Wireless Local Loop (WLL)

Definition

Sometimes called radio in the loop (RITL) or fixed-radio access (FRA), wireless local loop (WLL) is a system that connects subscribers to the public switched telephone network (PSTN) using radio signals as a substitute for copper for all or part of the connection between the subscriber and the switch. This includes cordless access systems, proprietary fixed radio access, and fixed cellular systems.

Overview

Industry analysts predict that the global WLL market will reach millions of subscribers by the year 2000. Much of this growth will occur in emerging economies where half the world's population lacks plain old telephone service (POTS). Developing nations like China, India, Brazil, Russia, and Indonesia look to WLL technology as an efficient way to deploy POTS for millions of subscribers—without the expense of burying tons of copper wire.

In developed economies, WLL will help unlock competition in the local loop, enabling new operators to bypass existing wireline networks to deliver POTS and data access. So the question isn't will the local loop go wireless, but when and where. This tutorial discusses the basics of WLL and examines the markets and future for this technology.

Topics

1. The Wireless Local Loop Revolution
2. WLL Technology Shake-Out
3. Economics of WLL
4. WLL Market Overview
5. Comparison of WLL Systems

   Self-Test

   Correct Answers

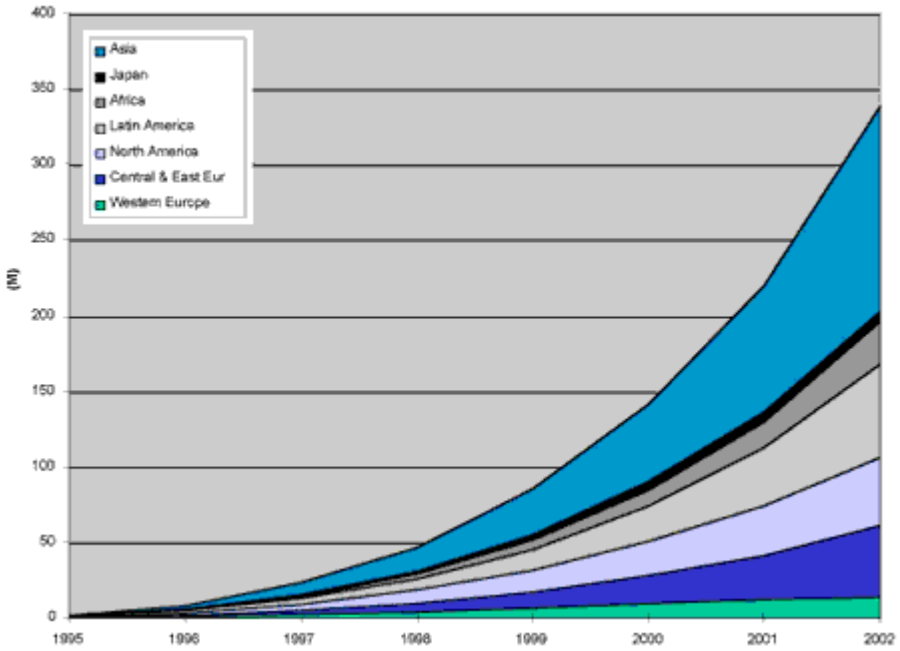
   Glossary

1. The WLL Revolution

Since the advent of the telephone system, copper wire has traditionally provided the link in the local loop between the telephone subscriber and the local exchange. But copper's heyday in the local loop is coming to an end. Economic imperatives and emerging technologies are opening the door for WLL solutions. Sometimes called RITL or FRA, WLL uses wireless technology coupled with line interfaces and other circuitry to complete the last mile between the customer premise and the exchange equipment.

Bill Frezza, president of Wireless Computing Associates, calls WLL "the hot telecom growth industry of the next decade." According to the research firm MTA-EMCI, the worldwide WLL market will reach 202 million subscribers by the year 2005. Herschel Shosteck Associates estimates there will be a demand for WLL service for 172 million to 307 million subscribers but that actual service will be provided for 50 million to 60 million subscribers by the year 2000 (see *Figure 1*).

Figure 1. Projected WLL Subscribers by Region



In developed economies, wireless technology's relatively low deployment and maintenance costs and learning-curve advantages make WLL a competitive bypass solution and a viable alternative to wireline networks for POTS and data access. Two issues will determine how quickly WLL will be deployed in developed markets: cost and bandwidth.

- Today's exorbitant access rates, coupled with regulatory changes, have created a competitive environment that gives new operators the incentive to invest in their own WLL networks. However, WLL deployment costs (expected to drop to $200 per subscriber installation) must be balanced with the potential for lower access fees.

- The growing demand for high-bandwidth transmission capable of supporting rich-data types places additional requirements on a WLL system. Operators must evaluate the various technologies based on their ability to support data rates up to integrated services digital network (ISDN) speeds.

2. WLL Technology Shake-Out

The WLL revolution is underway. WLL suppliers and operators are flocking to emerging markets, using whatever available wireless and line interface technologies are at hand to achieve fast time to market. Because there are no definitive WLL standards, vendors are faced with a bewildering choice of fixed-access, mobile, and digital cordless technologies.

Ultimately the appropriate protocol technology will depend on an array of applications considerations, such as size and population density of the geographic area (rural versus urban) and the service needs of the subscriber base (residential versus business; POTS versus data access). In fact, there are many good reasons why different wireless technologies will serve some applications better than others. The challenge for WLL vendors is to identify the optimal wireless protocol for their unique application needs, then reduce cost per subscriber through silicon and deliver integrated solutions to the marketplace.

WLL will be implemented across five categories of wireless technology. They are digital cellular, analog cellular, personal communications network (PCN)/personal communications service (PCS), cordless telephones 2nd generation (CT–2)/digital European cordless telecommunications (DECT), and proprietary implementations. Each of these technologies has a mix of strengths and weaknesses for WLL applications.

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 subscribers, 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.

Proprietary Implementations

Proprietary WLL systems encompass a variety of technologies and configurations. These systems are considered proprietary because they are not available on public wireless networks and are typically customized for a specific application. They generally do not provide mobility. This makes proprietary technology most effective for applications that cannot cost-effectively or time-effectively be reached by landline alternatives. Proprietary systems are, therefore, positioned to provide basic fixed wireless telephony in low-demand and medium-demand density applications.

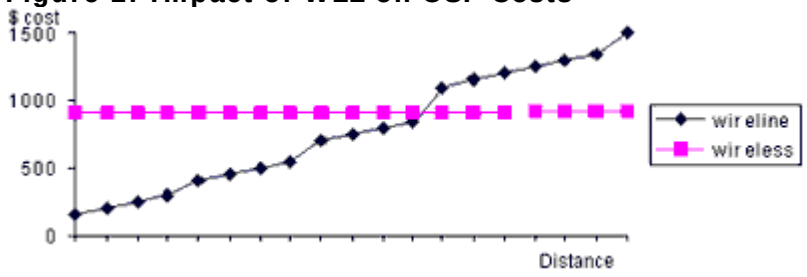
3. Economics of WLL

WLL technology has several economic characteristics that make it attractive to deploy for 20 to 50 percent of a typical telephone network. In some cases—e.g., adverse terrain or widely dispersed subscriber areas—WLL would be even more attractive. However, since WLL is a relatively new technology, there is considerable misunderstanding of it due to cost models that are not accurate. The primary inaccuracy of these models is that many of the ancillary expenses of deploying and maintaining WLL technology are not taken into account. This is a mistake that is usually not made by wireline providers, who understand well that the cost of provisioning service to a customer consists of elements such as switching, outside plant, personnel, and operations.

One important economic consideration is that a WLL network can be deployed very quickly: Activating a system within 90 to 120 days is feasible. Although this economic benefit is difficult to measure in purely economic terms, it is a key advantage in a market where multiple service providers are competing for the same user base. To illustrate, consider a region in which telephone service is first introduced (i.e., a pioneer rollout). In this situation, putting outside plant infrastructure in place is an uncertain investment. However, if a WLL system is deployed in the region with the intent of building a traditional outside plant afterwards, the WLL generates data that will confirm the traffic levels and user population models which are used to justify the outside-plant investment.

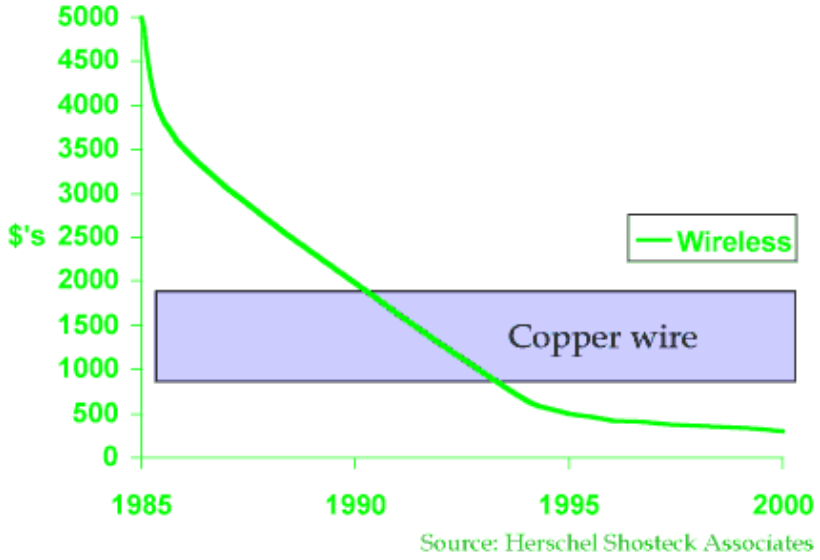
Because the expense of provisioning service via WLL is not affected by the distance between the subscriber and the central office (CO), WLL is more cost-effective than wireline operator service provider (OSP) for at least 20 percent of the service lines deployed in a network (see *Figure 2*).

Figure 2. Impact of WLL on OSP Costs



WLL has a much lower incremental investment cost than copper, and it is much cheaper to deploy at lower subscriber densities. As shown in *Figure 3*, the cost of deploying the last mile of connectivity will continue to fall for wireless while remaining constant for copper-wire networks.

Figure 3. Copper versus Wireless: The Cost of the Last Mile

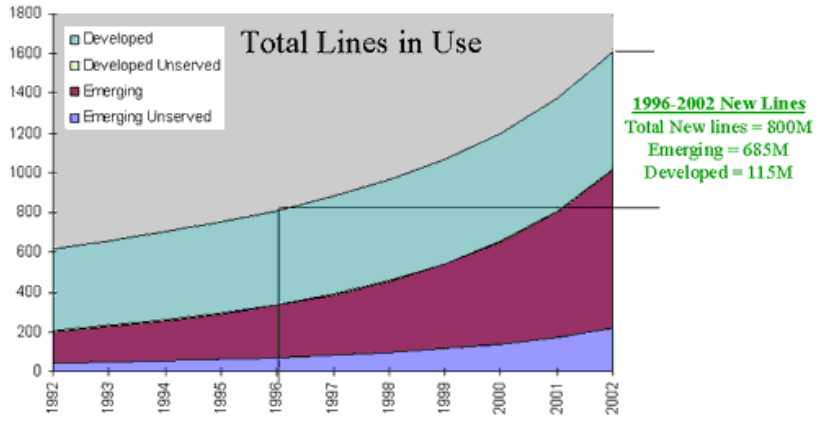


In short, ease and speed of service implementation, scalability and versatility, and maintenance and reliability make WLL the preferred alternative from an economic standpoint.

4. WLL Market Overview

According to the International Telecommunications Union (ITU), worldwide local-loop demand is expected to result in 800 million new lines by the year 2000. Of these, 685 million will be in emerging countries, and 115 million will be in developed countries. *Figure 4*, which has been sourced from ITU/AMD, is based on ITU historical data from 1992 to 1994. It assumes the growth rate for each country remains the same as from 1992 to 1994. It also assumes that unserved demand, which represents people on official waiting lists as of 1994 (43 million), will remain a constant percentage of installed lines.

Figure 4. Worldwide Local-Loop Demand



The WLL market is just entering its infancy. Because of this, projections have been extended out to the year 2002 to show the true potential of this market. By the end of 2002, forecasts indicate that there will be 339 million WLL lines installed throughout the world. The vast majority of these lines will be in emerging countries, with a small percentage in developed countries. The underlying assumption of this forecast is that demand for POTS in emerging countries will outstrip the post telephone & telegraph administration (PTT's) abilities to install copper wire. Also, the costs of WLL will continue to decline, while the cost of copper wire installation will stay flat. The lower cost of WLL (especially in low-density population areas) and the ability to install WLL more rapidly than copper wire will motivate the PTTs of the emerging countries to serve excess demand with WLL.

Some projections assume that although WLL serves only 5 percent of the current excess POTS demand in emerging countries, it will grow to serve 70 percent of the excess demand by the year 2002. Similarly, it is estimated that WLL will be used for a growing percentage of new lines even in locations where copper-wire service is already available. This forecast assumes that WLL's share of these lines in emerging countries will grow from 5 percent in current years to 35 percent by 2002.

The penetration of WLL into developed countries is assumed to be much lower than in emerging countries. The PTTs are able to keep up with the demand for new POTS lines so unserved demand is not an issue. The requirement for WLL in developed countries will come from companies that want to bypass the established local phone companies or customers who want the additional services that WLL can provide. This is a small subset of the total population so it can be assumed that WLL will gain only 5 percent (however, the competitive bypass could drastically increase this percentage) market share by 2002. *Table 1* summarizes the forecast for WLL.

Table 1. Worldwide Number of Potential WLL Lines (in millions)

empty	1997	1998	1999	2000	2001	2002
emerging countries	16	34	64	111	183	296
developed countries	7	13	21	31	37	43
total	23	47	85	142	220	339

WLL Market Segments

The two basic market segments for WLL are for basic phone service in emerging economies and for wireless bypass in developed economies. The requirements for each of these segments in urban/suburban and rural areas are shown in *Table 2.*

Table 2. Service Requirements for WLL by Market Segment

	Developed (Bypass)	Emerging (POTS)
urban/suburban	high-speed data enhanced services limited mobility high traffic/subscriber densities	POTS (voice quality) modem data no (limited) mobility high traffic/subscriber densities
rural	high-speed data enhanced services limited mobility low subscriber densities wide coverage	POTS (voice quality) modem data no (limited) mobility low subscriber densities

Table 3, which has been sourced from AMD, Shosteck, shows how the total number of new WLL installations by the year 2000 will be divided among the four quadrants of *Table 2*.

Table 3. Distribution of New WLL Installations by the Year 2000

	Developed	Emerging
urban/suburban	9 percent plus bypass upside potential of 25 percent	51 percent
rural	6 percent plus bypass upside potential of 10 percent	34 percent

5. Comparison of WLL Systems

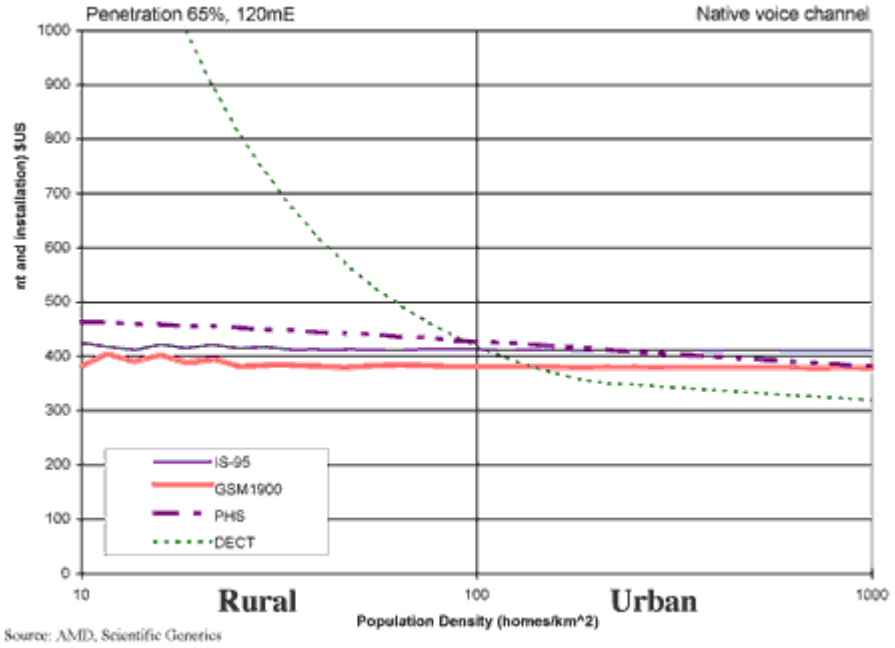
Various WLL technologies and deployment options should be evaluated in terms of the following:

- population density of the service area
- connection cost (i.e., equipment and installation)
- level of penetration
- whether the country/area served is developing or developed

A comparison of PHS, DECT, digital cellular, analog cellular, and proprietary protocols was conducted in 1997, taking into account the above variables. The results are shown in *Figure 5* and *Figure 6*. Costs included in the model are base-station site and infrastructure costs, costs of radio equipment (varies with channels used per site), costs of antenna equipment (varies with sectorization of base station), costs of baseband processing and protocol-conversion equipment,

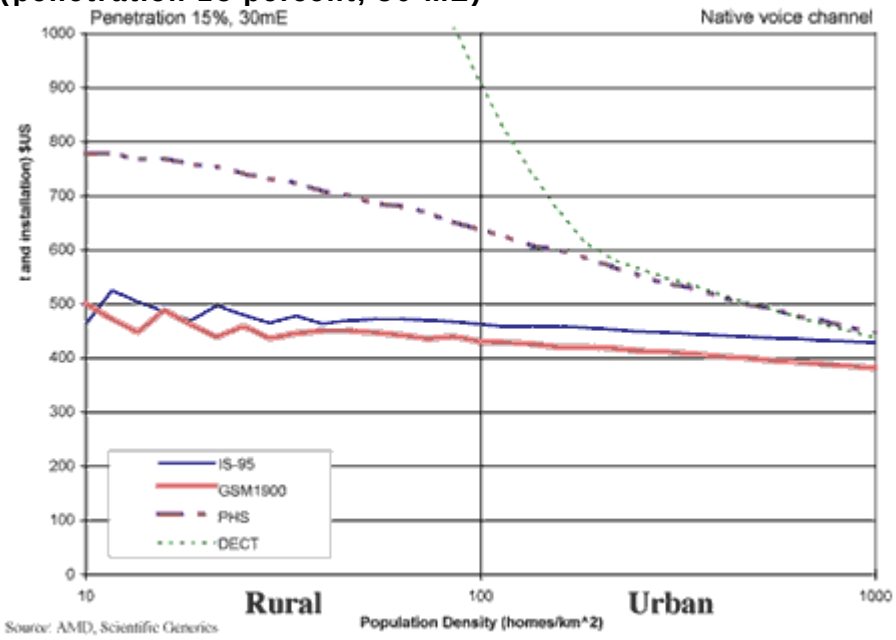
costs of backhaul from base station, costs of subscriber-premise equipment, and installation costs.

Figure 5. Connection Cost versus Population Density (penetration 65 percent, 120 mE)



Source: AMD, Scientific Generics

Figure 6. Connection cost versus Population Density (penetration 15 percent, 30 mE)



Source: AMD, Scientific Generics

It should be noted that this analysis assumes that backhaul costs are similar for all systems, yet this is probably not the case for microcellular systems. The costs shown in the two figures above are for installation only and do not include operation and maintenance or system/subscriber management software. Finally, it should be kept in mind that incremental investment costs must also be considered.

Based on the data in *Figure 5* and *Figure 6*, the appropriate technologies for various WLL market segments—both in developed and emerging countries—can be summarized as follows:

Table 4. WLL Technologies by Market Segment

	Developed	Emerging
urban/suburban	digital cellular DECT PHS proprietary	DECT PHS digital cellular proprietary
rural	digital cellular proprietary	digital cellular analog cellular proprietary

As can be seen, no one system is best for all applications. The right choice should be based on subscriber densities, traffic conditions, and data-support requirements. The conventional wisdom that microcellular (cordless) systems are better for urban areas and that macrocellular (cellular) systems are better for rural areas is not true for all conditions.

In summary, there are clear market opportunities in emerging economies for WLL, as well as an enormous potential upside in developed economies. The potential market is huge, but its various segments require the right system costs and features. Finally, more than one technology will evolve as the leader; for example microcellular applications will call for DECT and PHS, whereas macrocellular systems are better suited to TDMA, CDMA, and GSM.

Self-Test

1. Much of the growth of WLL in the future will come from emerging economies because it is an efficient way to deliver POTS for millions of subscribers.

    a. true

    b. false

2. The reason that WLL is attractive to developed countries is that it allows operators to bypass wireline networks to deliver basic telephone service and data access.

    a. true

    b. false

3. GSM is the digital-cellular standard that is most suited to WLL applications because of its high capacity, high quality voice, and high level of privacy.

    a. true

    b. false

4. Ease and speed of service implementation, scalability, versatility, maintenance, and reliability make WLL the preferred alternative to copper from an economic standpoint.

    a. true

    b. false

5. Market estimates show that the demand for WLL in emerging economies will be due to the fact that the demand for new POTS services will exceed the ability of the PTTs to install copper wire.

    a. true

    b. false

6. The market for WLL is huge, but various market segments require the right system costs and features. Therefore, more than one technology will evolve as the leader, depending on the application.

    a. true

    b. false

7. What two issues that will determine how quickly WLL will be deployed in developed markets?

    a. cost and population

    b. population and geography

    c. geography and politics

d. cost and bandwidth

8. Which of the following is not one of the five categories across which WLL will be implemented?

    a. digital cellular

    b. CT–2/DECT

    c. proprietary implementations

    d. none of the above

9. Which of the following technologies has significant advantages in medium-density and high-density population areas because it is capable of carrying higher levels of traffic, provides better voice quality, and can transmit data at higher rates?

    a. GSM

    b. PCS

    c. CT–2

    d. DECT

10. An important consideration for WLL is that it can be deployed and activated very quickly. It is feasible to deploy and activate a system within which of the following amounts of time?

    a. 10 to 15 days

    b. 15 to 30 days

    c. 90 to 120 days

    d. 180 to 360 days

11. Analysts predict that the cost of WLL will continue to decline rapidly, while which of the following is predicted to happen to the cost of installing copper?

    a. increase slowly

    b. decrease slowly

    c. stay the same

    d. increase rapidly

12. Various WLL technologies and deployment options should be evaluated in terms of which of the following?

    a. population density of the service area

    b. connection costs

    c. level of penetration

    d. all of the above

Correct Answers

1. Much of the growth of WLL in the future will come from emerging economies because it is an efficient way to deliver POTS for millions of subscribers.

    a. true

    b. false

    See Overview.

2. The reason that WLL is attractive to developed countries is that it allows operators to bypass wireline networks to deliver basic telephone service and data access.

    a. true

    b. false

    See Definition.

3. GSM is the digital-cellular standard that is most suited to WLL applications because of its high capacity, high quality voice, and high level of privacy.

    a. true

    b. false

    See Topic 2.

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    a. true

b. false

See Topic 3.

5. Market estimates show that the demand for WLL in emerging economies will be due to the fact that the demand for new POTS services will exceed the ability of the PTTs to install copper wire.

   a. true

   b. false

   See Topic 4.

6. The market for WLL is huge, but various market segments require the right system costs and features. Therefore, more than one technology will evolve as the leader, depending on the application.

   a. true

   b. false

   See Topic 6.

7. What two issues that will determine how quickly WLL will be deployed in developed markets?

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   b. population and geography

   c. geography and politics

   d. cost and bandwidth

   See Topic 1.

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   a. digital cellular

   b. CT–2/DECT

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   d. DECT

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    a. population density of the service area

b. connection costs

c. level of penetration

d. all of the above

See Topic 5.

Glossary

AMPS
advanced mobile phone system

CDMA
code-division multiple access

CO
central office

CT–2
cordless telephones 2nd generation

DCT–U
digital cordless telephone-United States

DECT
digital European cordless telephone

E–TDMA
Hughes Enhanced TDMA

FRA
fixed-radio access

GSM
global system for mobile communications

ISDN
integrated services digital network

ITU
International Telecommunications Union

NAMPS
narrowband advanced mobile phones system

NMT
Nordic mobile telephone

PACS
personal access communication systems

PCN
personal communication network

PCS
personal communication system

PHS
personal handyphone system

POTS
plain old telephone service

PSTN
public switched telephone network

PTT
post telephone and telegraph

RITL
radio in the loop

TACS
total access communications system

TDMA
time-division multiple access

WLL

wireless local loop