INTRODUCTION

Wireless local loop (WLL) is a system that connects subscriber to a public switched telephone network (PSTN) using radio signal as a substitute for copper for all or part of the connection between the subscriber and the switch Using a wireless link to provide last mile connectivity not only reduces the construction period but also reduces installation and operating costs. Wireless loops are expected to radically alter the traditional fixed telephone network, and make cost effective implementation of rural telephony. In developing economies, WLL is expected to help unlock competition in the local loop, enabling new operators to bypass existing wire line networks to deliver POTS and data access.

FUNDAMENTALS OF CELLULAR TECHNOLOGY

Spectrum has become very scarce and costly resource in the present scenario. Its efficient use is utmost essential to provide telecom services at reasonable price especially in the rural areas. As the available frequency spectrum is limited, we have to divide the geographical area into small cells so that we can re-use the available frequency band after certain distance, this is known as reuse of frequencies and the distance is known as the re-use distance. The systems using such technology are known as cellular systems.

WLL technology is basically cellular technology. Cellular technologies can be divided into two broad categories 'Macro-Cellular' and 'Micro-Cellular' based on coverage or the cell area. System based on Macro Cellular technology such as GSM /CDMA /DAMPS were adapted from cellular mobile system and have cell radii in few kilometers in urban environment, whereas system based on Micro Cellular architecture such as DECT (Digital Enhanced Cordless Communication) is an extension of Cordless Telephone System and have cell radii of few hundred meters in typical urban environments.

MULTIPLE ACCESS TECHNIQUES

The RF spectrum is a finite resource and is shared between users using multiple access (sometimes called channelization). Multiple access is used to separate different users of the spectrum. Different multiple access techniques are frequency division, time division, and code division multiplexing. Most communications systems use a combination of these multi-access methods.

Frequency Division Multiple Access

Frequency Division Multiple Access (FDMA) splits the available frequency band into smaller fixed frequency channels. Each transmitter or receiver uses a separate frequency. Transmitters are narrowband or frequency-limited. A narrowband transmitter is used along with a receiver that has a narrowband filter so that it can

demodulate the desired signal and reject unwanted signals, such as interfering signals from adjacent radios.

TIME Division Multiple Access

Time-division multiplexing involves separating the transmitters in time so that they can share the same frequency. The simplest type is Time Division Duplex (TDD). This multiplexes the transmitter and receiver on the same frequency. TDD is used, for example, in a simple two-way radio where a button is pressed to talk and released to listen. This kind of time division duplex, however, is very slow. Modern digital radios like CT2 and DECT use Time Division Duplex but they multiplex hundreds of times per second. TDMA (Time Division Multiple Access) multiplexes several transmitters or receivers on the same frequency. TDMA is used in the GSM digital cellular system and also in the US NADC-TDMA system.

CODE Division Multiple Access

Code Division Multiple Access **(**CDMA) is an access method where multiple users are permitted to transmit simultaneously on the same frequency. Frequency division multiplexing is still performed but the channel is 1.23 MHz wide. In the case of US CDMA telephones, an additional type of channelization is added, in the form of coding. In CDMA systems, users timeshare a higher-rate digital channel by overlaying a higher-rate digital sequence on their transmission. A different sequence is assigned to each terminal so that the signals can be discerned from one another by correlating them with the overlaid sequence. This is based on codes that are shared between the base and mobile stations. Because of the choice of coding used, there is a limit of 64 code channels on the forward link. The reverse link has no practical limit to the number of codes available.

ESSENTIAL REQUIREMENTS OF WLL

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The following are essential requirements of WLL systems which are to be deployed for providing last mile connectivity:

1) Quality

Since a WLL system serves as the access line for fixed telephone sets, it must provide the same level of quality as conventional telephone systems with respect to such aspects as speech quality, grade of service (GOS), connection delay and speech delay. In addition, since radio waves are used, careful consideration must be given to protection of confidentiality and terminal authentication.

2) Short construction period

3) Cost

The overall cost must be low, including equipment, construction and maintenance costs.

4) Interference with other wireless systems

A WLL system must not cause any interference with the operation of existing systems, such as microwave communications and broadcasting systems.

5) Traffic volume
One characteristic of a WLL system is that it supports a larger traffic volume per channel or circuit than mobile communications systems.

6) **Terrain and Obstructions**
Terrain is a key factor to consider when planning the deployment of a WLL System. Placement of towers must be chosen so that the appropriate number of subscribers will be able to receive the signal . the use of existing structures , such as tall buildings may also be taken into consideration to save costs . Future obstructions must also be taken into consideration.

CATEGORIES OF WIRELESS TECHNOLOGY

WLL technology can be implemented across 4 categories of wireless technology. They are:

1. Analog cellular
2. Digital cellular (CDMA)
3. Personal Communication Services (PCS)/ Personal Communication network (PCN) of Japan.
4. Cordless Telephones 2nd generation(CT-2)/ Digital European Cordless Telecommunication (DECT)
5. **Analog Cellular**

Given its wide availability resulting from serving high-mobility markets, there is significant momentum to use analog cellular for WLL. There are currently three main analog cellular system types operating in the world: advanced mobile phone system (AMPS), Nordic mobile telephone (NMT), and total access communications systems (TACS). AMPS and its cousin narrowband advanced mobile phone system (NAMPS) dominate the analog cellular market with 69 percent of subscriber s, while TACS has 23 percent and NMT has only 8 percent.

As a WLL platform, analog cellular has some limitations in regards to capacity and functionality. Due to widespread deployment, analog cellular systems are expected to be a major wireless platform for WLL, at least in the short term. Given its characteristics, analog cellular is best suited to serve low-density to medium-density markets that don't require landline-type features. Analog cellular is forecasted to account for 19 percent of the WLL subscribers in the year 2000.

Digital Cellular

These systems have seen rapid growth and are expected to outpace analog cellular over the next few years. Major worldwide digital cellular standards include global system for mobile communications (GSM), time-division multiple access (TDMA), Hughes enhanced TDMA (E–TDMA), and code-division multiple access (CDMA).

GSM dominates the digital cellular market with 71 percent of subscribers. Digital cellular is expected to play an important role in providing WLL. Like analog cellular, digital cellular has the benefit of wide availability. Digital cellular can support higher capacity subscribers than analog cellular, and it offers functionality that is better suited to emulate capabilities of advanced wireline networks. Its disadvantage is that it is not as scalable as analog cellular. It is forecasted that approximately one-third of the installed WLLs will use digital cellular technology in the year 2000.

Although GSM currently dominates mobile digital cellular, there has been little activity in using GSM as a WLL platform. Since GSM's architecture was designed to handle international roaming, it carries a large amount of overhead that makes it unwieldy and costly for WLL applications. In spite of these limitations, it is likely that GSM WLL products will be developed over the next few years. CDMA appears to be the standard best suited for WLL applications. CDMA employs a spread-spectrum modulation technique in which a wide range of frequency is used for transmission and the system's low-power signal is spread across wide-frequency bands. It offers higher capacity than the other digital standards (10 to 15 times greater than analog cellular), relatively high-quality voice, and a high level of privacy. The main disadvantage of CDMA is that it is only now beginning to be deployed on a wide scale.

PCS/PCN

PCS/PCN incorporates elements of digital cellular and cordless standards as well as newly developed radio-frequency (RF) protocols. Its purpose is to offer low-mobility wireless service using low-power antennas and lightweight, inexpensive handsets. PCN is primarily seen as a city communications system with far less range than cellular. PCS is a broad range of individualized telecommunications services that let people or devices communicate regardless of where they are. Some of the services include personal numbers assigned to individuals rather than telephones, call completion regardless of locations (find me), calls to the PCS customer that can be paid by either the caller or the receiver, and call-management services that give the called party greater control over incoming calls.

It is not clear which standards, if any, will dominate the WLL portion of PCS/PCN. The candidate standards are CMDA, TDMA, GSM, personal access communication systems (PACS), omnipoint CDMA, TDMA, upbanded CDMA, personal handyphone system (PHS), and digital cordless telephone United States (DCT–U). These standards will probably be used in combination to provide both WLL and high-mobility wireless services.

PCS/PCN has the advantage of being designed specifically to provide WLL by public wireless operators. The main weakness of PCS/PCN is that it is not yet commercially available.

CT–2/DECT

Cordless telephony was originally developed to provide wireless access within a residence or business between a base station and a handset. Since the base station is still hard-wired to the PSTN, this is not considered WLL. For the purposes of this

study, DECT is considered WLL when a public network operator provides wireless service directly to the user via this technology.

Although DECT does not appear to be ideally suited for rural or low-density applications, it has some significant advantages in medium-density to high-density areas. Cordless telephony has advantages in terms of scalability and functionality. As compared to cellular technology, DECT is capable of carrying higher levels of traffic, provides better voice quality, and can transmit data at higher rates. The microcell architecture of DECT allows it to be deployed in smaller increments that more closely match the subscriber demand, with reduced initial capital requirements.

In India WLL services are implemented through CDMA and CorDECT. The brief description of these technologies is given below:

CorDECT Wireless Access System
1. Introduction

corDECT is an advanced, wireless access system developed by Midas communication technologies and Indian Institute of Technology, Madras, in association with Analog Devices Inc., USA.

corDECT provides a complete wireless access solution for a new and expanding telecommunication network with seamless integration of both voice and internet services. It is the only cost-effective Wireless Local Loop (WLL) system in the world that provides simultaneously toll-quality voice and 35 kbps or 70 kbps Internet access to wireless subscribers.

corDECT is based on DECT standard specification from the European Telecommunication Standards Institute (ETSI).

2. Frequency of operation

The RF band originally allotted to DECT is 1880 – 1900 MHz. This band is to be shared with other similar systems. The extended band allocation in 1900- 1935 MHz is also provided.

There are 10 frequencies of operation in 20 MHz band, with channel spacing of 1.728 MHz. The data burst rate is 1.152 Mbps accommodating 24 TDMA time slots. The communication takes place in Time Division Duplex (TDD). The 24 time slots are divided in two groups of 12 each, a group for each direction of transmission . The frame duration is 10ms and a TDD slot is separated by 5ms.

The one of important feature of cor DECT systems is that all the slots in TDMA frame are not transmitted at the same frequency. Each of the 12 slots could be on a different frequency, though the pair of slots used for each TDD link must be on the same frequency. This feature is termed as multi carrier TDMA (MC-TDMA). The 12

slot grouping and 10 frequencies provides 120 independent channels. The user can operate on any of the 120 channels.

DECT Vs GSM

Lets begin with comparison of the factor *M,* the modulation and multi-access efficiency factor defined in section 4.7. Note that this also takes account the signaling overhead and determines the number of bps of payload per Hz of spectrum delivered by each technique.

GSM: Enables 8 channels each with 13 kbps payload using 200 kHz of spectrum. Obviously,

$$M \text{ (GSM)} = \frac{8 \times 13 \text{ kbps}}{200\text{kHz}} = 0.52\text{bps/Hz}$$

DECT: 120 channels of 32 kbps full duplex in 20 MHz band.

$$M \text{ (DECT)} = \frac{120 \times (32 \times 2) \text{ kbps}}{20{,}000 \text{ kHz}} = 0.384\text{bps/Hz}$$

It is obvious that modulation and multi-access efficiency is higher for GSM than for DECT. But DECT perform better as compared to GSM when it comes to reuse efficiency. DECT uses less efficient modulation (GMSK with $B_T = 0.5$) which can be implemented at a very low cost. It also uses a large signaling overhead. However, the dynamic channel selection in DECT, more than compensates for these deficiencies.

Main features of CorDECT WLL systems are given below:

i) CorDECT system is Micro Cellular Wireless Access system. It provides wireless access to subscriber between the Base Station (BS) Remote Station (RS), thus replaces drop wire and save copper pair from exchange to the distribution point.

ii) The transmit power of BS is +24dBm and sensitivity of fixed terminal is -88dBm. Therefore it can cover upto 200-300 meters inside building with an outside patch panel antenna at fixed subscriber terminal. In clear line of sight conditions, if available, it can cover up to 5Km from base station. As these systems operate in 1800 MHz band, the propagation losses are more as compared to other systems which operate in 900 MHz band.

iii) Hand held terminal is not available for corDECT system. If hand held terminals are made available in future, it is expected that coverage will be 50-100 meters from base station. Also due to non-availability of hand held terminal, limited mobility cannot be provided.

iv) The maximum capacity of BSC of corDECT is 1000 subscribers and that of Base Station is 50 subscribers.

CODE Division Multiple Access

CDMA is an access method where multiple users are permitted to transmit simultaneously on the same frequency. Frequency division multiplexing is still performed but the channel is 1.23 MHz wide. In the case of CDMA, an additional type of channelization is added, in the form of coding. In CDMA systems, users timeshare a higher-rate digital channel by overlaying a higher-rate digital sequence on their transmission. A different sequence is assigned to each terminal so that the signals can be discerned from one another by correlating them with the overlaid sequence. This is based on codes that are shared between the base and mobile stations. Because of the choice of coding used, there is a limit of 64 code channels on the forward link. The reverse link has no practical limit to the number of codes available.

The frequency band of operation for WLL systems using CDMA 824 MHz – 845 MHz paired with 869 MHz – 890 MHz. The mobile stations transmit their CDMA signal on a common frequency , but spaced 45 MHz from that used for base station transmission. The speech signal is conveyed on up to 62 channels. Each signal is digitally encoded at different rates from 1.2 kbps to 9.6 kbps depending on talker activity which allows reduction in interference level.

It can provide connectivity to the subscribers located at around 25 kms from the base station in LOS conditions without using repeaters. It is capable of supporting standard interfaces to provide services like telephone, Grp.3 FAX, Voice band data signals upto 14.4 Kbps and subscriber call charge meter.

Code division multiple access is a radio access that offers significantly increased capacity and improved quality over other technologies. The CDMA network utilizes single cell clusters, where each base station transmits its CDMA signal on same radio carrier frequency. The use of all frequencies in all cells improves trunking efficiency to a high capacity. Coding used in CDMA is binary phase shift keying (BPSK). The BPSK signal has constant amplitude during a bit period and when data bit hangs its value the phase of BPSK signal changes by 180˚. CDMA can use time division multiplexing (TDM) or frequency division multiplexing (FDM) for transmitting the signal after coding.

Main features of CDMA WLL systems are given below:

i) CDMA systems are based on Macro Cellular technology. It can provide wireless access to subscriber up to 10 Kms from Base Station, in non line of sight conditions, in typical urban environment. In clear line of sight condition it can cover up to 25 Kms from base station.

ii) The transmit power of Base Station is +43dBm and sensitivity of terminal is -104dBm. Therefore, it can cover upto 10 Kms inside building with outdoor patch panel antenna. CDMA can use sectored antenna at base station. As these systems operate in 900 MHz band, the propagation losses are less as compared to other systems which operate in 1800 MHz band.

iii) Hand held terminal is available in CDMA systems. With hand held terminal, coverage is up to 5 Kms on street level and 2-3 Kms inside building. Fixed as well as limited mobility can be provided.

iv) The capacity of BSC of CDMA is 20,000 subscribers and capacity of Base Station is 1,000.

CONCLUSION

Deployment of Wireless Local Loop Technologies

WLL systems may prove to be useful in areas where an increase in demand for telecommunication services cannot be fulfilled in a timely fashion due to the time required to lay cable, or in instances where the laying of new cable is impractical. In a developed nation that has existing wired infrastructure WLL systems may allow new providers to enter the market and offer solutions to subscribers at a cheaper rate. In a developing nation, WLL may allow the deployment of an entirely new telecommunications infrastructure quickly with a minimum cost.
Even though broadband technologies exist, narrowband technologies still play an important role as they are often cheaper and suit applications where only a voice service is required.
Because of the large variety of circumstances that exist throughout the world, many different WLL systems have been deployed to varying extents.

The Future of Wireless Local Loop

As technology improves, prices for WLL equipment will fall, while speeds will continue to increase, meeting demands of next generation applications. The basic consensus is that the individual voice, television and data networks will all converge into a single packet switched network where each subscriber is connected via a broadband link. In many circumstances it likely that this like would be most suitably provided by the Wireless Local Loop.

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