IoT Implementation for Cancer Care and Business Analytics/Cloud Services in Healthcare Systems

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1 INTRODUCTION

The advances in the Internet of Things (IoT) technology have significantly impacted our way of life, which has been seen in a variety of application domains, including healthcare. Most of the papers reviewed touched on some of the services in healthcare, there is practically little or no literature on the application or implementation of IoT in cancer care services. This has prompted the need to (re)assess the provision and positioning of healthcare services to harness the benefits associated with the use of IoT technology.

This research proposes the implementation of an IoT based healthcare system focusing on two services, namely, cancer care and business analytics/cloud services. This combination proffers solution and framework for analyzing health data gathered from IoT through various sensor networks and other smart devices to help healthcare providers to turn a stream of data into actionable insights and evidence-based healthcare decision-making to improve and enhance cancer treatment.

2 NETWORK METHODOLOGY & ANALYSIS

In supporting the proposed IoT based healthcare system, the use of sensors and actuators cannot be overemphasized because they are seen as an important component of the IoT technology [1, 3]. Body wireless sensor networks (BWSN) have now a broad range of applications: e.g. remote monitoring of physiological data, tracking and monitoring doctors and patients [2], and drug administration, and therefore they are becoming a prevalent solution in remote healthcare monitoring and chronic disease detecting.

The wireless devices are strategically attached to or implanted within human body to monitor patient under surveillance, in order to collect objective measures or data. Once deployed, the sensor nodes form an autonomous wireless ad hoc network, which will be embedded in the main network for the service. In the use of WSNs, some characteristics, such as routing protocols from one source to another have to be addressed. This can be achieved through appropriate routing strategies that are capable of managing the trade-off between optimality and efficiency to ensure computation and communication capabilities [3].

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3 SOLUTIONS FOR HEALTHCARE SERVICES

3.1 Cancer Care Services

The IoT technology can be applied in cancer care treatment by seamless and secure integration of wireless technologies for medical procedures, including chemotherapy treatments, monitoring, alerting, and following-up. Cancer treatments can be enhanced by attaching WSNs to patients such that the health practitioners can be alerted of any changes, complications, adverse drug effects and allergies, missed medications, haemoglobin level sensing and monitoring, drug allergic detection, drug interaction monitoring, etc. The wireless sensors detect automated alerts and blocks for incorrect prescriptions, and also automatically monitor and manage the creatinine value as used in the computation of Glomerular Filtration Rate (GFR) used in dosing for certain chemotherapy treatment.

It is also practicable to monitor cancer patients remotely by caregivers and families through WSNs. The cancer care services incorporate clinical devices that provide assistance to cancer patients in the event of any problems or complications through process or procedure automation, remote monitoring, communication alerts, and analysis based on IoT technologies. As related to the radiation oncology treatment, the linear accelerators (linacs) for radiation therapy can also be monitored by IoT connected devices. Fig. 1 illustrates the network design of the proposed cancer care services.

The Health Level-7 (HL7) connectivity is equipped with HL7 interface based on semantics and XML technology for data definition and message exchanging, sharing and reusing within and between lab centres, hospitals, and health regions, which interoperates two or more systems for information exchange and use. The Digital Imaging and Communications in Medicine (DICOM) connectivity, on the other hand, facilitates connection between the radiology centres to help expedite diagnosis and treatment, thereby linking networks together for diagnostic image transmission. The cancer care services through electronic medical record and embedded systems, such as Laboratory Interface System (LIS), Pathology Interface System (PIS) and Radiology Interface System (RIS), serve as access points for the health providers to access patient information relating to lab results, malignancy or abnormal (pathology) results, and radiology results. The RIS interfaces with the DICOM connectivity for the transfer or exchange of diagnostic imaging results from radiology centres while the LIS and PIS interface with the HL7 connectivity for the transfer or exchange of lab and pathology results from the lab services. All these systems along with the pharmacy, medical oncology, and radiation oncology servers allow access to comprehensive patient chart information from any device, either at the clinic(s) or via remote VPN access from outside the clinic(s).

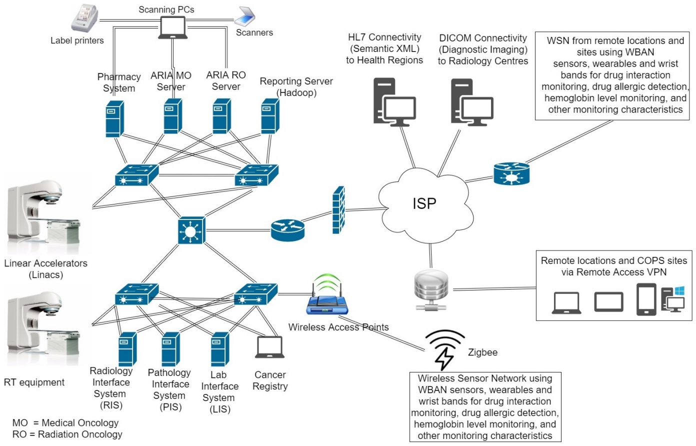

Figure 1: Cancer Care Services Network Architecture

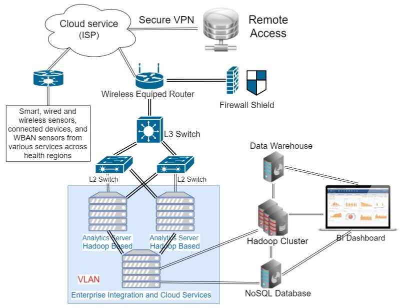

Figure 2: Business Analytics/Cloud Services Architecture

3.2 Business Analytics and Cloud Services

Through the business analytics and cloud services, patient health data are streamed from various sources and then deployed into the cloud so that the ever-increasing data can be managed and shared across the health care systems, services and sites. This, in fact, has put challenges for data to be analyzed, interpreted, aggregated, manipulated, clustered, and collaborated and made available for analytics, reporting and decision-making processes such as predictive, prescriptive, descriptive, and precision medicine using appropriate analytical tools and algorithms such as Bayesian networks, machine learning, deep learning, etc as applicable for medical and research related decisions and purposes. The solution is intended to engage data analytics in order to gain insights from all patient data that will be coming from various services in order to analyze the quality of care and risk, disease and epidemic pattern, patient/facility monitoring and optimization, etc. It will allow healthcare providers to turn stream of data into actionable insights and evidence-based healthcare decision-making about the health conditions of patients, and will also help the health providers and clinical experts to stay on top of the latest trends and breakthroughs in clinical and health care using appropriate analytics tools. The cloud approach is beneficial as it facilitates communications and data exchanges across the services and healthcare sites to the data center and reporting solution situated at the data center location. The details of the network architecture for the business analytics and cloud services are as depicted in Fig. 2. In processing and solving many types of workloads associated with massive amounts of data involved, the Hadoop Cluster or framework is considered to ensure transformations between source systems and data warehouses due to its wide range of benefits [4].

3.3 Operational Challenges and Security Issues

Certainty, there are some operational challenges and security issues that may impact the implementation of IoT-based healthcare system. These include but not limited to: government policies, rules, and regulation for compatible interfaces, network resources, protocols across various devices and equipment and platforms, interoperability issues, device diversity, vulnerability of security and devices, security breach, interests of various stakeholders of various health organizations and authorities, ownership of data collected and stored, data consent and utilization, just to mention a few. Other considerations can be inherent from those wireless devices and sensors that can impact the performance. These are: loss of signals and connectivity; strength and security of the communication channels; power capacity of the connected devices; frequency of charging sensors; wireless technologies that support low energy, etc.

It becomes extremely important to address and manage those issues and challenges based on the following approaches: ensure due diligence with all stakeholders, vendors and government representatives to ensure compliance and adherence to all sorts of policies and legislation; ensure user privacy, authentication and security are strictly adhered to; ensure reliability of network communication; ensure network that is able to accommodate different sensors and connected devices; ensure the use of low power consumption for the sensors such that the frequency of charging them is minimal; and ensure provisions for adaptability, adjustability, scalability, manageability, and supportability of the network for additional devices and services for future growth.

4 CONCLUSIONS AND FUTURE WORK

In conclusion, the proposed research work provides an implementation of the IoT based healthcare system with reference to cancer care and business analytics/cloud services for enhanced electronic health initiative, treatment, diagnosis, caring and monitoring of cancer patients. In the network design, a mesh topology is proposed such that every node in the network has a connection to each of the other nodes. There is a variety of services offered and delivered in healthcare related environment, but we have only covered the cancer care and business analytics/cloud services in this research. We anticipate integrating and considering more services in our future work in the same research domain that will ensure a more robust healthcare delivery.

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