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9.0 PCS/PCN

Objectives

This section will:

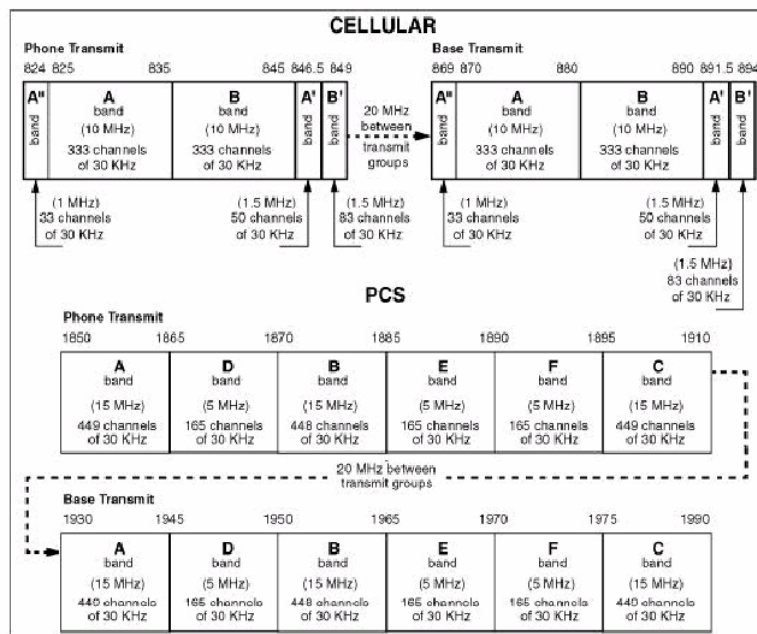
- Introduce the concept of PCS and PCN
- Examine the capabilities of high tier systems
- Consider the requirements of low tier systems
- Examine the European vision of UMTS

For more information:

- <http://www.pcsdata.com/>
- [AT&T PCS Tutorial](#)
- [Growth of PCS](#)

PCS is a class of cellular phone services and PCN is the network that provides them. In many cases, PCS and cellular technology are one and the same. Some authors make a distinction in terms of frequency, namely that cellular systems operate below 1 GHz and PCS operates above 1 GHz.

The following graphic is from the PCS Tutorial by AT&T Wireless Services.



In our case, the distinction will be on the service offering. Traditional cellular phone systems do not have an infrastructure that enables them to provide full

voice and data service over wide areas. PCS systems can provide such services over a continental and even global area.

There are a number of PCS standards being implemented throughout the world. These can be categorized into high and low tier systems.

High Tier Standards

Frequency (MHz): Rx: 1930-1990, Tx: 1850-1910

Multiple Access Method:

PCS TDMA (based on IS-136 cellular)

PCS CDMA (based on IS-95 cellular)

PCS 1900 (based on GSM cellular)

Wideband CDMA

Low Tier Standards

Frequency (MHz): Rx: 1930-1990, Tx: 1850-1910

Multiple Access Method:

PACS (based on PHS cordless)

DCT-U (based on DECT cordless)

Composite CDMA/TDMA

9.1 PCS

PCS[†] is one of the most talked about areas in modern telecommunications is that of portable and personal communications¹. The ultimate goal is to contact people and not places. This means that everyone would ideally have a small portable communicator that could access anyone anywhere in the world.

Personal communications services include:

- Complete portability
- A single device capable of accessing the network in a variety of environments (fixed, residential, office, mobile)
- A person oriented numbering plan
- Network intelligence to implement the plan
- Package of personal services such as voice telephony, paging, fax, and voice mail

PCS terminals are small, lightweight and low power. They must be capable of conveying both voice and data signals. The numbering plan must be people rather than terminal oriented.

Some of the very complex issues that must be addressed include efficient use of spectrum, network infrastructure, and service offering. The solutions to these problems are not found in one sector of the communications industry, but rather require the cooperation of government, industry and end-users.

[†] Personal Communications Systems

¹ *Personal Communications Services: Expanding the Freedom to Communicate*, IEEE Communications Magazine, February 1991

It is expected that there will be in excess of 40 million PCS subscribers in the US alone, by the turn of the century.

A number of different proposals have been put forward for implementing PCS. Some of these include²:

Proposed Standard	Sponsor
D1900	Siemens
PCS1900	Northern
Omnipoint	Omnipoint
DCS1800	Ericsson
DSC1900	Alcatel
DCT	Ericsson
PHP	Panasonic
PHP	PCSI
IS-54	Ericsson
IS-54	AT&T
IW-CDMA	IDC
CDMA	Qualcomm
W-CDMA	AT&T
A-CDMA	Oki
WACS-8+	Hughes
PPS1800	Motorola

Some of these proposals are suitable for advance cellular systems but may not necessarily have defined the entire supporting infrastructure. In 1993 a Joint Technical Committee was established by the Exchange Carriers Standards Association to examine some 17 different proposals for PCS systems. Later the TIA[†] reduced these to seven. This group contained three Canadian representatives: Stentor, Industry Canada, and Mobility Canada.

9.1.1 Services

PCS networks are expected to compete with cellular phone systems in the US since the FCC may license the frequencies to new carriers. In most other countries, it would seem more natural for the existing cellular phone providers to move into the PCS environment, since they already have so much experience with personal radio systems.

Applications for PCS include:

- Mobile micro cellular phone/messaging
- Wireless PBXs/LANs
- Transaction processing/EDI[‡]
- Alarm monitoring/utility meter reading
- Computer aided dispatch/traffic control
- Environmental monitoring

² TE&M, December 1, 1993

[†] Telecommunications Industry Association

[‡] Electronic Data Interchange

- Gateway services to wireline/cellular networks
- Value-added network support

Personal Communications Network Services of New York has an FCC experimental license to test PCS services in the 1850 – 1990 MHz band.³

9.2 PCN

TIA/JTC Standards for Consideration⁴

	Hybrid CDMA	IS-95A	PACS	IS-136	PCS1900	PWT	W-CDMA
Based on		IS-95	WACS	IS-54	GSM	DECT	IS-95
Access Method	CDMA TDMA	CDMA	TDM TDMA	TDM TDMA	TDMA	TDMA	CDMA
Duplex Method	TDD	FDD	FDD ³	FDD	FDD	TDD	FDD
Bandwidth/Ch. Spacing	5 MHz	1.25 MHz	300 KHz	30 KHz	200 KHz	1.728 MHz	5 MHz
Bit Rate [Kbps]	32	8 / 13.3	32	7	13	32	32
# Voice Ch./Carrier	32 (8 Kbps CELP)	20 + SHO ¹	8	3	8	12	128 (less with SHO)
Capacity x AMPS	16	10	0.8	3	2 - 3	0.2	16 (less with SHO)
Modulation	Cont. Phase Shift QM	OQPSK QPSK	$\pi/4$ D-QPSK	$\pi/4$ D-QPSK	GSMK	GFSK	OQPSK D-QPSK
Error Control (voice)	none	FEC	none	FEC	FEC	none	FEC
Frequency Reuse	3	1	16	7×3 ²	7 or 3×3	9	1
Max Ave Tx Power	—	200 mW	12.5 mW	100 mW	125 mW	20.8 mW	500 mW
Tx Power in Time Slot	1 W	—	100 mW	600 mW	1 W	250 mW	—
Slot Length	625 μ s		312.5 μ s	6.7 μ s	577 μ s	417 μ s	—
Frame Length	20 ms	20 ms	2.5 ms	40 ms	4.615 ms	10 ms	—
End to End Speech Delay	80 ms	50 ms	9 ms	110 ms	90 ms	28 ms	13.25 ms
Vocoder	CELP (8 Kbps) ADPCM (16, 24, 32, 40 Kbps)	Variable Rate QCLP (8/4/2/1 Kbps)	ADPCM (32 Kbps)	VSELTP (8 Kbps) LDCELP (16 Kbps)	RPE-LTP (13 Kbps)	ADPCM (16-32 Kbps)	ADPCM (32 Kbps)
Equalizer	no	no	no	yes	yes	no	no

Note:

- ¹ SHO = soft hand-off
- ² 7×3 = 7 cells, 3 sectors per cell
- ³ TDD in unlicensed band

³ *Interconnection/PCN: a 'synergistic' alliance?*, TE&M, September 15, 1991

⁴ *PCS and the Big Picture*, Table A-2, by Kenneth Brown
<http://strategis.ic.gc.ca>

This committee also identified two PCS environments:

- High tier: for high mobility and/or low-density applications
- Low tier: for low mobility and high-density applications

9.2.1 Low Tier Systems

[Microcellular Solutions by Nortel](#)

[CDMA Base Station Controller by Nortel](#)

The low tier systems are not clearly defined but operate much like the present home cordless phone. The handsets must be low cost, lightweight, and have low transmission power.

These systems would be used in high-density areas and utilize very small pico cells. Handsets would be usable inside buildings equipped with a wireless PBX. In outside environments, radio basestations would be placed on poles or other convenient structures throughout the coverage area.

The radio method used to implement low tier systems does not necessarily have to be the same as used in high tier systems. If however, the objective is to make a comprehensive PCS facility, dual mode phones are necessary. This unfortunately works against the handset objectives.

Frequency Band [MHz]	Rx: 1930-1990 Tx: 1850-1910
Access Method	PACS based on PHS cordless DCT-U based on DECT cordless Composite CDMA/TDMA
Cell Size	< 5 km
Terminal Speed	< 50 kph
Terminal Power Level	< 100 mW
Data Rate	32 Kbps

Although it appears that much of the world intends to use GSM for low tier systems, in North America DCT and PACS seem to be preferred.

9.2.2 High Tier Systems

These systems are more clearly defined than low tier systems and are in fact nearly identical to the present cellular networks.

Frequency Band [MHz]	Rx: 1930-1990 Tx: 1850-1910
Access Method	PCS TDMA based on IS-136 cellular PCS CDMA based on IS-95 cellular PCS 1900 based on GSN cellular
Cell Size	< 50 km
Terminal Speed	< 200 kph
Terminal Power Level	< 1 W
Data Rate	13 Kbps

In Europe, and much of the rest of the world, GSM900 is being deployed. This is expected to migrate to the 1.8 GHz band, where it is called DCS1800.

GSM is suitable for both high and low tier systems.

In North America, it appears that there will be three competing high tier systems: IS-54, IS-95, and PCS1900. Only the last one is based on GSM.

9.3 UMTS

<http://www.umts-forum.org/>

<http://home.intekom.com/cellular/umts.htm>

[UMTS Brochure from Nortel](#)

[Report No. 6 from the UMTS Forum UMTS/IMT-2000 Spectrum](#)

[Report No. 7 from the UMTS Forum Candidate Extension Bands for the UMTS/IMT-2000 Terrestrial Component](#)

[Report No. 8 from the UMTS Forum The Future Mobile Market](#)

One of the European proposals to providing PCS is called UMTS[†]. It is intended to support:

- 2 Mbps data for indoor users
- 144 Kbps data for WANs
- Mixed traffic [multimedia]
- Wideband local loop enhancement

A number of cell sizes have been identified in order to provide universal access.

Cell Type	Range	Application
Umbrella cells	Hundreds of km	Satellite mobile
Hyper cells	>20 km	Rural areas
Macro cells	1 – 2- km	Highways
Micro cells	100 m – 1 km	Cities
Pico cells	< 100 m	Offices, home

It is felt that this can be provided by the natural evolution of GSM and will be fully operational by the year 2005.

As of 1996, there were 153 GSM based networks [GSM 900, DCS 1800, PCS 1900] in operation in 91 countries serving 21 million subscribers. The subscription rate is presently increasing by 1.5 million a month. It is expected that the total number of users will reach 100 million by the end of the century.⁵

In order to provide worldwide coverage, GSM must be adopted by satellite service providers. It appears that this will be the case and Iridium, ICO, and Globestar will support it.

[†] Universal Mobile Telecommunications Services

⁵ GSM Evolution towards UMTS, by Greger Ber, www.ericsson.se

Significant developments are still needed to make this possible. At the moment, GSM can only support 9.6 Kbps data. This is sufficient for faxes and other low speed data service, but is completely inadequate for Internet access or multimedia communication. These needs are expected to be addressed by HSCSD[†] and GPRS[†].

9.3.1 HSCSD

<http://www.option.com/techno/hscsd.htm>

http://www.etsi.org/SMG/work/HSCSD_spec.htm

High-Speed Circuit Switched Data services can be provided by bundling up to 8 TDMA time slots. This will allow the service provider to offer variable bandwidth on demand. Among other things, it will make mobile videophone possible.

9.3.2 GPRS

<http://www.mobileapplicationsinitiative.com/>

<http://www.cellular.co.za/gprs-intro.htm>

<http://www.mobilegprs.com/>

<http://www.pcsdata.com/paprysavy.htm>

This packet switching technique uses channel coding to provide an effective throughput of 14.4 Kbps per channel. Concatenating 8 of these will result in a maximum throughput of 115 Kbps. This service will be used for bursty traffic. How this will eventually be increased to 2 Mbps remains unknown.

It is expected to operate in a similar way to the present SMS[†]. Messages will be stored by the service provider if the terminal is powered down. The user is automatically notified once they activate the terminal.

9.3.3 CAMEL[†]

In order to be universal, it is necessary that the system support worldwide IN services. It is expected that features such as roaming will be provided by CAMEL, which is part of GSM Phase 2+. The intent is to create a system that will provide constant speech quality, data services, security etc. throughout the world.

[†] High Speed Circuit Switched Data

[†] General Packet Radio Service

[†] Short Message Service

[†] Customized Applications for Mobile Networks Enhanced Logic

Assignment Questions

Quick Quiz

1. Some vendors make a distinction between cellular and PCS services based on transmission frequency. [True, False]
2. High tier PCS is based on cellular technology. [True, False]
3. Low tier PCS can be based on cordless telephone technology. [True, False]
4. It is not possible to base high and low tier PCS on the same technology. [True, False]
- 5.

Composition Questions

- 1.
- 2.
- 3.
- 4.

For Further Research

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Vendors <http://www.attws.com/>

<http://www.ameritech.com/>

<http://www.airtouch.com/>

<http://www.sprintpcs.com/>

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<http://www.nortel.com/>

<http://www.primeco.com/>

<http://www.qualcomm.com/>

<http://www.motorola.com/>

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<http://lgcwireless.com/>

<http://www.cellworks.com/hmpg.html>

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Comments

<http://web.globalserve.net/~punter/Technical%20Comparison.htm>

Pointer Sites

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PCS

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A list of the world's cellular systems

<http://www.teletechnics.com/reference/telecom/cellular.html>