Applications of IoT wearable device in healthcare: A consideration for healthcare services in Papua New Guinea

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Abstract

The interconnection of objects from the physical world comprised of sensors, actuators and connection to the Internet is called the Internet of Things (IoT). Driven by innovative ideas, these objects can be controlled and monitored remotely providing solutions to improve healthcare in terms of patient care, monitoring and management of patient health data while reducing the cost of healthcare. This paper aims to analyze the impact of IoT in healthcare. The paper further presents factors that motivate the use of IoT-WD in healthcare in developing countries. Finally, it discusses an architecture suitable for healthcare in Papua New Guinea.

Keywords: healthcare, Internet of Things, Unified Theory of Acceptance and Use of Technology, developing countries, LoRaWAN, systematic literature review, technology impact Analysis, Wearable device.

Introduction

The interconnection of objects from the physical world comprised of sensors, actuators and connection to the Internet is called the Internet of Things (IoT) (Dijkman et al., 2015). Driven by innovative ideas, these objects can be controlled and monitored remotely providing solutions to improve healthcare in terms of patient care, monitoring and management of patient health data while reducing the cost of healthcare. It has been considered to provide effective healthcare services to the elderly and patients with chronic diseases (YIN et al., 2016).

IoT's applications in healthcare range from managing chronic diseases to preventing them. The IoT wearable device (IoT-WD) can monitor blood pressure and heart rate but Gelogo et al. (2015) discussed specialized implanted IoT devices as well. There are emerging healthcare IoT platforms for antenatal and chronic patients to manage health necessities and recurring medical requirements.

This paper aims to investigate the applications of IoT-WD in healthcare by analyzing the impact of the technology. The paper will discuss the factors that motivate the use of IoT-WD in healthcare in developing countries. Finally, it will discuss an IoT-WD architecture suitable for healthcare services in Papua New Guinea (PNG).

Context of the study

The application of IoT-WD in healthcare has enabled patients to remain active when healthcare providers issue monitoring devices to allow them to continue their normal activities regardless of location (Lindén et al., 2016). Remote monitoring of a person's health status can enable early intervention and prevent conditions from developing further hence,

patients are prevented from suffering. This trend has now attracted the attention of the communication and health sector in recent years (Fotouhi et al., 2016).

A survey conducted in Europe from 2012 to 2013 shows that 9% of hospitals offer patients the possibility of using an internet-based application to monitor their health status (Maghiros, 2013). Two reports, "Mobile Usage in Medical Space 2013" and "Tablet Usage by Physician 2013" show similar results in the United States in 2012 where 39% of the surveyed doctors indicated the use of internet applications to communicate with patients (Granulo et al., 2016). In the Medium Term Development Plan III 2018-2022 (MTDP III) for the PNG Government, Key Result Area 3 describes the status of the traditional healthcare services and infrastructure in PNG which have deteriorated over the years due to priorities on curative rather than preventive healthcare (PNG Government, 2018). A clear example is the immunization coverage which is less than 40% compared to the global average of 80% not to mention the COVID-19 vaccination coverage in PNG.

Delivering an efficient, quality and improved healthcare service is a challenge for PNG (PNG Government, 2018). From the present literature, IoT-WD can improve quality and reduce the cost of healthcare services.

The IoT architecture

The IoT architecture is composed of a microcontroller unit (MCU), sensors, actuators, wireless adapters, and a wireless sensor network (WSN) that interconnect the nodes in the WSN (Dale & Gunik, 2019) (Figure 1). The MCU is a credit card-sized computer that controls the flow of data in the WSN. The MCU is customizable by both hardware and software to meet the purpose of deployment. The data generated by the sensor are unidirectional with the flow of data toward the MCU. The actuator operates in contrast to the sensor by having a unidirectional data flow from the MCU. For example, a temperature sensor monitors and transmits temperature data to the MCU. When high temperature exists in a room, instruction is sent to the actuator located next to the switch to turn on the fan to cool the room.

IoT has applications in various fields but this paper will focus on its application in healthcare.

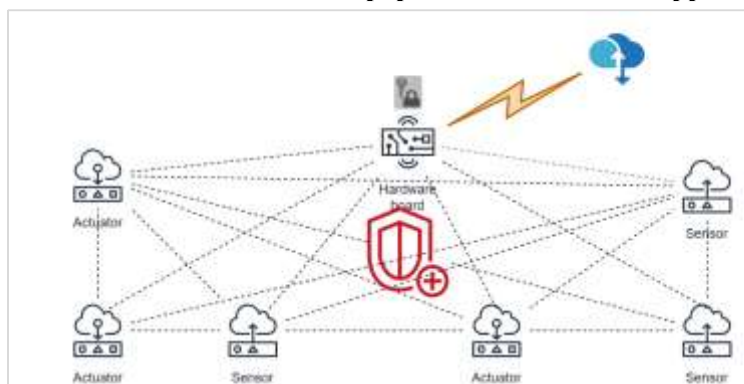

Figure 1: A simple IoT architecture composed of a microcontroller unit, sensors, actuators, and an internet connection to the cloud.

The architecture in healthcare

The application of IoT-WD in healthcare has emerged alongside others such as telemedicine, u-healthcare, e-healthcare, m-healthcare or the Internet of Medical Things (IoMT). The IoT in healthcare is a form of telemedicine that evolved from e-healthcare, to m-healthcare then IoMT (u-healthcare).

The IoT architecture in healthcare consists of the body area network (BAN), intelligent medical server and the hospital management information system (HMIS) (Gelogo et al., 2015). The BAN is a system of sensors attached to the human body to capture the biological signal. To allow patients freedom of movement, Wireless BAN collects patients' health data and forwards them using radio waves to a central node for analysis. The central node is a smartphone that connects to the Internet either by Universal Mobile Telecommunication Service (UMTS/3G), Long Term Evolution (LTE/4G), or the Wireless Local Area Network (WLAN) to forward patient data to a Data Processing Center (DPC). The DPC is a cloud service leased by a hospital to keep patient data. The HMIS is synchronized with the DPC to provide patient information to the nurses and doctors on demand.

Beyond the simple IoT architecture for healthcare discussed, there are more advanced IoT-WD being continually developed for healthcare. We now look at the impact of using this technology in the healthcare sector.

The impact on the healthcare

To investigate the impact of IoT-WD in healthcare, the Technological Impact Analysis (TIA) tool is used as demonstrated by Maddox, Boozer, & Forte (2007). They defined TIA as a simple and important learning tool that analyzes how specific technologies have developed, diffused and affected society in positive or negative ways.

The review conducted using TIA is focused on six questions that form the essence of the methodology. Below are six TIA questions tailored to suit the purpose of this study:

1. What are the historical and social origins of the Internet of Things in Healthcare? In other words, how and why has this technology become prominent?
2. What are key developmental markers in the emergence and diffusion of the Internet of Things in Healthcare?
3. What have been the most positive consequences of IoT in healthcare?
4. What has been the most negative consequence of IoT in healthcare?
5. What have been the unanticipated consequences of IoT in healthcare?
6. What ethical issues must be considered when evaluating the merit of the Internet of Things in healthcare?

Historical and social origins of the IoT in healthcare

Kevin Ashton coined the term "Internet of Things" (Dauwed & Meri, 2019) in 1998, which first appeared in a speech by Peter T. Lewis in 1985. According to Ashton, IoT is a tool used to facilitate the exchange of information over the World Wide Web. The concept is to have every physical object connected through the Internet with unique identifiers. The concept of the network of the smart device was discussed in 1982 at Carnegie Mellon University where

a Coca-Cola vending machine was modified to report its inventory and the temperature of newly loaded drinks. The actual use of IoT was estimated by Cisco System to be between 2008 and 2009. The application of IoT-WD in healthcare was to collect and analyze data for research and monitoring. It was realized in 2015 by Goldman Sachs that IoT could save the United States more than $300 billion annually in healthcare expenditure (Roman et al., 2015).

Development milestone in the emergence and diffusion of IoT in healthcare

The development milestone in the emergence and diffusion of IoT in healthcare began with the "information revolution" in the mid-1940s where the evolution of computer technology was driving the change that would improve lives and extend brainpower. In 1946, John Presper Eckert and John W. Mauchly developed the Electronic Numerical Integrator and Computer (ENIAC). The ENIAC was described as the first general-purpose electronic computer with operational characteristics including memory and arithmetic operation. International Business and Machines Corporation (IBM) launched the personal computer (PC) in 1981 running Microsoft's MS-DOS 1.0, a 16-bit operating system. In 1984 and 1985 the Apple Macintosh and Microsoft Windows were launched respectively. In 1989, the British computer scientist Tim Berners-Lee submitted a proposal for a distributed information system to the European Organization for Nuclear Research (CERN). A year later, a website and a server went live at CERN. In 1994, the development of game consoles such as Sega Saturn and Sony PlayStation had a significant impact and influence on home entertainment. The 2000s brought mass adoption of broadband internet in developed countries providing high-speed internet access to the users (Frangoul, 2018). Today's homes are transforming from smartphones, tablets, virtual assistants, and smart TVs. The merging of the physical and the virtual world brought about the concept of IoT.

Since the evolution of IoT, many disciplines have found the area for its use. The healthcare sector was not an exception.

Positive impact of IoT on healthcare

The application of IoT-WD in healthcare provides benefits to patients, caregivers and physicians. This section highlights benefits namely cost savings and transparency.

Patients with chronic diseases such as cancer, diabetes, lung disease or heart disease incur high medical costs due to continuous visitation to the healthcare centres. These costs may include re-hospitalization, transport, and the time spent out of work for the caregivers to attend to such patients (IEEE, 2021). The technology has the potential to reduce costs by bringing healthcare to the patient. With IoT-WD, vital patient information can be monitored and reported to healthcare providers and caregivers in real-time. Simple tests can be conducted on the patient and communication can be done using the same channel.

With an electronic health record, patients should not have to present health information to every new doctor upon visitation. The health information is shared with multiple doctors concerned while giving the patient insight into their health status and caregivers can monitor

the patient's health status (IEEE, 2021). Consequently, patients' and caregivers' expectations are increased with the quality of service received as the technology is more transparent.

Negative impact of IoT on healthcare

In contrast, drawbacks could affect the users and this section highlights two negative impacts namely privacy and security, and unintended use.

Privacy and security are issues for IoT due to the architectural components sourced from different vendors (IEEE, 2021). Consequently, the device lags behind regular updates and presents vulnerabilities. When the security of an IoT network is breached, the privacy of the patient is violated as data from the IoT-WD becomes insecure.

There are unintended uses of IoT-WD leveraged by persons in authority (IEEE, 2021). For example, the police can implant sensors on lawbreakers to conduct surveillance on their movement, parents can use sensors to monitor their children in school or husbands and wives to monitor each other. In contrast to unintended use, the unanticipated consequences are discussed next.

Unanticipated consequences of IoT in healthcare

Wearable sensors are part of the ecosystem of the IoT in healthcare that was developed to monitor patients for early detection and diagnosis of diseases. IoT-WD is now seen to have unintended consequences such as modification of behaviour and unpredicted challenges faced by regulatory authorities (Schukat et al., 2016). Modification of behaviour is encountered in instances where sensors are worn by both patients and healthy individuals.

As a result of relying on technology, an individual's behaviour may change such as decreased physical activity because of the notion that they are more active than they thought they were (Schukat et al., 2016). For example, certain activities cannot be done by the individual based on the device's advice. Intensive monitoring of individuals using body sensors can lead to anxiety. Users become so obsessed with self-monitoring beyond a healthy level of attention to oneself. IoT-WD used to track other aspects of lifestyle may detect an undiagnosed disease. Reliance on a device bears the risk that the device cannot perform as prescribed on paper in cases where caregivers rely on the IoT-WD for notification but it malfunctions at some point in time.

Challenges faced by regulators are evident in the case of the United States (US) where the US Food and Drug Administration (FDA) declaims the responsibility of regulating wearable sensors designed for lifestyle purposes (Schukat et al., 2016). FDA later requested medical device manufacturers to submit design decisions containing risk analysis due to the increasing security risks that the devices pose. As encountered by the FDA, regulatory authorities should inspect the import and utilization of wearables before reaching the outlets for consumers because of unpredicted challenges. Authorities should indicate how and where data from IoT-WD will be utilized.

Ethical issues of IoT in healthcare

Mittelstadt (2017) discussed ethical issues arising from the utilization of IoT in healthcare that share overlapping discussions in terms of privacy issues with Schukat et al. (2016). The discussion of ethical issues here concerns data and social isolation.

In general, IoT devices generate large volumes and varieties of data describing the health and behaviour of users (Mittelstadt, 2017). Medical research and consumer analytics use much of this data through protocols designed to enable users and third parties to access the dataset. In this case, information privacy is a concern, especially the personally identifiable data released to third parties. As health data are normally considered sensitive both in an ethical and legal sense, information privacy is a central concern for the deployment of IoT devices in healthcare (Mittelstadt, 2017).

Undesired sharing of information violates physical spaces or social relationships and can impede a user's capacity to make decisions because health data begin to profile users as "health impaired" or "at-risk" (Mittelstadt, 2017). The profile also influences the choices made available to third parties with access to the profile.

The use of IoT-WD to manage health conditions can contribute to the social isolation of users because visits from medical personnel and caregivers may be less necessary (Mittelstadt, 2017). Studies involving older people have revealed a concern that IoT will replace personal and social interactions with caregivers rather than supplementing them as promised (Mittelstadt, 2017). A different mode of interaction such as robots or social networking is not sufficient to replicate face-to-face interaction that contributes to the mental health and well-being of patients. This is an ethical problem concerning the nature and scope of medical and healthcare practitioners.

The six TIA questions tailored to suit the purpose of this study have been limited by judgment to suit the requirement of where this article is intended to be published. We now analyze factors from the theoretical adoption model influencing the adoption of IoT in healthcare in developing countries using a Systematic Literature Review (SLR).

Systematic literature review

To investigate these factors, SLR has been conducted as done by Carcary et al. (2018) who followed the 8 steps proposed by Okoli (2015) to extract data for secondary analysis of the literature. During the investigation, several theoretical adoption models were encountered such as the Technology Acceptance Model (TAM), Hedonic-Motivation System Adoption Model (HMSAM), Unified Theory of Acceptance and Use of Technology (UTAUT), Laddering technique, and Means-End methodology applied in various studies.

TAM has an ample number of applications within technology acceptance research and thus has received significant empirical support (Adapa et al., 2018). It centres around two core constructs; perceived ease of use and perceived usefulness. 'Perceived Ease of Use' is the degree to which the user expects the target system to be free of effort and 'Perceived

usefulness' defines the probability of using a system to increase job performance in an organization (Davis, 1989). HMS is the adoption model used to investigate motivation systems (HMS). HMS are systems used for pleasure rather than productivity as opposed to the Utilitarian-Motivation Systems (UMS) (Lowry et al., 2013). The Laddering methodology is used to discover and understand the fundamental values of factors influencing the adoption of a particular technology through an interview while the Means-End methodology focuses on consequences leading to the valued factor (Adapa et al., 2018).

UTAUT was formulated by Venkatesh et al. (2003) with four factors namely 1) performance expectancy (PE), 2) effort expectancy (EE), 3) social influence (SI), and 4) facilitating conditions (FC) (Venkatesh et al., 2003). The second version of the UTAUT model known as the UTAUT2 extends UTAUT by three additional factors of adoption; 5) hedonic motivation (HM), 6) price value (PV) and 7) habit (HA).

Table 1: Hypothesis and UTAUT2 factor mapping

UTAUT2 Factors		**Hypothesis**	
F1	PE	H1	The simplicity and effectiveness of providing healthcare using IoT-WD will positively influence the use of the technology in developing countries
F2	EE	H2	The least amount of effort required to use IoT-WD in healthcare will positively influence the use of the technology in developing countries
F3	SI	H3	Positive social influence regarding the use of the IoT-WD in healthcare will influence the use of the technology in developing countries
		H4	Negative social influence regarding the use of the IoT-WD in healthcare will affect the use of the technology in developing countries
F4	FC	H5	Available technical expertise to support the use of IoT-WD in healthcare will influence the use of the technology in developing countries
		H6	Availability of infrastructure to support the use of IoT-WD in healthcare will influence the use of the technology in developing countries
F5	HM	H7	The belief of experiencing fun in the use of IoT-WD in healthcare will influence the use of the technology in developing countries.
F6	PV	H8	The cost of using an IoT-WD in healthcare will influence the use of the technology in developing countries.
F7	HA	H9	Prior experience of using technology will influence the use of IoT-WD in developing countries.

Hypotheses are derived from the UTAUT2 factors (Table 1) and tested using a secondary data collection process done by Carcary et al. (2018). In this study, 8 steps approach proposed by Okoli (2015) was used to collect qualitative data from the literature as follows:

1) Purpose of the literature review: The author tries to synthesize relevant theories by examining several peer-reviewed journal articles in the stream.
2) Protocol and training: The systematic literature search is focused on synthesizing theories to categorize under H1, H2, H3, H4, H5, H6, H7, H8, and H9. The hypotheses are units of analysis in a concept-matrix table as demonstrated by Webster & Watson (2002).
3) Searching for the literature: The following terms should appear within the article title, abstract, and keywords; *IoT-device OR wearable device AND adoption AND*

healthcare AND developing countries OR low-middle income countries. The literature search is based on articles published between 2011 and 2021 inclusive on RefSeek.com, Google Scholar and Researchgate.

4) Practical screen: Based on the search criteria defined in the previous step, the author managed to collect 33 articles but the initial screening of abstracts and keywords resulted in the exclusion of 29 due to research background. The use of backward and forward citation tracking resulted in 89 papers being reviewed.
5) Quality appraisal: 10 papers evaluated are of acceptable quality based on their source.
6) Data extraction: From each paper reviewed, theories are synthesized, summarized and classified.
7) Synthesis of study: A concept-matrix was created to map the theories extracted on the row heading to the hypothesis with a cluster of UTAUT2 factors on the column heading. An indicator is used to represent the relationship between theories and hypotheses as a way of indicating the factors.
8) Writing the review: The final step provides a qualitative analysis of the data in the concept-matrix table and concludes the adoption factors of the IoT-WD in healthcare for developing countries.

Factors that influence adoption of IoT

This section contains the findings from the SLR showing factors that influence the adoption of IoT-WD in healthcare in developing countries. The findings using SLR are compiled in the concept matrix in Table 2.

Table 2: Data from SLR in a concept matrix.

Sr.	**Authors**	**PE**	**EE**	**SI**		**FC**		**HM**	**PV**	**HA**
		H1	*H2*	*H3*	*H4*	*H5*	*H6*	*H7*	*H8*	*H9*
1	Basholli et al., (2017)									X
2	Vo et al., (2011)	X				X	X			
3	Levine, (2017)	X			X	X				X
4	Basholli et al., (2014)	X					X		X	
5	Basholli et al., (2015)								X	
6	Darwish & Hassanien, (2011)	X							X	
7	Kakria et al., (2015)	X								
8	Binaymin & Hoque, (2020)	X		X		X	X	X		X
9	Rubin & Ophoff, (2018)	X								X
10	Toycan, (2018)					X	X			X
	Frequency	*7*	*0*	*1*	*1*	*4*	*4*	*1*	*3*	*5*

Performance Expectancy: The use of IoT-WD in providing healthcare in developing countries proved to be simple and effective. According to Table 2, H1 seemed to be common where 7 out of 10 articles indicate PE as the most likely factor influencing the adoption of IoT-WD in developing countries. Vo et al. (2011) proved that the use of technology to deliver healthcare remotely is an effective way of overcoming the barrier to care for communities located in rural and remote areas. Levine (2017) affirms that the investment in IoT-WD is worthwhile on mass scales in poor areas. Basholli et al. (2014) discussed technologies that support IoT-WD and claimed that a WSN will suit the health needs of developing regions where the number of patients is higher than the specialists. Darwish & Hassanien (2011) explain the importance of the BAN in medicine to minimize the need for caregivers and help

the chronically ill and elderly people live independent lives besides providing quality care. Kakria et al. (2015), Binaymin & Hoque (2020), and Rubin & Ophoff (2018) all indicate H1 to be a factor for developing countries.

Effort Expectancy: Having the least amount of effort to use IoT-WD in developing countries cannot be proven due to limited research done in this area in developing countries. Most of the papers reviewed for developing countries are based on non-empirical studies except Rubin & Ophoff (2018) who have done an investigation for health and fitness wearable devices in South Africa but are unable to prove effort expectancy. Darwish & Hassanien (2011) identified challenges and research problems encountered with the use of wearable and implantable sensors to assume design improvements required to influence the adoption of wearable in healthcare.

Social Influence: According to Binaymin & Hoque (2020), positive social influence (H3) can be a factor that influences the adoption of wearable devices in healthcare when someone influential such as parents, relatives, friends, co-workers, family, or media persuading an individual to engage in a specific action. The negative social influence (H4) can prevent the adoption of wearable devices in healthcare (Levine, 2017). These negative influences are present due to the challenges that arise in the deployment of IoT-WD in healthcare such as ethical and privacy issues, lack of standardization, and lack of value-added individualization.

Facilitating Conditions: The availability of technical specialists (H5) will influence the adoption of IoT-WD in developing countries as confirmed by Vo et al. (2011), Levine (2017), Binaymin & Hoque (2020), and Toycan (2018). Vo et al (2011) discussed the benefits of telemedicine using the existing mobile wireless platform to provide healthcare service to the remote population in Taxes which fits developing countries where the bulk of the population is located in remote or rural areas. The author assumes technical specialists are abundant where there is existing technological infrastructure. Levine (2017), Binaymin & Hoque, (2020), and Toycan (2018) situate their research in developing countries and all indicate the necessity of having a technical specialist. The availability of technological infrastructure (H6) can influence the adoption of IoT-WD in developing countries. As discussed by Vo et al. (2011), infrastructure is a platform to launch telemedicine services. Basholli et al. (2014) and Toycan (2018) confirm that without an infrastructure a barrier is created to adopt the technology in healthcare. Binaymin & Hoque (2020) modified the UTAUT2 by including two additional factors; government health policy and trust to understand the drivers of wearable health technology. From their findings, wearable device depends on the support of wireless networks and internet services to provide such healthcare services.

Hedonic Motivation: The belief that experiencing fun using IoT-WD will influence the use of the technology in developing countries. From the review, Binaymin & Hoque (2020) supports this factor with their findings. The other articles do not indicate this factor because the IoT-WD was not in actual use in their research or the technology is used in conditions that negate the experience of having fun such as discovered by Rubin & Ophoff (2018).

Price Value: The cost involved in using IoT-WD in healthcare will influence the use of the technology in developing countries as demonstrated in 3 out of 10 articles reviewed. Basholli et al. (2014) consider developing countries to be using wearable technology because of affordability. The paper argued that a good system architecture can suit the economic situation in a developing country. In another article, Basholli et al. (2015) analyzed the overall cost of living expenses in Kosovo a developing country and found living expenses to exceed the minimum cost of treatment for chronic conditions. They concluded the application of a wearable technology platform is a feasible and affordable method of dealing with chronic diseases. Darwish & Hassanien (2011) state that wearable and implantable WSN is a tool to reduce the cost of healthcare but improvement in the design will influence adoption.

Habit: Prior experience in using technology will influence the use of the IoT-WD in developing countries. According to Table 2, 6 out of 10 papers reviewed support the factor. Basholli et al. (2017) observed clinical centres in Kosovo are still using old and traditional health offering tools and equipment because they are accustomed to the use while there are high-tech healthcare devices available on the market. Levine (2017) discussed the challenges that might arise when deploying wearable technology to improve healthcare in developing countries. Low literacy rate, absence of a culture of healthiness, the culture of mistrust of technology, low health and tech literacy, poor knowledge of integrating technology, and failure to appreciate the impact of social determinants of health are among the challenges. Findings from Binaymin & Hoque (2020) indicate prior learning or experience of using a specific technology has a positive effect on the behavioural intention in the use of wearable technology. Rubin & Ophoff's (2018) study in South Africa showed habit is one of the two factors that influence the adoption of such technology.

Therefore, the findings suggest the factors of UTAUT2 influencing the adoption of wearable technology in healthcare in developing countries could be PE, SI, FC, HM, PV and HA. We now discuss a system architecture that is suitable for the healthcare system in PNG.

An architecture for PNG

IoT-WD in healthcare requires an existing network infrastructure to support its operation. A WSN is required for the technology to transform the healthcare sector by shifting focus from hospital-centred to patient-centred. Basholli et al. (2015) and Basholli et al. (2017) discussed the significance of having a sensor-based network with a mobile node using a WSN. Basholli et al. (2014), Vo et al. (2011), Basholli et al. (2014), and Darwish & Hassanien (2011) all discussed the suitability of a wireless network for such technology in healthcare.

In PNG, mobile technology infrastructure has reached some parts of the rural area compared to TCP/IP infrastructure. The Universal Mobile Telecommunication System (UTMA/3G) and Long Term Evolution (LTE/4G) are centred mainly in urban areas while Global System for Mobile Communications (GSM/2G) is common in rural areas.

The proposed WSN architecture for PNG that can support the deployment of IoT-WD in healthcare is the Long Range Physical (LoRA PHY) wireless module and LoRaWAN

protocols. LoRa PHY is a low-powered radio communication device with batteries that have a lifespan of 2 to 10 years. De Carvalho Silva et al. (2017) proposed a LoRa PHY network architecture that is similar to the telecommunication infrastructure in PNG. However, in the proposed architecture for PNG (Figure 2), base stations can be replaced by LoRa gateways deployed on telecommunication towers by lease agreements with telecommunication companies. The coverage range of a LoRa gateway is 45 kilometres (km) in radius, especially in the rural area where the bulk of the population is compared to urban the range will be less than 5 km. Sensors should be within the coverage range to transmit data to the LoRa gateway then the gateway forwards the data using GSM (in rural areas) or UTMA/LTE (in urban areas) to the HMIS via the Internet. Mesh topology configurations can support users who are slightly out of the coverage area.

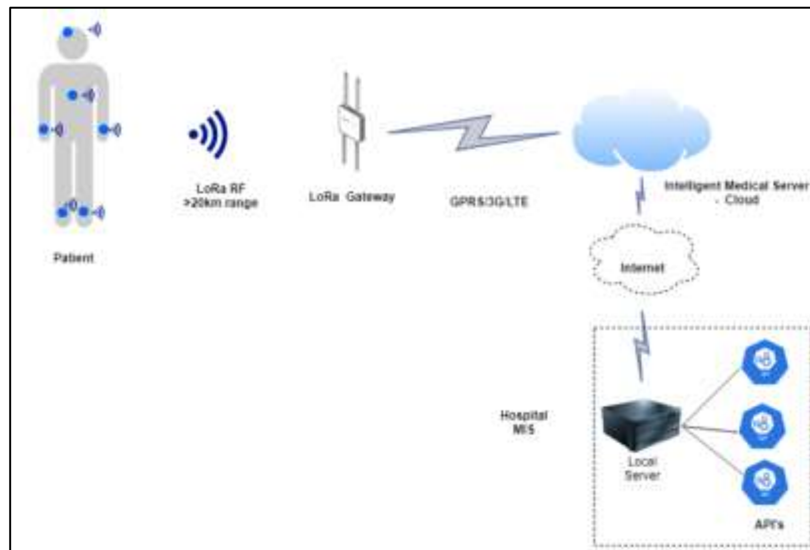

Figure 2: Proposed IoT-WD architecture for PNG

A separate paper will demonstrate the proposed architecture in more detail while comparing LoRa with other low-powered wide-area network protocols.

Conclusion

This paper discussed the application of IoT-WD in healthcare for PNG. The discussion began with the context in which the topic is based by reviewing literature about the application of IoT-WD in other countries and the stand of the PNG government for healthcare in the PNG MTDP III. The general architecture of IoT and the architecture that supports applications in healthcare were discussed. The TIA was used to analyze the impact of IoT by conducting a review based on the six TIA questions. The SLR was used to analyze literature to evaluate factors borrowed from UTAUT2 that motivate the use of IoT-WD in healthcare in developing countries which is a study PNG can be an example. The paper finally discussed an IoT-WD architecture for healthcare services in PNG.

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