

Pilot Projects for Deployment of Wireless IP Based Systems in Rural Areas of Developing Countries

1. BACK GROUND

The Valetta Action Plan (VAP), formulated at the second ITU World Telecommunication Development Conference (Valetta, 1998), sought to promote universal access to basic telecommunication, broadcasting and Internet as tools for development in rural and remote areas.

The WTDC 1998 also established the Focus Group 7 (FG7) to study new technologies for rural applications. The Focus Group 7 which completed its work in September 2000, concluded that there is a need for robust telecommunication systems combining low-cost, wireless access technologies with packet-based networks for the possible delivery of multimedia applications in rural and remote areas

Consequently, among the recommendations outlined in the final report of FG7, is a proposal for the conduct of packet-based wireless access infrastructure pilot projects in rural areas. The aim of these pilot projects is to confirm the technology's robustness in rural environments and effectiveness dealing with multimedia applications such as long distance education, telemedicine, local business development, and so forth.

The Focus Group 7 recommended that the BDT conduct 5 pilot projects in rural areas in developing countries within the next year. In order to ensure optimum utilization of resources and reduce the time needed for implementation it was suggested that packet-based wireless technology be installed in conjunction with existing or on-going ITU Projects such as, for example, Multipurpose Community Telecentres (MCTs).

It is envisaged that a progress report of the pilot projects will be presented to the WTDC of 2002. The successful projects will be used as models for future full-scale implementation of IP-based, wireless infrastructure in rural areas.

2. JUSTIFICATION

More than 2.5 billion people – over 40% of the planet's population – live in rural and remote areas of developing countries. Of the small fraction that has any access to telecommunications, radio broadcasts and voice telephony have traditionally been the main services provided. Today, a wide variety of new telecommunication applications such as e-mail, e-commerce, tele-education, tele-health, and tele-medicine, among others, have made access to interactive multimedia services as important for rural and remote communities as voice connectivity alone. Since each rural district or community requires a different mix of voice, text, image, video and audio communications to best meet its needs, today's telecommunication network operators must be able to support a wide range of services, applications and bandwidth levels at a reasonable cost.

To accommodate these new applications, the focus of new network construction around the world is shifting rapidly from conventional PSTN to IP-based technologies. It is important that developing countries, and rural areas in particular, not be sidelined during this process.

Focus Group 7 studied the technological developments that have the potential to support telecommunication applications which are commercially viable, or sustainable through other transparent financing mechanisms, in rural and remote areas of developing countries. It was found that there are an increasing number of technologies that are available to meet multimedia applications at a reasonable cost to rural network operators. Emerging packet-based wireless access technologies, such as IMT-2000 and wireless routers, are

being designed to deliver a wide range of traffic types more efficiently and inexpensively than traditional wired and cellular telephony networks.

3.OBJECTIVES AND OUTCOMES

3.1 Objectives

The specific objectives of the pilot projects are:

- a. To provide easy access to data and voice services where needed in rural areas and hence to:
 - Increase access to education facilities;
 - Increase access to medical information;
 - Stimulate the development and growth of local businesses; and
 - Develop ICT skills among the local population.
- a. To test the suitability of packet-based wireless access infrastructure for delivering multimedia applications such as long distance education, telemedicine, local business development, and so forth, in rural areas
- b. To serve as a case study for administrations in developing countries looking to implement IP technology.

3.2 Expected Outcomes

The objectives of the project will be realised through concrete outcomes:

Establishment/Extension of an MCT with packet-based, wireless access technology that will initially provide the following services:

- Data communication services for simple applications in the following fields:
 - Telemedicine (exchange of medical records, statistics, epidemic surveillance data, transmission of X-rays and EKG test data, consultations with specialists through e-mail, etc.);
 - Education and research (access to electronically stored libraries, training material and research papers and, possibly, trial courses for teachers, based on existing material, adapted as required;
 - Trade information services (access to databases with market information, contacts with suppliers and customers through e-mail, etc.);
 - Government and community information services.
- Voice services (depends on the regulatory environment).
- User training and support in use of IT and communication facilities;

It is also possible that given the location and the need for applications the following additional services may be provided:

- Interactive distance learning courses in relevant subjects, using multimedia and video conferencing facilities;
- Advanced telemedicine applications (in the hospital), such as remote diagnoses using interactive video besides transmission of X-rays, EKG, EEGs, and, possibly, Ultrasound and MRI; and
- Low-cost access to e-mail and data networks.

4. UNDERLYING CONCEPTS OF PACKET-BASED, WIRELESS TECHNOLOGY

Since the technology to be deployed in these pilot projects is relatively new to rural areas, it is useful to define what is meant by “packet-based, wireless access technology”. The following section provides definitions of the various technologies and provides an illustrative example of a wireless router system.

Packet-based network technology

Packet switched networks break up the data to be transmitted and send it in the form of packets along various routes to its destination. *WhatIs.com* describes the advantages of packet-based networks as opposed to traditional circuit-based networks:

Breaking communication down into packets allows the same data path to be shared among many users in the network. This type of communication between sender and receiver is known as connectionless (rather than dedicated). Most traffic over the Internet uses packet switching and the Internet is basically a connectionless network. Voice calls using the Internet's packet-switched system are possible.

Contrasted with packet-switched is [circuit-switched](#), a type of network such as the regular voice telephone network in which the communication circuit (path) for the call is set up and dedicated to the participants in that call. For the duration of the connection, all resources on that circuit are unavailable for other users.

In a relatively short time, packet-based networks have become the platform of choice for new telecommunication networks. For example, US operator, AT&T, announced that it would no longer purchase circuit-based switches, only IP-based routers and servers. The lure of a common platform for voice and data, and the expected cost savings, are strong driving factors towards this shift. (See Secretary General's report to the World Telecommunication Policy Forum, 2001. <http://web.itu.ch/wtpf/sgreport/index.html>.)

As developing countries look to build their telecommunications infrastructure, it is important that they chose systems which are “forward-looking”. In other words, an expansion of the network as well as an upgrade of services should be easily provided and at a low cost. Packet-based technology may prove to have the technical, and eventually, financial flexibility required in new network infrastructure.

Wireless Access Technology

Wireless refers to telecommunication in which electromagnetic waves, rather than wires, carry a signal over the communication path. According to *WhatIs.com*, wireless infrastructure can broadly be divided into 4 categories:

1. Portable wireless: refers to the operation of autonomous, battery-powered wireless devices or systems. These devices are used in the office, home, or vehicle but have a limited range of mobility.
2. Mobile wireless: refers to the use of wireless devices or systems aboard motorized, moving vehicles or while walking in the streets. Examples include the cellular telephone.

3. Fixed wireless: refers to the operation of wireless devices or systems in fixed locations such as homes. These devices usually derive their electrical power from the utility mains, unlike mobile wireless or portable wireless which tend to be battery-powered.
4. Infra Red wireless: the use of devices that convey data via [IR](#) (infrared) radiation. This is employed in certain limited-range communications and control systems (example of infrared communication between Personal Digital Assistants (PDA)).

Wireless technology is rapidly evolving and is currently viewed as one of the most important tools to reduce the digital divide. Wireless infrastructure provides faster roll out times, lower maintenance costs, and greater network flexibility. Through case studies and research, FG7 identified 10 types of wireless access systems, illustrating existing and emerging access options for rural communities.

The FG7 final report identified, among others, two types of packet-based wireless access infrastructure technologies that have yet to be tested in rural areas.

1. IMT-2000

Commercial IMT-2000 systems are expected to go into operation beginning in the spring of 2001 in Japan, in the summer of 2001 in Europe and with much of America following in 2002. However, a number of factors make it unlikely that IMT-2000 technologies will be deployed in rural areas of developing countries before 2005.

2. Wireless Routers

A router is a device, or in some cases, software in a computer, that determines the next network point to which a packet should be forwarded toward its destination. The router is connected to at least two networks and decides which way to send each information packet based on its current understanding of the state of the networks it is connected to. A router creates or maintains a table of the available routes and their conditions and uses this information along with distance and cost algorithms to determine the best route for a given packet.

It is technologically possible, using available products, to establish an access network in rural and remote areas using routing technology (as opposed to circuit-based technology).

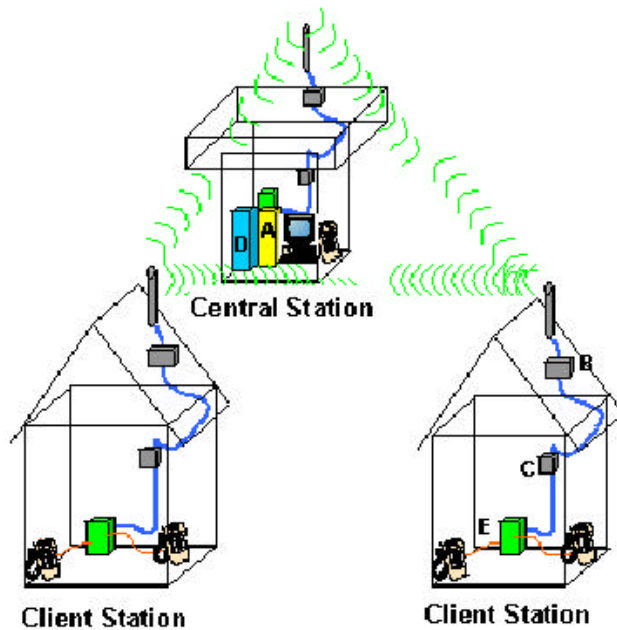
Router-based local access networks using TCP/IP in the network and transport layers (OSI layers 3 and 4) can be interconnected with the public switched telephone network using gateways that comply with ITU-T Recommendation H.323. Real-time voice calls can be transmitted at any quality over closed router networks with the use of voice over IP (VoIP) software. The quality of service can be maintained on a properly configured and managed network because traffic is controlled from the subscriber to the PSTN gateway by a single service provider. In this way, a router-based access network using IP is more analogous to a local area network (LAN) than to the global Internet. When combined with wireless technology in the local loop, such a network may provide an affordable solution for rural areas, particularly when the primary services delivered over the network will employ multimedia.

Focus Group 7 received one report describing the use of a wireless router network to create an IP-based, wireless local loop option for developing countries. Although this solution has been implemented in Japan, it has not yet been field tested in rural areas of developing countries.

Example: A Wireless IP Phone System for Rural Applications

The wireless IP phone system is based on the integration of two products: a wireless router and an IP Phone. The system consists of multiple Client Stations managed and monitored by computers located at a Centre Station as illustrated below.

Minimum configuration of a KDDI wireless IP phone system



System Components:

Wireless Router

	Symbol	Number (X)*
SNMP Server	A	1 (1)
Antenna		1 (3)
Main Unit	B	1 (3)
I/F Cable		1 (3)
Junction Unit	C	1 (3)
AC Adapter		1 (3)
10Base-T Cable		1 (3)

IP Phone

	Symbol	Number (X)*
Management Server	D	1 (1)
Gateway (2ch)	E	1 (3)
Telephone handset(200)		2 (5)

*(X) = minimum number of units required to form a network.

At the Client Station, the wireless router equipment consists of an antenna, a main unit, a junction unit, and interconnection cables. An IP phone gateway (GW) is connected to the router equipment using a 10 Base-T interface. The gateway contains two ports, each of which connects a standard telephone set.

The main Centre Station houses a management server for the IP phone network and an SNMP server to monitor the wireless router network. As with a PC-based local area network, an SNMP server is required for each unit system (comparable to a closed LAN). However, the IP phone management server has the capacity to serve a large number of unit systems and more than one is unlikely to be needed. Therefore local Centre Stations can be established at appropriate client sites, such as public office buildings, to house local SNMP servers. A client site is used in order to make the full set of wireless routers available to support customer lines.

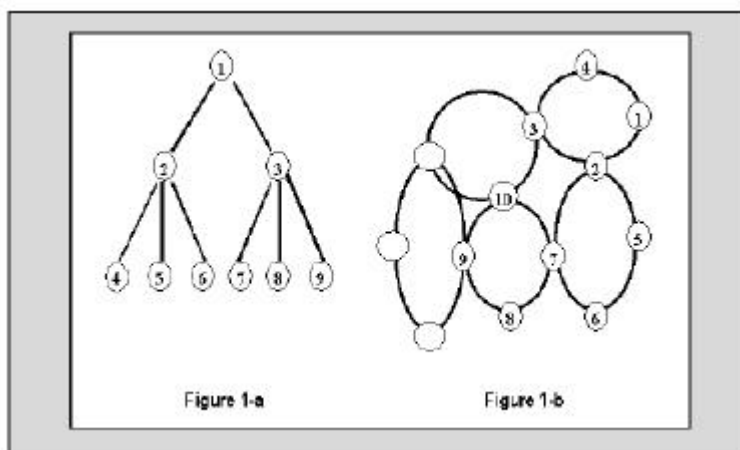
Since the network system is based on IP technology, normal PCs and other electronic devices that use TCP/IP can easily be operated on the network. With these devices, the network can provide the community with multimedia communication services including data, video, audio and image transmission as well as open or closed broadcasts. These multimedia functions may be used to enable rural access to distance education, health information services, and e-commerce, as well as telephony.

Some manufacturers have designed their wireless IP phone for usage in the 2.4 GHz band allocated to the ISM (Industrial, Science and Medical) service.

Flat Connectivity

In general, wireless LAN systems form hierarchical connectivity among nodes as shown in the figure below.

Hierarchical vs. Flat Connectivity



In contrast, the wireless router, which functions as a receive/transmit terminal as well as a repeater, creates a LAN system with flat connectivity, as in Figure 1b. In Figure 1a, for example, there is only one path between nodes 1 and 8, namely 1–3–8. In Figure 1-b, there are several paths between nodes 1 and 8, such as 1–2–7–8, 1–4–3–10–9–8, and so on. The network in Figure 1-b shows greater resiliency, more flexible node locations, and better traffic distribution than the network in Figure 1-a. This flexibility is crucial in a rural wireless system, particularly where the radio conditions are unstable.

Wireless Coverage

The wireless router provides circular coverage with a radius of up to 5 km when configured in compliance with certain regulations on frequency use and maximum transmission power (this is dependent on country regulations). In general, if higher power is allowed the wireless reach can be much longer.

Depending on the location of the client and the geographical conditions of the area, users may select the most suitable types of antennas to achieve the desired coverage.

Unit System

In this specific example, we assume that in a closed LAN, a maximum of 100 slots are available for registration of the wireless routers. In practice, however, the number of routers in a closed LAN depends on various factors including traffic volumes, traffic types, traffic profile, and the locations where routers are set. In the case of IP phone use, it is generally recommended that the number of client routers be no more than 20 in order to maintain communication quality. Thus, a system of 20 client routers (supporting up to 40 client handsets) can be regarded as a unit system for expansion of the network.

PSTN Interconnection

The wireless IP phone system can be easily interconnected with public networks through the use of a transit gateway (TGW) installed at the local exchange. All necessary signal conversions, including PSTN signaling, are performed at the TGW. The transit gateway gives rural communities the means to communicate with the outside world, in addition to its own community members, when connection to the PSTN or another network is available.

Essential Data for the Wireless Router System Described Above:

Wireless Router		
Modulation	Direct Spread Spectrum	
Frequency	2.4GHz (2.483/2.485GHz)	
Data Speed	2Mbit/s	
Base Band Modulation	DQPSK	
Transmission Power	10mW/MHz or less	
Transmission Distance	5km (depends on environmental conditions)	
Networking Protocol	TCP/IP	
Routing Protocol	RIPv2	
DHCP Server Function	Yes	
Interface	10 Base-T (RJ-45 Normal)	
Power Requirements	AC 100V/DC12V 1A	
Size & Weight	Main unit 216x145x100mm 2kg Junction unit 117x32x100mm 0.13kg	
Antenna		
Frequency	2.471GHz ~ 2.497GHz	
Input Impedance	50Ω	
Gain	6dBi (Includes cable loss)	
VSWR	Not more than 1.5 in the band	
Connector	N-P	
Antenna Type	Non-Directional	Directional
Characteristics	Horizon: non-directional Vertical: HPBW 9°	Horizon: HPBW 65° Vertical: HPBW 60°
Temperature/Humidity	-10~+50°C, 20~95°C	-30~+60°C, 20~95°C
Size	1,000mm	120mm x 120mm
Weight	1kg	0.5kg

As of February 2001, about 2000 sets of RTB-2400 are in operation in about 150 different places in Japan. Okinawa, which is famous for its strong winds, has installed a wireless router which has not reported any problems to date.

5. COST CONSIDERATIONS

The costs involved with a wireless router system will naturally vary according to location; population served, services offered, interconnection with the PSTN, and so forth. However, in order to obtain a general per-line costs for the system, the FG7 report considered a community that requires 200 telephone lines for voice communication. Five complete unit systems, each supplying up to 40 telephone lines, would be required.

In the planned pilot project, however, the concept of unit system and its expansions are not considered to give good model for evaluation. The scale of the pilot project model shall be minimized, as long as sufficient records and data are expected to be obtained. It also has functions from the beginning to serve multimedia applications and connections to PSTN. Costs shown below are estimated based on the basic model specially proposed in the pilot project and most recent equipment prices.

5.1 Basic Model (See Annex A for an example of the diagrams)

Assuming that a PSTN connection is made available at the local community (at telecentre for example).

Available Communication Tools:

(a) VoIP communication

Local community VoIP user can be connected to PSTN subscribers. The PSTN subscribers call numbers for Gateway (Transit Gateway) first and receive tone from the Gateway. They then call the extension number for the community specific VoIP user. From community network VoIP user, PSTN subscribers are directly called. Gate Keeper works for this calling number translation.

(b) Multimedia communication

Voice, picture, facsimile, video etc.(net-meeting) through local community network and Internet. Connection between local community network and Internet is done by PSTN if ISP is not available near the community. In this case Dial up router and modem may required.

(c) Internet services as electronic mail, web browsing, FTP, file downloading, telnet etc.

Configuration:

- 10 public spaces are selected from one rural community;
- on average, 3 personal computers, 2 VoIP terminal (handsets) and a set of peripheral package (printer, facsimile, scanner, digital camera (video/still), IP camera etc) will be supplied to each public space;
- community servers (mail/web/file etc) will be supplied to the community centre.

Equipment cost (FOB) plus basic installation fee:

(Based on the indicative figures provided to the Focus Group 7)

Items	Set	Cost
Wireless Routers (antenna included)	10	32,000
VoIP Facilities (10 Gateways and 1 Gate Keeper)	10	49,000
PCs	30	25,000
Peripherals	10	8,000
Community servers(mail/web/file etc.)	1	4,000
Other network components (Router/modem to PSTN)	2	2,000
Total		120,000

5.2 Installation

The time and technical skills needed for installation and commissioning, and hence the cost, varies depending on local conditions and system configuration. The table below provides a summary checklist of installation requirements for the simplest applications. In cases where the IP phone network will be connected to the PSTN or another network, the installation of the system requires additional setup work for about 5 - 10 days.

The basic features described above show that system installation is relatively simple, requiring little heavy construction work, which is generally needed to prepare towers, masts or shelters with temperature control. Since the system consists of small components, it is relatively easy to transport and install. Therefore, under ideal conditions, it takes approximately one week to be put into operation.

Summary of Installation Requirements

Station	Installation Requirements
Client Station	<ul style="list-style-type: none"> · Antenna fixing and direction adjustment · IP Address registration · Calling/Called number registration · Cable works · Test and readjustment
Centre Station	<ul style="list-style-type: none"> · Antenna fixing and direction adjustment · IP Address registration (centre and all clients) · Calling/Called number registration (centre and all clients) · Charging/Billing Data input · Cable works · Over all test and readjustment

Once the installation environment is prepared, a unit system can be installed by two experts with an appropriate complement of local staff, as described below:

• Field study, site environment check and network design	3 days
• Installation and setup of Client Station equipment	6 - 7 days
• Installation and set up of Centre Station equipment	1 day
• Network establishment and testing	1 - 2 days

Since some installation activities are conducted in parallel, generally 7- 10 days are required to put a system into operation.

5.3 Operation & Maintenance

All of the Client Stations on the network are monitored at the Centre Station. The parameters of the wireless routers can be reset from the Centre Station as well. If the TGW experiences problems, the Centre Station is signaled. As long as the network works properly, no routine maintenance work is required.

The Client Stations are identical and easy to add or remove from the network, which makes it possible to restructure networks easily and quickly.

5.4 Estimated budget costs

Equipment	\$120,000
Installation: 14 working days	\$10,000
ITU expert: 5 working days	\$3,000
Other	\$1,000
Total	\$134,000

6. PROJECT SITE SELECTION

The selection of the 5 pilot project sites will be based around the following issues:

6.1 Physical Environment

- The presence of rural or remote areas as defined by Annex B.
- The presence of telecom-related infrastructure elements (in the situation where electricity is not readily available, the wireless router is designed to work with solar-powered energy or wind energy).

6.2 General Context

- An existing or on-going ITU Multipurpose Telecentre Project. The ITU has established or in the process of establishing MCT pilot projects in several developing countries. The overall aim of the MCT pilot project programme is to provide access to telecommunication and information services to rural communities and engage them in the process of learning for development and ascertaining accessible models that can later be replicated at other sites.
- A favorable regulatory environment (for example, whether the regulatory situation allows Voice over IP)
- An identified demand (existing or potential) for telephone service, as well as multimedia applications such as long-distance education, tele-medicine, environment monitoring, and so forth.
- The socioeconomic impact of the pilot project on the rural community (the pilot projects should be developed to have the widest developmental impact, including support for education, health, small business development, governance and poverty reduction).
- The level of commitment from the government, local authorities etc.

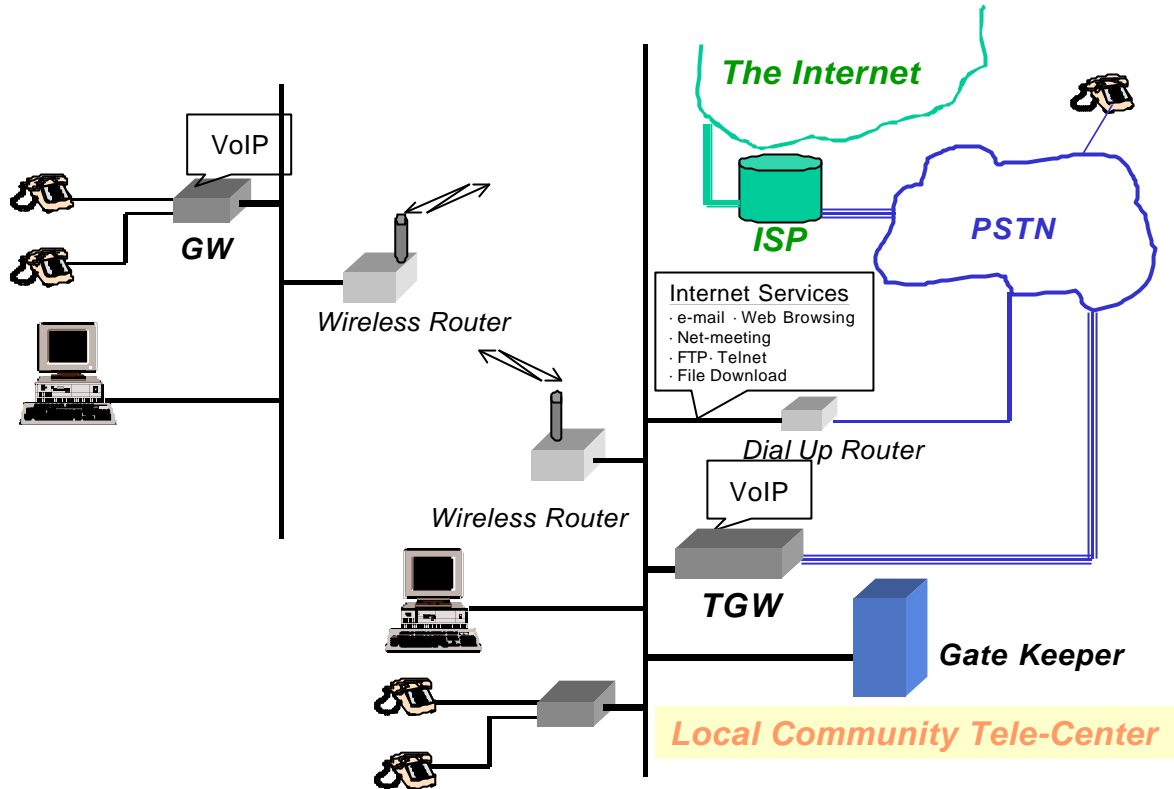
The local partners are expected to provide the following:

- counterpart task force team;
- assistance to the BDT staff in conducting field survey;
- installation support activities (necessary training will be offered by the ITU or by vendors);
- establish distance education/healthcare and e-government mechanism in the community in association with appropriate centre; and
- power supply (power consumption for wireless router: 12W (12V DC 1A), for VoIP Gateway: 10 – 20W, and for Gate Keeper: equivalent to a normal PC). It should be noted that the wireless router is designed to work with wind and/or solar energy.

7. TIMEFRAME

It is envisaged that a progress report of the pilot projects will be presented at the WTDC in March 2002. In order to prepare for this, documents should be submitted in early January 2002. By then, we would expect the pilot projects to be operational for a few months, ideally at least six months. According to this timeframe, the pilot projects should be launched around June 2001.

Network Example (1)



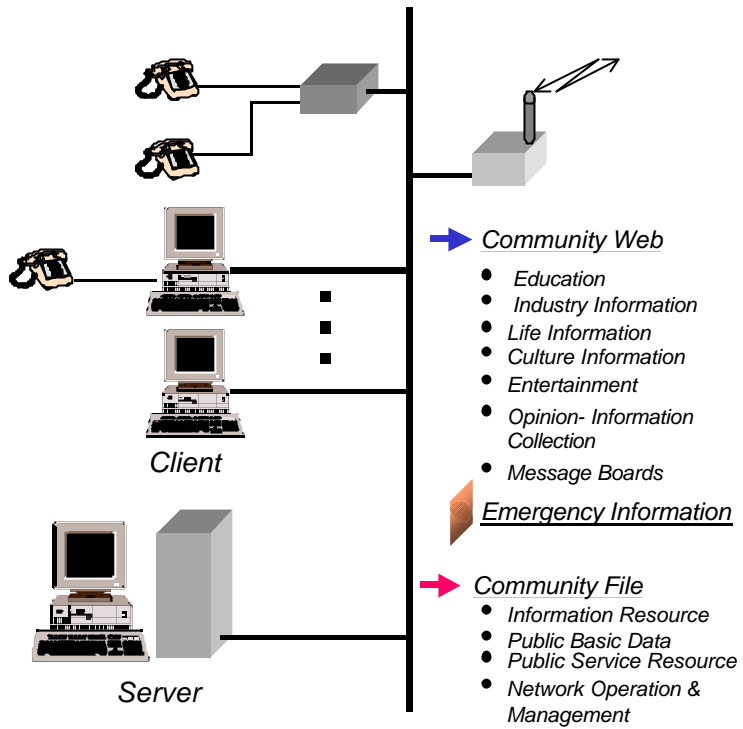
Network Example (2)

Clients PC

- Web Access
- post messages
- Real time communication
- File creation
- Data Submission

Local Community Server

- Community Web
- Community mail
- Community File



Local Community Center

Definitions of Rural or Remote Areas

Rural or remote areas exhibit more than one of the following characteristics:

- Scarcity or absence of public facilities such as reliable electric supply, water, access roads, and regular transport;
- Scarcity of technical personnel;
- Difficult topographical conditions which render the construction of wire telecommunication networks costly that make critical demands on equipment;
- Severe climatic conditions that make critical demands on the equipment;
- Low level of economic activity, based mainly on agriculture, fishing, handicrafts etc;
- Low per capita income;
- Underdeveloped social infrastructures;
- Low population density; and
- Very high calling rates per telephone line, reflecting the scarcity of telephone service and the fact that large numbers of people relay on a single telephone line.
