Business Scenarios Assessment in Healthcare and Education for 21st Century Networks in Asia Pacific

Chin Chin Wong, Chor Min Tan, and Pang Leang Hiew

Abstract—Business scenario is an important technique that may be used at various stages of the enterprise architecture to derive its characteristics based on the high-level requirements of the business. In terms of wireless deployments, they are used to help identify and understand business needs involving wireless services, and thereby to derive the business requirements that the architecture development has to address by taking into account of various wireless challenges. This study assesses the deployment of Wireless Local Area Network (WLAN) and Broadband Wireless Access (BWA) solutions for several business scenarios in Asia Pacific region. This paper focuses on the overview of the business and technology environments, whereby examples of existing (or suggested) wireless solutions (to be) adopted in Asia Pacific region will be discussed. Interactions of several players, enabling technologies, and key processes in the wireless environments are studied. The analysis and discussions associated to this study are divided into two divisions: healthcare and education, where the merits of wireless solutions in improving living quality are highlighted.

Keywords—Broadband Wireless Access, business scenarios, network deployment, Wireless Local Area Network.

I. INTRODUCTION

BUSINESS scenarios are important technique that may be used at various stages of defining enterprise architecture, to derive the characteristics of the architecture directly from the high-level requirements of the business. Business scenarios are used to aid in identifying and understanding business needs, and thus to derive the business requirements that the architecture development, and ultimately the information technology has to address.

The success of any major IT project is measured by the extent to which it is linked to business requirements, demonstrably supports and enables the enterprise to achieve its business objectives. The world today is charging forward at a soaring rate. Within this transformation wireless technology is rapidly evolving, and is playing an increasing role in the lives of people throughout the world. Wireless and radio technologies have been at the heart of many disruptive

businesses and activities. The people of today demand hassle free and compact products, which can be used at any time or anywhere alongside the best broadband connection. Wireless is the possible solution to meeting the needs or wants of the society.

This paper assesses the deployment of WLAN and BWA solutions for healthcare and education business scenarios in Asia Pacific region. The appropriate business and technology environments are identified, whereby interactions of several players, enabling technologies, and key processes are studied. In addition, the roles and merits of the wireless solutions are highlighted. The paper provides necessary understanding on how WLAN and BWA solutions can be integrated into 21st century wireless communications in Asia Pacific region.

II. PROBLEMS DESCRIPTION

Current healthcare sector suffers from profound technological inconsistencies [1]. Medical breakthroughs using some of the most advanced technologies ever developed are made available to the public. But at the same time, doctors and nurses struggle under mounds of paperwork, providers lose time trying to manage data, and the latest research takes years to reach medical practices [1]. By using advances in wireless technologies, one can put the right information in the hands of doctors and patients at the right time.

Businesses in other sectors have embraced the information revolution to reduce costs and improve productivity [1]. They use information technologies not as an end but as a means to innovate and improve. Consumers and patients need information, including access to their own health records, and the tools to make better choices, manage their care more effectively, and communicate more efficiently with their healthcare providers [1]. At the same time, the healthcare sector must also cultivate competition. Consumers need to know which doctors or care settings heal patients faster and better as well as relevant information about providers' experiences and outcomes [1].

Many schools have no space for computer labs, or they anticipate future renovations that would require wiring in classrooms to be redone [2]. To accommodate rapid expansion, some schools use mobile classrooms that can make wiring very challenging, and the number and placement of these mobile buildings change yearly to meet the changing needs of the schools [2]. Science labs, in particular, provide logistical complications that prevent fixed computers near

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water and chemicals [2]. This gives rise to the need for wireless solutions to eliminate these barriers.

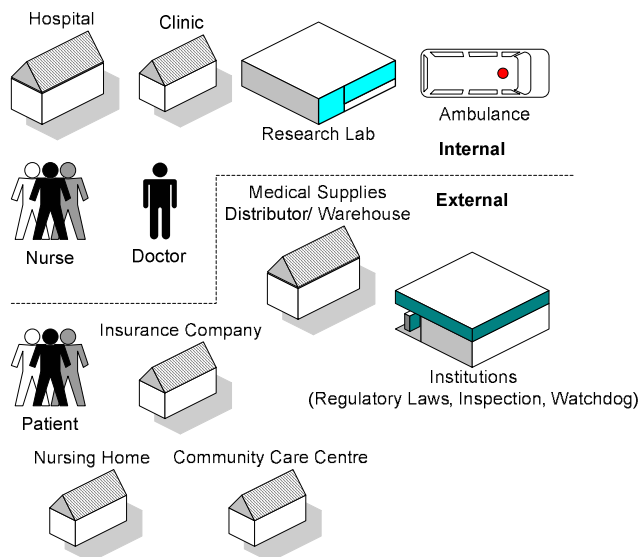### III. VIEWS OF ENVIRONMENTS AND PROCESSES

A. Healthcare Industry

Fig. 1 The business environment for healthcare industry

The figure depicts the relationships between stakeholders or actors and the environment in healthcare industry. The actors are able to interact with one another as well as other external entities if necessary. These users expect to be able to communicate with their colleagues, and to access information and IT services, when at other locations and while in transit.

Uses of Wireless Solutions in Healthcare Industry:

- Administration and resource management
  Wireless networks and handheld devices allow faster and efficient delivery of healthcare paperwork. Wireless access technologies like WiMAX or Wi-Fi mesh networks connect hospitals, clinics and doctor's offices directly to insurance companies so that claims can be submitted as the care is actually delivered [3]. Mobile computers and scanners can also keep medical supplies moving efficiently from the distributor, to the warehouse and to the healthcare facility [3]. The management of inventory and logging of equipment on wireless units can make the work of resource management much more efficient.

- Wireless pre-hospital care
  Wireless technologies can be implemented even before the patient enters the hospital with devices installed in ambulances [3]. Critical cases often call for paramedics to call ahead to the Emergency Department (ED) to prepare the waiting medical team [3]. Nevertheless, with a wireless based video system, video images, audio, vital signs, and electrocardiogram (ECG) rhythm strips can be captured and sent from a moving ambulance [3]. Images can be automatically captured from a moveable camera in

the ceiling of the ambulance. This information is reviewed in real or near-real time by not only the ED team, but also other tertiary centre specialists. This requires an assured Quality of Service (QoS) support in the wireless technologies employed, so that real-time communications (especially videos) can be assigned sufficient bandwidth and higher priority in order to minimise transmission loss, delay, and jitter. Currently, WiMAX has full support for QoS, while the upcoming IEEE 802.11e standard [4] promises to improve the QoS of the current Wi-Fi systems (note that IEEE 802.11a/b/g have poor QoS support).

- Mobile workstations
  Nurses will be able to benefit from wireless solutions as well. Healthcare personnel will be able to collect a wide array of patient information, as well as carry out real-time charting in the patient's electronic medical record, and place orders for equipment or other therapies anywhere within the wireless services coverage area [3]. The advantages of a nurse walking from patient to patient collecting and transmitting data on a mobile unit are apparent compared to running back and forth to the nursing station for manual input and retrieval of data. This can be achieved using in-house WLAN solutions.

- Medication management
  Handheld scanning devices, analogous to bar code scanners in supermarkets, can be used by nurses to retrieve information from electronic medication records databases. A nurse scans bar-coded medication and patient's bar-coded ID bracelet to confirm that right medication is given to patient at the right time and right dosage [3].

Example of Mobile Telemedicine System

Typing on the flat screen display of the wireless workstation, a nurse records the patient's history and vital signs directly into the patient's electronic record. As the patient continues to discuss his/ her family's medical history of heart disease, the nurse's pager rattles and buzzes, displaying an abnormal ECG rhythm and heart rate of a critical patient five rooms away. The nurse excuses himself and attends to the ECG alarm. Elsewhere in the hospital another nurse administers medication to another patient after using a wireless scanning device to double check that it is the right medication and dosage for that patient. Minutes later, the patient's physician walks in after reviewing the patient's dynamically updated medical record via her wireless digital assistant. After speaking with her patient at some length, she enters her notes and orders additional medication and physical therapy. These orders are instantly checked with the pharmacy and logged in at the physical therapy department.

The mobile telemedicine system example demonstrates the use of wireless solutions by personnel in the healthcare industry. It is not a real-life story, but puts together many real-life situations in a fictional setting to illustrate some key points of computing and communications support for the healthcare personnel. Example of projects currently being carried out in Asia Pacific includes:

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- *Development of ICT-Based Mobile Telemedicine System with Multi Communication Links for Urban and Rural Areas in Indonesia*
  The scope of this project is to develop and implement an integrated telemedicine system that can manage different telemedicine requirements in Indonesia [5]. The system can be used for information dissemination and health education, patient data acquisition, emergency healthcare condition in any health centre which is difficult to access, as well as home telecare for patients suffering from chronic and enduring diseases [5].

- *Healthcare.NET in Singapore*
  Seeking to extend the benefits of network technology to all public sectors, the Singapore government has also embarked on a healthcare initiative aimed at testing and developing the use of information and communication technologies to bring about a patient-centric, seamless, safe and cost effective healthcare system [6].

  Under the Healthcare.NET launched in November 2004, Alexandra Hospital (400-bed general and acute care hospital), IDA and Microsoft Singapore embarked on a series of projects aimed to integrate and upgrade existing legacy systems with innovative technologies such as biometrics, smart cards and RFID [6].

  In February 2005, the first phase of the three-year initiative was introduced [6]. Dubbed the Clinical Digital Dashboard, the wireless solution is currently being piloted at the Alexandra Hospital's Department of Emergency Medicine (DEM) [6]. Using WLAN (e.g. Wi-Fi) infrastructure and Tablet PCs, staffs are now able to register, consult, treat, and prescribe medication to patients all at one go [6].

  Alexandra Hospital also served as test-bed for RFID applications in Singapore's efforts to contain Severe Acute Respiratory Syndrome (SARS) outbreak in 2003 [6] – a proof of wireless enabler concept.

Business Processes

The healthcare industry-related business processes involved in the mobile telemedicine system example are:

- Medication administration
- Remote patient monitoring
- Healthcare personnel communications
- Mobile physician rounding
- Asset/ Medication management

B. Education Sector

Wireless is a new technology in the educational environment that offers enormous potential for change and improvement. Wireless connectivity gives teaching staffs and students the freedom to access IT resources and the Internet from anywhere on the campus. Wireless is a proven solution used within many schools and colleges which when combined with laptops, provides a fully mobile computer suite which can access the Intranet and the Internet [7]. The ability to decide where to use the computer suite offers teachers additional opportunities to incorporate ICT related elements into their classes, where many schools have reported substantial increases in productivity [7]. The following illustration shows the business environment of wireless applications used in educational institutions today.
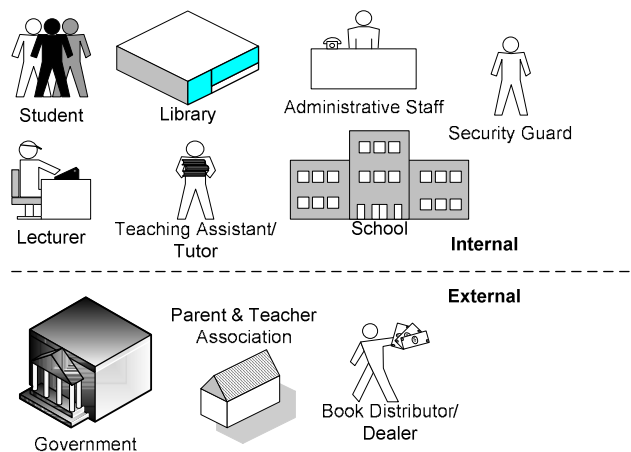

Fig. 2 The business environment for education sector

Uses of Wireless Solutions in Education Sector:

- Improved classroom interactivities/ mobile learning
  With the increased flexibility and mobility of advanced wireless services, students are able to access educational courses; teachers are able to develop different and more tailored experiences, and there is more free-flowing collaborations [2]. For example, wireless devices enable students to upload their assignments to the dedicated server for grading, even from remote locations where high-speed wired broadband is unavailable. Teachers can discuss the work directly with each student online (for example, with an interactive whiteboard), and each receives a corrected example for review [2]. Content can also be personalised to suit individual's learning needs. On top of this, learning material can also be made location-dependent. For example, when a student strolls in the botanical garden in the campus, information on flora and fauna in the garden can be displayed on students' PDA. In other words, wireless technology is the critical factor in establishing the real potential of information-supported educational activities occurring anytime and almost anyplace [2]. WLAN and BWA technologies (e.g. using Wi-Fi in campus and WiMAX away from campus) clearly play an important role in realising the vision of mobile learning described here.

- Performance-based assessment
  Mobile learning encourages interaction between lecturers and students. When each student is equipped with an Internet-enabled handheld device, students may rate their understanding on the subject taught after each class. Absentees or distant learning students can also learn at their own leisure by accessing online courseware, which allows them to download slides, recorded lectures (audio/ video clips), and engage in online discussions. Students can also finish the quizzes available in a specific time

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given. Both the lecturer and student will be able to assess the results to see how well the student performs in the quizzes. Basically, mobile learning allows one-to-one or group interaction anywhere anytime.

Example of Online Courseware

A lecturer conducts a lecture where every student is equipped with a laptop with wireless connection, thus, creating a paperless environment (note that most laptops shipped today are Wi-Fi enabled). Students make notes in their laptop or PDA. One student does not understand or would like to know more on one of the concepts; he searches for more information on the database provided by the library. Another student takes note of the prescribed text book and has put herself in the queue to borrow the book from the library via the online library system. The lecturer asks the students to rate their understanding of the concepts being taught. Based on the responses received, the lecturer is able to identify areas where students need more assistance and supports. Elsewhere, a student sends his report to another lecturer using his laptop after he analysed the collected sample from a nearby river for his science project. The lecturer looks through the report briefly and notices a few mistakes. He immediately sends his comments to the student. The student checks the forum to discuss the problem with his classmates and realises that he has to collect more samples as he has to carry out the test all over again. Fortunately, he does not have to make another trip as he is able to interact with his lecturer and classmates there and then. Example of online courseware for mobile learning deployed in Asia Pacific region includes:

- *Learning Activity Management System (LAMS)*
  LAMS is an Australian invention that has become the world's leading software for creating and running digital lesson plans [8]. Rather than being sold as proprietary software, LAMS is being released as freely available "open source software" for the public good of education by the non-profit LAMS Foundation [8]. There are hundreds of organisations from over 20 countries that are trialling LAMS, and LAMS articles have been published on the Web in six languages [8].

Fig. 3 Designing an activity sequence

LAMS is a revolutionary new tool for designing, managing and delivering online collaborative learning activities [8]. It provides teachers with a highly intuitive visual authoring environment for creating sequences of learning activities [8].

These activities can include a range of individual tasks, small group work and whole class activities based on both content and collaboration. Once the class activity sequence is defined, the system may wait for all learners to join before proceeding or allow learners to work at their own pace individually. The lecturer may also perform live monitoring of students by checking on students as they work, place stop points to allow the whole class to synchronise, and contribute to activities using the integrated monitoring panel.

Business Processes

The education sector business processes involved in the example of LAMS for educators and students are:
- Class activity sequence design
- Live monitoring of students' progress

IV. TECHNICAL ENVIRONMENTS

A. Healthcare Industry

The illustration below depicts the devices required to deploy wireless solutions in healthcare industry.
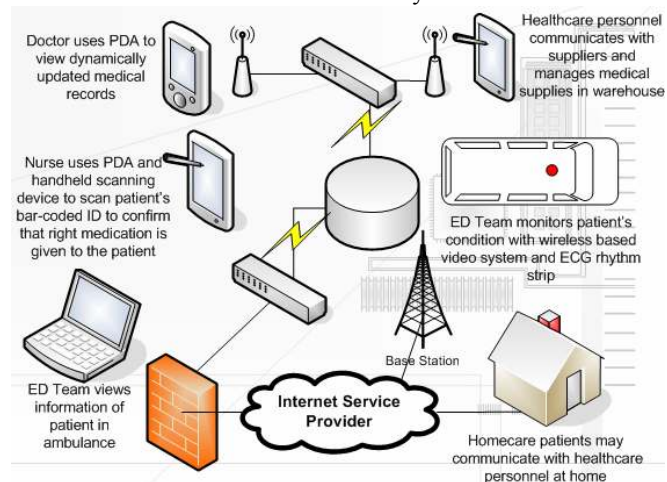
Fig. 4 Technical environment for wireless solutions in healthcare industry

Legend	
Symbol	Description
	PDA
	Router/ Switch
	House
	Data
	Hospital Database
	PDA and Handheld Scanning Device
	Firewall
	Wi-Fi Access Point
	Laptop
	WiMAX Base Station

In this business scenario, PDAs, laptops and handheld scanning devices can be used within the coverage of WLAN. Switches/ routers are connected (wired) to central database where healthcare personnel access electronic medical records, timesheet, inventory and so forth.

A firewall is required to protect the system from intrusion to ensure that confidential data is not tampered with. Access to the Internet is likely to be restricted by security policy. Healthcare personnel in ambulance will be accessing hospital database using Mobile-Fi (upcoming 802.20) or WiMAX (802.16e) that supports mobility.

It should be noted that this is the conventional way of establishing WLAN using Wi-Fi systems, whereby the users' devices within a local area are served by a specific Access

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Point (AP), and the APs do not communicate with each other. The coverage area of the WLAN can also be expanded by deploying Wi-Fi mesh network, where the users' devices can roam across a larger area served by multiple APs that are interlinked together. Although this is usually unnecessary for indoor deployment, Wi-Fi mesh can be an alternative solution to extend WLAN coverage area to difficult-to-wire areas. In addition, equipment can also be redeployed as the healthcare centre moves to a new location, changes workforce number, or seeks to enhance employee mobility. Also, the network must be robust, scalable, flexible, durable, and most importantly, secured. These requirements can easily be fulfilled today as most commercial Wi-Fi systems for WLAN deployment in enterprises have been equipped with various advanced capabilities. These include efficient power management, air quality monitoring, radio frequency (RF) management, enhanced authentication/ encryption techniques, auto-recovery from failure, and so forth [9].

B. Education Sector

The illustration below depicts the devices required to deploy wireless solutions in education sector.
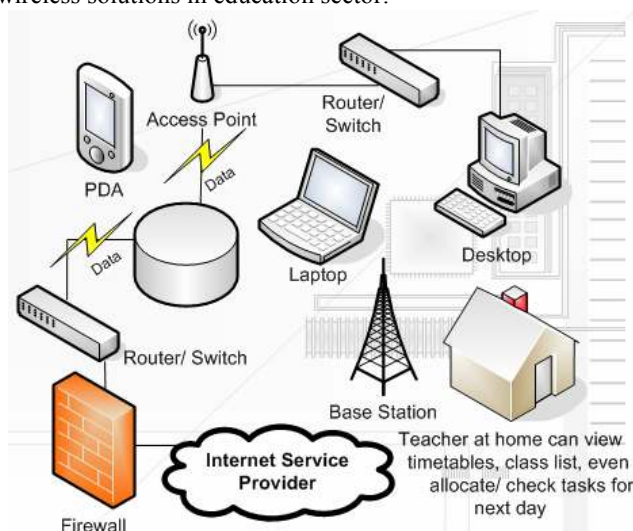

Fig. 5 Technical environment for wireless solutions in education sector

In this business scenario, students may access library databases for further reading; organise discussion group without the need of meeting up with every team members at the same place and so forth. A firewall is required to protect the system from intrusion to ensure that confidential data is not tampered with. Access to the Internet is likely to be restricted by university security policy. The university may set download quota for each student to ensure appropriate usage of bandwidth provided. The presence of firewall is important as security issues have been identified as one of the weaknesses in Wi-Fi. Currently, IEEE 802.11i Working Group is developing solutions to address this problem [10].

Mobile learning moves beyond the confines of traditional education and even online education to make learning truly continuous [11]. It allows unrestrained access to information

databases, learning objects, and courseware [11]. It offers a smooth and effortless learning experience, while ensuring unrestricted access to content and functionality in a portable device, whether disconnected from the network or connected in a wired or wireless approach [11].

With wireless solutions, lecturers, administrative staffs, and students may access relevant information anywhere within the WLAN coverage in the university. Note that Wi-Fi AP operating at 2.4 Ghz band based on 802.11b/g has an optimum coverage range of 50 m in a cluttered environment, while 802.11a system has a relatively smaller range due to extra attenuation caused by higher frequency band at 5.2 GHz. However, the 802.11n standard [10] (under development) is able to increase the range further by using advanced 'multiple antennas' techniques. Also, it should be noted that the data rate of the Wi-Fi system decreases as the separation distance between the communicating terminals increases.

V. TECHNICAL PROCESSES

The list of processes in the Business Processes section is by no means complete. However, all of these processes require certain *core activities* that use wireless technologies. It is by enabling and enhancing these core activities that wireless solutions improve the effectiveness of business and other high-level processes. These core activities contribute to the business processes directly. In addition, there are *supporting processes* that do not contribute directly to the business processes but enable the core activities to be carried out.

A. Core Activities

Conversation

A conversation is civil communication by two or more people, often on a particular topic [12]. In most cases it uses only voice communication, but a conversation may involve data, voice, or video, or any combination of these, especially in wireless environment. Instant messaging (IM) is the ability to easily see whether a chosen friend or co-worker is connected to the Internet and, if they are, to exchange messages with them [13].

IM differs from ordinary e-mail in the immediacy of the message exchange and also makes a continued exchange simpler than sending e-mail back and forth [13]. Most exchanges are text-only. However, some services, such as Skype, allow voice messaging and file sharing, with varying QoS supports however. Following the advances of wireless technologies, it will soon be possible to transmit Voice over Internet Protocol (VoIP) with guaranteed user experience via wireless networks – a new feature in 21st century networks.

Web/ Video Conferencing

Web conferencing is used to hold group discussions or live presentations over the Internet [14]. Participants may discuss specific topics, select options for multiple presenters, participate in polls and surveys, edit documents online, record and replay presentation and so on. Wireless based video system allows ED Team at the hospital to remotely monitor patient's condition while still in transit. This requires good QoS support in order to ensure best user experience. Advanced

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modulation and coding techniques must also be integrated into wireless access networks in order to reduce bit error rates.

Alerting

Alerting is different from messaging in that alerts are delivered to the recipient without the recipient making a specific request for them as quickly as possible. Instant messaging and paging are other methods in which their usages are increasing. This allows messages which require immediate attention to be automatically sent to employees. For example, when a machine in a healthcare centre has failed to function properly, a message can be automatically sent to healthcare personnel in order to notify them of the situation. In addition, if the security of a school has been breached, the security system should be able to notify security guards who are patrolling at that time.

Information Access

Information access ensures free and open access to information [14]. Information access covers many issues such as copyright, open source, privacy, and security [14]. Employees' and students' access to the World Wide Web within the organisation compound is restricted by strict policy. Access to organisation information is available via applications and database and usually requires username and password for identification purpose.

Information Update

The ability of mobile users to update the organisation's information database can be very valuable. Generally, it involves data communication in the form of a data connection between the updater and the information server. It may be carried out using a range of applications. For example, this eases the job of nurses when they walk bed to bed to check and update patients' electronic medical record.

B. Supporting Processes

Transmission

Transmission is the dispatching, for reception elsewhere, of a signal, message, or other form of information. They underlie the core activity technical processes such as conversation, alerting and messaging. This process is supported by adaptive modulation and coding schemes as specified in Wi-Fi and WiMAX air interface control.

Equipment Configuration and Upgrade

In many cases, equipment configuration and upgrade is now possible online over the Internet, either wired or wirelessly. This is an important service for employees away from their supporting organisation. For example, in software defined radio system [15], wireless devices can be upgraded and customised using software, eliminating the needs to acquire new (or separate) devices for different wireless system.

VI. CONCLUSIONS

This paper aids in addressing one of the most common issues facing executives: aligning IT with the business. The success of any major IT project is measured by the extent to which it is linked to business requirements, demonstrably supports and enables the enterprise to achieve its business objectives. This paper has presented business scenarios in healthcare and education sectors, where it can be appreciated that such analyses form important technique that may be used at various stages of defining enterprise architecture, to derive characteristics of the architecture directly from high-level requirements of the business. Here, this is achieved by examining business and technical environments as well as related processes to enable successful deployment of wireless solutions in healthcare and education sectors. The technique has been used to help identify and understand business needs, and thus to derive business requirements that the architecture development, and ultimately the information technology has to address. This help to encourage the uptake of wireless technologies in Asia Pacific region.

As a closing remark, it should be noted that wireless networks can be safely deployed in healthcare and education sectors, even though there have been some concerns of the safe use of wireless devices. Wi-Fi Alliance and Mobile Manufacturers Forum (MMF) [16] reported concerns pertaining to the use of wireless devices in healthcare sector. Interested readers may refer to the article for further justifications.

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