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Expansion of Optical Access Network to Rural Area

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SUMMARY The spread of optical access broadband networks using Fiber to the Home (FTTH) has not reached the rural areas of developing countries. The current state of global deployment of ICT indicates that it is difficult to sell network systems as stand-alone products due to prohibitive costs, and the demand is for total services that include construction, maintenance, and operation. Moreover, there is a need to offer proposals that include various solutions utilizing broadband networks, as well as for a business model that takes the sustainability of those solutions into consideration. In this paper, we discuss the issues in constructing broadband networks, introduce case studies of solutions using broadband networks for solving social issues in rural areas of developing countries, and discuss the challenges in the deployment of the solutions.

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key words: *Optical Access Network, FTTH, GE-PON, Solution.*

1. Introduction

The issues that need to be addressed in promoting the spread of optical access systems to rural areas of developing countries are listed as follows.

1. Necessity of high-speed networks
2. Stable power supply
3. Training of human resources for optical fiber laying and system installation
4. Training of engineers for maintenance, monitoring, and operation
5. Environmental countermeasures (protection against lightning damage, heavy rains, etc.)
6. Land tenancy and permission to use roads during construction
7. Total costs (laying, operation, and maintenance)
8. Sustainability
9. Stakeholders for maintaining the network facilities and carrying out solution services
10. Backbone networks

This paper discusses cases studies of introduction of optical access systems in Malaysia and Indonesia. [1]-[5]

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2. Optical Access System Introduction Case Study

2.1 Provision of Education and Health management solutions in Malaysia

2.1.1 Background of the Project

The project site is in the town of Bario in the island of Borneo, Malaysia. Bario, which is home to 12 longhouses and has a population of around 1000, lies along the Malaysia-Indonesia border between Sarawak, Malaysia and Kalimantan, Indonesia. Since the town only has a primary and a secondary school, students have to move to neighboring towns to enroll in senior high school. Also, since most of the primary and secondary school students live far from the schools, they stay in dormitories adjacent to the school. Residents of Bario belong to one of the minor indigenous tribes of Sarawak, Malaysia. They are engaged in farming, and the town is particularly known for the Bario Rice, a famous brand of rice in Malaysia. Many of the farm workers, however, have left to work for petroleum and palm oil companies in neighboring cities, in Brunei, and elsewhere. Thus, majority of the population are either elderly citizens or secondary school children and younger.

http://pamaja.orgfree.com/mymap.html

Fig.1 Location of Bario and Kuching on the Borneo map.

2.1.2 Purpose of the project

Since most of the town's residents are children, elderly, and women, we chose solutions for solving social issues using optical broadband particularly in the areas of education and health management.

2.2 Education solution in Malaysia

2.2.1 Overview of the educational solution

The educational solution for primary and secondary school students was created by one of the partner organizations, namely, the Faculty of Education of the Universiti Malaysia Sarawak. Figure 2 shows the flow of collection and processing of data used in the educational solution.

1) Capture data and contents for distribution to the students are provided using an Android-based application and device.
2) Students access the open-source Learning Management Server installed in the TeleCenter.
3) The education solution covers the medical sciences, ICT, communications, livelihood skills, and indigenous tribe knowhow and culture.

2.2.2 Benefits of the introduction of the education solution

The solution enables the children to gain an understanding and appreciation of the traditional culture, local language, local myths, and legends through digital contents. Also, the children are able to complement what they learn in school by adding on knowledge from their own local values and culture. Teachers can also enhance lesson contents using related information from the Internet. Teachers and students can easily share information through simple operations on the information devices used by the students. By maximizing the use of mobile information devices, teachers are able to hold classes beyond the confines of traditional curriculum-based learning.

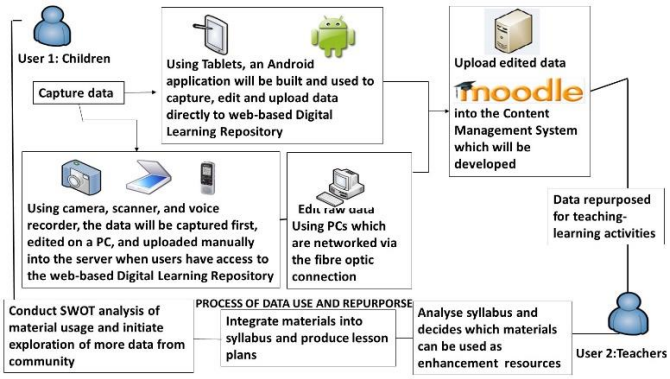

Fig.2 Process of data collection.

2.3 Health management solution in Malaysia (e-Health Check System)

2.3.1 Overview of the health management solution

The health management solution measures only basic data, namely, height, weight, and blood pressure. Each measuring device is connected to the computer via Bluetooth, and measurements are automatically entered into the Health Check Database. The database is consolidated in a server in the TeleCenter. Although currently the database only includes data on height, weight, and blood pressure, the use of optical broadband will also enable easy access for viewing image data in the future.

2.3.2 Benefits of the introduction of the health management solution

The solution aids in preventing diseases through regular examinations, particularly for the elderly, for whom there had been no blood pressure data available. Blood pressure measurement data showed that many of the elderly residents have high blood pressure without their realizing it. Regular examinations will change the residents' awareness towards health, and improvements in their eating habits and other health management initiatives will contribute to curtailment of medical costs of the town. Since the elderly make up the majority of the local population, plus due to the lack of professional health personnel on a permanent basis in Bario, health monitoring is a key concern for Bario residents. The health management solution was introduced in Bario, to enable the local community to conduct and manage their own health checks at their convenience. The Bario community has one health clinic established at the center of Bario, and medical officers visit in every two weeks to conduct physical checks on those in need. With the introduction of the e-Health check system the community became proactive in knowing about their health status. They were pleased that they were able to conduct their own checks, and that data from the checks were transmitted to the Health Check Database located at the local clinic. It enabled a systematic record of health checks, making it easier for medical officers to obtain records about the health of people in Bario.

2.4 Overview of optical fiber network system constructed in Bario, Malaysia

2.4.1 Overview of the optical fiber cable system

Since a multicore optical fiber cable is not needed in rural areas, and since installing a cable conduit line is costly, a low-fiber-count aerial drop optical cable was used to construct the optical fiber network system. Figure 3 shows the overview of the optical fiber network built in Bario.

We installed optical fiber cables from the TeleCenter (e-Bario) to the primary and secondary schools and from the TeleCenter to the new hospital and the existing clinic. One low-fiber-count optical drop cable was used for aerial installation and one low-fiber-count indoor optical fiber cable with SC connector was used for indoor installation. The existing poles once built for an abandoned hydropower supply project were utilized to install the optical fiber. One optical splitter was located installed each at the pole between the primary and the secondary school, and the pole between the new hospital and the existing clinic, respectively. Total fiber length is about 2.5 km from the e-Bario to the secondary school, about 2.3 km from the e-Bario to the primary school, about 500 m from the e-Bario to the new community hospital, and about 200 m from the e-Bario to the existing clinic.

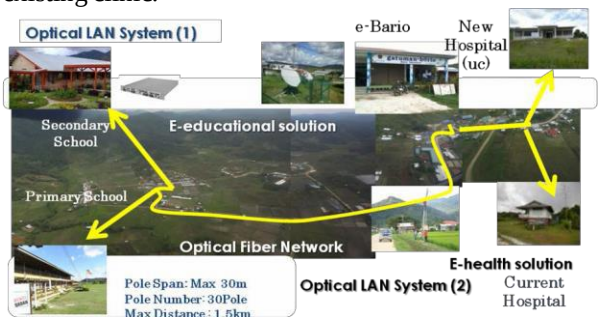

Fig.3 Optical LAN system.

2.4.2 Overview of optical network system

Since backbone networks connecting rural areas of developing countries are mostly through satellite channels and have limited capacity, broadband networks built in rural areas could not be used to their full potential. In order to affordably construct an optical fiber network, we constructed the network using GE-PON (Gigabit Ethernet-Passive Optical Unit). Figure 4 shows the overview of the network system constructed in Bario.

The GE-PON network consists of the following two PON lines: Line A from the TeleCenter to the primary school and the secondary school, and Line B from the TeleCenter to the existing clinic and the new hospital. Both Line A and Line B are terminated locally at the local TeleCenter by the OLT (Optical Line Terminal). The OLT relays packets over Line A or Line B to a server or a router via an L2 switch. The other ends of Line A and Line B are terminated by ONUs (Optical Network Units). An ONU has a LAN port to accommodate a PC, an L2 switch, or a WiFi BTS (Base Transceiver Station).

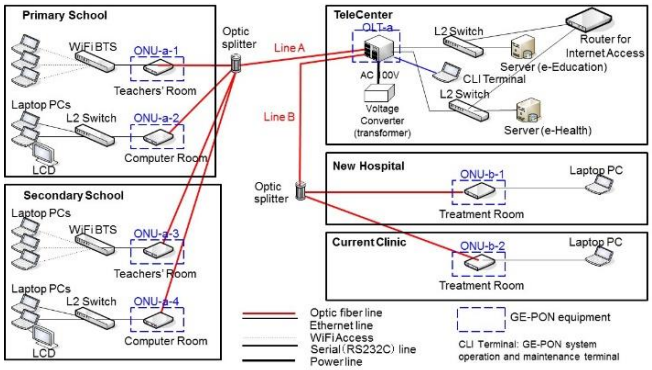

Fig.4 Bario network system configuration.

2.4.3 Construction of wireless access networks in the primary and secondary school premises

Tablet devices were provided to students of the primary and secondary schools to enable versatile use. WiFi access was provided so that students can use the devices freely within the school. WiFi access points allowed multiple tablets to simultaneously connect to the GE-PON network. The WiFi access points were compliant with the IEEE 802.11n standard to supporting maximum data rate and take advantage of the high performance GE-PON system. The WiFi coverage was within 50 meters from the WiFi access point.

2.4.4 Construction of central server

A total of four servers were deployed in the e-Bario TeleCenter for provision of various applications over the GE-PON network. The application servers are as follows: a) e-Health Database Server, b) Viscuit[6] Application Server, c) e-Education Contents Server, and

d) Backup Server for e-Health Database. The e-Health Database Server is a standard desktop computer that comes complete with a monitor display, keyboard, and mouse, and runs on Ubuntu platform. The Viscuit Application Server is a notebook computer that hosts all the proprietary Viscuit application services. Viscuit enables users who are not familiar with computers to create graphical animation by utilizing drawing tools. Using Viscuit allows users to learn the fundamental concepts of basic programming. The e-Education server runs on a Windows platform. The server hardware runs on the green computing concept and is known as the green server, wherein it is able to utilize energy, either from the TeleCenter, or from its own dedicated solar panel and battery system. The green server is a highly power- optimized computer system built from Intel Atom processors and other power-optimized system components, such as solid-state drive. Its power supply system is designed for native solar power input in order to

minimize the power conversion loss throughout the system.

2.4.5 Power supply implementation

A separate solar power system was designed and deployed to provide additional electrical power input for the e-Bario TeleCenter. Figure 5 shows the solar panel installed on the TeleCenter's rooftop. The capacity of the solar power system is 1.3 kW. The main purpose of the system is to provide power specifically for the network equipment, such as the GE-PON, switches, routers, and servers, deployed for the project.

Fig.5 Solar panel installation on Bario TeleCenter's rooftop.

2.5 Construction of network for local government agencies in Indonesia

2.5.1 Construction of network for local government agencies

We constructed an optical network for agencies of the Tanah Datar Regency of West Sumatra, Indonesia. As shown in Figure 6, the project was implemented under full funding from the APT (Asia-Pacific Telecomunity) for Phase 1. A network was built to connect seven government agencies that include a government-run ICT Center. After completion of Phase 1, a request was received for expansion of the project to other agencies. As shown in Figure 7, seven more agencies were added to the network, through funding split between the local government and the TTC (The Telecommunication Technology Committee) Promotion Committee. Approximately 80% of the costs for equipment and installation of optical fiber cables and network systems are due to labor for laying down the cables. In Phase 1, Japanese contractors provided guidance to local contractors on the methods for installing the aerial cables and making on-site connections. To reduce costs, in Phase 2, construction was carried out only by local contractors.

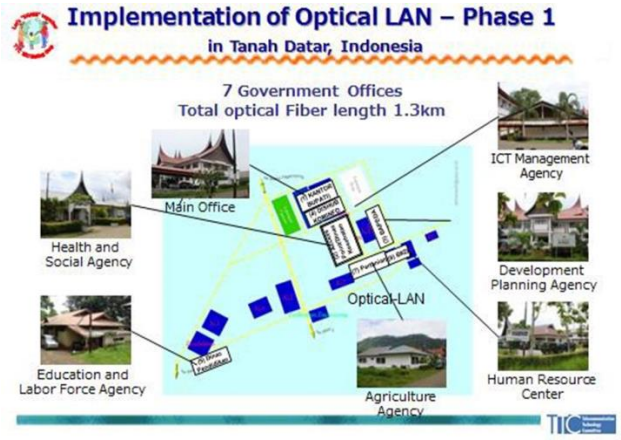

Fig.6 First phase implementation of optical LAN in Indonesia.

2.5.2 Benefits of the introduction of the optical access network

Before the network was introduced, input of data for the government's accounting operations was only possible through terminals installed in the ICT Center. Thus, during peak seasons, the ICT Center became crowded with people from different agencies, significantly reducing the efficiency of operations. The construction of a closed high-speed network among the local agencies enabled carrying out accounting operations without sending personnel from each agency to the ICT Center, greatly improving work efficiency.

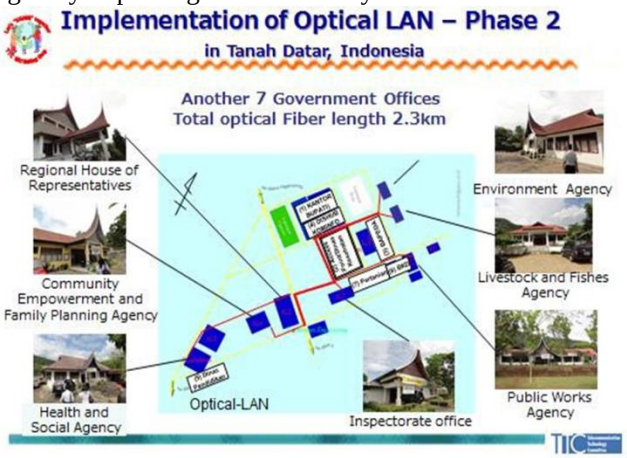

Fig.7 Second phase implementation of optical LAN in Indonesia.

2.5.3 Construction of optical fiber network among local government agencies

Figure 8 shows the overview of the components of the optical fiber network. As in the case of Malaysia, the network was constructed using low-fiber-count aerial drop optical cables and on-site connectors.

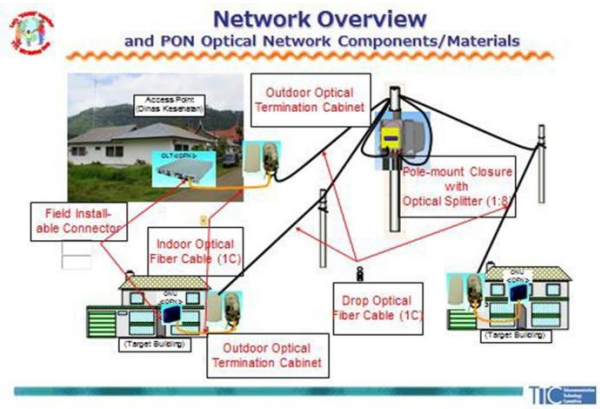

Fig.8 Overview of the components of the optical fiber network.

3 Considerations in solving of issues in the introduction of optical access systems in rural areas

Issues in the introduction of optical access systems in rural areas are listed in Section 2. This Section discusses these issues based on the pilot project case studies in Malaysia and Indonesia.

3.1 Sustainability and Stakeholders

In the case of the pilot project in Indonesia, operations were improved by enabling input of data to the internal government accounting system independently from each agency. Each agency therefore shouldered their own costs, making it possible to expand the installation to more agencies and to carry out prompt system restoration and support during failure. This pilot project demonstrated that sustainability is guaranteed because there will be demands for maintenance of the system, as long as the solution addresses the local needs. Although a failure due to rupture of optical fiber cable occurred, due to the necessity of the system, repair and recovery was immediately carried out.

3.2 Elimination of gaps

Due to the narrow bandwidth in the backbone network, there have been issues against the practicality of building high-speed optical fiber networks in rural areas. Although it is not possible to provide high-speed services in real-time, using cache servers to receive heavy contents at nighttime, the pilot project in Malaysia has realized an environment for rapid sharing of contents. We were also able to demonstrate through the pilot project in Indonesia that high-speed optical networks can be applied for solutions in a closed area.

3.3 Power supply

Some rural areas of developing countries do not have established public infrastructures such as power and water supply. In the pilot site chosen for the project, namely, the town of Bario in Borneo, Malaysia, it was necessary to supply power from solar power generators for the satellite transmission system of the backbone lines, as well as for the computers, room lighting, and the optical access system installed in the TeleCenter. The power supply equipment included solar panels and batteries. Since the use of electric power generators requires factoring in costs for fuel and other environmental considerations, an eco-friendly green system that uses natural resources, such as solar and hydroelectric power generation, was chosen for the project.

3.4 Local regulations

The construction of optical networks requires the renting of land for laying down conduit lines and utility poles and obtaining permission for the use of roads during construction. During the construction of the network for the government agencies of the Tanah Datar Regency of Sumatra, Indonesia, we were able to smoothly obtain permission for the use of roads and of utility poles within the agency premises because the agency having jurisdiction over roads also has jurisdiction over communications.

3.5 Construction of conduit lines and utility poles

The construction of optical fiber networks requires conduit lines for laying down optical fiber cables underground and utility poles for installing aerial cables. In the case of the pilot project in Malaysia, existing poles built for an abandoned national power supply project were utilized to install aerial optical fiber cables from the TeleCenter to the primary school, secondary school, and hospital.

3.6 ICT-based solutions for addressing social issues

The ability to provide a solution for solving the social issues faced by each rural area is the key to substantiating the necessity for high-speed networks (Issue 1). If the solution is necessary for the particular area, then it can also address the issue of sustainability (Issue 8), as well promote the training of human resources for operating and managing the solution (Issues 3 and 4), which is needed for expanding

deployment of the solution. In particular, these issues were addressed in the pilot project for the Tanah Datar Regency of Sumatra, Indonesia, by building a network to connect the government agencies in the Regency.

4 Conclusion and future plans

This paper featured case studies on the introduction of optical access networks in rural areas of developing countries and discussed the issues and considerations in the introduction of the networks. The key to substantiating the necessity for high-speed networks in rural areas is the ability to offer services that are needed by the residents, by leveraging the high-speed network. In regard to sustainability, it was demonstrated through the above case studies that stakeholders are willing to invest for the maintenance and operation of their own systems, as long as they need the offered services. We believe that offering solutions that can solve social issues by leveraging ICT will promote the spread of high-speed networks, which serve as basic communication infrastructures, even in rural areas.

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