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Report

WiMAX deployment: A report for a rural region of Thailand

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Abstract: We report on the deployment of WiMAX (worldwide interoperability for microwave access) in Mae Hong Son, a remote, rural and mountainous province in northern Thailand. WiMAX deployment is a means to enhance educational opportunities through technology. Three years after installation, we collected data from a wide range of stakeholders ranging from system administrators, teachers and students to government officials, who were potential beneficiaries of the new digital infrastructure. The results indicate that the WiMAX service can help improve the development of a rural area, in particular in the realm of education. Importantly, it can bridge the digital divide that exists between people in rural and city areas.

Keywords: Thailand, WiMAX, rural community, educational opportunities

INTRODUCTION

Since 2006 Thailand has adopted an aggressive approach to creating an information-oriented society. The National IT Policy Framework, IT2010 (2001-2010), aimed for the construction of a knowledge-based economy and society. This framework emphasised leveraging information technology (IT), development of IT human resources, and construction of information and telecommunication infrastructure. Like most other countries that have advanced their information and communication infrastructure, development in provincial cities in Thailand is quite slow; rural areas still lack access to telephones, the Internet and telecommunication infrastructure. As a result, the digitaldivide between urban and rural areas has widened, thus contributing to other disparities in terms of economic opportunity, education and quality of life in recent years [1]. Rectification of the digital divide has thus become one of the highest priority for development in Thailand [2].

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With support from Japan International Cooperation Agency (JICA) in the form of project equipment and from the National Broadcasting and Telecommunications Commission (NBTC) in the form of a trial frequency band, together with a Japanese advisory team and local agencies, the Worldwide Interoperability for Microwave Access (WiMAX) system was set up in the rural province of Mae Hong Son. Although the work entailed the implementation of a wireless communications system demonstration test, the goal was not simply for testing. It was anticipated that WiMAX would help improve the development of the area and that its deployment would be further extended into other rural provinces when the testing, establishing, disseminating and refining of the system for practical applications were completed.

It is important to realise the practical applications of a local wireless communications system and to enhance the IT knowledge for the local people so they can contribute to a local revitalisation. The WiMAX system was seen as having considerable potential for developing the rural and mountainous areas in Mae Hong Son. WiMAX is a technology that can provide an operator-independent telecoms service as long as the operator license is available locally [3]. WiMAX is faster than Wi-Fi and, more importantly, has a much greater fixed, nomadic and mobility coverage [4]. Rural areas frequently lack optical fibre or copper-wire infrastructure for broadband services, and providers are unwilling to install the necessary equipment for regions with low profit potential. Thus, many residents must do without broadband service. WiMAX can address this problem since a wireless infrastructure can be considerably cheaper and requires less time to set up compared with the traditional wired options [5].

In this paper we report on an impact survey conducted three years after the installation of WiMAX in Mae Hong Son province. We focus on two outputs: 1) actual usage of the WiMAX and development of local information technology infrastructure, and 2) economic development in terms of advancement of school curricula and online learning. Both quantitative and qualitative data were collected from three groups of stakeholders, i.e. system administrators, teachers and students, to gauge the impact of WiMAX on the rural community.

IT INFRASTRUCTURE IN RURAL COMMUNITIES

A viable IT infrastructure is vital for rural areas for the simple reason that people living in these areas are more isolated from the rest of the world and need technology to connect with others [6,7]. The uneven distribution of information and communications technology (ICT) access may mean that those who have no or limited access to this technology may be denied socio-economic opportunities such as social and economic equality, economic growth and access to innovations [8]. A study in South Korea identifies two factors influencing ICT use in rural areas: perceived usefulness for commerce and perceived entertainment value [9]. Since each developing economy exhibits different characteristics (in particular, problems and limitations), the goals of deploying ICT are diverse [10]. For example, in India the Communication Initiative Network 2000 [11] has focused on IT deployment for education purposes. The Warana Wired Village project [12] helps the villager gain access to information about agriculture, healthcare and education. In contrast, in Kenya, IT deployment has focused on improving agricultural practices [13]. Today, WiMAX receives growing acceptance and is a cost-effective method for delivering broadband internet service in rural and urban areas [14, 15].

Government and private initiatives can overcome the urban-rural digital divide by providing funds for investment and access to education [16]. Also, governments can provide subsidies and incentives to diffuse broadband to rural areas where people are still regarded as “broadband have-

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nots" [9]. Several countries have launched national broadband plans or frameworks involving ICT investment in rural areas [17, 18]. In summary, although investment in information technologies and infrastructure is not a panacea for all of the problems of developing countries, it is a proven enabler of economic development [8]. This is especially true for rural areas in developing or underdeveloped countries.

IT INFRASTRUCTURE AND DEVELOPMENT OF E-LEARNING PROJECT

The National Electronics and Computer Technology Centre (NECTEC), a Thai ICT research institution, and JICA, a Japanese government agency that assists economic and social growth in developing countries, initiated the 'Project of human resource development through utilising the information technology for rural community vitalisation in the kingdom of Thailand' in December 2007. The project aimed to realise the practical application of a local wireless communications system to enhance local vitalization and the specific deliverable was the deployment of WiMAX in Mae Hong Son province. After some delays, the WiMAX service and its supporting website were officially launched in Mae Hong Son on 28 March 2010.

In April 2009, before the start of the WiMAX project, baseline data were collected from local citizens residing in four areas within Mae Hong Son province: Muang, Mae Sariang, Pai and Kun Yuam. Questionnaires were hand-delivered to 17 local people in Muang, 16 in Mae Sariang, 9 in Pai and 2 in Kun Yuam. In total, all 44 questionnaires were returned and analysed. The major findings of the baseline survey (good points and problems) are summarised in Table 1.

Table 1. Major findings of baseline survey

Good Points	Problems
Awareness • Overall good awareness for the role that IT could play in improving education, economy and overall quality of life • Good awareness for the capabilities of Internet technology	**Infrastructure (computers)** • Lack of computers and hardware infrastructure; budget for human development preventing people from accessing the Internet • Inadequate number of personal computers (PCs) in schools (20-50 computers per school, 200-500 students per school) **Infrastructure (electricity and communication)** • Slow and inconvenient internet access • Poor conditions of existing infrastructure such as unstable supply of electricity **Appropriate Use** • Lack of use of e-learning systems on a regular basis • Too much concern about misuse of IT such as access to inappropriate contents (e.g. pornography) **Personnel** • Limited personnel for training and maintenance

Maejo Int. J. Sci. Technol. **2015**, *9*(02), 147-155; doi: 10.14456/mijst.2015.12

IMPLEMENTATION PHASE

WiMAX Installation

Over a one-year period, from January 2010 to January 2011, WiMAX base stations were installed in three districts of Mae Hong Son province: Muang, Pai and Mae Sariang. For each of the three sites, stakeholders were solicited from three sectors: schools and community colleges, government and local communities (Table 2). The survey focuses on a number of stakeholders in these sectors using stratified random sampling technique.

Table 2. Number of stakeholders by district

District	School	Government	Community	Total
Muang	9	8	2	19
Mae Sariang	12	3	1	16
Pai	6	3	1	10
Total	27	14	4	45

Personnel Training

Educating people correctly was a key success factor for achieving stated goals and managing the project in a systematic way. A training plan was created to maximise stakeholders' understanding of the technology. More than 20 training courses were offered throughout the areas from August 2009 to October 2011. Another role of the personnel was system support, so a system support structure was created and assigned to community members so that when a problem occurs they know how to fix it, and if they cannot fix it, they know where to go to find solutions.

Applications

LearnSquare is a Thai open source learning management system that was introduced in schools in March 2010 and allows users to design a content structure and create an online course. AcuConference is an application tool that supports video/audio conferencing. In this project this tool was mainly used for distance learning during project implementation.

POST-IMPLEMENTATION REPORT

Given this background, we conducted an impact survey over a three-year period (November 2010 - October 2013) following the installation of the WiMAX to gauge changes, outcomes and conditions in the rural communities. We contacted 45 local communities within the three districts: Muang, Mae Sariang and Pai. Kun Yuam was not contacted because while testing WiMAX, it was found that Kun Yuam was located too far from the WiMAX range to participate, the maximum range being five kilometers for this project. Thus, Kun Yuam was removed from the project. The objectives of this impact survey were: firstly, to collect and analyse data on the status of the current system, the users' training experience, and the actual e-learning content development and usage; and secondly, to identify the project success factors and ongoing issues that need to be addressed for further actions.

The project output after a series of infrastructure implementation and training courses with local people included the following:

- WiMAX system was up and running in 45 sites (schools, government offices and local communities) within Mae Hong Son province

Maejo Int. J. Sci. Technol. **2015**, *9*(02), 147-155; doi: 10.14456/mijst.2015.12

- Technical knowledge about WiMAX system was transferred to local people, and they could monitor and maintain the system on their own or with minimal guidance from the project team.
- The number of developed e-learning contents that had been created by the 45 local sites increased substantially.

Three sets of questionnaires and an interview protocol were designed to collect data from the identified targets. Survey data were collected from 45 IT administrators from all 45 sites, 40 e-learning teachers and 117 'IT-Valley' students from eight schools. Questions were asked in the areas of system status (number of PCs, network conditions, internet access and usage, wireless access and electricity), system training and e-learning outcomes for both teachers and students. In addition to the questionnaire survey, we also ran two focus groups and conducted individual interviews with 48 stakeholders, consisting of system administrators, teachers, government officials and business owners, to identify key success factors of the project as well as concerns that needed to be addressed for further actions. The data collection was done via two field trips to Mae Hong Son. Results from the questionnaire survey, focus groups and interviews were then analysed to generate a list of possible impacts of the WiMAX service on the target sites, which later was validated through an internal brainstorming session involving researchers, teachers, local governors and the project's funding sponsor.

Three years after the WiMAX installation, the findings were presented in the following five categories: awareness, personnel, electricity and communication infrastructure, computer infrastructure, and appropriate use.

Awareness

After the implementation of the WiMAX service, the number of system administrators that were aware of wireless technology trainings held in their area increased from 2 to 25. It was also found that there were more wireless training instructors and that their wireless skills (design, installation, monitoring, maintenance and configuration) expanded. People gained more understanding of how WiMAX wireless technology could improve their everyday lives. For example, people now use mobile devices including laptops and smart phones to connect to the Internet on a regular basis.

Personnel

There was no significant change in the number of staff members (teachers, IT instructors or administrators). Most students had computer proficiency and could use resources on the Internet. Compared to the baseline data, school size actually increased slightly. This might be because people had more opportunities to get access to the Internet and the contents in the Internet could influence them to send their children to school. However, there was no change regarding the number of students that could use computers and the Internet. Although the number of personnel did not change, their IT skills were greatly improved. They could use computer software, applications and the Internet without assistance from IT experts. This could be because they had more opportunities to learn, given the availability of the Internet access and e-learning.

Electricity and Communications Infrastructure

Compared to the baseline data, there were more connections through the Communications Authority of Thailand, increasing from 8 sites in 2010 to 19 sites in 2013. The number of system

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administrators per site also increased, with many sites reporting more administrators than those in 2010. Also, a better management of the network was reported, with a decreasing number of sites that had no identification or authentication system, and more sites with such a system available for all users. More than half of the servers (27 out of 45) were housed in a locked facility.

Most uninterruptible power supplies last for about 5-13 minutes after a blackout. As noted earlier, electricity problems were prevalent in Mae Hong Son areas. Blackouts were frequent (except in Pai), usually lasting for up to 1 hour each day. Voltage instability came mostly in the form of voltage drops and voltage fluctuation. Compared to the baseline data, there was an important improvement in blackout problems, shifting from a daily occurrence down to a few times a week.

Computer Infrastructure

Compared to the baseline survey, there was an increase in the number of PCs in organisations that could connect to the Internet, a jump in wireless communication throughput from 1 Mbps to >5 Mbps, and a big improvement in PC and network conditions for teaching an IT curriculum. Almost all sites had a Wi-Fi connection and 30 out of 45 sites could get WiMAX communication up and running. The majority of sites had at least 2 access points covering most buildings at each site. Compared to the baseline data, the use of wireless communication significantly increased during the year 2010, with Wi-Fi increasing from 27 to 41 sites and WiMAX going from zero to 30 sites. In addition, there were marked increases in the number of wireless access points as well as wireless locations and buildings. Most of the sites (69%) had a connection speed of at least 1 Mbps. Also, most system administrators/teachers thought the actual PC and current network conditions were quite sufficient for teaching an IT curriculum. Compared to the baseline data, the length (hours) of Internet usage per day remained unchanged. However, many students accessed the Internet more frequently, from a few times a week to daily usage.

Appropriate Use

After the installation of WiMAX, teachers tried to teach a subject using e-learning contents, and more than half developed some e-learning content themselves. Many teachers helped train others to support teaching and helped their colleagues master IT curriculum items such as Media creation, Graphics, Computer and IT, and Internet usage. In addition, most of the teachers felt that the contents of the IT curriculum fitted their needs.

Most of the teachers who used LearnSquare used it about once a month. For those who did not use the application, their reasons were the associated materials being not suitable for their class, failed attempts to use the application, and lack of time/personnel. As site users gradually improved their understanding and cooperation, a change in awareness was observed, and comments shifted from asking: "why should we develop content?" to stating: "we want to create content if we have the time" and "we can't develop them but we want to use them." Eventually, there were more than 800 contents stored on the e-learning server. Since the introduction of AcuConference late in 2010, only few teachers taught a class using that application.

Half of the students reported having learned online. They also expressed an interest in e-learning and thought it could be useful or helpful. Most students liked to participate a project to develop an IT curriculum content. Since there were in the e-learning system contents that still needed updating, selected students were encouraged to help teachers and IT instructors to improve them. The baseline data showed that most students had never used e-learning contents (in general).

Maejo Int. J. Sci. Technol. **2015**, *9*(02), 147-155; doi: 10.14456/mijst.2015.12

Three years later, all the students used e-learning contents and e-learning tools on a regular basis. The available subjects were the same because the contents had not updated from the previous years.

DISCUSSION

Overall, the project did increase the connectivity of the rural communities to the rest of the country and the world beyond. According to our findings, WiMAX could address social issues in several ways including education and economic opportunities, although it also had its own problems.

Education

The WiMAX service for local communities had strong signals in the coverage areas and the mobile WiMAX dongles were well received by all users. Wireless communication technology and knowledge was transferred to local communities and made a difference in the educational mission and outcomes. The project also helped build a strong network for local personnel in the field of information technology and education even beyond the WiMAX context. For the first time, a platform was built to allow local teachers to utilise IT to create digital content and share it with both colleagues and students. The project significantly helped the IT-savvy teachers improve their e-learning skills. Also, although new to e-learning, students showed a strong interest in e-learning activities and such IT curricula as programming and image editing. Despite being introduced late in the project, WiMAX had great potential to save time and travel expenses for a province like Mae Hong Son. Several IT-oriented teachers conducted e-learning classes to offset the shortage of specialised teachers.

Opportunities

One of our expectations was to see an increase in the number of PCs connected to the Internet. In this project the introduction of WiMAX vitalised the rural communities, was well accepted and received good support from both the community and the local government. In Mae Hong Son case most of the region is mountainous, so people have to spend more time and money in travelling within or between the provinces. The videoconference application was thus well accepted by the local government staff, because it enabled them to hold meetings across districts.

Schools in Mae Hong Son tend to lack teachers and also have high teacher turnover rates. E-learning can therefore be used as a tool to strengthen education in the province. An increase in PCs with Internet access leads to increased access to information for lessons and network collaboration [6]. In this case the WiMAX service can bridge the digital divide between rural areas and downtown if it is adequately implemented, managed, maintained and made cost-effective [7].

Problems

One of the major complaints about the WiMAX service was that users were unable to freely access the Internet via the system. Since use of the system was limited to a few specific functions for academic purposes, sometimes users felt they might not choose to use WiMAX, if they had an alternative connection. It is not surprising that users wanted access also to non-educational contents, especially for entertainment purposes, which might be blocked by the system. However, they could use their personal mobile phones or dial-up modems to access this content instead, although the cost of these connection methods was much higher while the connection speed was much lower and the users had to pay by themselves. We perceive this is not a long-term problem because users did not

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often use these connection methods. Also, the cost of connecting to the Internet using a smart phone (3G) decreases every year and the connection speed is always improving.

Time and motivation were issues for some local teachers. While many outstanding teachers were recognised and assigned as e-learning expert instructors, some were still not motivated enough to learn and create their e-learning content independently. Some teachers reported finding no content that would align with their needs. Also, at this stage of the project, LearnSquare was still used mainly by teachers to create contents and by students to download specified learning materials. Students must be encouraged to create e-learning contents themselves in the next stage of the project.

Another disadvantage was the limited selection of applications suited to rural areas. The applications were limited to educational items (e-learning, VoIP and TV conference) while a survey of wishes revealed that there was also a large demand for items related to e-health and e-tourism. Mae Hong Son's ex-governor and the tourism community strongly suggested using WiMAX service to promote the local tourism industry. It was apparent that not all demands for applications could be fulfilled.

CONCLUSIONS

This paper reports the impact of introducing WiMAX service to a rural province in northern Thailand. Importantly, the WiMAX service can bridge the digital divide that exists between people in rural and city areas. Hence education can be strengthened across the province regardless of geographical barriers. While this study addresses the adoption of a specific technology (WiMAX) in specific rural areas (Mae Hong Son), further studies on IT adoption in other rural areas using other technologies could be conducted in similar ways, using this project as a baseline work. However, distinctive characteristics of the local areas should be addressed before conducting future studies.

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