A Comparison of Wireless Local Loop Technologies with Reference to their Application in Rural Areas of Pakistan

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Abstract: In this paper LMDS, satellite systems, stratospheric platforms, DECT, PACS and PHS have been chosen as possible WLL technologies in rural areas of Pakistan. The low population density and great distances in Pakistan's rural areas make the installation of a fixed line telephone network prohibitively expensive. The result is that after 55 years there are still a large number of under-provisioned rural areas in Pakistan where telephone service still is not widely available. WLL technologies provide service providers with a rapidly deployable and comparatively cheaper alternative to fixed line local loops.

1. Introduction

The benefits of Wireless Local Loop (WLL) technologies are manifold. Most obviously, WLL does not require laying of a fixed line network which reduces cost. This reduces it's the time required to deploy the network. This means that the service provider is able to start offering service sooner and leads to a shorter time period to recover the initial investment. The service provider is also able to cut down on network support staff for that area because of reduced network maintenance overhead.

This paper focuses on the suitability of these technologies for provision of wireless access to the rural areas of Pakistan. Rural areas refer to areas with low population densities, which include small towns and villages. Two assumptions have been made,

1. The population growth rates of these areas are considerable and have to be taken into account when deploying a WLL technology.
2. The WLL technology should not restrict service support to telephone service only, but must enable broadband multimedia services, such as high speed internet, iTV, telelearning, telemedicine etc.

For the purpose of this paper, Local Multipoint Distribution System (LMDS), Satellite systems, stratospheric platforms, Digital Enhanced Cordless Telecommunications (DECT), Personal Access Communications System (PACS) and Personal Handyphone System (PHS) have been selected.

Section 2 of this paper outlines the key features of the six WLL technologies being compared. It provides brief information on each technologies channel capacity, bandwidth, cell size, coverage area, equipment cost, ease of integration in the existing telephony network and quality of service. In section 3 the comparison is done on the basis of each technology's profile. Section 4 states the conclusions.

2. Technology Overview

2.1 LMDS

LMDS has the highest bandwidth among the competing technologies, 34-38Mbps per cell. The cell size of LMDS may vary between 2-20km^2 depending upon the population density of the area, but typically lies in the range of 3-5km^2. Since only rural areas are considered in this paper, the higher value of 20km^2 is considered. The end-user equipment cost for LMDS WLL systems is very high compared to that of DECT, PACS and PHS. However, if the end-user equipment can combine IP over LMDS, video over LMDS, a home network access point and a satellite receiver in a single piece of equipment this can justify a higher equipment price [2]. The relatively high bandwidth available to individual users in LMDS networks allows for high quality speech transmission.

2.2 Satellite Systems

Channel capacity is very high. Individual bandwidth is very small, in the 16-100kbps/km^2. However, satellites are broadcast systems with a very large footprint, in the range of 3000km^2 – semi-global. End-user equipment cost is prohibitively high for mass deployment. Connection to the telephone network requires a gateway at the CO interfacing the Satellite Earth Station with the telephone network. Speech quality depends on the individual user's channel bandwidth. Overall, the exorbitant cost of providing cheap residential broadband services, other than broadcast services such as television, via satellite systems is makes this technology the least favorable for providing broadband services to homes. However, Satellite systems can play a role in connecting remote LMDS cells to a main cell. The only advantage of satellite systems is that their operational cost is insensitive to distance.

2.3 Stratospheric Platforms

Bandwidth available through stratospheric platforms is approximately 1Mbps/ km^2. The coverage area of one such beacon is approximately 5-10 km^2, which makes it slightly smaller than that of LMDS. Details about end-user equipment costs for this technology is not available yet because the technology is relatively new and there has not been any significant wide scale deployment which could bring down manufacturing cost due to economy of scales. Speech quality on a stratospheric network is expected to be reasonable. One major disadvantage of this technology is its strong dependence on weather. Extreme weather conditions can force service providers to temporarily take down the platform. This will requires a backup network to be available at all times.

2.4 DECT

In a coverage area, DECT supports 10 carriers of 11 data/ voice channels each. The minimum and maximum individual bit rates are 32kbps and 11x32kbps respectively. Cell Size for DECT is around 3km. Exact details about end-user equipment cost for DECT are not available, other than it is cheap. According to [3], connectivity of DECT WLL networks to the existing telephone network via CO or PBX is good. Speech quality of DECT WLL networks is comparable to FWL PCM [3].

2.5 PACS

In a coverage area, DECT supports 200 carriers of 7 data/ voice channels each. The minimum and maximum individual bit rates are 32kbps and 7x32kbps respectively. Cell Size for PACS is greater than DECT. Its larger cell size makes it more suitable for deployment in low-density population areas. Just like for DECT, PACS end-user equipment cost is low. Connectivity of PACS WLL networks to the existing telephone network via CO or PBX is good. Speech quality of PACS WLL networks is also good

2.6 PHS

In a coverage area, DECT supports 77 carriers of 4 data/ voice channels each. The minimum and maximum individual bit rates are 32kbps and 2x32kbps respectively. PHS cell size, equipment cost and speech quality is similar to PACS. However, connectivity of PHS to other networks is rated "average" in [3].

3. Comparison

As mentioned in section 2.1, satellite systems do not provide a viable delivery vehicle for residential broadband services to the homes in rural areas of Pakistan. The primary reason for that is high end-user equipment and bandwidth costs. Stratospheric platform solutions are still in their infancy and are neither scalable (population growth) nor mature enough for widescale deployment.

3.1 Scalability

Scalability of satellite systems is adequate for rural areas, but inadequate for thickly populated urban environments. The same holds true for Stratospheric platforms, PACS and DECT. PHS' small cell size makes it unsuitable for use in rural areas. Only LMDS is scalable enough for deployment in rural, suburban and urban areas.

3.2 Bandwidth

Satellite systems provide the least bandwidth. Stratospheric platforms, DECT, PACS and PHS provide bandwidth in the intermediate range to users, enough for high speed internet but inadequate for delivery of iTV services and other broadband multimedia services. LMDS is able to fill the gap here since it was designed for precisely this purpose.

3.3 Cell Size

Considering our requirements for Pakistan's rural areas, all technologies provide adequate coverage areas.

3.4 Equipment Cost

Equipment costs of satellite and stratospheric systems are the highest, and are the lowest for DECT, PACS and PHS. The cost of LMDS equipment lies between the two but is on the higher end. However, as mentioned earlier, the coast can be justified by integrating functionalities of other equipment in the end-user terminal.

3.5 Connectivity to Telephone Network

Connectivity to the existing telecom network does not seem to be an issue [4] with any of the technologies except PHS [3].

3.6 Speech Quality

Speech quality is not a problem on any WLL technology except satellite systems due to small individual bandwidth.

3.7 Availability

Availability is a problem with all WLL technologies since they are all sensitive to extreme weather conditions. However, LMDS, DECT, PACS and PHS perform comparatively better than Satellite and stratospheric systems.

4. Conclusions

After comparing the six WLL technologies under consideration, I have come to the conclusion that LMDS is the most suitable technology. DECT, PACS and PHS were not designed for WLL application, however, according to [3], they do provide satisfactory performance. The authors conclude that PACS is more suitable for low traffic, low population density rural areas, due to its large cell size, while DECT is the technology of choice in suburban areas with an intermediate population density. PHS is identified as the best WLL technology for urban, high-density population areas. Their conclusions show that there is not a single technology that is suitable to serve in all kinds of environments. It is quite possible that the WLL technology for a low population density area, currently served by PACS, may have been rendered useless due to the areas high population growth rate. In such a scenario switching from one WLL technology to another is a major undertaking, involving change of end-user equipment throughout the area as well as base station equipment.

Another advantage of LMDS' scalability for different population density areas is that service providers will not have to struggle with multiple access technologies in different areas. This brings down training costs of network support staff.

5. References

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