Selecting a Fixed Wireless Access (Wireless Local Loop) Technology for Consumer Applications
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Fixed Wireless Access (Wireless Local Loop)

Nortel Networks Internet Fixed Wireless Access System (Internet FWA) is a narrow-band fixed wireless access product that will provide a wide range of services to small business and residential consumers. It uses a technology that has been designed to provide access to the public Internet and telecommunications networks. Internet FWA will allow an operator or Internet Service Provider (ISP) to develop and deliver services to the customer without having to make significant and costly changes to existing network components and connects to both circuit and packet switching networks for voice and data.

The system offers wireline service quality and will support any service from a public switch or Internet point of presence that can be delivered over a wireline access network.

There are a number of competing technologies which provide Fixed Wireless Access (FWA) or Wireless Local Loop (WLL) service. Each has strengths and weaknesses, depending on the requirements of the operator. A discussion of the different technologies currently available and the technical and operational advantages they provide is given here.

The Alternatives

An operator considering radio access has a wide choice of technologies:

- Analog cellular derived from mobile telephone systems, using the AMPS/TACS or NMT standards
- Digital cellular, using the Digital AMPS (DAMPS), IS95 CDMA or GSM/DCS 1800 standards
- Digital cordless, using PHS or DECT standards
- Microwave point-to-multi-point, “rural telephone systems” using proprietary standards
- Proprietary FWA systems, including Nortel Networks Internet Fixed Wireless Access System, optimized to provide Fixed Wireless Access. Other proprietary technologies are available from other vendors, and these will be discussed below

Analog Cellular

These systems use analog transmission with conventional frequency modulation on either 25 kHz or 30 kHz channels in the 470 MHz, 800 MHz or 900 MHz mobile bands. Radio Network Terminating Equipment (RNT) is based on conventional mobile equipment modified to interface to a conventional telephone. A special adapter unit is used between the base stations and the network to provide an interface to conventional public exchanges.

Systems have been supplied based on both the AMPS/TACS standard and on the Nordic NMT standard.

Key Features

- Narrow-band analog transmission results in relatively poor speech quality and limits modem speeds to a maximum of 4,800 bps.
- Systems are vulnerable to eavesdropping using low-cost scanning receivers. Analog scrambling can be added, but reduces quality further.
- Since the access method is FDMA, the RNT cannot support more than one line per radio transceiver.
- Relatively low capacity due to the difficulty and cost of supporting large numbers of radio channels in analog cellular base stations. A typical analog base station may have 16 channels, which can serve around 125 residential subscribers in a cell.1
- Long radio range, especially with fixed RNTs; ranges of at least 30 km are possible.

1 All capacity figures are calculated for 0.08 Erlangs/subscriber and 1% probability of blocking using ErlangB.
Digital Cellular

The major digital cellular standards are D-AMPS (IS136) and GSM/DCS 1800 (European) and CDMA (IS95), based on proposals from Qualcomm in the USA. All these systems are characterized by the use of low bit-rate digital speech coding; both US systems use 8 kbps, while GSM system uses both 8 and 13 kbps.

Key Features

- The digital codec provides speech quality which is subjectively inferior to the normal PSTN (though better and more consistent than analog mobile quality), but also introduces substantial delay.
- Speech coding is not transparent to voice-band modem signals and special interfacing has to be used with fax machines to demodulate the modem tones so that the data can be carried digitally. The digital radio channel provides a maximum user bit-rate of 9,600 bps; consequently, the new generation of modems, fax machines and videophones which operate at 14,400 bps and higher speeds, will not operate over the radio link.
- Digital cellular systems are encrypted and provide high speech security with no impact on quality.
- Though both D-AMPS and GSM use TDMA and in principle may support multiple lines from a single RNTE, limitations in the protocol make this impossible.
- Digital cellular standards can provide high capacity and long range from a base station. A GSM base station with 8 radio transceivers for example, would provide 64 traffic channels and support over 600 residential subscribers in a cell, over a cell radius up to 30 km. In the near future GSM and IS95 CDMA systems will support higher data rates using packet data in the form of GPRS, EDGE and 1xRTT technologies. However these impose significant constraints in terms of number of users per cell as they gobble up bandwidth.
- A particular difficulty with mobile systems is that interfacing with normal exchanges is not easily achieved because a digital cellular radio terminal expects to see several functions in a network which have no counterpart in a wireline network. Consequently base station controllers are used between the base station and the mobile switch, the switch has to carry out billing functions which have to be duplicated in the mobile switch, leading to extra administration.

Digital Cordless Systems

DECT systems are digital cordless telecommunication systems standardized by ETSI (European Telecommunications Standards Institute). DECT products are now widely available, for both Telepoint and cordless PBX applications and for cordless LANs. In Japan the PHS (personal handyphone) system has been deployed in a telepoint application. This technology has also been developed for FWA (WLL) applications. Its performance is very similar to that of DECT and it operates in the same frequency band.

DECT Key Features

- TDMA access protocol, providing a basic traffic channel bandwidth to the user of 32 kbps.
- Normal speech is carried using the G726 algorithm; the G726 coding system will handle voice-band data only up to 4800 bps, limiting fax and modem transmission rates.
- ISDN 2B+D service can be supported in a standardized way, but speech service within this is still carried as a 32 kbps G726 stream. A new packet data standard is also being introduced on DECT, which will provide for peak data rates up to 512 kbps. However this will reduce capacity for voice and voice band data.
- Comprehensive security provisions including authentication and encryption.
- The DECT base station is designed for a maximum of typically 8 traffic channels, which will support over 40 residential subscribers.
Cordless System Range
PHS and DECT both have a similar radio range. They are designed for “mobile” use using hand-portable terminals, and in this application reliable range is likely to be of the order of 100 meters or less.

For fixed wireless access, directional antennas can be used. The reliable range is of the order of 1 km or less, in urban environments.

Microwave Point-to-Multi-point Systems
These systems are essentially designed to provide telephony in rural areas. Although the details of their design differ, they all offer either 2 Mbps or 4 Mbps radio trunks using microwave transmission generally in the 1.7 GHz or 2.4 GHz bands (depending on availability). All use TDMA and provide the user with access to a 64 kbps channel, either for PCM speech or data. They will therefore support all PSTN data modems and some products also support ISDN. Despite the systems being digital, they do not generally incorporate encryption. RNTE equipment is available which can support either a single customer with one or two lines, up to small communities with tens of lines. Most of the systems available use cabled connections for the final hop. For this reason several vendors have developed an add-on wireless sub-system, using DECT or another point to multi-point technology, to complete the hop with radio to the home (RTTH).

Key Features
- Designed to support relatively small numbers of subscribers in sparsely populated rural areas.
- Inefficient use of frequency spectrum in dense urban areas.
- A typical base station has 30 or 60 traffic channels (depending on the system) and could support 256 or 512 residential subscribers respectively.
- Very long ranges (over 50 km), but require a line-of-sight path between the base station and all subscriber units: generally this means that their installation has to be planned using a terrain map to ensure that antenna heights and locations avoid obstacles.
- Systems are susceptible to multi-path delay spread, and the high channel bit-rate would make the equalizer required complex and costly; another reason for requiring a line-of-sight path.
- These systems usually have a cabled unit at the subscribers end of the link to provide copper based access for the final few hundred meters. As an alternative they can also be used with a low range cordless system, see above, to complete the link using radio.

FWA Technologies
The Nortel Networks Internet Fixed Wireless Access System was specifically designed to avoid the various limitations of other systems which provide consumers with fixed access using radio to conventional PSTN and Internet services. This system enables a new operator to compete with an established operator for fixed telecommunications and meet the demands of consumers used to an increasingly competitive market for telecom services.

Key Features
- Excellent speech quality achieved using the CCITT G726 algorithm.
- Future enhancement possible by introduction of the CCITT 16 kbps (G728) coding algorithm to increase capacity for voice traffic.
- 64 kbps PCM coding for voice-band data signals—supports conventional telecommunication terminals exactly as a conventional wired connection. This includes fax machines at 14.4 kbps and modems operating at speeds up to 56 kbps with the latest V.90 standard.
- The RNTE will support one or two independent PSTN lines for use by one or two subscribers as well as an “always on” Internet data line for direct connection over an RS-232 or USB serial connection to a personal computer.
Flexible radio range to reach both distant rural subscribers and also accommodate high penetration using small cells when necessary. Nominal radio range with the RNTE installed on the subscriber's premises roof in urban areas is 5 km; minimum cell sizes of 0.2 km. In rural areas a line-of-sight range of 20 km is standard with an extended range option up to 40 km is available.

Maximum capacity for an omni-directional base station (58 useable traffic channels) is 600 PSTN lines; for a 3-sector base (174 useable traffic channels) it is 1840 PSTN lines. In addition the system can provide Internet access to 1500 computers from a single basestation.

Base stations designed specifically to interface to digital local exchanges. Versions with the new V5.2 standard concentrating interface are available. Internet data traffic is separate from PSTN traffic and is sent to the ISP’s point of presence where it can be terminated on an IP server such as the Nortel Networks Shasta 5000 Broadband Service Node. This avoids the need for modem banks and preserves the capacity of the PSTN network from being swamped by data traffic, especially in countries where local calls to the Internet are not metered.

Cost “per establishment passed” is only about 10% of wireline cost. This is because the large cell size is capable of serving a large number of customers from a single base station. With the maximum range of 40 km the area covered by a base station exceeds 5,000 km².

Other FWA technologies are available from a variety of manufacturers including Airspan, Motorola, Marconi, Aditus, ECI Telecom and SR Telecom. Most are designed for the small business market offering connectivity for PBXs, LANs and multi-tenant buildings. Consequently they are lower capacity, urban deployment friendly systems, not necessarily suitable for residential or rural situations as well as their urban counterparts.

Selecting an FWA (WLL) Technology

Any operator assessing the viability of a particular technology will want to be assured that the system meets its own commercial criteria and, just as importantly, the expectations of its prospective customers.

From the operator’s perspective, the key benefits of Fixed Wireless Access (Wireless Local Loop) are lower initial capital cost, faster network roll-out and lower maintenance costs—all clearly important considerations to ensure an attractive business plan. The other major requirement is to be able to provide a high quality service that generates revenue and minimizes churn by offering users a package of services that is unbeatable.

In many developed markets users are already served by a high-quality system and a new operator cannot anticipate very rapid market penetration. Since revenues will grow rather slowly, the operator must minimize the up-front costs of building the network in order to realize a worthwhile return on investment. Thus, the “cost per establishment passed” should be as low as possible. But as take-up increases it should be possible to upgrade and expand base stations without loss of service and without large cost increments. This means the system should be scalable.

The radio system also has to interface to digital telephone exchanges and ISP points of presence. This is a particular issue for an operator with an existing long-distance network (and therefore switches) which need to bypass competitors’ local-loops. In these circumstances, the access network must interface to existing switches.

Another important consideration is the cost of radio spectrum. Most regulators and governments are now auctioning spectrum for use in mobile and fixed

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1 “Cost per establishment passed” is a parameter widely used in comparing access technologies. It measures how much an operator deploying a network has to spend to get to the stage where a customer requesting service can actually be served.
access applications. Any system designed to use mobile spectrum in a fixed application is going to be relatively expensive for the fixed operator because of the large premium now being attached to mobile spectrum prices. The only way to avoid this is to use spectrum that has been specifically earmarked for fixed applications and which will therefore be lower in price; generally spectrum at 2.4 GHz, 3.5 GHz, 26-28 GHz and 42 GHz. Narrowband applications will generally use the lower two of these while broadband will use the higher two with some systems at 3.5 GHz as well. Most consumer applications are rapidly converging to the 3.5 GHz band as this provides the right mix of bandwidth and propagation characteristics and is actively being licensed globally.

Beyond these requirements, any operator must be sure that a radio access system will actually deliver the service required by customers. What exactly are these requirements?

- The network must provide a technical quality of service at least as good as (preferably better) than that offered by the main competitor. This means that ordinary telephones as well as any advanced terminal, which works on a copper-wire pair, must work equally well on the radio access network. Modern third generation fax machines already operate at 14.4 kbps, and PSTN modem speeds have increased to 56 kbps.

- Internet access is an important differentiating point for an operator in the local loop market; therefore the system must allow the new operator to offer an “always on” unmetered access. As demand for higher Internet access speeds increases from residential as well as small and medium businesses there is an increasingly attractive case for deploying packet data lines in the local network.

- Conventional network operators usually install two copper pairs to all premises, even though most customers use only one. This means that second line provision can be very easy. The radio system should allow for at least two lines to be provided; for small businesses and shared dwellings more than two lines are desirable.

- The rate of growth of penetration will be determined by per-capita income and the ability of the operator to roll out infrastructure quickly. This may result in quite low penetrations for the first few years of operation. The operator therefore needs a system, which can be economically viable with wide coverage yet low penetration.

- Although the main requirement is often seen to be simple telephony, many customers will be small businesses who need good quality fax and data services, particularly to communicate with overseas customers.

- The demographics of the country often combine large rural areas (sometimes with virtually no telephones at all) with very densely populated cities.

In summary, operators are likely to find very attractive a technology, which minimizes “cost per establishment passed” and “cost per establishment connected” and enables the maximum number of potential customers to be covered in the minimum time. This requirement places a premium on system range, especially for covering rural customers, and eliminates cordless systems from consideration.

Analog and digital cellular systems meet the range requirement, and indeed systems derived from cellular are being used in this marketplace. They allow the operator to use a proven technology to provide a quick solution. However, they have significant service limitations (especially digital cellular systems) and the generally low capacity of analog systems makes the per-user costs high. Cellular solutions cannot therefore be regarded as more than a temporary solution, allowing an operator to provide a basic service quickly.

Microwave point-to-multi-point systems are designed specifically for deployment in very sparsely populated rural areas and can be used in developing countries for rural applications. However, they quickly reach capacity limits in urban areas and do not therefore pro-
provide a viable permanent solution. These also have to use a separate wireless subsystem to provide the final hop. So the operator is faced with acquiring two lots of spectrum and deploying two wireless networks.

Nortel Networks Internet Fixed Wireless Access System is a technology, which has come into being precisely because of the limitations of other technologies. It has been purpose-designed for an operator to provide connections to residential and small business customers, and has been optimized for the features listed below.

• The maximum system range and base station capacity are large, to make the “cost per establishment passed” as low as possible. This minimizes the entry cost for an operator.

• Customer connection cost is low, so that the overall “cost per customer” is significantly lower than wire-line, or indeed other radio systems.

• The system is capable of small-cell operation where required, to serve urban areas.

• Conventional terminals, such as fax machines and high-speed modems, can be supported “transparently,” allowing customers to upgrade their terminals as new modem technology is introduced.

• The technology will support high speed “always on” Internet access, taking data away from the PSTN directly to the ISP. It enables the user to simply plug and play and get connected to the Internet without any additional cost.

• Conventional fixed digital switches can be used. This allows the operator to exploit the competitive switch market to get attractive prices and extend the full range of advanced switch-based services to customers.

Further Information:
More detailed information about the advantages of the Nortel Networks Internet Fixed Wireless Access System is available from the web at http://www.nortelnetworks.com/fwa

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