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International Workshop on Healthcare systems And Internet of Things for Humanity (e-HealthForHumanity'2015)

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CALL FOR PAPERS

International Workshop on Healthcare systems
And Internet of Things for Humanity (e-HealthForHumanity'2015)
Conjunction with the conference MCETECH'2015-Springer, Montreal, Canada
May 13th 2015, Montreal, Canada

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Workshop MCETECH 2015 will bring together leading scientists, academics, engineers, medical and healthcare practitioners, and policy makers from government, municipality, academia and private sectors. It offers an opportunity to network with organizations and experts in the field. This e-HealthForHumanity'2015 workshop seeks to be multidisciplinary forum exchanging ideas and sharing visions on the latest development and use of e-health and Internet of things Technologies. The workshop seeks contributions on use of remote monitoring, context-aware modeling, reasoning in health care systems, smart cities, home, and devices, resilience of citizens, architecture of ubiquitous and collaborative computing.

Submitted papers must represent original material that is not currently under review in any other workshop, conference or journal, and has not been previously published. All authors of the MCETECH 2015 conference are invited to submit their papers, specifically, their rejected papers in MCETECH 2015. Authors must submit their work electronically through **https://easychair.org/conferences/?conf=ehealthforhumanity20** The paper could have one page, 4 pages, or maximum 11 pages in the Springer format (available in LNBIP style). Submitted papers may be published in a conference proceeding or authors may be invited to submit to a special issue of a journal.

* Full papers: presenting contributions that address a clear research question in the field, as well as the theoretical and/or empirical evaluations (max. 6 pages in LNBIP style).
* Position Papers: describing a PhD or Master thesis in progress or discussing controversial issues in the field (max. 4 pages in LNBIP style)
* Abstract paper: describing in one page the problem and idea of solution in LNBIP style.

IMPORTANT DATES
The workshop will take place in conjunction with the MCETECH'2015 Canada

- Paper Submission: April 27th, 2015
- Paper Notification: April 29th, 2015
- Camera Ready Copy: May 1st, 2015
- Workshop: May 13th, 2015

MAIN TOPICS
The topics for contribution include, but are not limited to, the following:

- Healthcare Process monitoring systems
- Performance management for healthcare
- Context-aware applications
- Healthcare Knowledge Systems
- Knowledge representation in Health care systems
- Software architecture of healthcare systems
- E-Health and Chronic Diseases Management
- Tele-monitoring for diseases persons
- Ubiquitous Computing for Healthcare systems
- Healthcare Modeling and Simulation
- Big Data and Data mining for Healthcare systems
- Bio-Informatics for Humanity
- Modeling and simulation of Biomedical Computing
- Patient Monitoring Systems
- Smart home and devices
- Modeling and simulation of Smart city
- Internet of things for healthcare systems
- Interoperability, availability and transparency of healthcare systems
- Performance and Adaptation of healthcare applications
- Safety, security, and privacy for healthcare systems
- Collaborative computing for healthcare systems
- Mobile Health Monitoring
- Healthcare Information Systems
- Human mobility modeling and analytics
- Video games for healthcare systems

Organization committee

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Program of the workshop

8:30-9:00 Keynote speaker 1

MEDTEQ, le consortium de recherche collaborative industrielle et d'innovation en technologies médicales, Christiane Barette, Consortium MEDTEQ, Montréal (Québec), Canada

9:00-9:30

Paper 7: A Prognosis for SDN Deployment in Healthcare. Rubina Lakhani and Liam Peyton.

9:30-10:00

Paper 6: A Survey on Collaborative IoT. Jabril Abdelaziz, Mehdi Adda and Hamid Mcheick.

10:00-10:30 Coffee break

10:30-11:00

Paper 8: A proposal of Using RFID Technology in Improving Scheduling and Route Planning for Pickup and Delivery of Medical Instruments at a Hospital. Afrooz Moatari-Kazerouni and Ygal Bendavid.

11:00-11:30

Paper 4: Towards a Goal Model Development Framework for Online Business Processes. Mohammad Alhaj, Kavya Mallur and Liam Peyton.

11:30-12:00

Paper 3: Symptoms Interdependencies Prototype for Patients based on Context-aware parameters. Hamid Mcheick and Mohamed-Dhiaeddine Messaoudi.

12:00-13:30 Lunch Break

13:30 – 14:15 Keynote speaker 2

Challenges of Wirelessly Managing Power and Data for Wearable and Implantable Medical Devices, Mohamad Sawan, Polytechnique of Montreal, Montreal (Quebec), Canada

14:15-14:45

Paper 5: A Systematic Approach to Quality Assurance of a Health Care Business Process. Kavya Mallur, Mohammad Alhaj, Liam Peyton and Bernard Stepien.

14:45-15:00 Posters

Towards a Seamless Hand Hygiene Monitoring System. Omar Badreddin and Ryan Simmons and Ricardo Castillo.

15:00-15:30 Coffee break

15:30 – 16:30 Round Table

Challenges, solutions and future trends of e-health and Internet of Things.

16:30 – 17:30 Keynote speaker 3

On developing and deploying assistive technologies in a living lab involving cognitively impaired people.
Sylvain Giroux, University of Sherbrooke, Sherbrooke (Quebec), Canada

Key Notes description

Key note 1: Christiane Barette

Présentation de MEDTEQ, le consortium de recherche collaborative industrielle et d'innovation en technologies médicales

- Notre modèle d'affaires
- Les thématiques de recherche

Directrice de projet chez MEDTEQ, Montréal (Québec), Canada

http://medteq.ca/fr/projets/

Key note 2: Mohamad Sawan

Title: Challenges of Wirelessly Managing Power and Data for Wearable and Implantable Medical Devices

Mohamad Sawan, Professor, Fellow, IEEE, Canada Research Chair in Smart Medical Devices

Polystim Neurotech Lab, Electrical and Biomedical Engineering, Polytechnique Montreal

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http://www.mohamadsawan.org

Abstract –– Emerging implantable and wearable biosystems for diagnostic and recovery of neural vital functions are promising alternative to study neural activities underlying cognitive functions and pathologies. Following a summary of undertaken neuroprosthesis and Lab-on-chip devices dealing with spike and ion based neurorecording and neurostimulation, this talk covers the architecture of typical device and employed main building blocks, with a focus on the RF parts including both the recovery of energy to power up used Microsystems and the bidirectional data interface for its real-time operation. Multi-technology integration in chips and in mini-boards facilitates needed transcutaneous RF powering and data exchange using low-power high-data rate custom transceivers. Facts impacting on power efficiency and reliability such as calibration and adaptive techniques, microsystems architectures, power management, and reliable devices will be described. Brain imaging and Brain sensor networks for epilepsy and vision are among the case studies

Biography

Mohamad Sawan received the Ph.D. degree in 1990 in Electrical Engineering, from Sherbrooke University, Canada. He joined Polytechnique Montreal in 1991, where he is currently a Professor of microelectronics and biomedical engineering. His interests are the integrated Mixed-signal (analog, digital and RF) circuits and microsystems. Dr. Sawan is a holder of a Canada Research Chair in Smart Medical Devices, he is leading the Microsystems Strategic Alliance of Quebec (ReSMiQ), and is founder of the Polystim Neurotechnologies Laboratory. Dr. Sawan is founder and cofounder of several international conferences such as the IEEE NEWCAS, ICECS, and BIOCAS. He is also cofounder and Associate Editor (AE) of the IEEE Trans. on BIOCAS, and he is Editor and Associate Editor, and member of the board of several international Journals. Dr. Sawan is founder and chair of the Eastern Canadian IEEE-Solid State Circuits Society Chapter. He published more than 650 peer reviewed papers, two books, 10 book chapters, and 12 patents. Dr. Sawan received several awards, among them the Queen Elizabeth II Golden Jubilee Medal, the Bombardier Award for technology transfer, the Jacques-Rousseau Award for achieved results in multidisciplinary research activities, the medal of merit from the President of Lebanon for his outstanding contributions, and the Barbara Turnbull Award for spinal-cord research in Canada. He is Fellow of the IEEE, Fellow of the Canadian Academy of Engineering, Fellow of the Engineering Institute of Canada, and Officer of the Quebec's National Order.

Key note 3: Sylvain Giroux

Title: On developing and deploying assistive technologies in a living lab involving cognitively impaired people

Abstract:

In close collaboration with the Centre of rehabilitation-Estrie, DOMUS has implemented a living in a residence hosting 10 people with traumatic brain injuries. This living lab is the natural extension of the DOMUS' on-campus smart apartment. Thanks to this living lab, researchers, clinicians, and end users can meet in a common place and achieve interdisciplinary researches and studies that would otherwise be impossible to conduct. A participatory design approach helps to combine scientific research and social needs of the clientele of the Centre of rehabilitation-Estrie. The living then enables to experiment, validate and transfer progressively in the real world results of the research.

The keynote will first present how the living lab was put into place. Then a summary of a study on the expectation and the needs of residence stakeholders will be briefly outlined. Finally research projects

currently run in the living lab and at Domus will be sketched. They will illustrate how smart homes can help to maintain at home cognitively impaired people, improve their autonomy, and alleviate the burden put on informal and professional caregivers.

Biography

Sylvain Giroux is a well-established scientist working as professor at the Department of Computer Science at the University of Sherbrooke, Canada. He received a Ph.D. in computer science from the University of Montreal in 1993. He has worked on a wide variety of R&D projects in Canada, France, and Italy. His professional experience is well balanced between academic institutions and private corporations. As a result, Sylvain Giroux has contributed to the development of information systems in interdisciplinary contexts and domains as varied as distance learning, geophysics, electronic commerce, tele-medicine, task-support systems, and smart homes. He is one of the co-founder the DOMUS interdisciplinary laboratory of the University of Sherbrooke. With his team, he has put into place 1) *the compulsory blend of expertise* (computer science, engineering, psychiatry, occupational therapy, neuropsychology, industrial design, ergonomy, social workers, administration), 2) *a rich network of organizations* (in particular AGE WELL National Center of Excellence, Centre de Réadaptation-Estrie), and 3) *a unique infrastructure* (on the campus, an apartment of 4½ rooms fully equipped with sensors, effectors, networks and a living lab in a residence of 10 apartments). Research work at DOMUS explores pervasive computing in smart habitats for people suffering from cognitive deficits. His main research interests are smart homes, mobile computing, pervasive computing, cognitive assistance, multi-agent systems, tangible user interfaces, and user modeling.

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SDN Deployment Issues in Healthcare Networks

Rubina Lakhani, Liam Peyton

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Abstract. Software Defined Networking (SDN) provides an emerging architecture for managing the complexities of internet clouds. A systematic literature review was conducted to determine if Software Defined Networks are beneficial for healthcare applications. This included a review of a SDN deployment at Kanazawa University Hospital. SDN is an emerging technology and must be approached with a healthy skepticism to address the specific challenges of healthcare. Performance, scalability, security and interoperability are among the issues that must be addressed before considering deployment of any network.

Keywords: Software Defined Networking, Cloud Computing, Healthcare, Systematic Literature Review, eHealth.

1 Introduction

A systematic literature review was conducted to determine if Software Defined Networks (SDN) [7] are beneficial for application in medical networks, such as LANs (healthcare campuses), enterprises solutions (eg. communications between universities and hospitals), and eHealth WANs that communicate rurally, nationally or internationally. SDN deployments and use cases [9] were largely absent in the literature, which led to a secondary question as to whether cloud computing has been deployed with SDN and if so, how it was managed. Citations were scoped to publications between 2011-2015, in the English language.

Kanazawa University Hospital was employed in this paper as one of the few SDN deployments cited in scholarly work. The network consists of the following:

- 16 OpenFlow switches
- 2 OpenFlow controllers
- 2 controlling network switches with optical fiber connection.
- OpenFlow network connected to access LAN and attached to a core Layer 3 switch using link aggregation.

The hospital has deployed this network to interoperate between their many systems which include (but are not limited to) EMR, Physical Order Entry, PACS, ECG, US, EEG, and X-ray. [6]

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Software Defined Networking is an emerging architecture that provides a framework for advanced management of control of converged networks. SDN is a set of techniques used to facilitate the design, delivery, and operation of network services in a deterministic, dynamic and scalable manner [12]. The main feature of SDN is the decoupling of data, and the control of this data. The control of data specifies its source, destination, priority, etc. SDN takes this aspect of data and moves it out of the network element (switch, gateway, router etc) and into a separate entity, the SDN Network Controller as shown in Figure 1 for the Kanazawa University Hospital described in [6]. The separation of data from its control results in the ability to abstract the infrastructure logically and virtually. SDN uses flow tables that articulate layer 1-4 OSI in the packets. Using north-south and east-west APIs, the result is a powerful way to manage multivendor, multi-technology, multi-tenant domains. The SDN architecture allows for network configuration and changes to be applied over the entire network through network policies that are managed by the controller [7, 8].

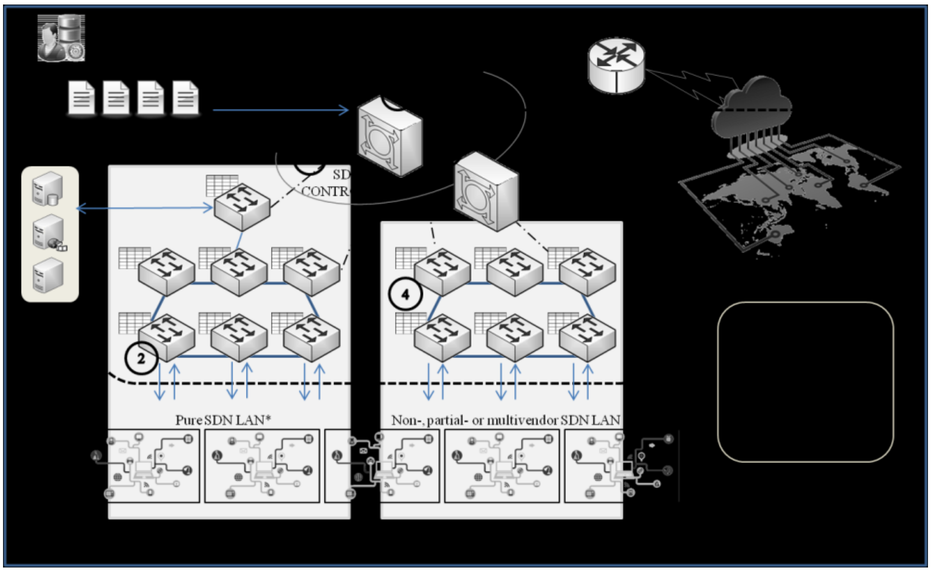

Fig. 1. SDN Network Environment Highlighting a Hospital Implementation

There are many other advantages to this architecture that are making SDN popular. As a service operation, healthcare requires “continuous and systematic innovation” to achieve efficiency, cost effectiveness and timeliness while delivering high quality services [2, 5]. In healthcare networks, SDN implementation is an enabler for new innovation and new applications. Other advantages include: more granular control of the network; enabling programmability of the network by other stakeholders such as hospitals, network operators, users, independent software vendors – not just equipment manufactures; as well as, cost effectiveness [7].

However, SDN is an emerging technology and must be approached with a certain caution to address the specific challenges of healthcare. One of the most important distinctions of healthcare network environments is the technical complexity in medical application software and hardware. Data type diversity is also a big factor, [1, 4, 11] as is the underlying network requirements which include wired, wireless and optical infrastructure. The following are some issues to consider.

2 SDN Switch Performance

Traditional switches have been optimized and will typically meet performance requirements. One of the biggest issues related to the SDN architecture is the performance of an SDN switch. To date, there have been few reported performance evaluations of OpenFlow [8] and SDN [4]. Figure 1 shows an SDN implementation at the Kanazawa University Hospital in Japan [6]. Dr. Keisuke Nagase reports no performance issues within the LAN; however, he identified that as SDN is deployed enterprise-wide, expansion of switch flow tables may result in performance deterioration. Given the mission critical nature and requirement for performance, healthcare network planners should consider studying performance before considering deployment. Performance considerations include: the impact of throughput and latency on processing speed. Performance may also be traded-off for switch flexibility – acting on flows in a reactive manner [10]. In healthcare, it is very likely that SDN switches will be regularly re-programmed as new equipment types, protocols or polices are added to the network. Figure 1 shows other areas where performance could be an issue. These areas are marked as 2.

3 Scalability of SDN Controller

An SDN network controller will likely exist in a hybrid network of SDN and non-SDN switches in a typical healthcare communications network. These controllers may be centralized or distributed. Interoperability between the SDN and traditional controller using the east and westbound APIs will introduce additional complexity in the network since these APIs are not standardized. Network controller interoperability was not a consideration in the Kanazawa University Hospital where a single vendor solution was deployed. However, Nagase did identify this as a likely future problem along with the management of multiple domains, versions and vendor compatibility [6]. Figure 1 shows areas where scalability could be an issue. These areas are marked as 1. Another aspect of scalability is the issue network latency between a single controller and multiple switches. Finally, the size and operation of the controller database must also be investigated. A related problem of relates to the distribution of data in distributed networks where controller replicas may exist [4, 10].

4 Security

While network forensics and security policy management is part of SDN, vulnerabilities exist at many points in an SDN network as shown in Figure 1. Security, while being discussed in standards bodies such as the ONF, is still largely unaddressed [10]. Healthcare data security consists of confidentiality, integrity, authentication, access control, non-repudiation, privacy and audit-ability [2]. The network controller must deal with diverse policies for multiple organizations with multiple applications. Sezer reports that " in the absence of a robust, secure controller platform, it is possible for an attacker to masquerade as a controller and carry out malicious activities", resulting in greater damage than attacks on DNS servers [10]. Another concern is that network programming simplification is achieved through the use of open protocols and interfaces. This is fundamentally an open invitation to attack. The SDN community is still dealing with this concern. It is imperative that healthcare providers effectively participate and influence comprehensive SDN security standards. Note that there was little mention of security in the Kanazawa University Hospital Implementation, except to say it must be considered. Figure 1 shows areas where security could be an issue. These areas are marked as 3.

5 Interoperability in Hybrid Networks

As mentioned, the Kanazawa University Hospital is a single vendor deployment. The hospital was expanding anyway and deployed an SDN LAN. In effect, they swapped out one network for another. However, in the vast majority of cases, this may not be possible, and is only applicable to campus networks and data centers [10]. As healthcare become more technically enabled, SDN healthcare WANs will become a reality. Therefore, transitioning to SDN necessarily requires multi-vendor, legacy, multi technology (wireless, wired, optical) support. Standard bodies such as the IETF, ETSI and ONF must have representation by healthcare to address its unique considerations such as cost, stability, availability, and flexibility [2]. Figure 1 shows areas where interoperability could be an issue. These areas are marked as 4.

6 Conclusion

Lena Griebel, et al. report that there are very few successful implementations of cloud computing in healthcare [3]. Based on research in the MEDLINE database using PubMed, the authors purport that there is a general misunderstanding regarding the actual definition of cloud computing, and hence its actual deployment in healthcare. The authors may be correct, which would explain the dearth of scholarly work in SDN for healthcare. These authors cite that trust in external providers is an important issue. Note that several large scale deployments of cloud computing do indeed exist based on findings in scholarly articles in engineering and computer science [5]. The fact that there are major deployments by external cloud partners may indicate that the tide is changing as it relates to trusting outside parties. It may also be an indication that medical IT professionals may not be taking SDN seriously, and hence not participating in a substantial way in SDN standardization work.

While there are few publications, several major vendors cite examples of SDN deployments. More scholarly work is required to capture the opportunities and issues in specific implementations. This will enable other healthcare providers to learn from real world user experience and foster greater confidence and trust. SDN is important in healthcare and should be seriously considered, especially for campus and data center type deployments. All of the issues described in this paper become exacerbated if SDN is considered for WAN and core carrier networks.

Performance, scalability, security and interoperability are among the issues that must be addressed before considering deployment of any network. This paper has highlighted some of these issues and has demonstrated that further research is required, especially for healthcare. In conducting the literature review, however, the author realized that as the medical model moves from reactive patient care, to proactive disease prevention, SDN has the possibility to have a profound impact healthcare delivery. The advantage of having a global view of the network has enormous implications on the "democratization" of network infrastructure. Should networks be considered in the same light as roads, bridges and highways? Who should own, manage and pay for these networks? Should certain data be protected using a military model? Should the elements of SDN be regulated in the same way as medical devices? SDN is coming, and research is needed to understand the potential impact.

7 References

1. Abawajy, J., "Comprehensive analysis of big data variety landscape." International Journal of Parallel, Emergent and Distributed Systems 30(1), 2014, pp 5-14.
2. AbuKhousa, E., Mohamed, N., & Al-Jaroodi, J., "e-Health Cloud: Opportunities and Challenges. Future Internet, 4(3), 2012, pp 621–645.
3. Griebel, L. et al , "A scoping review of cloud computing in healthcare", BMC Medical Informatics and Decision Making, 15(1), 2015 pp 1–16.
4. Kreutz, D. et al, "Software-Defined Networking : A Comprehensive Survey", Proceedings of the IEEE.103(1), 2015.
5. Kuo, A. M.-H., "Opportunities and challenges of cloud computing to improve health care services", Journal of Medical Internet Research, 13(3), 2011, e67.
6. Nagase, K. "Software Defined Network Application in Hospital", The Journal of Innovation Impact, 6(1), 2013, pp1–11
7. "Software-Defined Networking", Open Networking Foundation. April 13, 2012. https://www.opennetworking.org/images/stories/downloads/sdn-resources/white-papers/wp-sdn-newnorm.pdf last access April 7, 2015.
8. "Open Flow Switch Specification 1.3.4", Open Networking Foundation. March 27, 2014. https://www.opennetworking.org/Openflow last access April 7, 2015

9. Garrison, Steve, "Emerging Use Cases for SDN", SDxCentral, February 20, 2015, https://www.sdxcentral.com/articles/contributed/emerging-use-cases-for-sdn-steve-garrison/2015/02/ last access April 7, 2015
10. Sezer, Sakir, et al. "Are we ready for SDN? Implementation challenges for software-defined networks." Communications Magazine, IEEE 51.7 (2013): 36-43.
11. Wang, Guohui, T. S. Ng, and Anees Shaikh. "Programming your network at run-time for big data applications." Proceedings of the first workshop on Hot topics in software defined networks. ACM, 2012.
12. Boucadair, M., & Jacquenet, C. (2014). Software-Defined Networking: A Perspective from within a Service Provider Environment. Retrieved from http://www.rfc-editor.org/info/rfc7149

A proposal of Using RFID Technology in Improving Scheduling and Route Planning for Pickup and Delivery of Medical Instruments at a Hospital

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Abstract. The healthcare sector will be strongly affected by Internet of Things (IoT) while Radio Frequency Identification (RFID) technology contribute to make IoT vision, a reality. In this paper, we investigate the potential of using an RFID-enabled traceability system for improving the efficiency of scheduling and route planning at a hospital. A case study approach is suggested to study the tasks of central sterilization department (CSD) employees, for delivering clean as well as picking soiled instruments and bedsides for different clinical units of a hospital in Montreal, Canada.

Keywords: Internet of Things (IoT), RFID technology, traceability, process redesign, delivery and pickup scheduling and route planning, hospitals

1 Introduction: RFID as an Enabler of IoT in Healthcare

Few months ago, Gartner analysts highlighted the top ten technology trends that are strategic for most organizations in 2015 and presented their findings among which "Computing Everywhere", "The Internet of Things" (IoT), and "Advanced, Pervasive and Invisible Analytics" occupied respectively first, second and fourth place in the ranking [12]. For another year, the IoT has been identified by the professional community as a trend "that organizations cannot afford to ignore in their strategic planning processes". European and international experts proposed a common definition for IoT as "a dynamic global network infrastructure with self-configuring capabilities based on standard and

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interoperable communication protocols where physical and virtual "things" have identities, physical attributes, virtual personalities, use intelligent interfaces, and are seamlessly integrated into the information network" [6, p.6]. The adoption of Radio Frequency Identification (RFID) technology (as a data capture and sensing layer) is closely related to IoT as it allows any tagged object (e.g., patient or medical asset) to communicate electronically, in real time, with its environment through the global infrastructure of wireless internet (communication layer) where automated transactions can be conducted (service/application layer). Information retrieved from such an (RFID tagged) object, turns it into a potential "smart" object, enabling access, monitoring and control of those smart objects over "an Internet of connected things" [14].

IoT is still emerging as a new concept. Before its vision can be made a reality, IoT's technical and business issues are still substantial and numerous research questions remain to be answered; whereas many applications are already penetrating everyday life. For instance, in their survey that has focused on IoT industry solutions (i.e. solutions that have been proposed, designed, developed, and brought to market), [13, p11] sees a substantial interest in supply chain management applications and novel methods to optimize processes, "especially through real-time data collecting, reasoning, and monitoring". In analyzing potentialities for developing new intelligent applications, [5] regrouped IoT applications in three overlapping domains, namely (i) industrial domain, (ii) smart city domain, and (iii) health well-being domain; suggesting that the medical and healthcare sector will be strongly affected by IoT. In the healthcare context, numerous researchers have already investigated the ambient assisted living environment for mobile health applications from an IT architecture and data security standpoint [14], data management issues [10], or healthcare quality services improvement from a patient perspective [16]. For any of these patient centered applications, as well as for the ones related to sustaining logistics processes, RFID is a promising technology that enables the IOT environment in the healthcare industry [11]. None the less, although the technology has the potential to play critical roles in improving service delivery in healthcare [2,9,17] and "despite the benefits of RFID in creating a pervasive environment for the healthcare industry, its adoption remain low" [7, p.67]. While numerous scientific papers have been written on the impact of RFID technologies on logistics processes, much of the research on RFID in the healthcare supply chain and logistics management is still limited (e.g., [3]).

This paper is a partial and propositional response to this gap as it investigates the potentials of implementing an RFID-enabled traceability system for improving the efficiency of scheduling and route planning at a hospital. A case study approach is recommended to study the tasks of central sterilization department (CSD) employees, for delivering clean as well as picking soiled instruments and bedsides for different clinical units at the hospital. Section 2 of this proposition paper discusses the current processes and reasons behind the actual inefficiencies. The objectives and research problems are proposed in section 3 and finally the impacts of using an RFID enabled traceability system to resolve these issues are envisioned in the last section of the paper.

2 Pickup and Delivery: Processes and Existing Issues

This position paper studies a hospital in Montreal, Canada. It consists of 11 buildings, with several clinical units in each. A 12th building is planned to be constructed and incorporated among other buildings, while several of these clinical units as well as the CSD will be relocated to this new building. Currently, the task of providing clean instruments and bedsides and collecting the soiled ones from the clinical units is a shared responsibility between CSD and clinical units.

2.1 Soiled Pickup and Clean Delivery Process

Presently, the process of soiled pickup starts from CSD, where an employee uses an empty cart and travels to different locations for collecting the soiled items (*see* left side of Fig. 1). Approximate pickup times are imposed by clinical units. During his travel, an employee uses a timesheet and manually takes note of the exact pick up time as well as the number and type of items collected. In regards to the routes and order of visiting clinical units, there is no specified path or order and it differs from one CSD employee to another. Although, these employees have a good common sense of proximity of units, some may decide to collect soiled items in every floors of one building and then go to another building, while others may go floor by floor throughout all the buildings. After all pickups are done, the employee brings back the filled cart to the CSD for washing and decontamination of soiled items. While CSD employee is the main responsible for picking up soiled items from different clinical units, some of these units have allocated one of their own employees to take soiled items to CSD for reprocessing. Majority of these units are located in a far distance from CSD; hence it is difficult for the CSD employee to travel there, especially when he is carrying a cart filled with large loads of soiled items.

Similar to the pickup process, a CSD employee uses a cart to deliver cleaned items to clinical units (*see* right side of Fig. 1). CSD received requisitions from units via fax or phone calls. However, the schedules are not regular and clinical units may ask for different quantities each day while they do not always send their requests on specific hours.

Fig. 1. Soiled pickups and clean instruments and bedsides deliveries in carts

This leads to CSD employee not being able to deliver on time; hence the clinical units' employees have to come by the CSD to follow up with their requests. Before departing, the CSD employee manually records the quantity of items and approximate time for delivering the requests in a timesheet.

2.2 Issues with Existing Pickup and Delivery Processes

According to the current processes, some identified issues are:

- Lack of visibility on pickup requirements: while pickups appointments are scheduled upfront, a unit may not have any soiled items to be collected. Since CSD employee do not have access to this information, they travel throughout every single unit;
- Lack of visibility on delivery requirements: since clinical units do not have precise timetable for sending their requests, CSD cannot replenish items efficiently;
- No standard process: sometimes, non-CSD employees bring soiled items directly to the CSD, or come by to inquire about their request and make pickups;
- Manual recording of pickup and delivery information by the CSD employees: this increases the probability of errors (e.g., wrong number of collected soiled items);
- No specific route paths for pickups and delivery: employees rely on their habits and common sense to perform the processes following convenient but non optimal routes.

3 Research Objectives

Scheduling and route planning are usually applied in logistics and transportation [15]. For example, in dynamic multi-period vehicle routing problem with probabilistic information [8] the objective is to satisfy requests for customer service where a customer requiring a service in later time periods is unknown. The challenge is then to estimate the "best time period" to serve each request in order to minimize the costs while ensuring an adequate level of service delivery. In the context of hospitals, the same techniques can be applied for improving the efficiency of delivery and pickup problems. As an example, [1] described the improvements in the delivery of linens to different clinical units at a teaching hospital by reassessing the quantities of linen to be delivered and redesigning the delivery schedule. In order to address similar problems, RFID technology is used for supporting the replenishment of medical products [3], and the same approach could be applied to the replenishment of equipment and bedsides with real time visibility. Additionally, since the implementation of an RFID-enabled system is often done in conjunction with the redesign of processes as well as the design of a facility layout, these aspects have to be taken into account as they directly and indirectly results in higher efficiency of the material flow and control [11].

In defining the research problem of this study, by moving to the new building, the responsibilities related to the replenishment process of instruments and bedsides are aimed to be relied on the CSD. In fact, the new building will be restricted to CSD employees, preventing maverick interventions of non CSD employees. Also, since the CSD and clinical units will be relocated, the most efficient routes are yet unknown.

In this context, the main objective of the research will be to assess the performance of an RFID enabled traceability system to improve the efficiency of scheduling and route planning for pickup and delivery of items to clinical units. In order to investigate this objective, the following sub objectives should be addressed: (a) identifying how RFID technology can facilitate the replenishment process based on real needs for clinical units vs. pre-planned orders, (b) estimating the number of CSD employees required to fulfill the delivery and pickup tasks, and (c) planning the most efficient traveling routes (with the least distance) for delivery and pickup.

4 Concluding remarks and Further Work

In this position paper, we mainly exposed the problem and the objectives of research. Analyses will be conducted for scheduling and route mapping of the 70 clinical units and the *"As-Is"* situation will be studied by shadowing CSD employees to collect information on (a) pickup and delivery locations (b) times, (c) types of items, and (d) their loads. This data collection will further allow estimating the actual frequency for pickup and clean deliveries as well as the required number of CSD employees to ensure the services.

It is anticipated that embracing RFID technology in clinical units will allow automatic identification and tracking of instruments, carts, and eventually (if required) employees, resulting in real-time visibility on operations and improved decision marking. At a high level, a solution based on passive UHF RFID is envisioned. RFID readers and antennas may be installed in specified reading zones (e.g., soiled rooms, dropping areas) of the clinical units and the CSD and RFID tags will be attached to instruments and carts.

Based on the Kanban principles, as tags' ID are captured in real time, this information is used to automatically trigger pickup and replenishment requests associated to the soiled items in each room. Therefore, instead of stopping at every unit, an employee would receive a request on his mobile device and would only visit the entailed zones when needed. Business rules will hence need to be defined and configured in the RFID middleware in order to leverage on this real time visibility in a way that hospital managers may be able to move away from actual pre-planned scheduling and route planning to dynamic routing. Here, an RFID enabled traceability system will automatically computerize the recording and archiving of information for the time, quantity, destination, responsible, etc. for each round of delivery or pickup. This will help better estimating CSD employee's workload and develop an adaptive service policy aiming to satisfy requests for service. These automated access to accurate, timely and precise information on (a) replenishment needs at the point of use, (b) on the locations of carts and instruments, as well as (c) on the positioning of employees, opens the door to the hospital real time management and will constitute one application among others in the IoT concept.

The next step will then be to (a) envision the design of an RFID solution, (b) model the new processes, (c) simulate impacts of the solution on the replenishment processes, and (d) develop a prototype of the system to validate the technical feasibility (e.g., readability as items are stacked in the rack) as well as the performance improvement on the scheduling and route planning processes.

References

1. Banerjea-Brodeur, M., Cordeau, J.F., Laporte, G., Lasry, A.: Scheduling Linen Deliveries in a Large Hospital. J. Oper. Res. Soci. 49(8), 777-780, (1998).
2. Bendavid, Y.: RFID-enabled Applications to Improve the Delivery of Healthcare Services: A Typology and Supporting Technologies. *J. Med Biological Eng.* 33(5), 433-442, (2013).
3. Bendavid, Y., Boeck H., Philippe R.: RFID-enabled traceability system for consignment and high value products: a case study in the healthcare. *J. Med. Sys.* 36(6), 3473-3489, (2012).
4. Bendavid, Y., Fosso Wamba, S., and Barjis J.: RFID: towards Ubiquitous Computing & the Web of Things, J. theor. Appl. Electron. Commer. Res. 8, (2), III–XI, (2013).

5. Borgia E. The Internet of Things vision: Key features, applications and open issues. *Computer Communications*, 54(1), 1-31, (2014).
6. CERP-IoT. Internet of Things: Strategic Research Roadmap. Report from the Cluster of European Research Projects (FP7) on the Internet of Things (CERP-IoT), (2009), www.internet-of-things-research.eu/pdf/IoT_Cluster_Strategic_Research_Agenda_2009.pdf
7. Chong A.Y.L., Liu M.J., Luo J., Keng-Boon O.: Predicting RFID adoption in healthcare supply chain from the perspectives of users, *Int. J. of Prod. Econ.* 159, 66–75 (2015).
8. Elena Fernández, M., Laporte, G.: The dynamic multiperiod vehicle routing problem with probabilistic information. *Comp. & Oper. Res*., 48, 31-39, (2014).
9. Fosso Wamba, S., Anand, A., and L. Carter, (2013). A literature review of RFID-enabled healthcare applications and issues. *Int. J. Inf. Mgt*. 33(5), 875-891.
10. Gartner Research: Gartner Identifies the Top 10 Strategic Technology Trends for 2015. Special Report (2015), www.gartner.com/technology/research/top-10-technology-trends/
11. Moatari Kazerouni, A., Chinniah, Y. Agard, B. Integrating Occupational Health and Safety in Facility Layout Planning, Part I: Methodology; Int. *J. Prod. Research; Online first* (2014).
12. Paschou M., Sakkopoulos E., Sourla E., Tsakalidis A. : Health Internet of Things: Metrics and methods for efficient data transfer. *Sim. Model. Practice and Theor.*, 34,186-199 (2013).
13. Perera C., Liu C.H., Jayawarden S.: The Emerging Internet of Things Marketplace From an Industrial Perspective: A Survey. *IEEE Trans. on emerging topics in comput.,* 99, 1-14, (2015).
14. Santos A., Macedo J., Costa A., Nicolau M.J.: Internet of Things and Smart Objects for M-health Monitoring and Control. *Procedia Tec.,* 16, 1351-1360 (2014).
15. Tompkins J. A., J.A. White, Y.A. Bozer, J. M .A. Tanchoco. *Facilities Planning.* John Wiley& Sons; 4 ed., USA, (2010).
16. Turcu C.E., Turcu C.O.: Internet of Things as Key Enabler for Sustainable Healthcare Delivery. Procedia - Social and Behavioral Sciences, 73(27), 251-256 (2013).
17. Yao, W., Chu C. H., Li Z.: The adoption and implementation of RFID technologies in healthcare: a literature review. *J. Med. Sys.* 36(6), 3507-3525, (2012).

Symptoms Interdependencies Prototype for Patients based on Context-aware parameters

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Abstract. Context-aware applications are emerging as an important class of applications to improve services of health care systems. Existing approaches do not properly design the essence of context, in terms of relevance for the application and also in terms of best practices essential to take into account the pertinent contextual parameters, to understand their interdependencies and dynamicity. We consider the context as the location, heart pulse rate, and many more. This article proposes and validates a context-aware interdependency prototype to help and advice the monitoring persons such as nurses, medicines, parents. Two case studies are developed as a proof of concept of this model. This model can be applied also in the case of Alzheimer diseases.

Keywords: Interdependency of Context-aware, Diseases and symptoms, Health Care system, Ubiquitous Computing, Tele medicine, Bio-informatics.

1. Introduction

Over the years the mobile phone has evolved to become an important device to capture data and monitor persons remotely. Therefore, the use of mobile technologies is opening new and innovative ways to improve health care systems and applications [1]. The question is how we can efficiently monitor things like medical conditions of children at school [3], or control chronic obstructive pulmonary disease (COPD) in seniors persons based on many context-aware parameters to help doctors and nurses make good decisions?

The user can query the intelligent system which instantly responds according to several parameters (context). However, many researchers have questioned the real meaning of "context" and sought for it, to deduce a clear definition. Existing approaches [5, 9, 10, 13] do not design properly the essence of context, in terms of relevance for the application and also in terms of best practices essential to take into account the contextual elements (parameters), and to understand the interdependencies between them in ubiquitous computing [11, 12].

To understand the problem, consider monitoring health care application. Suppose the monitored person (patient or student) has a COPD symptom which composed of a set of parameters. Some of these parameters can be used to diagnosis the other symptoms such as heart attack or other symptoms. Therefore, we need to advise the

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nurse, medicines and even the patients by predicting and offering them a relation between COPD and heart attack using parameters. The parents of students can receive an alert on their smart phones to describe the details of the abnormal situation of their children at school. They can know the location, temperature, pressure blood, respiratory rate, pulsation, position (standing or lying), and many more.

Having patient (Mike) with COPD or heart disease in school makes parents worry all the time about his health condition, especially when the child or patient tries to make an effort to do the same activities as his friends do at school. The main question is how we can help these parents and nurses to detect the probable symptoms in real time and take a best decision.

The bracelet can be used in medical circumstances; it shows many parameters such as heartbeat rate which is transferred to Smart phone of students. The activity tracker will measure the child's heart beats and every specific period of time (30 sec.).

This article is organized as follows. Section 2 presents briefly existing approaches to define context and its parameters, and monitor patients. Section 3 describes context definition and the interdependency of symptoms of patients. As a proof of concept, we simulated and implemented two case studies in section 4 and show the results. A conclusion and future works are given in section 5.

2 Related Works

This section describes briefly the two main topics related to this research paper which are context modeling and monitoring systems.

The concept of context has led to many models and definitions. In 1995, Schilit *et al.* [4] have modeled the context as the user location, identity and status of people and objects around. In 2001, Dey *et al.* [5, 6] defined the context as "any information used to characterize the situation of an entity which can be a person, a place or an object (very used)". Chaari *et al.* [7] defined the context in 2005 as the set of external parameters that can influence the application behavior. In 2011, Bacha *et al.* [8] have developed a generic context model for the design of user interfaces. In 2012, Popovici divided the context depending on the terminal (i.e. its characteristics), available services, the user's environment and the user himself [9]. These definitions are either very general [5, 8] or very specific [9], and in both cases, they are not very useful in context aware applications [13]. Also, there is no clear relation in health care systems between parameters and phenomena of patients.

Many monitor devices and tools have been developed to monitor persons around the world. The GPS monitoring solution enterprise developed a bracelet monitoring device to monitor teenagers at all times [2, 15]. The cost for its service is expensive for parents: 9$ per day, plus insurance and an installation/enrollment fee. The devices are monitored around the clock by a live staff providing parents with peace of mind that someone is watching. Omnilink Systems also develop Electronic Monitoring devices to reduce School Truancy [3]. Many other devices are developed such as Dallas-based AIMTruancy Solutions which use mobile phone [17].

These monitoring systems do not handle the relations between the symptoms and diseases. Next section proposes context-aware interdependency prototype to predict the diseases related to given symptoms.

3 Context-aware interdependency prototype for Health Monitoring

Dey's definition of context is considered as the most adopted definition by the researchers: "Any information that can be used to characterize the situation of an entity (person, place, or object)" [5]. This definition is very generic one and it is not clear how to apply it when different variations of context are possible.

We define the context as a set of parameters that influence many kinds of diseases such as Psychopath, Depression, Heart Attack, Alzheimer, Chronic Obstructive Pulmonary Disease (COPD), etc. Our aim is to define the context for these kinds of diseases, apply it to many case studies, and then revaluate it. Then, we identify in our prototype the dependency of different symptoms and diseases of patients. We have defined two types of parameters in our context:

- Static parameters that change infrequently
  - ✓ Name: Identifies the patient in the database.
  - ✓ Age, size and smoking status: Allow a diagnosis
- Dynamic parameters that change each measure
  - ✓ Oxygen in blood, Blood glucose, FEV1 forced expiration volume per 1 second, many others like temperature, pulsation to complete diagnosis

Note that this definition applied in section 4 will be extended later to develop an adequate definition of context for the medical domain.

The dependency between symptoms and diseases can be represented by the schema of figure 1 below. Three phenomena are discussed: Psychopath, Depression and COPD. These phenomena (symptoms) can be measured by parameters of context and can cause Oxygen deficient in blood, which in turn can be measured by Oxygen Saturation. These parameters are related to diagnostic of the different symptoms of diseases. For example, Oxygen Saturation is related to Heartbeat parameter.

To summarize, a context is characterized by a set of parameters. A parameter has a property name and type and context can evolve in a dynamic way by enabling and disabling some other parameters. The dependence of the parameters is an inference rule: if value of parameter is very high (not standard), then the symptom A is true. One must find the cause of A (figure 1): B, C, D, or combination of them. We deduce that if P1 (Oxygen Saturation value) is outside the norm value, then that the patient could have HeartBeat disease.

These symptoms (phenomena) are related indirectly by parameters: consider the case of Oxygen deficient O2 in blood. Therefore, the nurses, medicines, or parents deduce that they could take care of three symptoms in this case: A, B and C. So, we use the parameters to identify the dependency between symptoms and then help persons in diagnosis. Figure 2 show a basic idea of this prototype to identify this relation between symptoms. If we consider Martin as patient who has two abnormal values of two parameters, this prototype filters the symptoms to deduce the disease he has by considering the intersection of symptoms related to these two parameters. Martin has diabetes which is offered to the nurses and medicines (see figure 2).

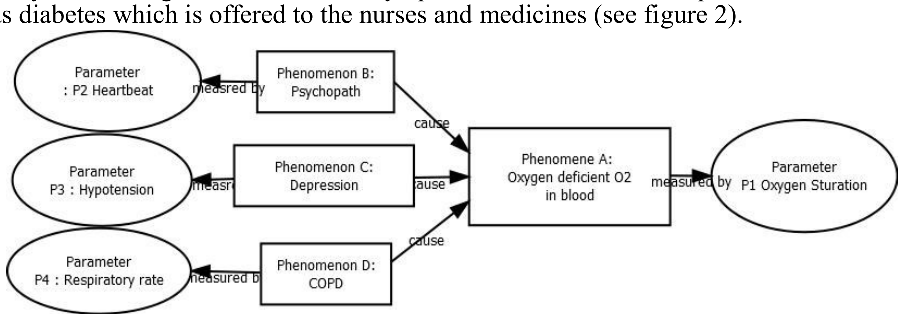

Fig. 1. Remote Monitoring Model.

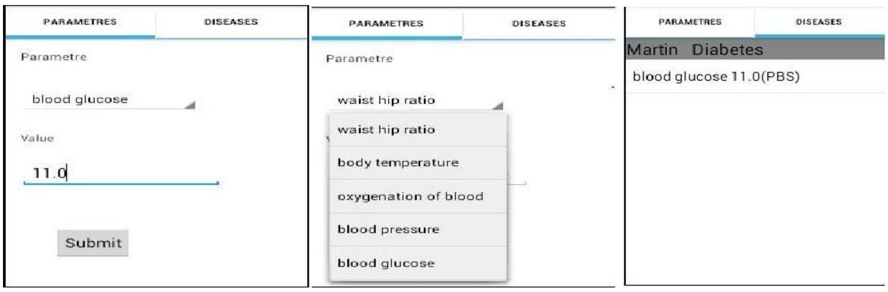

Fig. 2. Symptoms and their dependencies in context-aware model.

4 Simulation and results

We have implemented two case studies of Psychopath and COPD diseases, which are chosen to validate the context-aware interdependencies prototype given in section above. A Psychopath's disease patient suffers from personality disorder, which is characterized by enduring antisocial behavior, lack of empathy and bold behavior. This person can get confusion and does abnormal behaviors. This disease does not only affect the patient but also his or her family and society. As the disease progresses, a Psychopath's disease patient will become increasingly dependent upon his or her caregivers. This project is designed to help these families cope with the devastating illness and diminish the burden of caregiving.

Our project is made up of two applications and smartphones. In the first application, the patient should wear a medical alert bracelet, which is connected to the first application locally, it measures parameters such as pressure, blood respiratory rate, pulsation, position (standing or lying) and GPS coordinates (latitude and longitude). The second application receives this information and identifies the location of patient in the map, then makes tests: when the patient leaving his house to do some activities such as shopping, encounters some health problems or takes off the bracelet his family will be alerted via their mobile.

Figure 3 shows the monitoring persons (like parents) with GPS position, heartbeat, temperature and other information. Based on these values, the school's nurse or the parents will receive an alert describing the states monitored person (Mike: student or patient has a bad temperature or bad heartbeat rate).

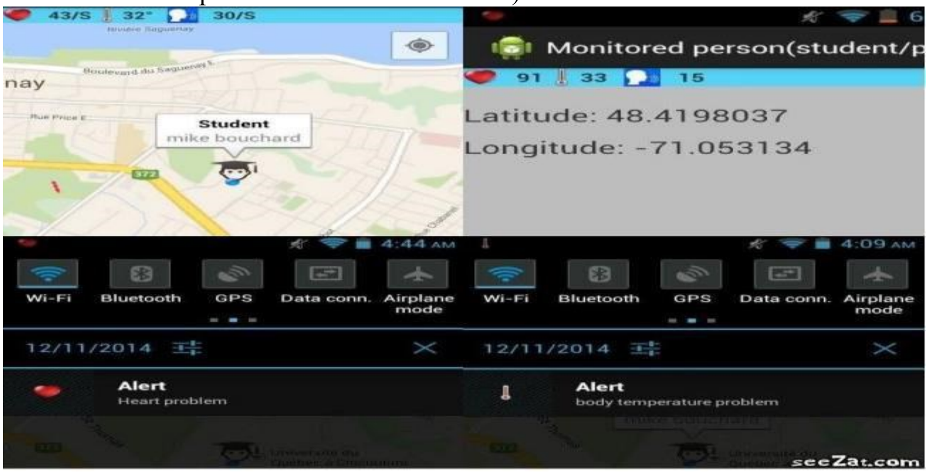

Fig. 3. Validation of Remote Monitoring Model using Mobile devices.

The scenario of COPD uses two parameters to represent a context and is given in detail in our previous article [14].

These scenarios demonstrate that the relations between symptoms can be predicted to help nurses, medicines, parents and even patients in their daily life and they help parents to monitor their children. The issue is to identify the relations of symptoms and diseases based on information of experts in the domain. Another issue is to identify the good diseases linked to some parameters. This prototype should be applied in more case studies using big number of patients with their records.

5 Conclusion and Future Works

To satisfy the needs of users, context-aware and mobile applications need to be intelligent and identify the dependencies between symptoms of patients. This context should also be investigated and defined in medical domain to achieve user’s activity. Thus, monitoring intelligent systems help people to improve their quality of the life.

This paper proposes symptoms interdependencies and context definition for monitoring patients and their activities. Interdependencies prototype is described to map the symptoms of patients to parameters of context and then to diseases. Two scenarios of Psychopath and COPD are done to validate these models. In the case of Psychopath, we have applied it in the case of student at school to detect an abnormal status, and then alert the parents, nurses and medicines about his status (position, heartbeat, blood pressure, and many others). Our prototype helps those persons and institutions to control activities of each user.

In the future works, this context model should be improved based on more scenarios (Alzheimer and Depression diseases). The relations of symptoms and diseases should be intelligently predicted by using more advanced intelligent techniques.

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References

1. Shih, C.S., and Trieu, T.K, Shadow Phone: Context Aware Device Replication for Disaster Management.pp446-454. Proc. of Research in Adaptive and Convergent Systems, RACS'13-ACM, Montreal, Canada, October 2013.
2. Mcheick, H., and Goudafi, A., Reliable and Optimal Location System for Monitoring Geolocation Objects, International Living Usability Lab Workshop on AAL Latest Solutions, Trends and Applications (BIOSTEC-AAL'11-Springer), 2011, Italy.
3. Omnilink Systems Inc., Monitoring devices, http://www.omnilink.com/school-truancy/
4. Schilit, B., Adams, N., and Roy, W. Context-Aware Computing Applications. IEEE, Supported by Xerox, 1995.
5. Dey, A., and Häkkilä, J., Context-Awareness and Mobile Devices, IGI Global, Chapter 3, 2008.
6. Dey, A. K., Abowd, G. D., and Salber, D., A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications. Human-Computer Interaction Journal, 16(1), 2001.
7. Chaari, T., Laforest, F., and Flory, A., Adaptation des applications au contexte en utilisant les services web. Proc. of 2nd French-speaking Conference on Mobility and Ubiquitous Computing, pp 111-118, ACM, 2005.
8. Bacha, F., Oliveira, K. and Abed, M., Using context modeling and domain ontology in the design of personalized user interface, International Journal on Computer Science and Information Systems (IJCSIS) 6, pp.69–94, 2011.
9. Popovici, D., Gestion du contexte pour des applications mobiles dédiées aux transports. Thèse de doctorat Grade de Docteur de l'Université de Valenciennes et Du Hainaut-Cambresis, Décembre, 2012.
10. Dockhorn Costa P. Architectural Support for Context-Aware Applications: From Context Models to Services Platforms. Ph.D.-Thesis Series, No. 07-108 ISSN 1381-3617; No. 07-108, The Netherlands, 2007.
11. Mamo, B., and Fjigu, D., A Generic Layered Architecture for Context Aware Applications. International Symposium on Emerging Inte-networks, Com. and Mobility (EICM), Elsevier, Ontario, Canada, Aug.17-21, 2014.
12. Mcheick, H., Sbeity, H., Hazimeh, H., Naim, J., and Alameh, M., Context Aware Mobile Application Architecture (CAMAA) for Health Care Systems: Standardization and abstraction of context aware layers, 2014 IEEE International Humanitarian Technology Conference (IHTC-IEEE). June 1-4, 2014, Montreal, Canada.
13. Mcheick, H., Modeling Context Aware Features for Pervasive Computing, The 5th International Conference on Emerging Ubiquitous Systems and Pervasive Networks (EUSPN-2014), Journal title: Procedia Computer Science, Procedia Computer Science (2014), pp. 135-142 DOI information: 10.1016/j.procs.2014.08.022. Elsevier, September 22-25, Halifax, Canada, 2014.
14. Mcheick, H., Sbeity, H., Hazimeh, H., Naim, J., and Alameh, M, Context Aware Mobile Application Architecture (CAMAA) for Health Care Systems : Standardization and abstraction of context aware layers, 2014 IEEE International Humanitarian Technology Conference (IHTC-IEEE). June 1-4, 2014, Montreal, Canada.
15. Mcheick, H., Khreis, K., Al-kalla, M., and Sweidan, H., CARE Framework: Context-Aware Reliable Engine Health Focus On Traffic Monitoring System, the 16 International Conference on Modeling and Simulation UKSIM-IEEE, pp.410-415, Mar. 26-28, 2014, UK.

Towards a Goal Model Development Framework for Online Business Processes

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Abstract. Business Process Management (BPM) is used in many organizations to move existing paper-based business processes online in order to improve the quality of provided services and reduce costs. Traditional approaches to business process management focus on the implementation of the online business process and neglect validating the improvement of process quality in terms of defined business goals. It is desirable to detect and anticipate any deficiencies in meeting business goals during the business process development when corrective actions can be more easily made. In this paper, we propose a business process development framework where a goal model is used to provide metrics that will measure the performance of online business processes during the validation and verification stage. This can ensure that the development of online business processes will improve quality, by giving early indications of any problems before deploying the business process.

Keywords: Business Process Management, Business Process Development, Goal Model, Quality Assurance, Health Care.

1 Introduction

Business Process Management (BPM) is used in many organizations to move existing paper-based business processes online in order to improve the quality of provided services and reduce costs. Traditional approaches to BPM focus on the implementation of the online business process and neglect validating the improvement of quality the new process is supposed to achieve in terms of defined business goals. It is desirable to detect and anticipate any deficiencies in meeting business goals in the stages of business process development when corrective actions can be more easily made.

During the traditional approach of business process development, the Business Process team creates the requirement documents, which are mainly a natural language description of functional and non-functional requirements, and scenarios illustrating the business process. The requirement documents come in the form of spreadsheets, forms, text, emails and reports. The Development team uses the requirement documents, based on their interpretation, to build the business process model.

The Quality Assurance (QA) team uses a web application testing tool to validate the developed business processes with respect to the specification of the requirement documents. After every testing, the QA team creates a testing report that outlines the results of the testing that has occurred, including any unexpected results. The business

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process bugs and errors are assigned to Development team members for fixing. The developed business processes are finally released into production.

There are two shortcomings for the traditional approach, first using natural language in describing the requirement documents causes confusion in the business process specification, lack of clarity, and is subject to differing interpretations by the developers. Second, we will not know if the business process is performing well or improving, since the development does not validate or measure the outcome of the business processes with the defined business goals. To counter the negative pattern of the traditional approach, we propose a development framework as an attempt to evaluate the business goal of an existing business process.

In this paper, we propose a business process development framework where a goal model is used to provide metrics that will measure the performance of online business processes as they are being developed. With our Business Process Development Framework, developers can track the metrics of the business goals into business processes and report them rather than neglecting them. The paper is organized as follows: Section 2 presents the background and related work; Section 3 presents the proposed approach; Section 4 presents a Lung Cancer Intake case study; and section 5 presents the conclusion and future work.

2 Background and Related Work

Business process workflow can be modeled using Business Process Modeling Notation (BPMN) [7] and Business Process Execution Language (BPEL) [6]. The User Requirement Notation (URN) [5] can be used to model user requirements in terms of business goals using Goal-Oriented Requirement Language (GRL) and business scenarios using Use Case Maps (UCM). The i* [10] and Knowledge Acquisition in automated specification (KAOS) [3] are other goal oriented requirements languages for capturing goals of business processes.

In the literature, many approaches propose monitoring health care processes, Aladin et al in [1] proposed a Care Process Monitoring Application (CPMA) to measure the performance of a care process with respect to the business goals. In [2], the authors also developed an architecture for event processing applications to manage and monitor the business processes of a cardiac patient flow system. Abel et al in [8] proposed a process-oriented software development for configuring and monitoring of managed processes at runtime. Gattnar et al in [4] presented an approach that standardizes the evaluation of the process efficiency and quality using a clinical reference process model and generic KPIs. In [9], a framework is used to monitor the business processes by integrating the performance measures produced by the Business Activity Monitoring (BAM) with the semantic of business process lifecycle. In [11], the authors use the workflow management system to integrate the components of the workflow model with the legacy system for a radiology process. Later, the work was updated in [12] by creating a monitoring dashboard to collect the patient data from the workflow management system and integrate it with other information systems in the department.

3 Business Process Development Framework

We propose an approach, to address the issues listed above, for modeling, implementing and testing of the business processes as in figure 1. Initially, the Business Analyst team creates the requirements model which defines a goal model and a set of scenario models to define different execution paths of the business process. The Development team uses the requirement models to build: a) the business process model, b) the service integration models and c) the service components. The business process model is a high level of the business workflow that describes the sequence of processes and sub-processes linked by control flows and controlled by business decisions, iterations and concurrencies. The service integration model is used to connect services together to create higher-level processes. Each service defined in the service integration model is associated to different underlying service components, such as forms, service library and reports. The architecture team is responsible for supplying, maintaining and supporting the infrastructure of the enterprise such as Services, Processors and Databases. The Quality Assurance (QA) team uses a suite of testing tools to perform service unit testing, web application interface testing and performance reports to validate business performance against goal model. At the end of each testing iteration, the quality assurance portal produces the performance report which is used to measure the achievement of business goals and testing report for functional errors and bugs.

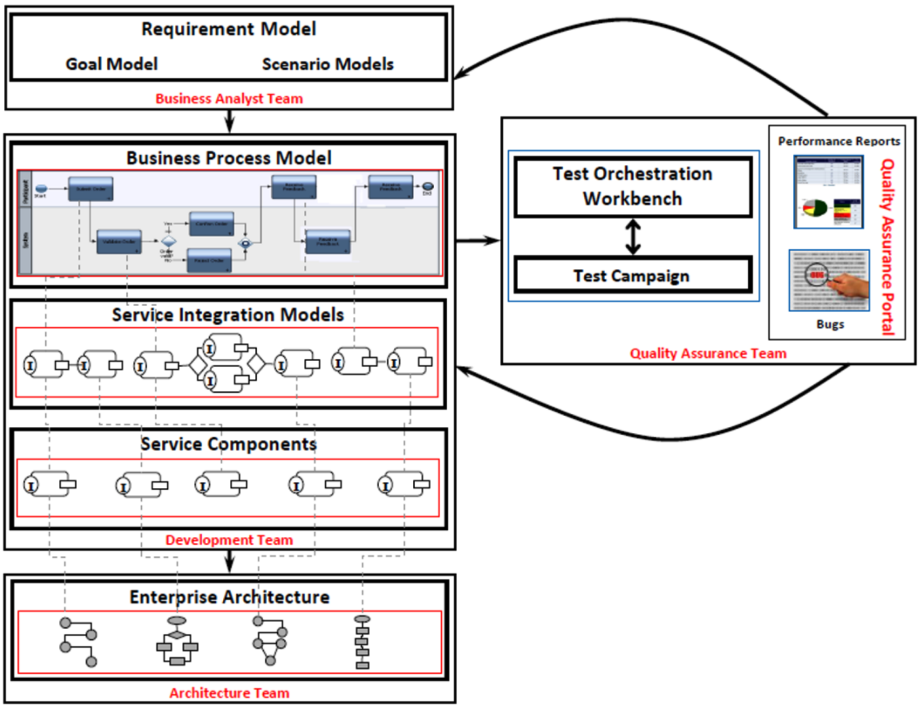

Fig. 1. Business Process Development Framework

4 Case Study: Lung Cancer Intake process

We use the proposed approach described in section 3 to develop the business process of a Lung Cancer Intake project at the Cancer Assessment Center of The Ottawa Hospital. The goal of automating the business process is to increase the patient satisfaction by reducing the patient's waiting times for the provided services.

Figure 2 presents a sample of the goal model of the Lung Cancer Intake. The business goal is "Patient Satisfaction" presented at the top with a contribution of a "Lung Cancer Intake" project as a goal. There are eleven tasks contribute to the goal and represent the functional behavior of the business process. The "Reduce the Waiting

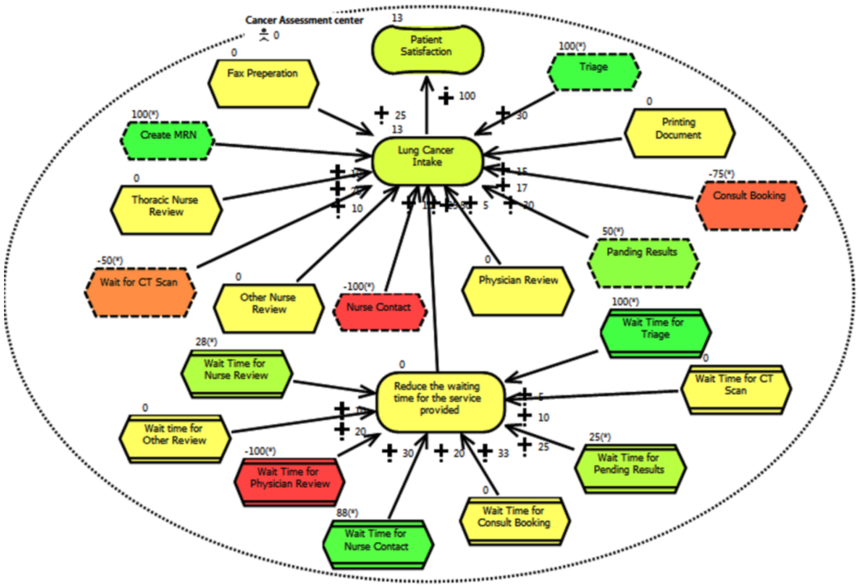

Fig. 2. A goal model of the Lung Cancer Intake

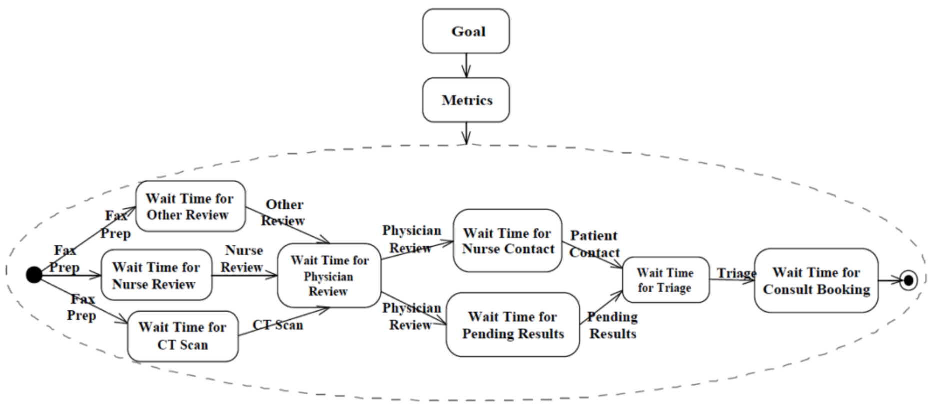

Fig. 2. Mapping waiting times to Performance Measurement

Time for the service provided" is also contribute to the "Lung Cancer Intake" goal and connected to eight KPIs which are used to measure the waiting time at different stages of the Lung Cancer Intake process.

As part of the requirement models, each task defined in the goal model is linked to one of the scenario model to describe the behavior of the processes. The development team uses the requirement models to build the business process model, the integration service models and the service components of the Lung Cancer Intake project.

In order to measure and monitor the performance of Lung Cancer Intake process, the metrics of the goal model must be linked with the data captured in the information systems of the business process project. We use the "State and Event" concept defined in [2], where data fragments are received from different sources in the business process and interpreted as triggered events that pass the transition from one state to another within the process as shown in Figure 3. These data are used to calculate the goal metrics.

The QA team uses the testing campaign first to verify that the functionalities of the product meet the business requirement specifications and ensure that the Forms satisfy the expectation of the end users. The first version of Lung Cancer Intake project is released after a number of testing iterations and bug fixings. The released version is exposed to specific and limited number of the end users, i.e., physicians, nurses and clerks. The purpose is to measure and monitor the business performance against the goal model. Figure 4 describes a performance report generated from the dashboard which shows the measures of the waiting time metrics and number of patients with respect to time. The results of the performance report are monitored with target values of the metrics.

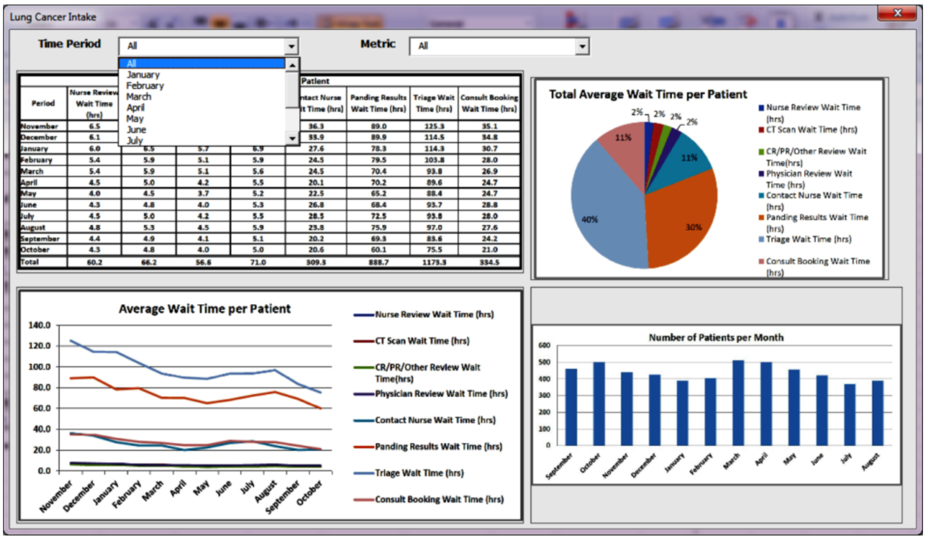

Fig. 3. Performance Report for Lung Cancer Intake project

5 Conclusion and Future work

The paper proposes a business process development framework that bridges the gap between a performance metrics of the goal model and the operational data model of the business processes. The goal model provides performance metrics that will measure the performance of online business processes as they are being developed to ensure that the development of online business processes quality is improving. In general, traditional approaches relegate the evaluation of business goals to the last stages of business process development. In many situations the development process proceeds without a real measuring of business goals where metrics are computed and extracted from historical data. As future work, we are planning to use the model-driven methodology to al- low the mapping between the user requirement domain and the business process domain. In order to do that, we need to create a metamodel which describes the construction and development of the model elements, rules, constraints and data-types of the business process development frame work.

References

1. Baarah, A. H.: An Application Framework for Monitoring Care Processes. Thesis, University of Ottawa, 2013.
2. Baarah, A., Mouttham, A., Peyton, L.: Architecture of an Event Processing Application for Monitoring Cardiac Patient Wait Times. International Journal of Information Technology and Web Engineering (IJITWE), 7 (1), 1-16, 2012.
3. Almisned, F., Keppens, J.: Requirements Analysis: Evaluating KAOS Models. J. Software Engineering & Applications, 2010, 3, 869-874, doi:10.4236/jsea.2010.39101.
4. Gattnar, E., Ekinci, O., Detschew, V.: A Novel Generic Clinical Reference Process Model for Event-Based Process Times Measurement, In Business Information Systems Workshops Vol. 97, Springer Berlin Heidelberg, 2011.
5. International Telecommunication Union (ITU-T), Recommendation Z.151 (11/08): User Requirements Notation (URN) - Language Denition, Nov. 2008.
6. Oasis Standard: Web Services Business Process Execution Language Version 2.0. 11 April 2007.
7. Object Management Group: Business Process Model and Notation (BPMN) Version 2.0. 2011.
8. Tegegne, A., Peyton, L.: Application framework support for process-oriented software development, International Journal of Electrical Business, 232-253, 2013.
9. Wetzstein, B., Ma, Z., Leymann, F.: Towards Measuring Key Performance Indicators of Semantic Business Processes. 11th International Conference on Business Information Systems, pp. 227238. Innsbruck: Springer Berlin Heidelberg, 2008.
10. Yu, S., K, E.: Towards Modeling and Reasoning Support for Early-Phase Requirements Engineering.RE '97 Proceedings of the 3rd IEEE International Symposium on Requirements Engineering, USA, 1997.
11. Zhang, J., Lu, X., Nie, H., Huang, Z., Van der Aalst, W.: Radiology information system: a workflow-based approach, International Journal of Computer Assisted Radiology and Surgery, 509-516, 2009.
12. Zhu, Q., Nie, H., Lu, X., Duan, H.: Radiology Workflow-Based Monitoring Dashboard in a Heterogeneous Environment, 3rd International Conference on Biomedical Engineering and Informatics, pp. 2494- 2498, 2010.

A Survey on Collaborative Internet of Things

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Abstract. The Internet of Things is no more a promising idea but a current reality. Our phones, tablets, and other wearable devices are already perceiving our world; their environment. Each new model of these devices is equipped with sensors, actuators, and different capabilities (hardware/software). This paper will discuss this phenomenon called Internet of Things from a collaborative perspective. Our final aim is not to just compare existing work, rather to establish a start point for future collaborative-enabling technologies in the Internet of Things.

Keywords: Internet of Things, Collaborative IoT, sensor, survey.

1 Introduction

The Internet of Things (IoT) is an emerging super network that connects physical resources and people together with suitable appliances. Collaborative IoT, in particular, focuses on the way physical resources will interact and collaborate with each other and with people. Motivated by the promising opportunities that IoT will bring to human's daily activities, many works tackling the main problems related to this domain, such as heterogeneity, connectivity, and security issues have been presented. This paper is a description of the works that have been led and the issues to be dialled with in future research projects.

The idea behind a Collaborative IoT is intellectually seducing. Thus, it gained significant attention in academia and industry. The goal is to create a world where objects around us know what we like, what we want, and what we need and act accordingly with no explicit instructions [10]. The IoT concept has first appeared as the title of a presentation by Kevin Ashton in 1999 [5]. It is worth mentioning that the idea was mentioned several times by Billy Joy [27] as the Device-to-Device Internet (D2D) that embed machine intelligence. However, it was until 2005 that the concept of IoT came broadly into public with the International Telecommunications Union publishing the first report to address the subject [18]. According to Cisco IBSG [6], the IoT is estimated to be born, the physical existence, sometime between 2008 and 2009.

To capture the different aspects of IoT, many definitions has been given. In 1999, Kevin Ashton [5] stated that passive RFID transponder, as a very simple and low-cost

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computer, can be connected to the Internet through readers. Subsequently, computers will be able to see, to smell and to hear the world without the human-introduced data. The term "Internet of Things" semantically means "*a world-wide network of interconnected objects uniquely addressable, based on standard communication protocols*" [11]. From a data centric perspective, according to Aggarwal *et al.* [3], "*the internet of things refers to uniquely addressable objects and their virtual representations in an Internet-like structure*". This vision of the Internet of Things implies that the uniquely addressable and Internet-connected objects use the same protocols that connect our computers to the internet.

Beyond the dilemma of definitions, the future is to move from objects with identities toward networks of object with personalities. The first step was collecting data. Nowadays, the goal is to use these real world data to optimize systems towards higher performance, better user experiences, more energy efficiency, as well as toward the generation of wisdom.

2 Existing systems and frameworks

Many approaches and tools have been developed for collaborative computing and especially for low-level collaboration. In 1998, Rudenko *et al.* [28] presented an approach to decrease power consumption and ensure an extended battery life on an untethered laptop through wireless remote processing of power-costly tasks. In this context, Kremer *et al.* [21] presented a compilation framework for remote task execution. The solution aims to generate two versions of the initial application, one to be executed on the client mobile and the second on the server machine. Ensuing efforts to reduce energy consumption, Shang *et al.* [8] presented an economics-based power-aware protocol. The Distributed Economic Subcontracting Protocol (DESP) allows dynamic distribution of workload among mobile devices in both cooperative and competitive ad-hoc wireless networks.

Joining the efforts in the networking field, Jacquet *et al.* [19] proposed an Optimized State Routing Protocol to support routing in a heterogeneous MANET where nodes have many interfaces. In OLSR a flat mechanism is employed, whereby a node sends control messages through all interfaces without regards to the link capacities of the other network. OLSR do not scale and support the heterogeneous nature of Ad Hoc Networks (MANET) [33]. The Hierarchical OLSR is an extension to the former OLSR aimed to reduce the overhead caused by sending messages regardless link capacities and to make the routing algorithm more scalable. In spite the HOLSR improves the scalability of the MANET, it affects the network scalability. Indeed, in order to reach the destination node, data travels among normal ways up to the topological level where the destination node is located. Perich *et al.* [26] developed a collaborative query processing protocol. The CQP protocol is based on the Contract Nets principles and it is designed to reduce the computational and energy consumption of the devices implicated in a collaboration. The features of the protocol enable any device, irrespective of its limited computing, memory, and battery resources, to locate and obtain data source streams on other peer-devices in order to answer its queries. The Constrained Application Protocol (CoAP) [20] allows the connection of resource-constrained devices to the World Web. CoAP client, using a publish/subscribe mechanism, can receive the last update of resources in URI path representation. Since the protocol is based on UDP it supports group communication using IP multicast.

The interoperability issues also gained much interest in research world. Shepherd *et al.* [29] suggested the use of parallel processing across handheld devices to enhance robot sense capabilities. The DynaMP, a message passing system was developed to allow communication in the "scatternet" network using Ad-Hoc On-Demand Distance Vector based routing to reduce energy consumption. Based on the Java class loading mechanism, this environment may be deployed on any device with a Java virtual machine. In 2005, Harihar and Kurkovsky [17] attempted to pave the road to Jini in the world of pervasive mobile computing. The paper discussed the use of this platform's networking capabilities to develop pervasive computing environments. As claimed by the authors, this framework has the ability to satisfy the demands of ubiquitous systems, namely context awareness, intelligent behaviour, interaction, reliability and safety. In order to avoid connecting physical objects directly to the Internet, some approaches suggested abstracting those objects as services by adopting the Service Oriented Paradigm [13, 14, 25]. For instance, the work presented by Guinard *et al.* [13] describes the architecture of the Web of Things (WoT) based on the principles of the traditional Web such as scalability and modularity. They promote the reuse and the adaptation of existing Web technologies such as REST architectural style[12] to interact with IoT objects.

Many attempts have been made to connect physical objects to the networks. Diya *et al.* [9] proposed a framework intended for Mobile Collaborative Environment (MCE) infrastructure. The MCE is based on socket communication which allows any devices to connect easily with the other devices on the network. Yet, this approach still a server-centric one. The server IP and listening port must be known to the client in order to allow transmission of code files between both ends.

In order to insure the interconnectivity of IoT devices, many API and technologies are developed. An information sharing architecture for collaborative IoT is presented in [32]. The authors suggested the concept of a user-centric architecture of the IoT that seamlessly integrates IoT objects, Web protocols, Web applications, and Social platforms, etc. Adda *et* Saad [2] presented a data sharing framework for the collaborative IoT. The framework introduced a formal theoretical model, the IOTCollab domain specific language, and an IDE that implements this model. The Xively project [23] is a Platform as a Service (SaaP) intended to ease the connection of applications, objects, devices, and users to the internet. ThingSpeak [30] is an open source application platform and API for that aims to facilitate data storage and retrieval from IoT devices. One of the advantages of the project is its openness to different hardware profiles. The AllJoyn software framework [4] is a promising open source framework and services for collaborative IoT to allow smart things discover, expose their capabilities and work together.

The security issues are in the core of the collaborative IoT. The widespread adoption of smart devices means that more data is being collected on people than before, and so any gaps on security will have a colossal effect on personal privacy. From a service-oriented perspective, [34] proposed a workflow-oriented and attribute-based access control model to treat access control issues. Attributes related to the subject, resources, the environment, and the task to have authorization for, all those parameters have been taken into consideration to obtain a fine-grained model. Authors in [24] presented the Identity Authentication and Capability based Access Control (IACAC) scheme. The capability creation is based on the identity to grant access to on a local network. Thus, this scheme still not fully suitable for small devices within a collaborative IoT. Following the same vein, [15, 16] promoted the use of capability-based security approach to manage access control in the Internet of Things. Indeed, a capability defines the resources, the subject and the granted rights and authorizations. In [22], authors proposed a model that combines location and time with security level to control access to information named Location-Temporal Access Control Model. This is meant to give access to requested operations on a defined node only if the requested node is located in an appropriate location regarding the object. By exploiting smartphone built-in sensors, the Context-Aware Platform using Integrated user Mobile sensors platform (CAPIM) [7] is a user authentication and session management based on Public Key Infrastructure (PKI). This platform has been used to manage access to secure area within a building. To tackle the security issues in the collaborative IoT, the paper in [1] proposed two access control models. The Collaborative Role-Based Access Control (CollRBAC) and the Collaborative Attribute-Based Access Control (CollABAC) models. The paper presented a comprehensive-comparison study in order to evaluate both access control models.

Current solutions for the future collaborative Internet of Things stand on a set of inappropriate models and do not provide the true interoperability, privacy and security handling. Hence, future research projects have to aim at allowing a seamless integration of collaborative IoT technologies with current and future heterogeneous architectures.

3 Open issues for Collaborative IoT

The potential connectivity of the Internet of Things is astonishing. However, it is still in its early stages due to a number of factors, which limit the full exploitation of the collaborative IoT. Before we can begin to turn the promise of the digital universe into reality, fundamental challenges and problems must be addressed. Challenges including the lack of standards, the global-scale issues, and an immature ecosystem with security concerns.

Under the specificity and variability of IoT devices, the compatibility and the interoperability of already deployed IoT devices is far from being certain. Furthermore, despite the many ongoing efforts to overcome this problem, there is not yet a one size fits all solution. In this context, two kinds of communications may be distinguished: The Device-to-Device (d2d) communication and the Device-to-Internet communication. The second kind is usually based on the TCP/IP stack in its general manifestation and on HTTP(S) when the devices are intended to interact with Web resources. Consequently, communication interoperability is theatrically easily achievable using, for example, software layers at the Internet level such as adapters, proxies, middleware, gateways, etc. The first kind, however, is achieved using different protocols (Wi-Fi, ZigBee, Bluetooth, GPRS, etc.). Thus, the Device-to-Device communication suffers from a high energy consumption and the heterogeneity of the involved devices, as both hardware and software heterogeneity are concerned.

Despite being in its first stages, the recent Samsung Nest initiative is intended to overcome the aforementioned issues. This initiative consists of an IPv6 standard based technology called Thread [31]. The main limitation of Thread is that it is only usable in a local environment (homes) and is not designed for a large-scale Internet.

Global recognition of interoperability standards is a required need for the expansion of a collaborative IoT. Many subjects related to the communication have to be considered. Starting with 1) the communication with sensors, to perceive the physical world, and with actuators to perform actions coming from the digital world; 2) solution to allow fluid information exchange between objects, the set of gateways between those devices, and the Internet; 3) reliable and energy-efficient protocols tailored for the IoT; 4) and scalable management algorithms and protocols.

4 Concluding remarks

In this his paper we discussed the rise of the Internet of Things from a collaborative perspective. We presented the advances made in recent years. In addition to remaining issues that have to be addressed, in order to push the IoT to the next level of maturity, to deliver new solutions, and to pave the way for innovative applications.

References

1. Adda, M. et al.: IOTCollab , Access Control Model. The 6th International Conference on Ambient Systems, Networks and Technologies. pp. 1–8 Elsevier Science (2015).
2. Adda, M., Saad, R.: A Data Sharing Strategy and a DSL for Service Discovery, Selection and Consumption for the IoT. Procedia Comput. Sci. 37, 92–100 (2014).
3. Aggarwal, C.C. et al.: The Internet of Things: A Survey from the Data-Centric Perspective. In: Aggarwal, C.C. (ed.) Managing and Mining Sensor Data. pp. 383–428 Springer US (2013).
4. Allseen Alliance: AllJoyn, https://allseenalliance.org/, Accessed: 7 April 2015.
5. Ashton, K.: That Internet Of Things, In the real world, things matter more than ideas, http://www.rfidjournal.com/articles/view?4986, Accessed: 18 March 2014.
6. Cisco: Cisco IBSG, http://www.cisco.com/web/solutions/trends/iot/overview.html, Accessed: 14 February 2015.
7. Comaneci, D.G., Dobre, C.: Electronic ID: Services and applications for context-aware integrated mobile services. Proceedings - 4th International Conference on Developments in eSystems Engineering, DeSE 2011. pp. 502–507 Ieee (2011).
8. Dick, R.P., Jha, N.K.: DESP: a distributed economics-based subcontracting protocol for computation distribution in power-aware mobile ad hoc networks. IEEE Trans. Mob. Comput. 3, 1, 33–45 (2004).
9. Diya, H.Y. et al.: A Framework for Mobile Collaborative Environments. 5, April, 163–166 (2005).
10. Dohr, A. et al.: The Internet of Things for Ambient Assisted Living. Proceedings of the 2010 Seventh International Conference on Information Technology: New Generations. pp. 804–809 IEEE Computer Society, Washington, DC, USA (2010).
11. European Commission: Internet of things in 2020 road map for the future. (2008).
12. Fielding, R.T., Taylor, R.N.: Principled design of the modern Web architecture. ACM Trans. Internet Technol. 2, 2, 115–150 (2002).
13. Guinard, D. et al.: A resource oriented architecture for the Web of Things. 2010 Internet of Things (IOT). pp. 1–8 IEEE (2010).

14. Guinard, D. et al.: From the Internet of Things to the Web of Things: Resource-oriented Architecture and Best Practices. In: Uckelmann, D. et al. (eds.) Architecting the Internet of Things. Springer Berlin Heidelberg, Berlin, Heidelberg (2011).
15. Gusmeroli, S. et al.: A capability-based security approach to manage access control in the Internet of Things. Math. Comput. Model. 58, 5-6, 1189–1205 (2013).
16. Gusmeroli, S. et al.: IoT Access Control Issues: A Capability Based Approach. 2012 Sixth International Conference on Innovative Mobile and Internet Services in Ubiquitous Computing. pp. 787–792 IEEE (2012).
17. Harihar, K., Kurkovsky, S.: Using Jini to enable pervasive computing environments. Proceedings of the 43rd annual southeast regional conference on - ACM-SE 43. p. 188 ACM Press, New York, New York, USA (2005).
18. ITU: ITU Internet Reports, The Internet of Things. (2005).
19. Jacquet, P. et al.: Optimized Link State Routing Protocol for Ad Hoc Networks. (2003).
20. Kovatsch, M.: CoAP for the Web of Things: From Tiny Resource-constrained Devices to theWeb Browser. Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication - UbiComp '13 Adjunct. pp. 1495–1504 (2013).
21. Kremer, U. et al.: Compiler-Directed Remote Task Execution for Power Management. Presented at the (2000).
22. Lee, C. et al.: A Location Temporal based Access Control Model for IoTs. AASRI Procedia. pp. 15–20 Elsevier B.V. (2013).
23. LogMeIn: Xively, https://xively.com/whats_xively/, Accessed: 8 April 2015.
24. Mahalle, P.N. et al.: Identity Authentication and Capability Based Access Control (IACAC) for the Internet of Things. J. Cyber Secur. Mobil. 1, 4, 309–348 (2013).
25. Pascual-Espada, J.: Service Orchestration on the Internet of Things. Int. J. Interact. Multimed. Artif. Intell. 1, 7, 76 (2012).
26. Perich, F. et al.: Collaborative joins in a pervasive computing environment. VLDB J. 14, 2, 182–196 (2005).
27. Pontin, J.: ETC: Bill Joy's Six Webs, http://www.technologyreview.com/view/404694/etc-bill-joys-six-webs.
28. Rudenko, A. et al.: Saving portable computer battery power through remote process execution. ACM SIGMOBILE Mob. Comput. Commun. Rev. 2, 1, 19–26 (1998).
29. Shepherd, R. et al.: Parallel Computation in Mobile Systems Using Bluetooth Scatternets and Java. International Conference on Parallel and Distributed Computing and Networks. (2004).
30. ThingSpeak: ThingSpeak, https://thingspeak.com/, Accessed: 6 April 2015.
31. Thread Group: Thread, http://www.threadgroup.org/Technology.aspx, Accessed: 8 April 2015.
32. Uckelmann, D. et al.: An Architectural Approach Towards the Future Internet of Things. In: Uckelmann, D. et al. (eds.) Architecting the Internet of Things. Springer Berlin Heidelberg, Berlin, Heidelberg (2011).
33. Villasenor-Gonzalez, L. et al.: HOLSR: A hierarchical proactive routing mechanism for mobile ad hoc networks, (2005).
34. Zhang;, G., Liu, J.: A Model of Workflow-oriented Attributed Based Access Control. Int. J. Comput. Netw. Inf. Secur. 3, 1, 47–53 (2011).

A Systematic Approach to Quality Assurance of a Health Care Business Process

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Abstract. Companies are increasingly moving their business processes online using Business Process Management tools and technologies. Often the approach to quality assurance for online business processes is similar to what would be done with any other web application. This is insufficient as it only provides rudimentary verification of single user-role behavior ignoring the orchestration of tasks across many users and software systems and does not leverage business process model to ensure consistency, completeness and enable automation. The approach does not validate that a business process is contributing towards the achievement of business goals. This paper proposes a model-driven quality assurance framework for BPM. The framework is evaluated using hospital's Cancer Care Assessment business process.

Keywords: Business Process, Business Process Model, Quality Assurance, Web Application Testing, Verification & Validation, Health Care.

1 Introduction

Online business processes are different from traditional web applications. They involve the collaboration of multiple user roles interacting with multiple services in parallel [3]. They are usually implemented using Business Process management (BPM) technology that defines an explicit business process model to flexibly combine and orchestrate ***forms*** delivered through a web browser with ***services*** accessible through Internet protocols [2][6]. One also needs to that the online business process is achieving business goals as intended [5].

To address quality assurance of online business processes, Ilieva et.al, proposed a service oriented framework called TASSA that supports automatic test case generation for path coverage functional testing [4]. The framework offers tool support for the generation of tests from a BPEL definition, but failed to address multi-role, multi-service orchestration in parallel. It did not address validation of business process against business goals. Wynn et.al, suggested formal verification approaches for service orchestration using Petri Nets [9]. The proposed approach focused on two main features- Cancellation and OR-Joins. Run-time issues like performance or unexpected side effects are not addressed. It also did not address multi-role, multi-service orchestration, in parallel, nor did it address validation against business goals. Joseph et.al, demonstrated business process validation against business goals by coupling their

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framework with an agile BPM platform called SARI [7]. The framework does not address forms testing or multi-role, multi-service orchestration testing in parallel. TTCN-3 is a standard for Telecommunications testing that can test multi-user, multi-service orchestration scenarios. [8]. It is extended to test web applications with several users, by leveraging its powerful Parallel Test Components (PTC) feature that allows dual structuring mechanism [1].

3 Health Care Case Study- Cancer Care Assessment

We collaborated in the development of an online health care process '*Cancer Care Assessment*' at a local hospital. The process was implemented using IBM BPM 8.5.5 to reduce service times and wait times of cancer patients. Initially, the process was tested in a rudimentary way as a web application. We did a gap analysis of the current testing practice and took a systematic approach to evaluating commercially available tools and their suitability for BPM: (i) **Junit** for unit testing of services; required manually written test scripts in Java; Testing was incomplete, inconsistent and took 3 weeks to write 16 unit tests; Not suitable for any other tests. (ii) **Selenium** for unit testing of forms; Manually recorded tests for forms; Was better than JUnit, but incomplete and inconsistent and took 6 days to create 12 unit form tests and was not suitable for other testing. (iii) **IBM BPM Testing Asset;** automatic model-generated a complete set of service and form unit tests in 3-4 hours, did not handle multi-role, multi-service orchestration testing. (iv) **TTCN-3;** handled multi-role, multi-service orchestration manually, however tests were complete and consistent based on scenarios and (v) **Cognos**; for performance reports to validate against business goals.

We then constructed a prototype test framework (described in section 4) which integrated the best combination of tools and evaluated how well it addressed quality assurance for the *Cancer Care Assessment* process.

4 Proposed Quality Assurance

Fig.1. shows the organization of our prototype framework. The business process model was implemented using IBM BPM 8.5.5. The suite of tools in our workbench consisted of IBM BPM Testing Asset (with Selenium embedded) and TTCN-3 tool from Testing Tech (with JUnit and HTMLUnit embedded) as well as Cognos. IBM BPM Testing Asset inferred the relevant forms and services automatically from the business process model, while TTCN-3 script writing required manual inspection. We extended the business process model with user scenarios (explicit list of allowed alternate paths through the process) and a goal model (defined in URN) to fully capture requirements. The scenarios were used to write the TTCN-3 scripts for multi-role, multi-service orchestration testing. The goal model was used to identify the performance reports needed from Cognos BI. Finally, a systematic test plan was defined to manage, plan, and execute the test scripts generated by BPM Asset, written in TTCN-3 and the performance reports written in Cognos BI.

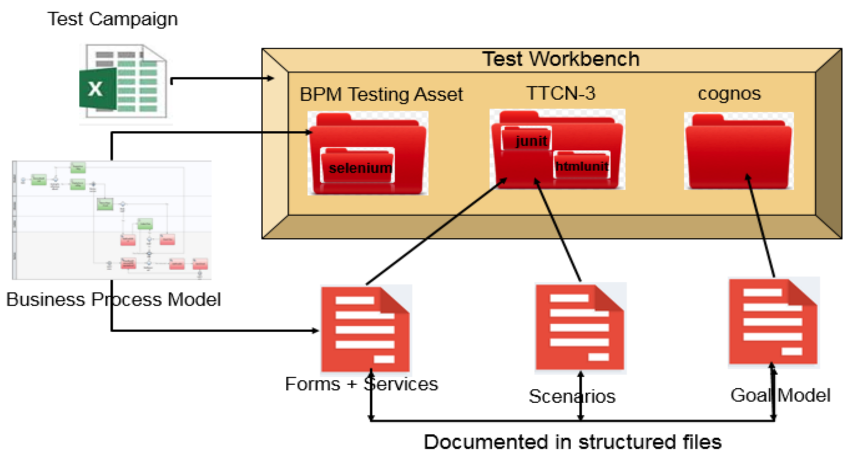

Fig. 1. Quality Assurance Framework Prototype.

5 Results

Table 1 compares our proposed framework with the related works. TASSA drives model-based test generation. The work involving Reset Nets is partially model-driven and targets formal verification of model but no model-based test scripts generation. Only our framework addressed all four elements of BPM testing (Forms, Services, Orchestration, and goals). Only TASSA (and BPM Testing Asset) were completely model-driven. TTCN-3, which had not previously been used for BPM was the key to addressing multi-role, multi-service orchestration testing. Based on our experiences, we believe model-driven support for TTCN-3 and goal validation could be provided by incorporating formal user scenarios and goal models.

Table 1. Framework Comparison with Related Works.

Features	**TASSA**	**Reset nets**	**SARI**	**QA Framework**
Model-Driven	Yes.	Partial. Formal model verification, but not generated	Partial. Simulation models used to generate inputs for scenarios.	Partial. No model support for TTCN-3
Forms	Yes.	No.	No.	Yes.
Services	No.	Yes.	Yes.	Yes.
Multi-Role, Multi-Service	No. Multi-Role only.	No. Multi-Service only.	No.	Yes.
Goal Validation	No.	No.	Yes.	Yes.
Test Script Effort	Low. Model-generated.	High.	Medium. Manual but test data injected.	Low for BPM Asset. Medium for TTCN-3

6 Conclusions and Future Work

In this work, we have introduced a QA framework for BPM that leverages three types of tools: model-driven unit testing for BPM services and forms; multi-role, multi-service orchestration testing; and performance reporting. We have clearly shown the need for an integrated workbench to make the right tool available for the job, but there is still a long way to go.

The next step of the research is to evaluate our framework with more sophisticated business processes to ensure the framework is practical and feasible for industry use. We would like to expand support of TTCN-3 for BPM which includes development of a complete generic codec for BPM, and fully leverage business process model and user scenarios to automatically generate TTCN-3 tests. And lastly, we would like to enhance performance reporting for BPM by supporting model-driven generation of reports from business process model and goal model.

References

1. Bernard Stepien, Liam Peyton. "Innovation and evolution in integrated web application testing with TTCN-3." International Journal on Software Tools for Technology Transfer, June 2014: pp. 269-283.
2. Bruce Silver Associates. The 2006 BPMS report: Understanding and evaluating BPM suite. BPMInstitute.org, 2006.
3. Ertugrul, Ali Mert , and Onur Demirors. "An exploratory study on role-based collaborative business process modeling approaches." S-BPM ONE '15 Proceedings of the 7th International Conference on Subject-Oriented Business Process Management. New York, NY, USA, 2015.
4. Ilieva, Sylvia, Ilina Manova, and Dessislava Petrova-Antonova. "Towards a Methodology for Testing of Business Processes." Wroclaw: IEEE, 2012. pp.1315 - 1322.
5. Kang, J. G., & Han, K. H. "A Business Activity Monitoring System Supporting Real-Time Business Performance Management." Third International Conference on Convergence and Hybrid Information Technology. Busan: IEEE, 2008. pp.473-478.
6. Leymann, F, D Roller, and M T Schmidt. IBM2, Web services and Business Process Management. IBM Systems Journal, 2002.
7. Schiefer, J, G Saurer, and A Schatten. "Testing Event-Driven Business Processes." Journal of Computers, Vol 1, No 7, 2006: pp.69-80.
8. Stepien, Bernard, Liam Peyton, and Pulei Xiong. "Framework testing of web applications using TTCN-3." Int J Softw Tools Technol Transfer (2008) 10:371–381. Springer-Verlag, 2008. pp. 371-381.
9. Wynn, M T, H M W Verbeek, W M P van der Aalst, A H M ter Hofstede, and D Edmond. "Business process verification – Finally a reality!" Business Process Management Journal, Vol. 15, 2009: pp.74-92.
10. Pourshahid, A., Chen, P., Amyot, D., Forster, A.J., Ghanavati, S., Peyton, L., and Weiss, M., Business Process Management with the User Requirements Notation. Electronic Commerce Research, 9(4), Springer, December 2009, 269-316