Communication Networks Research in Nepalese Context

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Summary
In developed countries, communication network facility is abundantly available and has become an indispensable part of people's daily life. These countries are now pursuing research projects, such as the new generation network project in Japan, to design and develop more advanced networks to serve the ubiquitous computing society of the future. However, many developing countries are still lacking communication infrastructure for fulfilling basic communication needs of their people. In this article, I outline the existing technologies, their limitations, and possible extensions for making them suitable to serve economically deprived rural regions. Experiences gained by deploying cost- and local resource-effective networks in these areas would provide more challenges and possible solutions to be addressed in the future Internet research and development.

1. Introduction

Two types of communication networks are currently serving human society: the Internet and telephone. The Internet is based on packet switching technology invented over 40 years ago. About a century before the invention of packet switching, circuit switching technology based telephone systems were invented as an improvement over telegraph and have been in use till today. Both packet switching and circuit switching have advantages and disadvantage. In packet switching networks, information is bundled into data packets, each of which begins with a header containing source and destination addresses. Here, information means voice, video, or text messages or data that people want to exchange, and a data packet can be thought of as a postal letter which includes the sender's and receiver's addresses on the envelope as the data packet does in its header. A router, a computer like device, in the communication network looks at the destination address in each packet's header and forwards the packet to the next router that is supposed to be nearer the destination. This process of address lookup and forwarding continues at all routers located in the path leading to the destination computer. The packet switching network is cheaper because it does not require reserving network resources such as frequency, bandwidth and timeslot to set-up an end-to-end communication path before the actual data transport starts. However, it cannot guarantee the availability of network resources for the timely delivery of data. In circuit switching telephone networks, on the other hand, the resources are reserved to set up an end-to-end communication channel before beginning to transport user data. In this type of network, wastage of resource is very likely when users do not send as much data as supported by the channel. That's why a circuit switching network is generally more costly for users because of the under-utilization of reserved network resources. This is one of the reasons that voice communication is more expensive over the telephone network than over the Internet.

Both the Internet and telephone networks have not yet been readily available in a developing country, like Nepal, where terrain is irregular with many hills and mountains, reliable and steady power grid is not available, and villages with a single house or few

houses are widely spread. Due to such geographical and physical constraints, current network technologies are still expensive to be fully deployed in Nepal. Laying wires or optical fibers and maintaining them to connect every village is not effective both in terms of cost and utilization.

2. Current wireless technologies and their limitations

Wireless technologies for connecting user devices (such as computers and phones) are available to avoid the cost and complexity of wire or fiber connections. However, these technologies are also not much appropriate in the Nepalese geographical context. The low speed cellular systems, which have been deployed in some urban areas in Nepal for mobile wireless telephony, require expensive infrastructure and larger user population in small areas. Although new cellular access technologies such as the 3rd Generation Partnership Project's (3GPP) Long Term Evolution (LTE) have been under development to provide higher speed data transmission to mobile users, they are not cost effective and thus unable to fulfil the communication demand of Nepal. Wireless local area networks, also known as WiFi, which are based on the IEEE 802.11 open standards, are being widely used in developed countries to support data transmission speeds up to 54 megabits per second (Mbps). This technology is cheaper than cellular systems because of two reasons: its equipment is cheap because of mass production based on open standards; and it operates in the license free frequency spectrum. However, as its coverage is very small, it is good for short distance (up to few hundred meters) communication only. Another newly developed technology is WiMAX (Worldwide Interoperability for Microwave Access), which is based on the IEEE 802.16 open standards. WiMAX supports high speed data transmission (up to tens of megabits per second) and covers distances of several kilometers. Although WiMAX has not matured yet and its equipment is still costly, it is considered to be a suitable technology for backbone networks connecting wide spread villages in the near future. In such a case, WiFi may be used to distribute data within a village. But to make the WiFi and WiMAX combination more suitable for serving rural communities, both the technologies need to include provisions for adjusting system configuration parameters, such as radio frequency and transmission speed, power, and direction. Such provisions would help make the network less vulnerable to physical adverse conditions such as low power supply and malfunctions in some communication equipment.

The currently available WiFi and WiMAX radio systems are not provisioned well to allow the users and network service providers to adjust the operating parameters because of the governmental regulations of developed countries where the systems are manufactured or supposed to be used. In those countries, radio frequencies are scarce resources as they have already been very tightly used for different purposes such as military, public telecommunication, and radio/television broadcast. In such cases, the transmission power, thus the communication range, is fixed to avoid radio interferences to adjacent frequency bands or the same frequency band used in the surrounding locations. However, the situation is different in a developing country like Nepal, where rural areas have plenty of frequency bands available for telecommunication. In such areas, the inclusion of facility for adjusting transmission power or frequency in communication equipment helps in providing wider coverage while supporting higher speed data transmission. Therefore, researches are necessary to find out the list of adjustable parameters and the range of their possible values so that recommendations can

be made to equipment manufacturers to produce network equipment suitable for developing regions.

3. End-to-end connection is expensive

Besides the wireless access technologies, the current network systems (both cellular and the Internet) and their operations are costly in Nepalese context because for the following two reasons.

(1) The network systems require maintenance of real-time end-to-end connections, which in turn stipulate that reliable and steady electric power supply be readily available and that all equipment along the end-to-end path work properly all the time.
(2) Network infrastructure is based on proprietary technologies, which limit the interoperability of components manufactured by different companies thus increase cost due to lack of choices in selecting network equipment and vendors.

Maintaining always-on, real-time end-to-end connections is demanded by only few applications like two-way voice conversation and interactive web access. Whereas, there are several other applications like email, document transfer and offline text or voice messaging that do not require real-time end-to-end connections and that would work properly even if data is delivered offline. However, as the current network systems transport data only when an end-to-end connection is available, the non-real-time applications are also forced to use the expensive, end-to-end connection oriented networks.

Research for the development of low-cost, offline data delivery networks is important for developing regions. Two approaches can be applied for the development of such delay or disruption tolerant networks (DTN):

(1) modify/adapt the operating conditions of the current Internet and wireless access technologies so that they would transport data offline without requiring end-to-end connections, or
(2) design a completely new network architecture incorporating DTN.

The former approach has some advantages that the modification may take shorter time and less effort, thus the deployment may be possible within some years. For example, DTN support can be achieved by adding mechanisms and capacities in user devices and routers to store data in memory for a longer time and transfer data to the next router when a connection between them becomes available. This modification requires user devices and routers to have many tuneable parameters to adapt the network to the local geographical and infrastructural constraints. The later approach, possibly more efficient and challenging than the former one, is being considered in the future Internet research projects of the U.S.A., Europe, Japan, and South Korea. Since the latter approach may take several years for research and development before getting truly deployed to serve the public, the deployment of the former approach as ad hoc solutions would help the latter approach by providing more insights into the challenges and possible solutions for realizing a future network system that would serve not only the affluent people of the developed countries but all the people of the world.

4. Concluding remarks

Not only the availability of network equipment, but also the government policies and public participation play vital roles in the development of cheaper, durable and dependable communication facility in rural areas. In summary, the following are the general requirements of network equipment, government policy and public participation.

1. Network equipment shall have many tuneable parameters so that network operators and users can change settings to adapt the network to the local needs and capacities. The technology shall be based on open standards and be self-configurable and remotely manageable to avoid frequent visits of experts. The equipment shall include mechanisms for self-recovery from power failures or adverse operations.
2. Government policy shall set region-based flexible limits on radio frequency spectrum usage and transmission power. It should create conducive environments for fair competition among network service providers, and help private organizations to deploy physical infrastructures (such as transmission towers, fibers or wires) and guarantee their safe-guarding. It should also encourage public to deploy their own local networks in license-free frequency bands.
3. Public shall be aware of the value of exchanging local information and use networks not only for voice communication but also for other useful services such as collecting/distributing information about agriculture products, education material, health awareness and medical support, social functions, environment and wildlife conservation, and local tourism promotion. They should involve in network ownership and gradually develop local manpower to operate and maintain networks.