Wireless local loop

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Abstract-A local loop connects a subscriber to the service provider’s switch, this connection is usually a wire; typically copper wire. Advanced studies on the capabilities of copper wire as a transmission medium has made it possible to use the local loop to offer services other than the basic voice service. This technology known as digital subscriber line technology (DSL) utilizes the existing copper wires to provide high speed data services. Optical fibre is a better option particularly for its large bandwidth but cost restricts its use as a local loop.

Wireless local loop eliminates the need for wires as the subscriber’s equipment is wirelessly connected to the provider’s network. Wireless local loop (WLL) is a popular alternative as it has been deployed in both developed and developing nations because of its advantages. With an ever increasing demand to access the internet, the wireless local loop has evolved seeking to meet such demand.

This paper looks at the several wireless local loop technologies as well as its prospects and future as a medium for broadband wireless services.

Keywords:
Wireless Local Loop, Internet, Broadband

INTRODUCTION

The local loop refers to the circuit terminating at the subscriber’s premises connecting the subscriber equipment to the switch of the telecommunications provider. It is the last lap of the provider’s infrastructure over which services are delivered to the user, hence, the term “ last mile” is

also used to refer to the local loop. Copper wires have been the principal candidate for the local loop providing voice service for telephony. However, digital subscriber line technology (DSL) makes it possible to use existing copper wires to offer services other than voice such as data, video, and multimedia services. One form of digital subscriber line technology (DSL), asymmetric digital subscriber line (ADSL) is the most commonly used today. Optical fibre has a lot of advantages over copper wire and that makes it an excellent choice for local loop but its cost is prohibitive.

Wireless local loop also known as radio local loop uses radio signals to complete the last lap to the user’s premises. Wireless local loop is particularly suited to remote locations providing access to provider’s infrastructure and in areas where the terrain makes it impossible to lay cables. Wireless local loop offers a number of advantages over its wireline counterpart.

1) Fast deployment

2) Low installation cost

3) Low maintenance cost

4) High system capacity

There are several wireless local loop (WLL) technologies available, hence, the technology deployed for a particular area will depend on the population density and service needs of the users.

The rest of the paper is organized as follows, in section II, the wireless local loop architecture is considered. Section III presents the wireless local loop technologies followed by the wireless local loop for broadband services in section IV. Section V concludes the paper.

WIRELESS LOCAL LOOP SYSTEM ARCHITECTURE

The wireless local loop architecture is shown in figure 1. The fixed subscriber unit (FSU) is an interface between subscriber’s wired devices and wireless local loop network. The wired devices can be computers as well as telephones. The fixed subscriber performs channel coding and decoding, modulation and demodulation, and transmission/reception of signal via radio.

The base transceiver system (BTS) performs channel coding/decoding, modulation and demodulation as well as transmission and reception of signal via radio. The base transceiver system is also referred to as the radio port (RP). A base station controller (BSC) controls one or more base transceiver systems (BTSs) and provides an interface to the local exchange (switch) in the central office [22].

WIRELESS LOCAL LOOP TECHNOLOGIES

A. Microcellular based systems

These systems provide low delay, low power and high quality services in a small coverage area. Compared with the cellular based wireless local loop, more base stations are required to cover the same service area. They are typically operated at 800MHz, 1. 5GHz, 1. 8GHz, and 1. 9GHz frequency bands [77].

1) Personal access communication system (PACS)

Personal access communication system (PACS) is a low power radio system for both personal communication system applications and for fixed wireless loop applications. Personal access communication system is optimized to provide basic capabilities to support wireless local loop and additional capabilities to support mobility. The service capabilities of personal access communication system include voice, fax, voiceband data, and wireless digital data. The basic personal access communication handset can handle user with vehicle speeds up to about 50km/hr []. The personal access communication system architecture is shown in figure 2.

The radio port (RP) function as radio frequency (RF) modems. Personal access communication system (PACS) uses time division multiple access (TDMA) on the uplink and time division multiplexing (TDM) on the downlink. The personal access communication system protocol supports switching to alternate channels when one radio port (RP) is busy [36].

2) Personal handyphone system (PHS)

Personal handyphone system is a low range personal communications services (PCS) technology that was developed in Japan to support very high density pedestrian traffic and wireless local loop. It is built on a foundation of digital cordless technology and microcell architecture [26]. Personal handyphone system (PHS) personal stations consist of handheld units that can operate as simple cordless phones, as transceivers for communications with other personal stations, or as mobile terminals to access the public switched telephone network (PSTN). The mode of operation must be selected by the user [26].

3) Digital enhanced cordless telecommunications (DECT)

Digital enhanced cordless telecommunications (DECT) is a radio interface standard developed in Europe mainly for indoor

wireless applications [26]. Digital enhanced cordless telecommunications is a flexible digital radio access standard for cordless communications in residential, corporate, and public environment. In Europe, digital enhanced cordless telecommunications utilizes the 1880-1900 MHz frequency range. The DECT radio interface is based on the Multicarrier/Time division multiple access/Time division duplex (MC/TDMA/TDD) radio access methodology. Basic DECT frequency (1800-1900 MHz) is allocated to 10carrier frequencies, and the time is organized in frames. Each frame lasts for 10ms and consists of 24 timeslots separated into two fixed parts [37].

The fixed part (FP) consists of three entities; radio fixed port, central system, interworking unit. The radio fixed port terminates the air interface protocol. The central system provides a cluster controller functionality managing a number of radio fixed ports. The interworking unit provides all the necessary function for the DECT radio system to interwork with the attached wireline network; which can be: the public switched telephone network (PSTN), and the packet switched public data network [36].

B. Cellular based systems

These systems are characterised by large power, high mobility and relatively low data rate over a large area.

Cellular wireless local loop technologies are primarily used to expand the basic telephony services. Typically, they operate in the mobile frequency

bands at 800-900 MHz, 1. 8-1. 9 GHz, and sometimes at 450 MHz or 1. 5 GHz. For relatively sparsely populated rural and even urban settings, wireless local loop technologies based on existing cellular systems can be economical and rapidly deployed [77].

1) Time division multiple access (IS-136/GSM)

Time division multiple access (TDMA) is a multiple access technique which divides a channel into a number of timeslots. For TDMA system, there are two prevalent standards: North American telecommunications/electronics industry association (TIA/EIA) IS-136 and European telecommunications standards institute (ETSI) global system for mobile telecommunications (GSM). The IS-136 standard uses π/4-Quadrature phase shift keying (π/4-QPSK) modulation scheme while the GSM standard uses Gaussian minimum shift keying (GMSK) modulation. Also the channel bandwidth of the two systems is different (30 kHz for IS-136 and 200 KHz for GSM). GSM has a frame length of 4. 615 ms instead of 40 ms for IS-136 [26].

Although GSM currently dominates mobile digital cellular and provides high quality voice, there has been little activity in using GSM as a wireless local loop platform. Being designed to handle international roaming, it carries a large amount of overhead that makes it unwieldly and costly for wireless local loop applications [36].

2) Code division multiple access (IS-95/W-CDMA)

Code division multiple access (CDMA) is a multiple access technique that employs spread spectrum technique. CDMA (IS-95) is a direct sequence spread spectrum (DSSS) system where the entire bandwidth of the system 1. 25 MHz is made available to the user. The bandwidth is many times larger

than the bandwidth required for transmitting information [26]. IS-95A standard has been

TABLE 1

SUMMARY OF WIRELESS LOCAL LOOP SERVICES

developed for a digital cellular system with direct sequence (DS) CDMA technology, operating at 800MHz band. IS-95 based CDMA wireless local loop can support two rate sets. A code channel (traffic channel) operates at a maximum of 9. 6 kbps with the rate set 1 or 14. 4 kbps with rate set 2. IS-95B offers high speed data services through code aggregation. In IS-95B systems, multiple codes (up to eight codes) may be assigned to a connection [22]. In CDMA systems pseudo-noise (PN) sequences are used for the different user signals with the same transmission bandwidth [26].

Wideband code division multiple access (W-CDMA) in comparison with narrowband CDMA systems (IS-95) use higher chip rate for direct sequence spread spectrum and, thus, spread its information into wider spectrum bandwidth (typically, equal to or over 5 MHz). Thus, data rate per code channel in W-CDMA can be higher than that in narrowband system. The wireless local loop standard defines several options for voice codecs: 64 kbps PCM, 32 kbps ADPCM, 16 kbps LD-CELP, and 8 kbps conjugate structure algebraic-code-excited linear prediction (CS-ACELP) [22]. CDMA based systems offer higher capacity and flexibility compared to other digital standards [36].

C. Satellite based systems

These systems provide telephony services for rural communities and isolated areas such as islands [26]. These systems can be either of technology

designed specifically for wireless local loop applications or of technology piggybacked onto mobile satellite systems as an adjunct service. Satellite technology has been used to provide telephony to remote areas of the world for many years. Such systems provide an alternative to terrestrial telephony systems where landlines are not cost effective or where an emergency backup is required [77]. A user can access the public switched telephone network (PSTN) via satellite indirectly from a wireless local loop facility through a small satellite terminal and a geostationary earth orbit (GEO) satellite. A very small aperture terminal (VSAT) terminal usually includes a 0. 6-2. 4 m dish antenna and a transceiver radio (outdoor unit) as well as a set of baseband and intermediate frequency (IF) subsystems (indoor units). In hybrid architectures, the VSAT is connected to a wireless local loop base station through the local switching exchange [24].

D. Proprietary systems

These systems are considered proprietary because they are not available on the public wireless networks and are typically

customized for a specific application. They generally do not provide mobility. Proprietary systems are, therefore, positioned to provide basic fixed wireless telephony.

WIRELESS LOCAL LOOP FOR BROADBAND SERVICES

For services requiring large bandwidths, such as video on demand, broadband wireless systems are suitable because of their higher frequency ranges.

A. Local multipoint distribution systems (LMDS)

Local multipoint distribution systems (LMDS) is a radio based access technology with cellular architecture offering flexible

high capacity connections to private users and organizations [8]. Depending on the particular spectrum allocation policy, operation of LMDS systems take place at millimetre waves (typically 28 GHz in the United States and 40 GHz in Europe), enabling the exploitation of more than 1GHz operational bandwidth. This allows a plethora of multimedia services at data rates of hundreds of megabits per second [2]. Interactive LMDS has a point to multipoint downlink and a point to point uplink. The capacity of the return channel is determined by the needs of the individual user [8].

B. Worldwide interoperability for microwave access (WiMAX)

Worldwide interoperability for microwave access (WiMAX) is a wireless communication technology capable of providing very high data rates over a large area. According to standards, WiMAX can support up to a 75 Mb/s data rate (single channel) and cover up to 30 miles [6]. The technology can provide fast and cheap broadband access to areas that lack infrastructure such as rural areas [4]. WiMAX technology supports two network modes: point to point (PMP) and mesh. A PMP network is designed primarily to provide for providing last mile access to the service provider, it consists of a base station (BS) and subscriber stations (SSs) and both uplink and downlink channels are shared among the subscriber stations. PMP mode requires all subscriber stations to be within the transmission range and clear line of sight (LOS) of the base station. The mesh network, on the other hand, is a

multihop ad hoc network in which all nodes act as relaying routers in addition to their sender and receiver roles [1].

CONCLUSION

The advantages of wireless local loop over the wired loop especially in the areas of fast deployment and installation cost continue to make it an attractive option for rural areas and difficult terrains.

As with most wireless communication systems, the quality versus coverage area compromise remains an issue. However, the emergence of broadband wireless systems promises quality service over a considerable area, though, cost is a limiting factor. The wireless local loop market is expected to continue to grow in developed countries to compete with wired loop providers and in developing countries to connect many that are without service.

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