Chapter Contents

7.0 Radio Systems

Objectives

This section will:

- Examine various multiplexing schemes
- Discuss cellular radio techniques
- Examine the Nortel DMS-MTX
- Consider international approaches to cellular phones
- Introduce mobile data radio

Minimum Reading

Wireless Internet Networks by Alcatel

For Advanced Students

http://www.cellular.co.za/cellular-networks-world-a-ch.htm

Wireless Internet Network Communications Architecture by Motorola

There are several terrestrial radio based communications systems deployed today. They include:

- Cellular radio
- Mobile radio
- Digital microwave radio

Mobile radio service was first introduced in the St. Louis in 1946. This system was essentially a radio dispatching system with an operator who was able to patch the caller to the PSTN via a switchboard. Later, an improved mobile telephone system, IMTS, allowed customers to dial their own calls without the need for an operator. This in turn developed into the cellular radio networks we see today.

The long haul PSTNs and packet data networks use a wide variety of transmission media including:

- Terrestrial microwave
- Satellite microwave
- Fiber optics
- Coaxial cable

In this section, we will be concerned with terrestrial microwave systems. Originally, microwave links used FDM exclusively as the access technique, but recent developments are changing analog systems to digital where TDM is more appropriate.

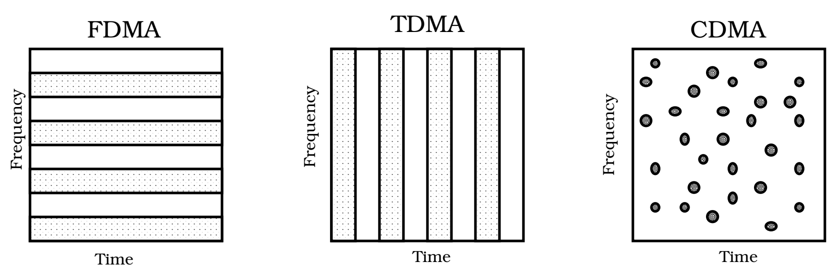
7.1 Access Techniques

Access techniques can be divided into two categories: fixed assignment, and random access.

7.1.1 Fixed Assignment Access

Three basic methods can be used to combine customers on to fixed channel radio links:

- FDMA† - analog or digital
- TDMA† - three conversation paths are time division multiplexed in 6.7 mSec time slots on a single carrier.
- CDMA† - this uses spread spectrum techniques to increase the subscriber density. The transmitter hops through a pseudo-random sequence of frequencies. The receiver is given the sequence list and is able to follow the transmitter. As more customers are added to the system, the signal to noise will gradually degrade. This is in contrast to AMPS where customers are denied access once all of the frequencies are assigned code division multiple access [digital only]



FDMA and TDMA have already been covered to some extent. CDMA is a method that has been around for quite some time, mainly for military applications.

CDMA uses frequency hopping to spread the signal over the entire time-frequency window. The modulated bandwidth may be hundreds of times greater than that of the baseband signal. The frequency-hopping pattern is determined by a code known only between the transmitter and designated receiver. Consequently, this system has high antijam and security properties.

† Frequency Division Multiple Access

† Time Division Multiple Access

† Code Division Multiple Access

Notes

Capacity Comparison[1]

Characteristic	FDMA [AMPS]	TDMA	CDMA
Operating Cellular Bandwidth [MHz]	12.5	12.5	12.5
Frequency Reuse Factor [K]	7	7	1
RF Channel Bandwidth [MHz]	.03	.03	1.25
# RF Channels	12.5/.03=416	12.5/.03=416	12.5/1.25=10
# RF Channels per Cell	416/7=59	416/7=59	10/1=10
Voice Usable RF Channels per Cell	57	57	10
# Voice Channels per RF Channel	1	3	~38
# Voice Channels per Cell	57x1=57	57x3=171	10x38=380
Sectors per Cell	3	3	3
Voice Calls per Sector	57/3=19	171/3=57	380
Capacity vs. AMPS	1x	3x	20x

7.1.2 Random Access

The random access techniques are found in time multiplexed schemes and include:

- ALOHA [pure, slotted, reservation]
- CSMA/CD

These techniques are used exclusively for data applications and will be discussed later in this section.

7.2 Cellular Telephone Systems

Minimum Reading

http://www.cnp-wireless.com/index.html

http://www.iit.edu/~diazrob/cell/intro.html

http://www.wow-com.com/

Cellular telephones provide mobile voice/data access to the telephone network and should not be confused with older radio telephone systems which requires an attendant operator to connect the end-user to the telephone network. Modified versions called dispatcher networks are still used by taxicab companies and others in private networks.

The current cellular system is experiencing unprecedented growth in subscribers, services, and technological innovation. Some of the offered services include:

- Paging, vehicle location
- Text, data, facsimile transmission
- Traffic, weather information
- Emergency aid dialing
- Electronic funds transfer for fare payment

[1] Telecommunications, March 1993

There are however, some areas of great concern:

- Computerized call hand-offs between cell sites
- Caller identification
- Remote diagnostics
- Reliability
- Technology mix [digital, analog, UHF, audio, computer]
- Billing
- Long distance paging

Each subscriber is assigned transmit and receive frequencies for the duration of a call. The frequency pair is sometimes referred to as the forward and reverse channels, or the up and down link. Under control from the cell site, the cellular phone must be able to tune to any of the hundreds of frequency channels in the system.

Some of the adjacent cells will monitor the signal strength from the portable unit in order to help the central exchange to determine which cell site should handle the call. If at some time, this signal becomes weaker because the customer has moved into another cell service area, a call hand–off will be necessary. This requires that the cellular phone switch to another set of frequencies, and the calling path be rerouted. All of this must appear transparent to the user.

7.2.1 Cellular Phone Services

Roaming

In some areas, there may be more than one cellular system. In other areas, two different systems may be adjacent to each other. Many subscribers in one system may find it beneficial to be able to access both networks. This is normally accomplished by the subscriber also registering in the competing network. This can be done in advance or on a per call basis. Or it may be done by a prior agreement between the various cellular carriers.

DIMA[†]

This allows a telephone user to page any mobile user within the service area.

Networking

As cellular systems become more wide spread, it may become necessary to offer the local MTX services over a multi host environment. For example, an MTX to MTX hand-off or DIMA can be expanded to include a wide area search to locate a customer who may have left the local MTX coverage area.

[†] Direct Inward Mobile Access

Notes

Analog Cellular Systems[2]

Standard	Principle Location	Mobile Tx/Rx [MHz]	# Channels	Spacing [KHz]
AMPS	Americas Australia	824-849/869-894	832	30
TACS [1]	Europe	890-915/935-960	1000	25
ETACS	UK	872-905/917-950	1240	25
NMT 450	Europe	453-457.5/463-467.5	180	25
NMT-900 [2]	Europe	890-915/935-960	1999	12.5
C-450 [2]	Germany, Portugal	450-455.74/460-465.74	573	10
RTMS	Italy	450-455/460-465	200	25
Radiocom 2000 [3]	France	192.5-199.5/200.5-207.5 215.5-233.5/207.5-215.5 165.2-168.4/169.8-173 414.8-418/424.8-428	560 640 256 256	12.5
NTT [2, 3]	Japan	925-940/870-885 915-918.5/860-863.5 922-925/876-870	600/2400 560 480	25/6.25 6.25 6.25
J/NTACS [2,3]	Japan	915-925/860-870 898-901/843-846 918.5-922'863.5-867	400/800 120/240 280	25/12.5 25/12.5 12.5

Notes:

[1] 890-915/935-890 MHz is now allocated to GSM in Europe

[2] The channel spacing is half the normal channel bandwidth, the system uses frequency interleaving to overlap channels

[3] Different frequencies are used in different parts of the country

Cellular System Comparison

Characteristic[3]	AMPS	GSM1	GSM2	ADC	JDC
System Bandwidth [MHz]	25	25	25	25	25
Channel Bandwidth [KHz]	30	25	12.5	10	8.33
Channels per System	832	1000	2000	2500	3000
Re-use Factor	7	3	3	7	4
Channels per Site	119	333	666	357	750
Erlang Density	12	40	84	41	91
Capacity Gain	1	3.4	7.1	3.5	7.6
Access Method	FDMA	TDMA	TDMA	TDMA	TDMA
Carrier Spacing [KHz]		200	200	30	25
Users per Carrier	1	8	16	3	3
Voice Bit Rat [Kbps]	–	13	6.5	8	8
Total Bit Rate [Kbps]	–	270	270	48	42
Required C/I [dB]		9	9	16	13

Notes:

ADC - American Digital Cellular. Introduced in 1991

JDC - Japanese Digital Cellular

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[2] Based on Table 1, *Overview of Wireless Personal Communications*, IEEE Communications Magazine, January 1995

[3] *Cellular Gets Personal*, TE&M, February 15, 1992

7.2.2 AMPS

AMPS† is an analog system based on FDMA and used extensively in North America. It has been slightly modified since its inception and some of its characteristics are:

- Channel width: 30 KHz
- Duplex spacing: 45 MHz
- Data transmission: BFSK ±8 KHz deviation
- Output power: .6 to 4 watts

Characteristic	Original AMPS	Present AMPS
Full duplex channels	666	832
Mobile Tx Frequency Range	825.03 - 844.98 MHz	824 - 851 MHz
Mobile Rx Frequency Range	870.07 - 889.98 MHz	869 - 896 MHz

The present system divides the 832 channels into two blocks of 416 channels. Within each block, 21 channels are reserved for signaling.

Some of the weaknesses associated with this system include:

- Call blocking during busy hours in urban areas
- Misconnects and disconnects due to rapidly fading signals
- Lack of privacy and security
- Limited data transmission [1200 bps]

One technique, which has been put forward to resolve some of the congestion problem now found in the major urban areas, is to narrow the channel broadcast bandwidth. NAMPS† increases system capacity by splitting each 30 KHz AMPS channel into three 10 KHz channels. This is seen as an interim solution until a better scheme is agreed upon.

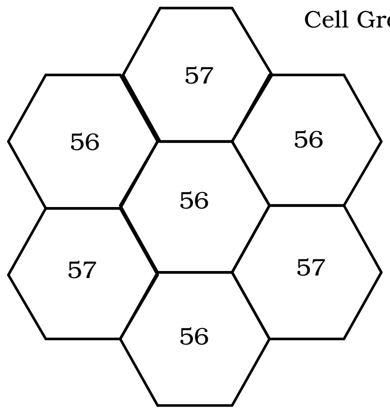
Cell Channel Allocation

It is not possible to assign all channels to each cell since adjacent cells using the same frequencies would interfere with each other. The channel distribution in the 832-channel system is as follows:

- A cell group of 7 adjacent cells, share 416 full duplex channels
- No cell contains any adjacent frequency channels
- 4 cells are assigned 56 channels
- 3 cells are assigned 57 channels
- 21 channels are reserved for control

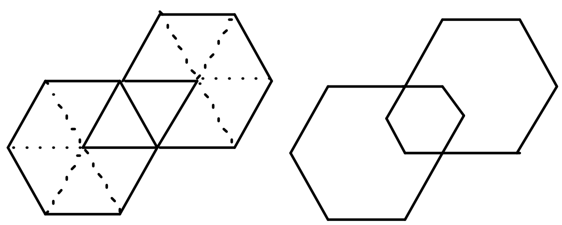
† Advanced Mobile Phone Service

† Narrow band AMPS



Frequency utilization can be improved by cell splitting and sectoring. These approaches effectively reduce the size of the customer service area and allow frequencies reuse. This increases the number of hand-offs and other demands on the MTX.

Cell splitting involves the creation of a new smaller cell from two larger ones, while sectoring is the breakup of a single cell into smaller ones. Typically, cell sites are split 3 or 4 to 1.



Cell Sectoring   Cell Splitting

To minimize spill over into nearby cells, the cell antennas are given a slight downward tilt, and the output power is limited to 100 Werp.

Another way to increase utilization is by channel borrowing. A few channels are allowed to violate the normal frequency assignments and move between cells. This allows the system to dynamically vary the number of customers that can be served in a given cell. Careful consideration must be given to potential co-channel interference

This principle can be further extended to provide dynamic channel assignment, where the assigned cell frequencies are continually changing to meet the shifting demand patterns.

DMS-MTX System[4]

☞ Minimum Reading

[DMS-100 Wireless System (Product Brief)]

[DMS-100 Wireless System (Carrier Solutions)]

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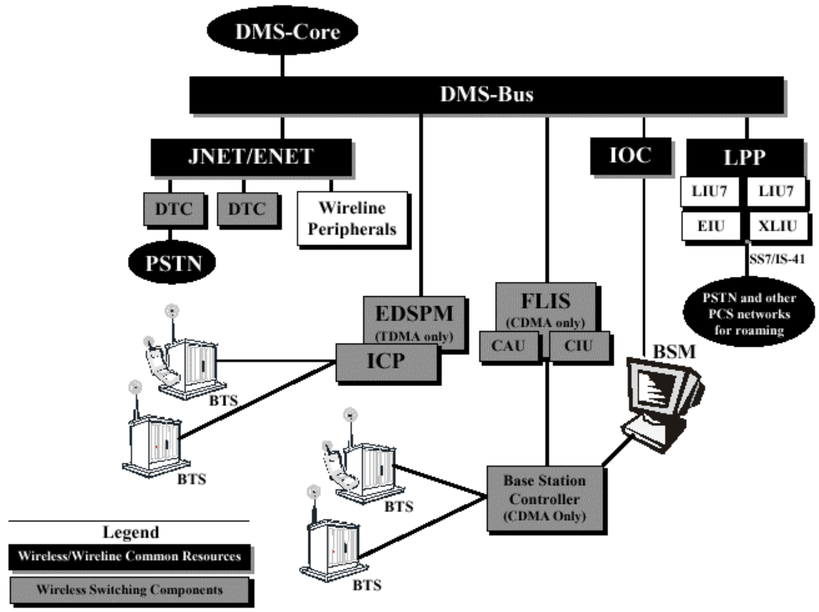
4 *DMS–MTX Cellular Mobile Telephone System*, Telesis 1988 four

_____ Notes _____



JNET – Junctor Network. JUNCTOR - An intraoffice trunk set up as a connection between points in a switching system.

The DMS-MTX is based on the DMS-100 SuperNode and can be configured in two basic ways:

- Stand-alone system interfaced to the PSTN, with a maximum of 50,000 subscribers
- A multi-function DMS such as the DMS-250/MTX, which acts as two distinct switches sharing the same CPU, memory, and network resources.

Because of the wide range of radio transport standards being implemented, the Nortel product has been designed for maximum flexibility. Some of the radio standards it supports include:

- IS-95 CDMA
- IS-41 TDMA
- AMPS
- CDPD
- Dual modes

The cell site is capable of backhauling voice and data traffic over ATM links to either public or private ATM networks.

Cell Site Controller

The cell controller is based upon the XPM peripherals, occupies a dual shelf, and runs in the hot standby mode.

Each equipment shelf consists of:

- Signaling Processor

Handles the Tx and Rx messages to the MTX by an HDLC controller and generates the system overhead messages

- HDLC Controller
  Performs link synchronization & control, error detection & recovery, and sanity monitoring. It communicates to the signaling processor by an X.25 link.
- Master Processor
  Performs the call processing, maintenance & diagnostics, and administrative functions

Radio Control Units

- Control Channel - handles paging/access functions and maintains the data stream
- Voice Channel - used to carry the conversation and process the SAT[†] , ST[†] and RSSI[†]
- Locate Receiver - measures the RSSI for hand-off

Call sequence initiated by the mobile user:

- Mobile user enters the telephone number and depressed a SEND key
- The radio sends an access request to the cell site on a signaling channel including a MIN[†]
- The cell site relays the request to the MTX
- The MTX verifies the MIN and validates the number called, and allocates an idle voice channel at the cell site
- The cell site controller informs the mobile radio via the control channel, of the frequency assignment and transmits a SAT on that channel
- The mobile radio loops back the SAT to the cell site to confirm the channel selection
- The cell site informs the MTX that the link has been established, and sends a ring back tone to the mobile unit
- The MTX seizes an idle outgoing trunk to the PSTN and forwards the number called
- When the called party answers, the ring back tone is discontinued and the two parties are connected

If the mobile unit disconnects:

- A 1.8 second signaling tone is sent to the cell site
- The radio channel controller idles the voice path and messages to the cell site controller
- The site controller relays the message to the MTX which then drops the PSTN trunk

If the far end disconnects the process direction is reversed.

[†] Supervisory Audio Tone

[†] Signaling Tone

[†] Received Signal Strength Indicator

[†] Mobile Identification Number

To call a mobile user:

- The PSTN alerts the MTX
- The MTX sends a page request to all cell sites
- All cells broadcast the MIN over a signaling channel
- All cellular radios in the calling area are constantly scanning the control channels for their MIN
- The mobile unit generates a page response an call setup is initiated

For Advanced Students

7.2.3 Aurora 400 Obsolete

This system is used in Alberta and operates at 400 MHz. There is also an Aurora 800 system but its fate is uncertain.

7.2.4 TACS

The TACS† system has a 25 MHz bandwidth and a 25 KHz channel spacing, allowing for a possible 1000 subscribers in a cell cluster.

Frequency	860 - 960 MHz
Channel Spacing	25 KHz
Duplex Spacing	45 MHz
Signaling Rate	8 Kbps

7.2.5 C-450

This system is actually comprised of two networks running in two different frequency bands. The 450 MHz system can handle more than 100 thousand subscribers and the 900 MHz one can handle more than 2 million.

The cell boundaries are not fixed, but are dynamically adjusted for load sharing, and hand-off can be forced on distance criteria alone. The mobile and cell site transmit power levels are automatically adjusted to match the calculated distance to the subscriber. Each cell regularly interrogates users within its boundaries, thus the network knows the location of all mobile users.

If co-channel interference occurs, the cell site can generate an intra-cell hand-off by reassigning the mobile frequency.

- Tx & Rx frequencies are assigned only after the connection through the PSTN is completed
- Speech is time compressed to include a 5.28 Kbps FSK data burst in the voice channel. This is used for intra-cell hand-off
- A 256 state scrambler is assigned on each speech channel to ensure privacy
- The system architecture is decentralized

† Total Access Communications System

7.2.6 NMT-900

http://www.damm.dk/nmtsys/nmtsys.htm

The NMT-900[†] is considered by some to be the leading system in the world, covering large parts of Sweden, Norway, Finland, and Denmark. It is also found in Spain, Tunisia, Netherlands, Austria, and Ireland.

The MTX is an AXE-10 switch. The system has a maximum of 1999 channels in a cell cluster, nearly double that of TACS.

NMT450 450 - 470 MHz original system 180 channels

NMT900 860 - 960 MHz new system

- A 4 KHz tone is added to the speech channel to monitor transmission quality
- If the tone quality deteriorates, the mobile phone generates a hand-off request

7.2.7 Radiocomm 2000

This system is deployed in France.

The following frequencies are assigned in the major centers:

Mobile Tx/Rx 192.5 - 199.5 / 200.5 - 207.5 MHz

Mobile Tx/Rx 215.5 - 233.5 / 207.5 - 215.5 MHz

The rest of the country is assigned:

Mobile Tx/Rx 165.2 - 168.4 / 169.8 - 173 MHz

Mobile Tx/Rx 414.8 - 418 / 424.8 - 428 MHz

Channel Spacing 12.5 KHz

- Subscribers can only access repeater stations to which they are registered
- At busy times, repeater stations invoke a call time limit
- Cell Tx power is 50 Watts, with a radius of 20 - 30 Km
- Connections between cells is made via the PSTN

7.2.8 GSM [5]

Minimum Reading

GSM by IEC

North American GSM Service Areas

http://www.comms.eee.strath.ac.uk/~gozalvez/gsm/gsm.html

[†] Nordic Mobile Telephones

[5] *The GSM cellular telephone system and its components,* Electronic Engineering, March 1991

GSM† is a third generation wireless telephone technology that will allow roaming in 17 European countries[6]. It supports:

- Voice and data integration over a single channel and will assist in the deployment of ISDN
- Speech and data encryption
- Group 3 fax

GSM uses a TDMA access format and has a call hand-off capability, thus increasing customer mobility and allowing inbound calls. Base stations can handle 124 frequency bands. Channel 0 is performs a dual role of providing a signaling channel and monitoring signal strength. All other channels can be assigned to subscribers.

Up Link Frequency 890 - 915 MHz

Down Link Frequency935 - 960 MHz

Carrier Spacing 200 KHz

- Can support 1000 speech or data channels
- Uses GMSK† modulation

One of the few areas where there is an improvement over the NTM900 system is in better noise immunity.

It may be that GSM will evolve into GSM1800 operating at 1.8 GHz, and supporting PCN.

7.3 PCN

PCN† is one of the most talked about areas in modern telecommunications is that of portable and personal communications[7]. 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.

In some areas the acronym PCS is used instead of PCN. There are a number of different proposals for PCS standards:

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† Groupe Speciale Mobile

6 *Europe's GSM: Passage to Digital*, TE&M, September 15, 1990

† Gaussian Minimum Shift Keying

† Personal Communications Network

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

Potential PCS Standards[8]

Standard	Company
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

In the United States, the TIA[†] has suggested that the number of proposed systems to be considered limited to seven.

TIA/JTC Standards for Consideration[9]

	TAG-1	TAG-2	TAG-3	TAG-4	TAG-5	TAG-6	TAG-7
Based on	_	IS-95	PACS	IS-136	DCS/GSM	DECT	_
Access	CDMA/ TDMA/ FDMA	DS-CDMA	TDMA	TDMA	TDMA	TDMA	DS-CDMA
Duplex	TDD	FDD	TDD/FDD	TDD/FDD	TDD/FDD	TDD	FDD
Modulation	QCPM	OQPSK / QPSK	π/4 - DQPSK	π/4 - DQPSK	GMSK	GFSK	OQPSK / QPSK
Speech rate [Kbps]	32	8 & 13.3	32	7.95	13	32	32
Channel spacing	5 MHz	1.25 MHz	300 KHz	30 KHz	200 KHz	1728 KHz	5 MHz
# time slots	32	–	8	6 (3)	8	24	–
Slot length	625 μs	–	312.5 μs	6.7 ms	577 μs	417 μs	–

PCN 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 PCN environment, since they already have so much experience with personal radio systems. It is expected that there will be in excess of 40 million PCN subscribers in the US alone, by the turn of the century.

The immediate applications for PCN include:

- Mobile microcellular phone
- Wireless PBXs

[8] TE&M, December 1, 1993

[†] Telecommunications Industry Association

[9] *T&M vendors get ready for the PCS challenge*, ep&t, March/April 1996

- Wireless LANs
- Transaction processing
- Alarm monitoring
- Computer aided dispatch
- Environmental monitoring
- Traffic control
- Utility meter reading
- Gateway services to wireline/cellular networks
- On line transaction processing
- Voice messaging
- Electronic data interchange
- Value-added network support

Personal Communications Network Services of New York has an FCC experimental license to test PCN services in the 1850 – 1990 MHz band.[10]

7.4 Mobile Data Radio Systems

This industry is reported to be worth 10B$US in 1999. http://www.cellular.co.za/

Minimum Reading

A Survey of mobile Data Networks by Salkintzis et.al.

There are a number of systems providing these types of services[11].

System	Comments
ARDIS	Provides 1 - 3 channels, 4800 bps, in-building & on the street coverage for data only. Available in 500 cities.
CDPD	19.2 Kbps, fixed or mobile data only. Uses the existing cellular radio facilities & can provide cell site vehicle location.
CoveragePLUS	Provides approximately 20 channels, 4800 bps, mobile data and voice in most areas. Uses satellite facilities & can provide vehicle location via LORAN C.
Digital Radio Networks	Provides only 1 channel, 5000 bps, fixed data only. Available in 65 cities.
Mobitex	Provides 10 - 30 channels, 8000 bps, fixed or mobile data only. Uses packet switching techniques to increase capacity. This system was first developed in Europe, where it also carries voice. It can now be found in about 100 North American cities

Many of these systems use the existing cellular telephone networks, which can be supplemented by microcellular equipment. In-building fiber or fiber to the

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

11 *Wireless MANs/WANs Offer "Data to Go",* Business Communications Review, February 1991

curb, coupled to ONUs with wireless access, create microcellular environments. Wireless applications and issues are being widely examined.[12]

The principle access technique for radio data systems is some form of ALOHA or CSMA/CD.

7.4.1 ARDIS

For Advanced Students

http://www.ardis.com/

ARDIS[†] is the result of corroboration between Motorola and IBM, and provides both mobile and in-building coverage in more than 500 US cities. Although it does not support voice, allows customers to communicate via RF data packets to truck fleets. Its two-way file transfers size is usually less than 10 K bytes. The base stations transmit 40 watts, providing a coverage radius of 10 to 15 miles.

Host controllers are located in: New York, Lexington, Chicago, and Los Angeles. There are approximately 32 network controllers, and 1250 base stations. The network backbone is implemented on leased telephone lines.

The FDMA RF links operate in the 800 MHz band has a bandwidth of 25 KHz and a duplex spacing of 45 MHz. The link supports 19.2 Kbps, of which 8 Kbps is for the customer and the balance, is overhead. It supports X.25, SNA, async, or bisync.

The portable units use DSMA[†] access that is very similar to CSMA/CD except that it is sensing the state of a busy bit originating from the base station.

7.4.2 Mobitex

For Advanced Students

http://www.mobitex.org/

http://www.data-mobile.com/

http://www.ericsson.com/wireless/products/mobsys/mobitex/mobitex.shtml

The Mobitex system has been implemented in Europe and North America. The North American version however, does not carry voice. This system is more hierarchical than that of Ardis.

The overall network consists of 5 layers: NCC[†], national switches, regional switches, local switches, and base stations. At the moment there are about 800

[12] *Enabling Technologies for Wireless In-Building Network Communications – Four Technical Challenges, Four Solutions,* IEEE Communications Magazine, April 1991

[†] Advanced Radio Data Information Service

[†] Data Sense Multiple Access

base stations in the US. The distributed switching structure allows two end-users in the same service area to contact each other without having to route all the way to the NCC.

Mobitex operates in a similar way as the cellular telephone system except that hand-offs are manages by the mobile user instead of the network. As the mobile user enters a new service area, the mobile terminal registers with the nearest base station. This allows the network to support roaming and gives it store-and - forward capability.

The mobile station transmits in the 896 - 901 MHz band and receives in the 935 - 940 MHz band. Each channel has a bandwidth of 12.5 KHz and supports 8 Kbps half-duplex data. The modulation scheme is GMSK, and the access method is dynamic slotted ALOHA.

Scotiabank and Rogers Cantel into the wireless banking and discount brokerage business. The agreement between Rogers Cantel and Scotiabank will enable Scotiabank customers to receive financial information, including bank account and credit card balances and statements, stock quotes, portfolio information and e-mail - all on their Cantel AT&T Interactive Messaging device.

Cantel is no newcomer to transmitting sensitive information over the air. In August of last year, Cantel announced that the Royal Bank of Canada had approved the use of Cantel' s AirPOS (wireless point-of-sale) terminals to service credit and debit card transactions.

The underlying network being used for the Cantel AT&T Interactive Messaging Device is the Mobitex network. Mobitex data communications networks have a rich history of transmitting sensitive, short message data.

7.4.3 CDPD[†] Consortium

For Advanced Students

http://cdpd.org/cdpd/

CDCP by Compaq

This radio packet system is an overlay on the AMPS cellular phone system and is supported by IBM and 8 of the largest cellular carriers in the US[13].

It uses CSMA over unused voice channels. The data connection is switched to another channel when the current channel is needed to make a voice connection. Since numerous carriers are pursuing this idea and no standards organization is responsible for the development of the technique, it is expected that CDPD will become a de facto standard.

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† Network Control Center

† Cellular Digital Packet Data

13 Wireless Information Networks, Kaveh Pahlavan & Allen Levesque, Wiley, 1995

The CDPD basestation [MDBS] is attached to the telco's cellular radio transmitter to facilitate channel sharing. The MDBS is connected to a switching center known as an intermediate system [MD-IS]. The MD-IS connection can be established either by a dedicated microwave link or through the telco.

Each data channel is 30 KHz wide and can support a bit rate of 19.2 Kbps. However, the end-user does not receive this entire rate because of the error detection and flow control algorithms. The RF modulation scheme is GMSK.

Data in the forward channel, to the mobile user [M-ES], is encapsulated into HDLC frames. It is then segmented into 273 bit long blocks. 8 bits for MDBS and MD-IS identification is added. The block is then expanded to 378 bits by a Reed-Solomon coding and by adding synchronization bits.

Data in the reverse channel, to the MDBS, is similarly formatted except that several M-ES can share the same channel. Access is made possible by DSMA/CD, which is the digital equivalent of CSMA/CD.

7.5 ALOHA

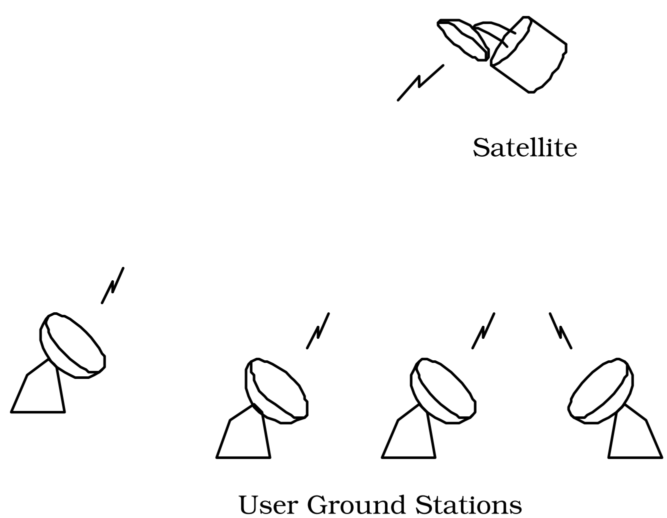
For Advanced Students

http://www-net.cs.umass.edu/kurose/ethernet/LAN.htm

http://mars.mcs.kent.edu/ksuthesis/node18.html

ALOHA is Hawaiian for hello and good-bye.

This type of communications system has great appeal because of its inherent simplicity since it has neither a switch nor controller. There are several versions of ALOHA, each with certain advantages. It is often implemented over a satellite link but it can be used on any radio facility.



User ground stations can transmit data packets to the satellite at any time. The satellite acts as a repeater and broadcasts the packet to all users. To ensure some sort of privacy, the users must provide their own encryption. It is possible however, that two or more users may attempt to transmit up to the satellite at the same time. This condition is called a collision since the data packets involved will be damaged.

To determine whether a collision has occurred, the user initiating the transaction listens to the rebroadcast signal and compares it with the original. If the packet has been corrupted, a collision is assumed to have occurred. Stations attempting to broadcast then back off for a random time and attempt a retransmission. ALOHA systems come in a number of variations, each attempting to increase the overall throughput by minimizing collisions.

7.5.1 Simple ALOHA

In order to simplify the analysis, the following assumptions are made:

- All packets are of constant length
- No cannel noise [i.e. the error rate is not noise dependent]
- Each station can transmit its packet before the next one arrives
- The incoming request for service follow a Poisson distribution.

Definitions:

S network throughput. This expresses how much data the network is actually carrying. It is usually normalized [designated by *s*] and expressed as a fraction of network capacity.

G total data rate presented to the network. This is also generally normalized [designated by *g*].

I total data rate generated by the nodes.

D average delay

The users are independent from each other but share a common uplink resource. Data collisions can occur in the uplink. The total traffic on a channel [*G*] is given by:

$$G = S + R_t$$

Where S = number of new packets arriving

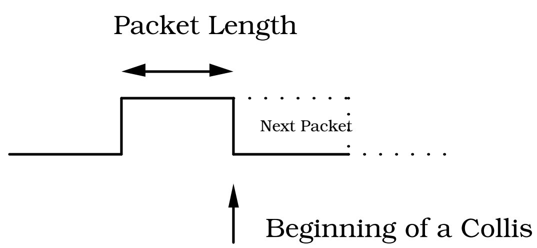
R_t = number of retransmitted packets due to collisions

The number of retransmissions [R_t] is:

$$R_t = G \; x \; PoC$$

Where PoC = probability of collision.

The collision vulnerability period is twice the packet length.



If packets arrive with a Poisson distribution at an average rate of λ, the probability of collision (*PoC*) in a given period of time [*t*] is:

$$PoC = 1 - e^{-\lambda t}$$

Therefore the probability of colliding during a 2 packet length period is :

$$PoC = 1 - e^{-2G}$$

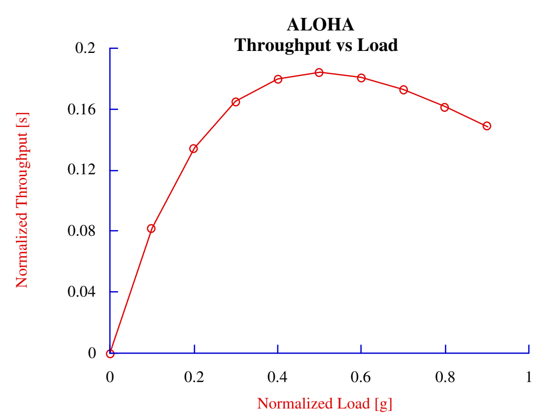
Making the appropriate substitutions, we can express the total traffic [*G*] as:

$$G = S + G\left(1 - e^{-2G}\right)$$

Solving for throughput (*S*):

$$S = Ge^{-2G}$$

A normalized plot of this function [with load varying between 0 and 1] is:



As can be seen from the graph, the throughput rises to a maximum and then falls off. To find the maximum possible throughput, differentiate the equation with respect to *G* and set the result equal to zero:

$$\frac{dS}{dG} = e^{-2G} - 2e^{-2G} \qquad \text{Therefore} \qquad 0 = 1 - 2G$$

In normalized units the maximum system load is, $g = 0.5$. Substituting back into the original equation, we find that the maximum throughput is, $s = 0.18$.

_____ Notes _____

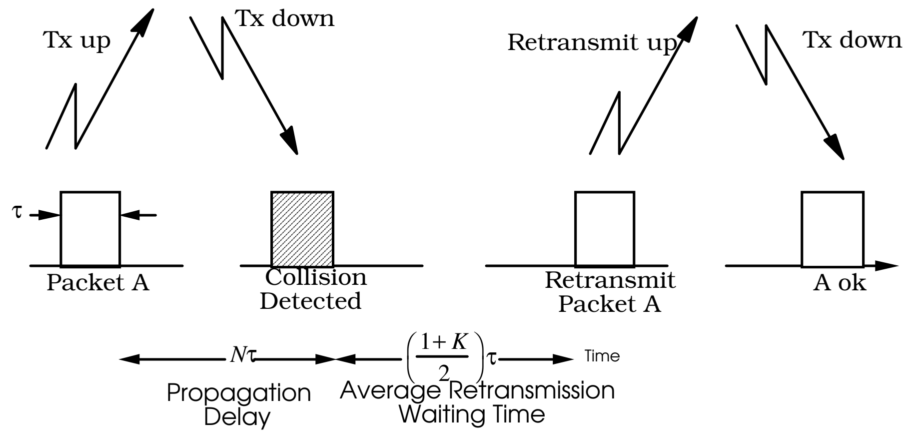
Therefor at maximum throughput:

- The system is running at 1/2 maximum capacity.
- But the actual useful throughput is only 18% of the theoretical maximum
- And the average packet is transmitted g/s = 0.5/0.18 = 2.78 times.

7.5.1.1 Delay Characteristics

Inevitably collisions will occur, forcing a retransmission and creating an inevitable delay. The delay will increase as system load increases since the probability of will collisions increase.

ALOHA Delay Characteristics



Where: τ = packet length

$N\tau$ = propagation time up and down to satellite as a multiple of the packet length

If a collision is detected, a random waiting period of 0 to K packet lengths is invoked before retransmission is attempted. Therefore the average waiting time is:

$$AWT = \frac{(1+K)\tau}{2}$$

This process is repeated G/S times since traffic/throughput represents the average number of times each packet has to be retransmitted before being successfully delivered. The total average delay is then :

$$TAD = \tau + \left[N\tau + \frac{(1+K)\tau}{2} \right] \frac{G}{S} - \frac{(1+K)\tau}{2}$$

The last term removes the average random waiting time on the last transmission since it was successfully received.

Another expression for TAD is:

$$TAD = \frac{\tau}{2}\left[1 + e^{2g}(1+2N) + K\left(e^{2g} - 1\right)\right]$$

Notes

Example:

An ALOHA channel has a maximum capacity of 50 Kbps. If the average packet length is 20 mSec, the propagation delay is 250 mSec, and K = 10, find *G, S, TAD*, and the number of times the average packet is transmitted before being successfully received, if the system is running at maximum throughput.

Solution:

For a simple ALOHA system, the capacity peaks at $g = 0.5$.

Therefor the maximum load is: $G = 0.5 \text{ x } 50 \text{ Kbps} = 25 \text{ Kbps}$

The throughput also peaked at $s = 0.184$.

Therefore the maximum throughput is:

$$S = 0.184 \text{ x } 50 \text{ Kbps} = 9.2 \text{ Kbps}$$

The propagation delay in terms of packet lengths is:

$$N = \frac{250\, mSec}{20\, mSec} = \quad 12.5 \text{ packets}$$

$$TAD = \frac{0.02}{2}\left[1 + e^{2\times.5}(1 + 2\times 12.5) + 10\left(e^{2\times.5} - 1\right)\right] = \quad 0.89\ Sec$$

Average number of times a packet is transmitted before being successfully received:

$$\frac{g}{s} = \frac{0.5}{0.184} = \quad 2.72$$

This may seem to be an inefficient system, but it does have some significant advantages:

- Simple allocation protocol
- Overall average delay is small (typically < 1 sec.)
- No channel capacity is dedicated to inactive users

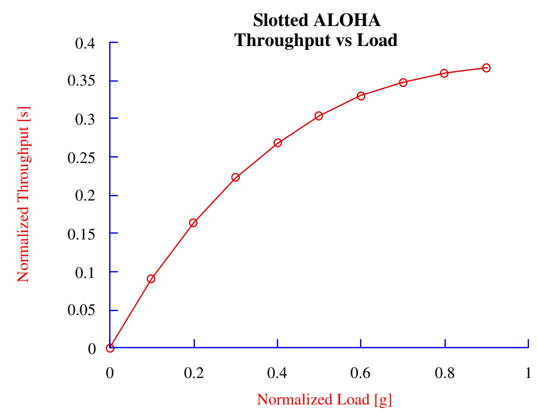
7.5.2 Slotted ALOHA

By establishing fixed time slots, the vulnerability period can be cut in half since packets will entirely collide or not at all. This is accomplished by having the satellite transmit a clock, and ground stations transmit only at the beginning of a time slot, thus preventing partial collisions.

The disadvantages of this system is that the ground stations become potentially complex, as they now must synchronize to the satellite and compensate for its range, which controls the propagation time delay. This also means resources are wasted if the packet is smaller than the time slot.

The throughput for this system is given by: $s = ge^{-g}$.

The maximum throughput of 37% occurs when the load reaches 100%.



At peak capacity, slotted ALOHA can double the channel throughput with a slight increase in average delay. At it peak, the average packet would have to be transmitted *g/s* or 1/0.37 = 2.7 times before being successfully received.

$$TAD = \tau\left(e^{g} - 1\right)\left[\left(1 + 2N + \frac{K+1}{2}\right) + 1.5(N+1)\right]$$

Example:

An S-ALOHA channel has all the characteristics of the previous example. Find *G, S, TAD*, and *g/s*, if the system is running at maximum throughput.

Solution:

G = 1 x 50 Kbps = 50 Kbps

S = 0.368 x 50 Kbps = 18.4 Kbps

TAD = 1.49 Sec.

g/s = 2.72

7.5.3 CSMA - Carrier Sense Multiple Access

This is a listen before talk approach, where the station wishing to transmit only does so when the medium is idle. In order to obtain any benefit, the packet time length must be greater than the propagation delay.

A user may attempt to transmit immediately when the channel is free. This approach is known as I-persistent CSMA, because of its immediacy or 1-persistent CSMA, because the transmission probability is 1. Since collisions occur when two stations transmit simultaneously, and both are equally persistent, the system may go into deadlock. Because of the long transmission delays, this approach does not work on satellite links.

One way to avoid dead lock this is to wait a random time before attempting to transmit. This is known as non-persistent CSMA.

Notes

P-persistent CSMA is used in slotted ALOHA networks. It monitors the channel and sets a timer to some random value with an average value [*p*], which is some fraction of the channel width. If $p = 0$ the stations transmit as soon as the channel is clear, and if $p = 1$, the stations transmit after a one frame time-out. The problem is to determine the optimum value for *p*.

If there are *n* stations, then the number of stations wishing to transmit is *np*. If $np > 1$ then collisions occur more frequently and the system will eventually clog up. If $np < 1$, the stations wait longer before attempting retransmission, therefore reducing collisions, but increasing the average delay.

Modifying the basic frame structure can increase throughput. Each of the following variations increased the complexity and cost of the end-user station:

Reservation

- A frame structure is imposed on a slotted ALOHA channel
- The frame length exceeds the satellite round trip delay
- Each frame is synchronized by a preamble generated by the satellite or a master ground station
- Each packet slot is numbered
- A user wishing to transmit, selects a slot which was not used in the previous frame

Borrowed Slots

- A slot within each frame is assigned to a user
- Users may transmit in any other slot if it has been empty for one frame
- When the rightful owner wishes to use the slot, a transmission is initiated, resulting in a collision
- The borrower, detecting the collision abandons the slot

Subdividing Channels

- A master frame is divided into sub-frames
- The first sub-frame is used to make reservations by identifying the slot number and number of frames to be transmitted
- All other users keep track of each others reservation requests

Summary of ALOHA and CSMA Throughput[14]

Pure ALOHA $s = ge^{-2g}$

slotted ALOHA $s = ge^{-g}$

unslotted 1 - persistant CSMA

$$s = \frac{g\left[1 + g + ag\left(1 + g + \frac{ag}{2}\right)\right]e^{-g(1+2a)}}{g(1+2a) - \left(1 - e^{-ag}\right) + (1 + ag)e^{-g(1+a)}}$$

slotted 1 - persistant CSMA

$$s = \frac{g\left[1 + a - e^{-ag}\right]e^{-g(1+a)}}{(1+a)\left(1 - e^{-ag}\right) + ae^{-g(1+a)}}$$

unslotted nonpersistant CSMA

$$s = \frac{ge^{-ag}}{g(1+2a) + e^{-ag}}$$

slotted nonpersistant CSMA

$$s = \frac{age^{-ag}}{1 - e^{-ag} + a}$$

7.6 Wireless LANs

Minimum Reading

Wireless Data Communications by DEC

Tutorial on IEEE 802.11 by Intersil

For Advanced Students

Wireless LANs by DEC

WIN[†]

Minimum Reading

Wireless Applications Protocol by Apion

Wireless Applications Protocol by phone.com

This approach has the possibility of completely eliminating the large wiring harnesses currently being deployed in large buildings. This would reduce costs, while offering increased flexibility to the end-user. There are however, some serious concerns, which may prevent the universal adoption of wireless. Some issues yet to be completely addressed include:

- Reallocation of the radio spectrum

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14 Wireless Information Networks, Kaveh Pahlavan & Allen H. Levesque, Table 11.1

† Wireless In-building Network

- Interference
- Security
- Long term health risks

The main competitor to in-building wireless will probably be fiber optics, which has none of the above concerns. In spite of this, Motorola is developing an 18 GHz microwave LAN which will initially offer an 15 Mbps bandwidth, and may expand eventually to 100 Mbps.[15] The coverage diameter is reported to be a maximum of 35 miles.

For Advanced Students

7.7 Digital Microwave Radio

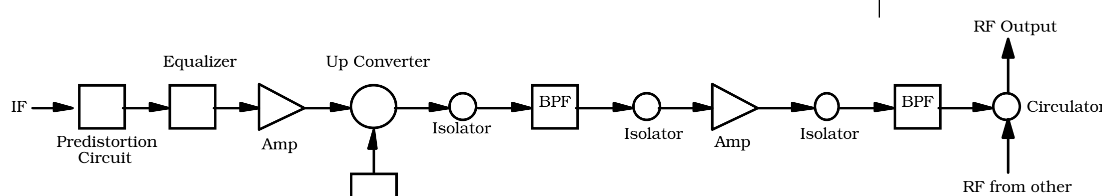
RD Series Digital Microwave[16]

	RD-4A	RD-6A	RD-6B	RD-11
Frequency [GHz]	3.7 - 4.2	5.9 -6.4	5.9 - 6.4	10.7 - 11.2
Data Rate [Mbps]	90.77	135.5	151.93	135.5
Digital Interface	2 x DS-3	3 x DS-3	139.26	3 x DS-3
Power Out [dBm]	25.4	27.5	27.5	33.5
Output Amplifier	solid state	solid state	solid state	TWT
Receive Threshold for 10^{-3} BER [dBm]	-75.0	-73.0	-72.5	-71.3
System Gain [dB]	100.4	100.5	100.0	104.8

The RD series digital microwave radio consists primarily of two components:

- Transmitter/receiver unit
- Signal processor

Transmitter



RD Series Radio Transmitter

The IF input to the transmitter is a 70 MHz, 64 QAM signal. Since the output amplifier compresses high amplitude signals, a pre-distortion circuit applies emphasis to the high amplitude IF components, thus allowing the output amplifier to operate at its maximum power. This has the overall effect of improving the systems linearity, and help lower the bit error rate to 10^{-13}.

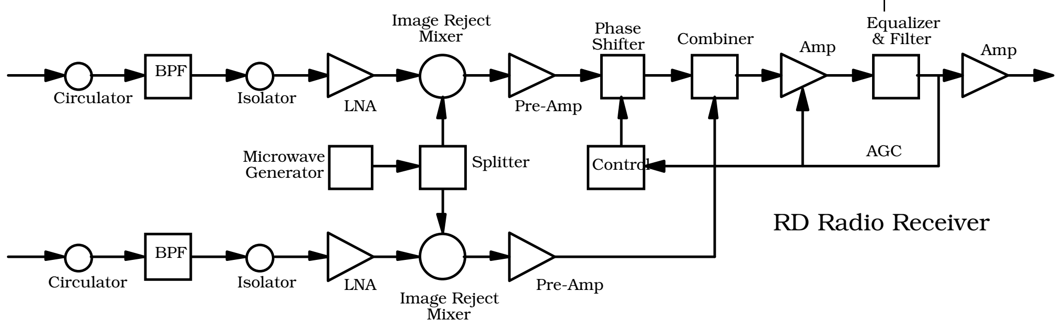
15 *Wireless Communications: The Next Wave*, Telecommunications, December 1990

16 *RD series: Digital microwave radio meets today's challenges*, Telesis 1985 three

The equalizer compensates for group delay caused by the up-converter bandpass filter. The filter strips off one of the sidebands created by the heterodyne operation. An isolator follows each major component after the up-converter. These are ferrite devices that allow signals to pass in the forward direction, but not in the reverse direction. This prevents signals from feeding back into the amplifier and causing damage.

The RF amplifiers operating at 4 - 6 GHz are composed of GaAs FETs, but at 11 GHz traveling wave tubes are employed.

Receiver



RD Radio Receiver

RD-6B

Traffic Allocation	Bit Rate [Mbps]
140 Mbps	139.3
2 x 2 Mbps	4.1
4 x 64 Kbps + 3 x 50 Kbps	0.4
Forward error correction parity	5.3
Overhead	2.4
Total	151.1

SONET Radio

This system is continuing to be expanded as the transmission characteristics of feeder networks continue to improve. In conjunction with the development of FiberWorld, BNR has introduced 512 QAM digital microwave radio.[17]

Nortel offers radio products to meet the low-capacity requirements of cellular, PCS, local access and private networks and high-capacity and long-distance SONET requirements:

- The RD-4/U4 Digital Radio Systems operate in the lower 4 and upper 4 GHz frequency bands and have a main traffic capacity of two DS-3 RD-4C/U4C0 or one E4 (RD-U4B) signals, equivalent to 1,344 or 1,920 voice circuits per channel.
- The RD-6/U6 systems operate in the lower 6 GHz and upper 6 GHz frequency bands and have a main traffic capacity of two or three DS-3s (RD-6C/U6C) or one E4 (RD-6B/U6B).

[17] Telesis, 1989 three

- The RD-8B Digital Radio Systems operate in the 8 GHz frequency band and have a main traffic capacity of one E4 signal, equivalent to 1,920 voice circuits per RF (radio frequency) channel.
- The RD-11 Digital Radio System operates in the 11 GHz frequency band and has a main traffic capacity of three DS-3 (RD-11C) or one E4 (RD-11B) signals equivalent to 2,016 and 1,920 voice circuits per RF channel.
- The S/DMS TransportNode SONET Radio 4/40 system operates in the upper and lower 4 GHz bands with 40 MHz channels. 512 QAM carries up to six STS-1 streams, equivalent to 4,032 voice circuits over each radio channel. SONET Radio4/40 provides an external DS-3 or STS-12 baseband.
- The SDH Radio x/40 product family is a technically advanced digital microwave radio system. Network elements use 512 QAM technology. A single equipment bay can support two STM-1 streams per 40 MHz RF channel, or one STM-4. This corresponds to a spectral efficiency of more than 8 bits/Hz.
- The RW Series is a low and medium-capacity digital microwave radio operating in the 2, 7/8, 15, 18, and 23 GHz frequency bands. It has a capacity of 1, 4, or 8 E1 (DS-1s) or one E3 (DS-3).

7.8 Radio Telecommunications Standards

There are many types of radio telecommunications systems. The following is a list of the more common ones.

Radio System	Standards
Analog Cordless Telephones	CT0, JCT, CT1, CT1+
Digital Cordless Telephones	CT2, CT2+, DECT, PHS
Analog Cellular Telephones	AMPS, TACS, NMT
Digital Cellular Telephones	IS-54/-136, IS-95, GSM, DCS 1800, PDC
Wireless WAN/LAN Data	CDPD, RAM-Mobitex, Ardis-RD-LAP, IEEE 802.11
PCS	High Tier, Low Tier

Some detail for each of these systems are:

Analog Cordless Telephones

CTO-Cordless Telephone O

Frequency (MHz):

2/48 (U.K.)

26/41 (France)

30/39 (Australia)

31/40 (The Netherlands, Spain)

46/49 (China, S. Korea, Taiwan, USA)

48/74, 45/48 (China)

Multiple Access Method: FDMA
Duplex Method: FDD
Number of Channels: 10, 12, 15, 20 or 25
Channel Spacing: 1.7, 20, 25 or 40 KHz
Modulation: FM
Channel Bit Rate: n/a

JCT-Japanese Cordless Telephone
Frequency (MHz): 254/380
Multiple Access Method: FDMA
Duplex Method: FDD
Number of Channels: 89
Channel Spacing: 12.5 KHz
Modulation: FM
Channel Bit Rate: n/a

CT1/CT1+ Cordless Telephone 1
Frequency (MHz): CTI: 914/960, CTI+: 80
Multiple Access Method: FDMA
Duplex Method: FDD
Number of Channels: CT1: 40, CTI+: 80
Channel Spacing: 25 KHz
Modulation: FM
Channel Bit Rate: n/a

Digital Cordless Telephones

CT2/CT2+ Cordless Telephone 2
Frequency (MHz): CT2: 864/868, CT2+: 944/948
Multiple Access Method: TDMA/FDM
Duplex Method: TDD
Number of Channels: 40
Channel Spacing: 100 KHz
Modulation: GFSK (0.5 Gaussian Filter)
Channel Bit Rate: 72 kb/s

DECT-Digital European Cordless Telephone
Frequency (MHz): 1880-1900
Multiple Access Method: TDMA/FDM
Duplex Method: TDD
Number of Channels: 10 (12 users/channel)
Channel Spacing: 1.728 MHz
Modulation: GFSK (0.5 Gaussian Filter)
Channel Bit Rate: 1.152 Mbps

Notes

PHS-Personal Handy Phone System

Frequency (MHz): 1895-1918

Multiple Access Method: TDMA/FDM

Duplex Method: TDD

Number of Channels: 300 (4 users/channel)

Channel Spacing: 300 KHz

Modulation: 1/4 DQPSK

Channel Bit Rate: 384 Kbps

Analog Cellular Telephones

AMPS-Advanced MObile Phone Service

Frequency (MHz): Rx: 869-894, Tx: 824-849

Multiple Access Method: FDMA

Duplex Method: FDD

Number of Channels: 832

Channel Spacing: 30 KHz

Modulation: FM

Channel Bit Rate: n/a

TACS-Total Access Communication System

Frequency (MHz): ETACS: Rx: 916-949, Tx: 871-904

NTACS: Rx: 860-870, Tx: 915-925

Multiple Access Method: FDMA

Duplex Method: FDD

Number of Channels: ETACS: 1240, NTACS: 400

Channel Spacing: ETACS: 25 KHz, NTACS: 12.5kHz

Modulation: FM

Channel Bit Rate: n/a

NMT-Nordic Mobile Telephone

Frequency (MHz):

NMT-450: Rx: 463-468, Tx: 453-458

NMT-900: Rx: 935-960, Tx: 890-915

Multiple Access Method: FDMA

Duplex Method: FDD

Number of Channels: NMT-450: 200, NMT-900: 1999

Channel Spacing: NMT-450: 25 KHz, NMT-900: 12.5 KHz

Modulation: FM

Channel Bit Rate: n/a

_____ Notes _____

Digital Cellular Telephones

IS-54/-136

North American Digital Cellular
Frequency (MHz): Rx: 869-894, Tx: 824-849
Multiple Access Method: TDMA/FDM
Duplex Method: FDD
Number of Channels: 832 (3 users/channel)
Channel Spacing: 30 kHz
Modulation: 1/4 DQPSK
Channel Bit Rate: 48.6 kb/s

IS-95

North American Digital Cellular
Frequency (MHz): Rx: 869-894, Tx: 824-849
Multiple Access Method: CDMA/FDM
Duplex Method: FDD
Number of Channels: 20 (798 users/channel)
Channel Spacing: 1250 KHz
Modulation: QPSK/OQPSK
Channel Bit Rate: 1.2288 Kbps

GSM

Global System for Mobile Communications
Frequency (MHz): Rx: 925-960, Tx: 880-915
Multiple Access Method: TDMA/FDM
Duplex Method: FDD
Number of Channels: 124 (8 users/channel)
Channel Spacing: 200 KHz
Modulation: GMSK (0.3 Gaussian Filter)
Channel Bit Rate: 270.833 Kbps

DCS 1800

Frequency (MHz): Rx: 1805-1880, Tx: 1710-1785
Multiple Access Method: TDMA/FDM
Duplex Method: FDD
Number of Channels: 374 (8 users/channel)
Channel Spacing: 200 KHz
Modulation: GMSK (0.3 Gaussian Filter)
Channel Bit Rate: 270.833 Kbps

PDC-Personal Digital Cellular

Frequency (MHz):
Rx: 810-826, Tx: 940-956

Notes

Rx: 1429-1453, Tx: 1477-1501
Multiple Access Method: TDMA/FDM
Duplex Method: FDD
Number of Channels: 1600 (3 users/channel)
Channel Spacing: 25 KHz
Modulation: 1/4 DQPSK
Channel Bit Rate: 42 Kbps

Wireless Data (WAN/LAN)

CDPD-Cellular Digital Packet Data (WAN)
Frequency (MHz): Rx: 869-894, Tx: 824-849
Multiple Access Method: FDMA
Duplex Method: FDD
Number of Channels: 832 (4 users/channel)
Channel Spacing: 30 KHz
Modulation: GMSK (0.5 Gaussian Filter)
Channel Bit Rate: 19.2 Kbps

RAM-Mobitex (WAN)
Frequency (MHz):
(North America) Rx: 935-941, Tx: 896-902
(Europe/Asia) 403-470
Multiple Access Method: TDMA/FDM
Duplex Method: FDD
Number of Channels: 480
Channel Spacing: 12.5 KHz
Modulation: GMSK (0.3 Gaussian Filter)
Channel Bit Rate: 8 Kbps

Ardis-RD-LAP
Frequency (MHz): Rx: 851-869, Tx: 806-824
Multiple Access Method: TDMA/FDM
Duplex Method: FDD
Number of Channels: 720
Channel Spacing: 25 KHz
Modulation: FSK (2 and 4 level)
Channel Bit Rate: 19.2 kb/s

IEEE 802.11-Wireless LAN
Frequency (MHz):
(North America/Europe) 2400-2483
(Japan) 2470-2499
Multiple Access Method: CSMA

Duplex Method: TDD

Number of Channels: FHSS: 79, DSSS: 7

Channel Spacing: FHSS: 1MHz, DSSS: 11 MHz

Modulation: FHSS: GFSK (0.5 Gaussian Filter), DSSS: DBPSK (1/MB/s), DQPSK (2 MB/s)

Channel Bit Rate: 1 or 2 Mbps

Personal Communications 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

7.9 UMTS

Minimum Reading

http://www.umts-forum.org/index.html

http://www.gsmdata.com/artholley.htm

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

For Advanced Students

No.6 Report from the UMTS Forum

No.7 Report from the UMTS Forum

No.8 Report from the UMTS Forum

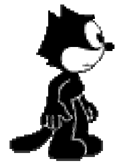
UMTS[†] is a Third Generation mobile system being developed by ETSI within the ITU's IMT-2000 framework. It will provide data speeds of up to 2 Mbps, making portable videophones a possibility. UMTS has the support of many major telecommunications operators and manufacturers.

WRC'92 identified the frequency bands 1885-2025 MHz and 2110-2200 MHz for future IMT-2000 systems, with the bands 1980-2010 MHz and 2170-2200 MHz intended for the satellite part of these future systems.

† Universal Mobile Telecommunications Service

It is expected that UMTS service will be inaugurated in 2002. Full commercial phase is expected in 2002-2005.

Assignment Questions



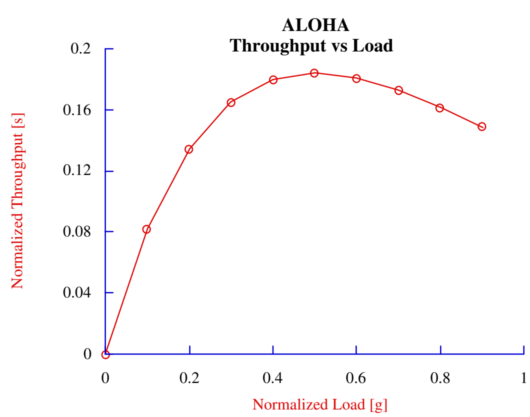
Quick Quiz

1. Frequency hopping is a natural feature of FDMA. [True, False]
2. GSM2 has can place [3.4, 7.1, 7.6] more subscribers than AMPS in the same spectral slot.
3. The AMPS system currently uses [1, 3, 21] control channels per cell.
4. The C-450 cellular system is used in [France, Germany, England].
5. Group 3 fax cannot be supported by GSM. [True, False]

Composition Questions

1. Describe the channel distribution in the Cantel AMPS cellular telephone system.
2. Draw the block diagram of the DMS - MTX system.
3. Discuss the following topics in cellular telephone communications:
   a) Call sequence
   b) Hand-off
   c) Roaming
   d) European systems

4. Explain the significance of the following curve:



5. Discuss the operation and characteristics of the following packet systems:
   a) Simple ALOHA
   b) Slotted ALOHA
   c) CSMA ALOHA

_____ Notes _____

For Further Research

Brody and Ma; "DMS-MTX Cellular Mobile Telephone System", Telesis 1986 four

Pahalavan, Kaveh and Levesque, Allen H.; Wireless Information Networks, Wiley, 1995

Prentiss, Stan; *Introducing Cellular Communications*

Lee, William C. Y.; *Mobile Communications Design Fundamentals*

Mixed–Signal Design Seminar, Analog Devices, 1991

IEEE Communications, January 1995, a special issue on Wireless Personal Communications

http://www-us.semiconductors.philips.com/comms/support/telecomstandards/index.stm

Manufacturers

http://www.dtsx.com/home.html

http://www.fujitsu.co.jp/hypertext/Telcom/digit.html

http://www.fujitsu.com.au/products/networks/sdhradio.htm

http://www.calmike.com/

http://www.nec.com/necwave/

http://www.dmcstratexnetworks.com/

http://www.ericsson.se/

European Microwave News

http://www.pacsat.demon.co.uk/main.htm

GSM

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