K. B. (2002). Personal health records. *Journal of the American Medical Informatics Association*, 9(2), 171-180.
- Kukafka, R. (2005). Public health informatics: the nature of the field and its relevance to health promotion practice. *Health Promotion Practice*, 6(1), 23-28.
- Lahteenmaki, J., Leppanen, J., & Kaijanranta, H. (2009). *Interoperability of personal health records*. Paper presented at the International Conference of the IEEE on Engineering in Medicine and Biology Society, EMBC Minneapolis, MN.
- Lin, H., & Inouye, A. (2001). Democratic Processes in the Age of the Internet: A Framework for Action. *CSTB Division on Behavioural and Social Sciences and Education, National Research Council The National Academies*.
- Lindlof, T. R., & Taylor, B. C. (2010). *Qualitative communication research methods*: Sage Publications, Inc.
- Löhr, H., Sadeghi, A. R., & Winandy, M. (2010). *Securing the e-health cloud*. Paper presented at the ACM International Health Informatics Symposium.
- Lopez, D. M., & Blobel, B. G. (2009). A development framework for semantically interoperable health information systems. *international journal of medical informatics*, 78(2), 83-103.

- McDonald, C. J., Overhage, J. M., Barnes, M., Schadow, G., Blevins, L., Dexter, P. R., et al. (2005). The Indiana Network for Patient Care: a working local health information infrastructure. *Health Affairs*, 24(5), 1214-1220.
- Moreno, L., Peterson, A., Bagchi, R., & af Ursin, A. (2007). Personal Health Records: What Do Underserved Consumers Want? : Mathematica Policy Research, Inc.
- Mytilinaiou, E., Koufi, V., Matamateniou, F., & Vassilacopoulos, G. (2010). A Context-Aware Authorization Model for Process-Oriented Personal Health Record Systems. *Certification and Security in Health-Related Web Applications: Concepts and Solutions*, 46.
- Noumeir, R. (2008). Integrating the healthcare enterprise process. *International Journal of Healthcare Technology and Management*, 9(2), 167-180.
- Oostvogels, N. (2009). *Facilitator's guide to participatory decision-making*. USA: Jossey-Bass.
- Organization for Economic Co-operation and Development –OECD (2001). *Citizens as partners: OECD handbook on information. Consultation and public participation in policy-making*, OECD, Paris.
- Papa, M. J., Daniels, T. D., & Spiker, B. K. (2007). *Organizational communication: perspectives and trends*. USA: Sage Publications, Inc.
- Pisani, E., & AbouZahr, C. (2010). Sharing health data: good intentions are not enough. *Bulletin of the World Health Organization*, 88(6), 462-466.
- Refsdal, A., & Stølen, K. (2008). Extending UML sequence diagrams to model trust-dependent behavior with the aim to support risk analysis. *Electronic Notes in Theoretical Computer Science*, 197(2), 15-29.

- Robbins, M. D., Simonsen, B., & Feldman, B. (2008). Citizens and Resource Allocation: Improving Decision Making with Interactive Web-Based Citizen Participation. *Public Administration Review*, 68(3), 564-575.
- Ross, S. E., Schilling, L. M., Fernald, D. H., Davidson, A. J., & West, D. R. (2010). Health information exchange in small-to-medium sized family medicine practices: Motivators, barriers, and potential facilitators of adoption. *international journal of medical informatics*, 79(2), 123-129.
- Ryan, A., & Eklund, P. (2008). A framework for semantic interoperability in healthcare: a service oriented architecture based on health informatics standards. *Studies in health technology and informatics*, 136, 759.
- Savic, D., Antovic, I., Vlajic, S., Stanojevic, V., & Milic, M. (2011). *Language for Use Case Specification*. Paper presented at the 34th IEEE Conference on Software Engineering Workshop (SEW), Limerick.
- Schoen, C., Osborn, R., Huynh, P. T., Doty, M., Peugh, J., & Zapert, K. (2006). On the front lines of care: primary care doctors' office systems, experiences, and views in seven countries. *Health Affairs*, 25(6), w555-w571.
- Shetty, R. (2007). Portable Digital Personal Health Record: To Bridge the Digital Gap in Medical Information Storage of Individuals with Personal Health Records in Flash Drives. *The Internet Journal of Health*, 5(2).
- Silveira, N. (2008). *Exploiting service oriented architectures for the design of E-health systems*. Paper presented at the 1st International Conference on Health Informatics.

- Sood, S. P., Nwabueze, S. N., Mbarika, V. W. A., Prakash, N., Chatterjee, S., Ray, P., et al. (2008). *Electronic medical records: a review comparing the challenges in developed and developing countries*. Paper presented at the Proceedings of the 41st Annual on Hawaii International Conference on System Sciences, Waikoloa, HI.
- Sridaran, R., Padmavathi, G., & Iyakutti, K. (2009). A survey of design pattern based web applications. *Journal of Object Technology*, 8(2), 61-70.
- Stoves, J., Connolly, J., Cheung, C. K., Grange, A., Rhodes, P., O'Donoghue, D., et al. (2010). Electronic consultation as an alternative to hospital referral for patients with chronic kidney disease: a novel application for networked electronic health records to improve the accessibility and efficiency of healthcare. *Quality and Safety in Health Care*, 19(5), 1-4.
- Straub, D., Loch, K., Evaristo, R., Karahanna, E., & Srite, M. (2002). Toward a theory-based measurement of culture. *Human factors in information systems*, 61-82.
- Suh, R. (2006). *Health Information Technology 2006: Current Status and Future Directions*. Paper presented at the Preventive Medicine. Annual Meeting of the American College of Preventive Medicine.
- Sykes, T. A., Venkatesh, V., & Rai, A. (2011). Explaining physicians' use of EMR systems and performance in the shakedown phase. *Journal of the American Medical Informatics Association*, 18(2), 125-130.
- Tambouris, E., Liotas, N., & Tarabanis, K. (2007). *A framework for assessing eParticipation projects and tools*. Paper presented at the 40th Annual Hawaii International Conference on System Sciences,, Hawaii.

- Taylor, R., Bower, A., Girosi, F., Bigelow, J., Fonkych, K., & Hillestad, R. (2005). Promoting health information technology: is there a case for more-aggressive government action? *Health Affairs*, 24(5), 1234-1245.
- Tuil, W., Ten Hoopen, A., Braat, D., de Vries Robbe, P., & Kremer, J. (2006). Patient-centred care: using online personal medical records in IVF practice. *Human Reproduction*, 21(11), 29-55.
- Vaishnavi, V., & Kuechler, W. (2008). Design research in information systems. *wwwisworldorg*, 22(2), 1-16.
- Walker, J., Pan, E., Johnston, D., Adler-Milstein, J., Bates, D. W., & Middleton, B. (2005). The value of health care information exchange and interoperability. *Health Affairs-Millwood Va Then Bethesda MA-*, 24, 5.
- Werner, R. M., & Bradlow, E. T. (2006). Relationship between Medicare's hospital compare performance measures and mortality rates. *JAMA: the journal of the American Medical Association*, 296(22), 2694-2702.
- Xu, W., Deng, L., & Liu, Y. (2010). *A resource-based approach to formalize use case specification for web applications*. Paper presented at the IEEE International Conference on Progress in Informatics and Computing (PIC), Shanghai.
- Ying, Y. Z., Ye, L. J., & Guo, Y. X. (2009). Transformation from UML Sequence Diagram to Petri Net Based on XML. *Jisuanji Gongcheng/Computer Engineering*, 35(22), 84-87.
- Zaharias, P., & Poylymenakou, A. (2009). Developing a usability evaluation method for e-learning applications: Beyond functional usability. *Intl. Journal of Human-Computer Interaction*, 25(1), 75-98.

Zhang, R., & Liu, L. (2010). *Security models and requirements for healthcare application clouds*. Paper presented at the IEEE 3rd International Conference on Cloud Computing (CLOUD), Miami, FL.

Zhou, L., Soran, C. S., Jenter, C. A., Volk, L. A., Orav, E. J., Bates, D. W., et al. (2009). The relationship between electronic health record use and quality of care over time. *Journal of the American Medical Informatics Association*, 16(4), 457-464.