S-72.238 Wideband CDMA systems (2 cr.)

- Responsible teacher

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Goals of the course

- To present the driving factors and ideas behind the development of third generation cellular system standards.
- To describe the characteristics of CDMA, its possibilities and problems in a multipath radio channel.
- To facilitate to understand of the WCDMA concept as applied to the UMTS UTRA.
- To give an overview of the UMTS core and radio access network.

Literature

The Course book: “WCDMA for UMTS. Radio Access For Third Generation Mobile Communications.” Edited by: H.Holma, A. Toskala. 2000, John Wiley&Sons. 322 pp.

Also good reading:

“UMTS Networks. Architecture, Mobility and Services.” H. Kaarinen et.al.. 2001,John Wiley&Sons. 302 pp.

“Radio Network Planning and Optimisation for UMTS.” J.Laiho. et. al.. 2002. John Wiley&Sons. 484 pp.

“The UMTS Network and Radio Access Technology.” J.P. Castro. 2001,John Wiley&Sons. 354 pp.

Specifications http://www.3gpp.org/

Outline of the course

1. Introduction to 3G cellular systems. Cellular propagation environment for 3G radio links. Standardisation process.
2. Evolution from GSM to UMTS. UMTS network Architecture.
3. Packet traffic modelling.
4. Introduction to WCDMA: modulation demodulation methods made available at the network level: handover, power control.
5. Radio Access Network architecture (chapter 5).
6. Physical layer (chapter 6).
7. Radio interface protocols (chapter 7).
8. WCDMA radio network planning (chapter 8).
9. Radio Resource management (chapter 9).
10. Packet access (Chapter 10).
11. Physical Layer performance (Chapter 11).

Outline of the lecture

- History of mobile communication.
- Radio Communication peculiarities.
- Vision for UMTS.
- Standardisation process.

History of mobile communications

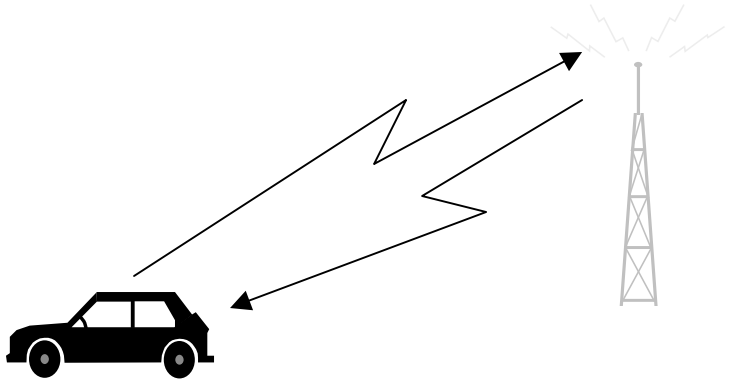
- 1873 Maxwells equations.
- 1886 Hertz demonstrates the existence of radio waves.
- 1895 Marconi patents the wireless telegraph.
- 1900 Fessenden succeeds to transmit voice over radio:
  - Ship to shore radio communication,
  - Aircraft to ground radio communication.
- 1921 Police car radios, Detroit.
  - First private radio telephone systems.
- 1946 First public radio telephone systems, St. Louis.
- Introduction of HF radio telephones.
- Introduction of VHF radio telephones.
- 1970 Introduction of Finnish ARP-network

History of mobile communications 2

1979 Introduction of AMPS cellular networks.
1980 POCSAG paging standard.
1982 INMARSAT services.
1982 NMT450 cellular networks.
1984 TACS cellular networks,
CT1 cordless telephones.
1985 CT2 cordless telephones.
1991 GSM cellular networks.
1992 DECT cordless telephones.
1995 First CDMA network.
1995 ERMES paging network
1996 TETRA networks.
1991 Development of FPLMTS/IMT2000 and UMTS standards.

Fundamentals of Radio communications

- Radio waves as a transmission medium
- Time dependent electromagnetic fields produce waves that radiate from the source to the environment.
- The radio wave based radio communication system is vulnerable to the environmental factors: mountains, hills reflectors, … .
- The radio signal depends on the distance from the base station, the wavelength and the communication environment.
- Main problems of radio communication are:
  - Multipath propagation phenomena
  - Fading phenomena
  - Radio resource scarcity

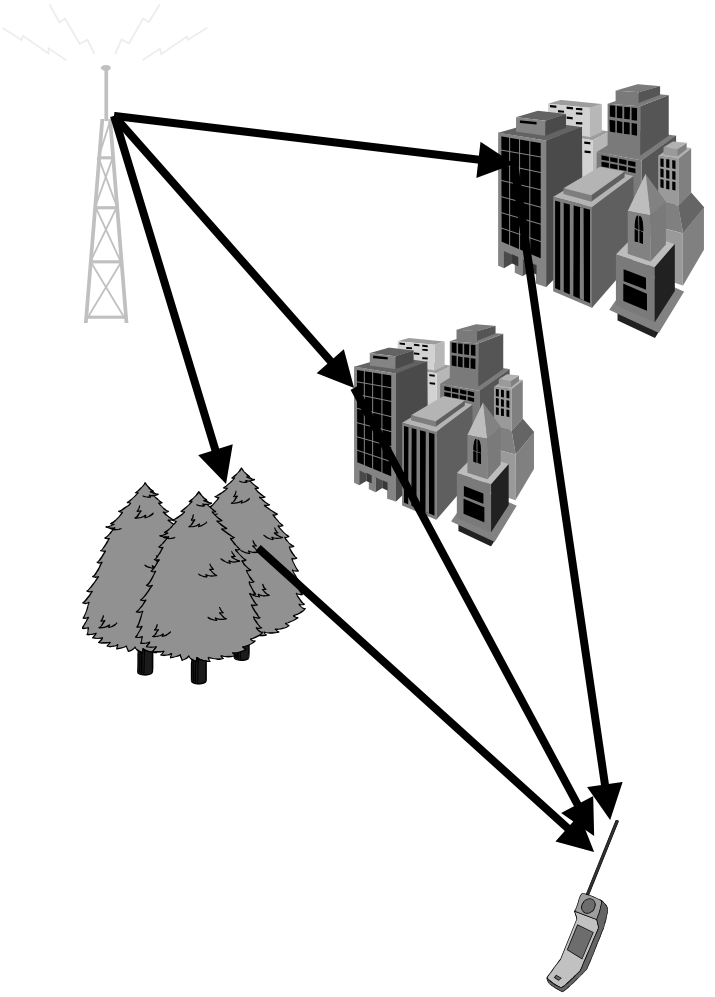


Multipath propagation

- Advantage: connection in case of Non-line-of-Sight.
- Fluctuation in the received signal's characteristics.

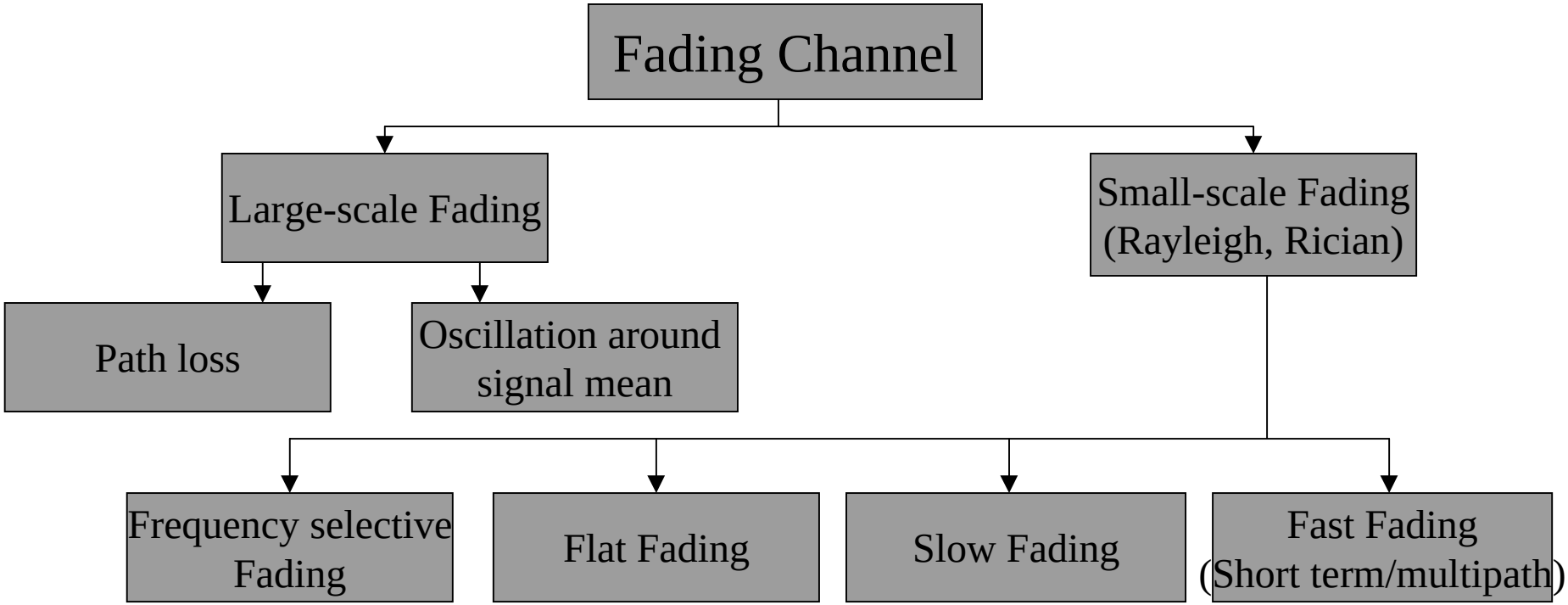
The factors affecting radio propagation:

- Reflection: collision of the electromagnetic waves with an obstruction whose dimensions are very large in comparison with the wavelength of the radio wave. Reflected radio waves.
- Diffraction, shadowing: collision of the electromagnetic waves with an obstruction which is impossible to penetrate.
- Scattering: collision of the radio wave with obstructions whose dimensions are almost equal to or less than the wavelength of radio wave.

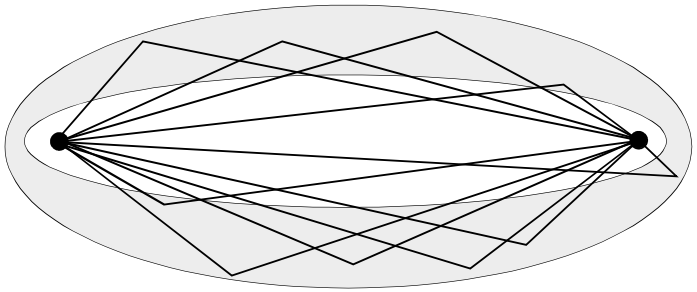


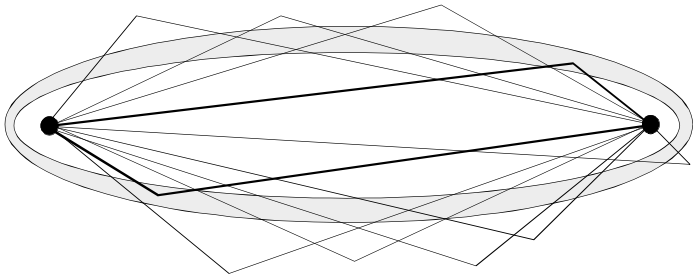
Radio Channel description

- Link budget: to determine the expected signal level at a a given distance from transmitter.
  - Covering area, Battery life
- Time dispersion: estimation of the different propagation delays related to the replicas of the transmitted signal which reaches the receiver.



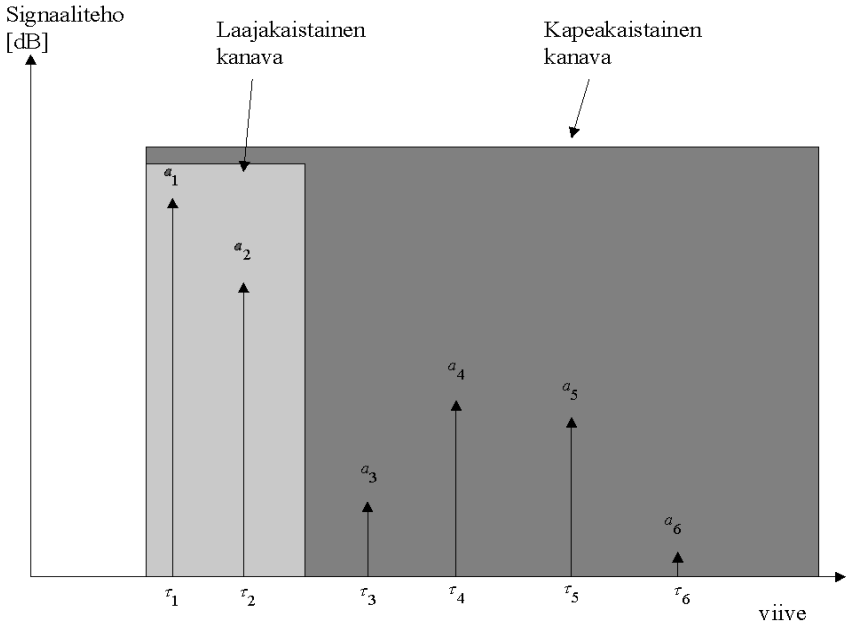
Channel Bandwidth



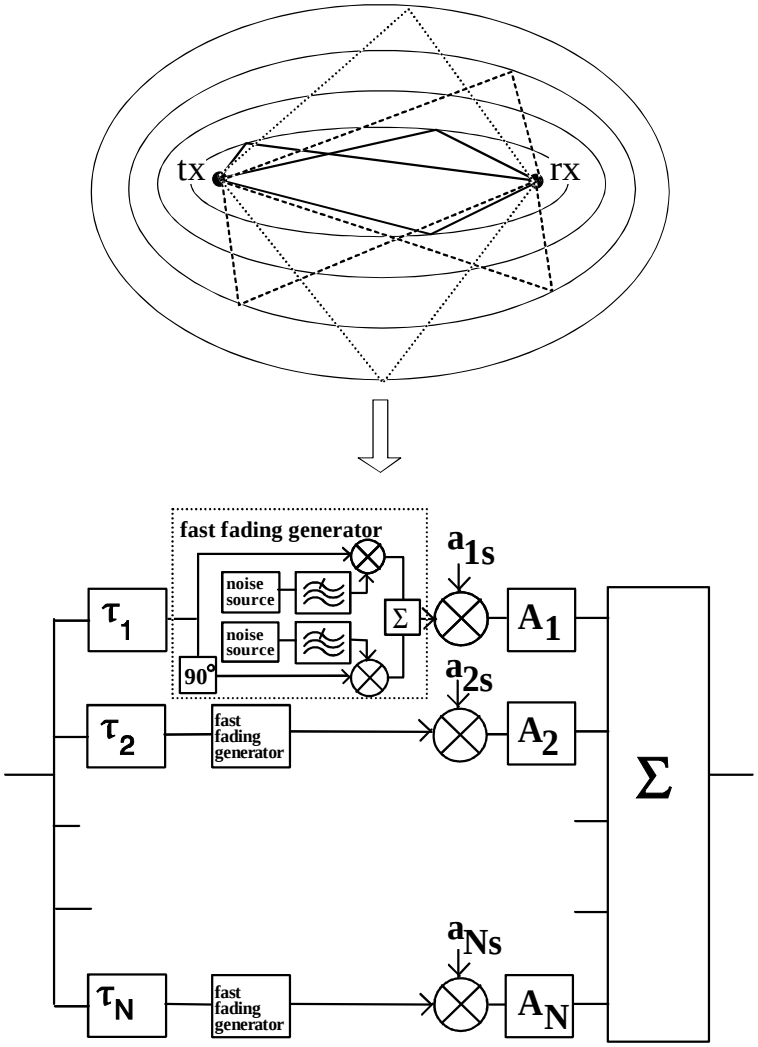


Impact of wide bandwidth

- The number of taps increases.
- New tap amplitude statistics are needed.



Wideband Channel Modelling

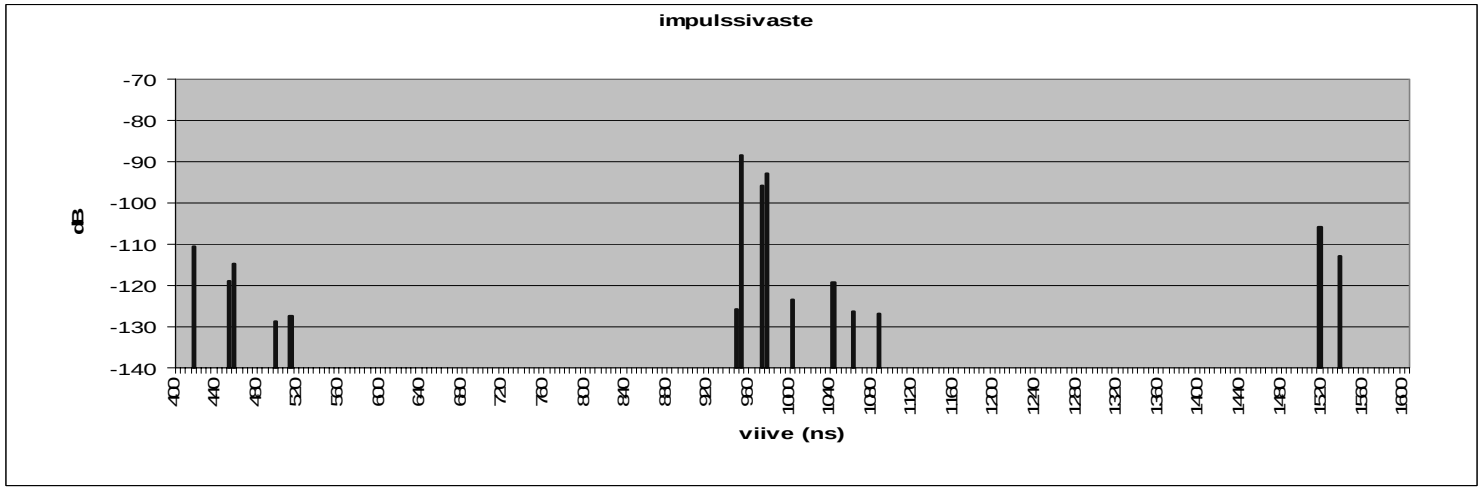


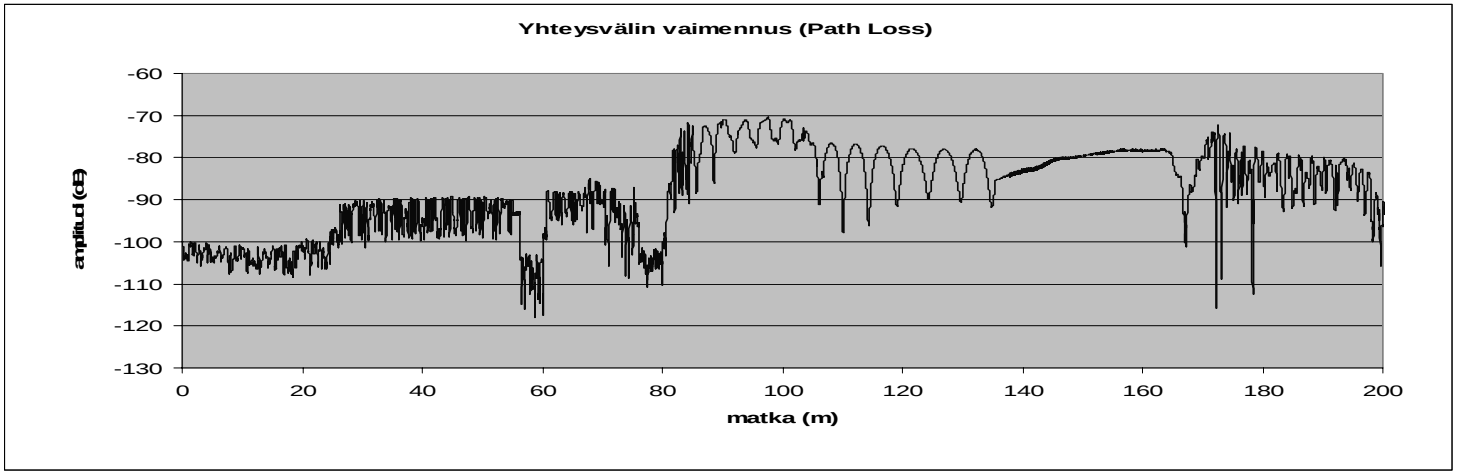
- The channel can be represented as a sum of flat fading Rayleigh- or Rician components.
  - Each component has its own doppler spectrum
  - Equivalent model is tapped delay line

$$h(\lambda, t) = \sum_{k=0}^{M-1} h_k e^{j2\pi\nu_k t} \delta(\lambda - \tau_k)$$

- Geographical area from where multipath components arrive to the receiver can be divided into elliptical zones.
- The with of the zone gives enough small delay variation of the zone.
- The transmission function for a zone is mostly constant.

Signal amplitude in the channel





Examples of channel models used in GSM development

Bad urban

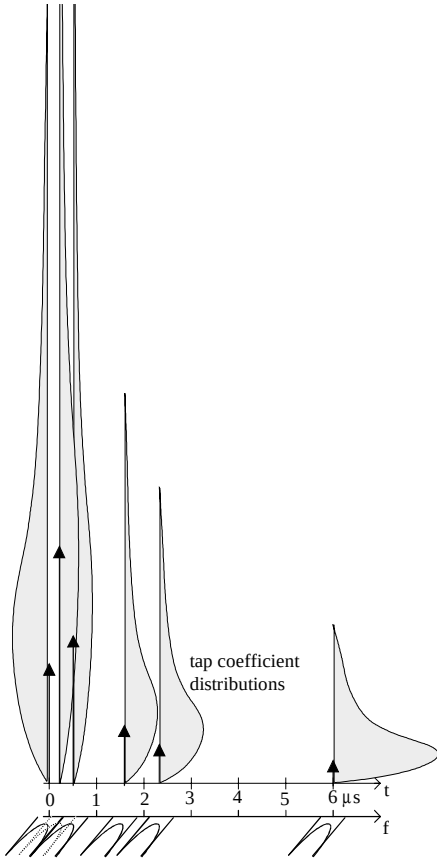
i	1	2	3	4	5	6
$\tau_i/\mu s$	0	0.3	1.0	1.6	5.0	6.6
P_{im}/dB	–2.5	0	–3.0	–5.0	–2.0	–4.0
	class	class	class	class	class	class

Typical urban

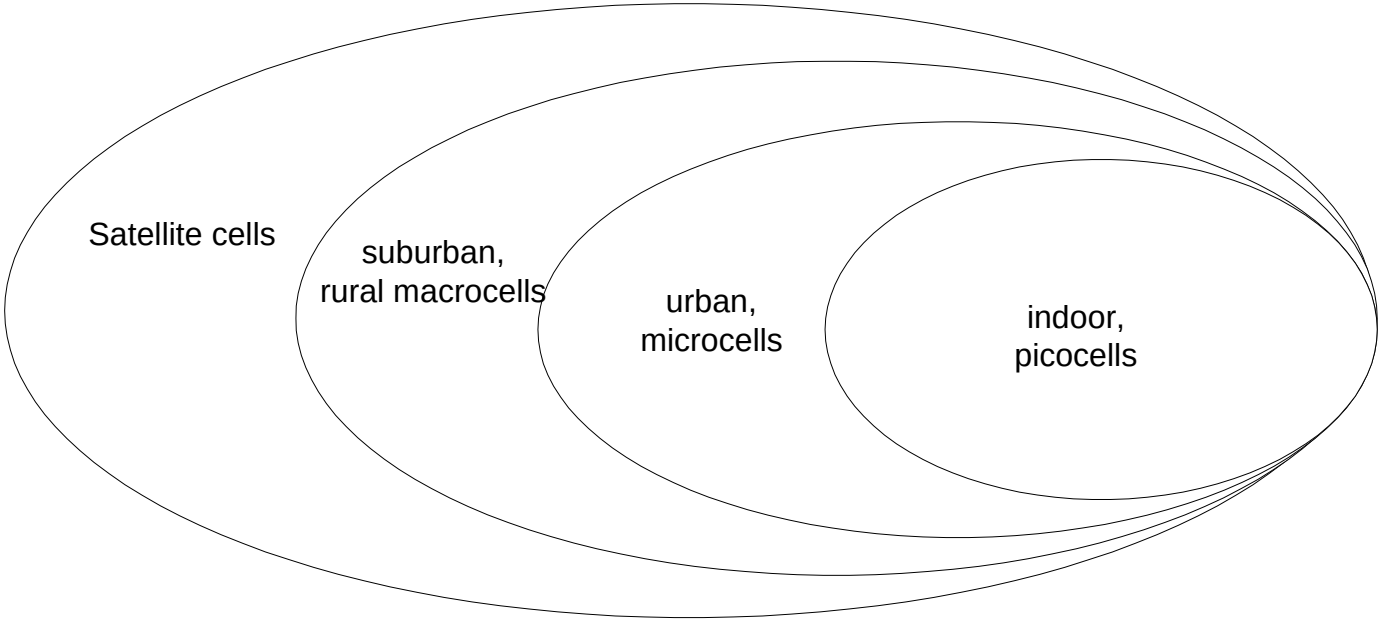
i	1	2	3	4	5	6
$\tau_i/\mu s$	0	0.2	0.5	1.6	2.3	5.0
P_{im}/dB	–3.0	0	–2.0	–6.0	–8.0	–10.0
	class	class	class	class	class	class

Rural area

i	1	2	3	4	5	6
$\tau_i/\mu s$	0	0.1	0.2	0.3	0.4	0.5
P_{im}/dB	0	–4.0	–8.0	–12.0	–16.0	–20.0
	Rice	class	class	class	class	class

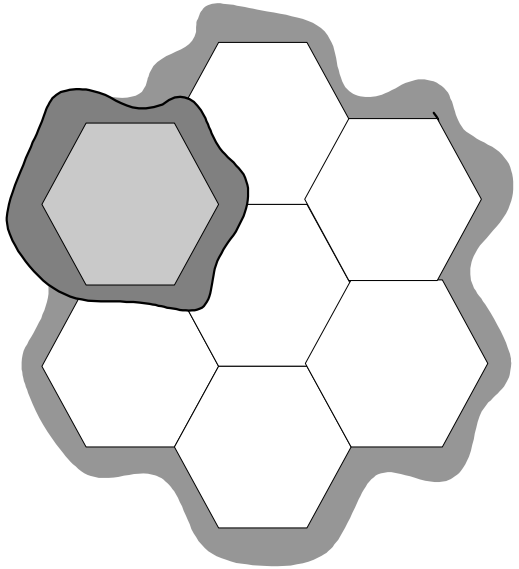


UMTS user environments



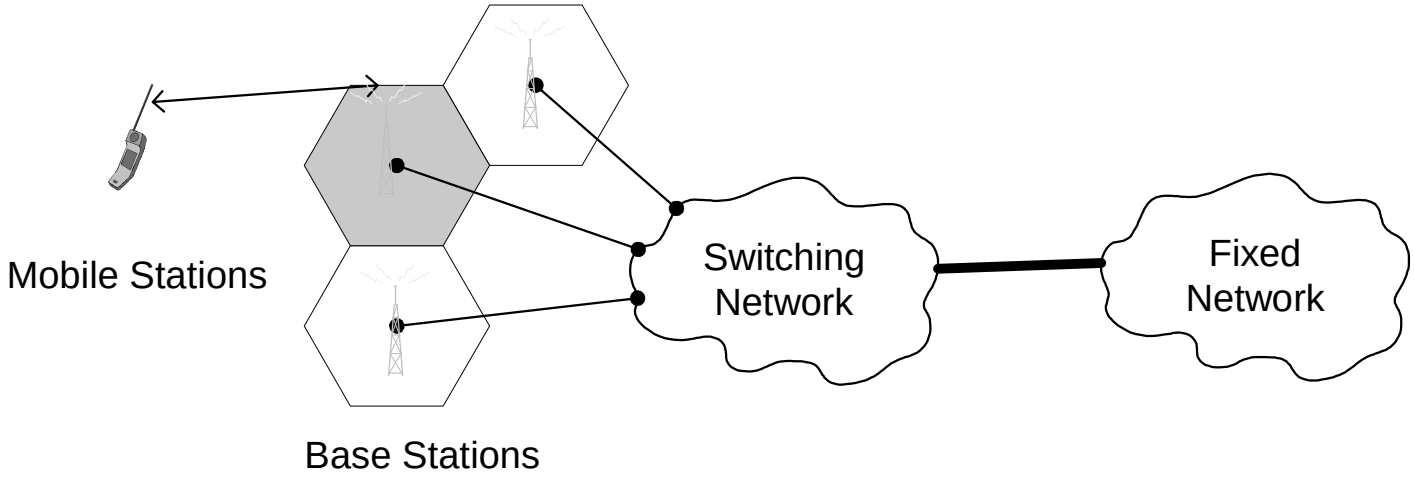
Cellular radio communication principles

- Public radio communications should offer duplex communication.
- The signal strength deteriorates together with distance.
- Every transmitter can offer only limited amount of simultaneous radio links to the end-users.
- Cellular concept:
  - large area is divided into a number of sub-areas - cells.
  - Each cell has its BS which is able to provide a radio link for number of simultaneous users.



A clusters of cells in a cellular network

Architecture of mobile systems

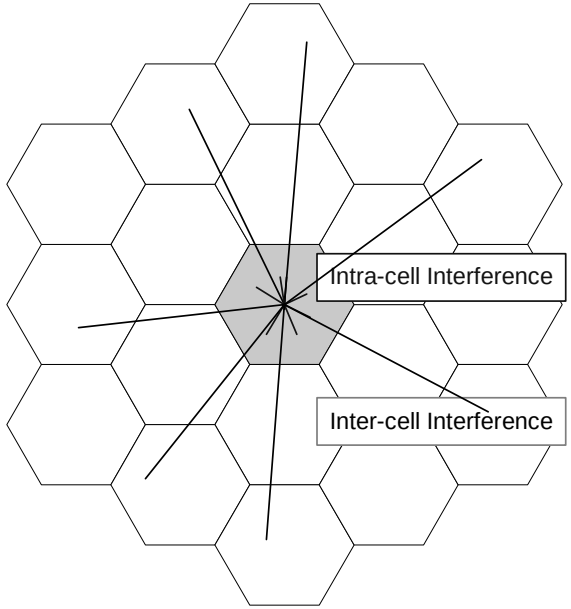


Basic structure of a cellular network

- Problems
  - Interference due to the cellular structure, inter- and intra-cell interference
  - Mobility handling
  - Cell based radio resource scarcity

Interference

- Assume the asynchronous users sharing the same bandwidth and using the same radio base station in each coverage area or cell.
- Intra-cell/co-channel interference due to the signal from the other users in the home cell.
- Inter-cell/adjacentchannel interference due to the signal from the users in the other cell.
- Interference due to the thermal noise.



Inter-cell and intra-cell interference in a cellular system

Methods for reducing interference:

- Frequency reuse: in each cell of cluster pattern different frequency is used
  - By optimising reuse pattern the problems of interference can be reduced significantly, resulting in increased capacity.
- Reducing cell size: in smaller cells the frequency is used more efficiently.
- Multilayer network design: macro-, micro-, pico-cells

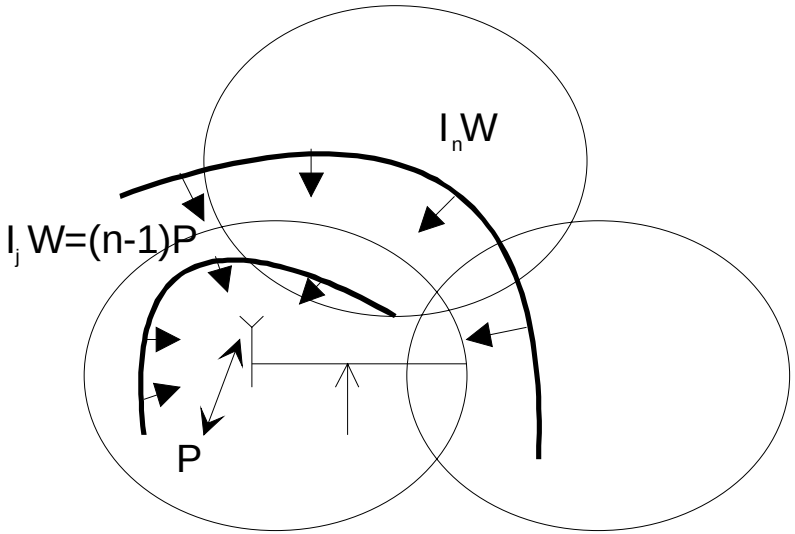
Signal and interference

P Signal received at the BS

I_j Spectral density of interference from other users in the cell

I_n Spectral density of interference from users in other cells

N_0 Thermal noise spectral density



$$P = E_b P_b$$

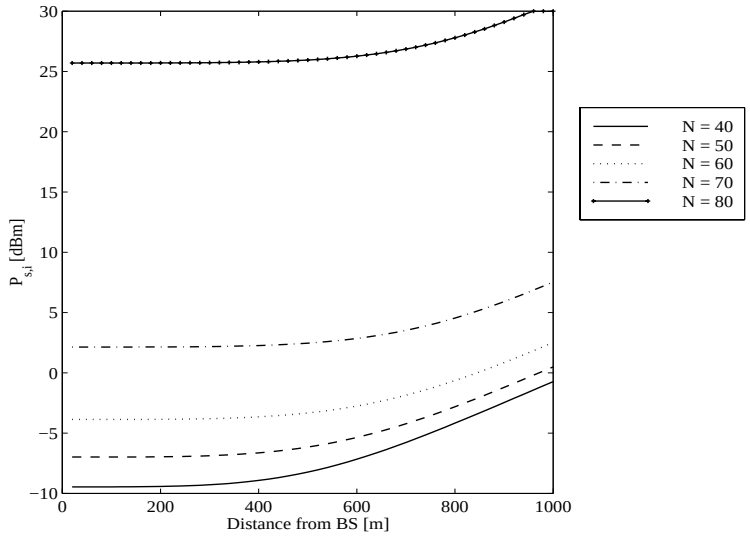
E_b Energy per bit of data

R_b data rate

$$CIR = \frac{P}{\left(I_j + I_n + N_0\right)} = \frac{E_b}{I_0}\frac{R_b}{W}$$

Cell breathing

- Reasons
  - same spectrum for all users
  - power control
  - interference depends on location of users



- Outcome
  - system capacity sensitive to instantaneous conditions in the cell
  - for “bad” users configuration the demanded capacity will be more than available capacity
  - all users increase their transmission power
  - some users reach their available power and CIR requirement for them will be violated

Mobility

- Mobility provides the possibility of being reachable anywhere and any time for the end-user

The mobility is provided through:

- Handover: gurantees that whenever the mobile is moving from one BS area/cell to another, the signal is handed over to the target BS.

When there is no continuous active radio link between mobile and BS the mobility is supported by:

- Location update: user registers in the network that it can be found in given area. Mobile always initiates the location update procedure.
- Paging: indication to the user about the the need for transaction. Paging procedure is always initiated by the network.

Cellular generations

1G Systems: NMT, AMPS, TACS.

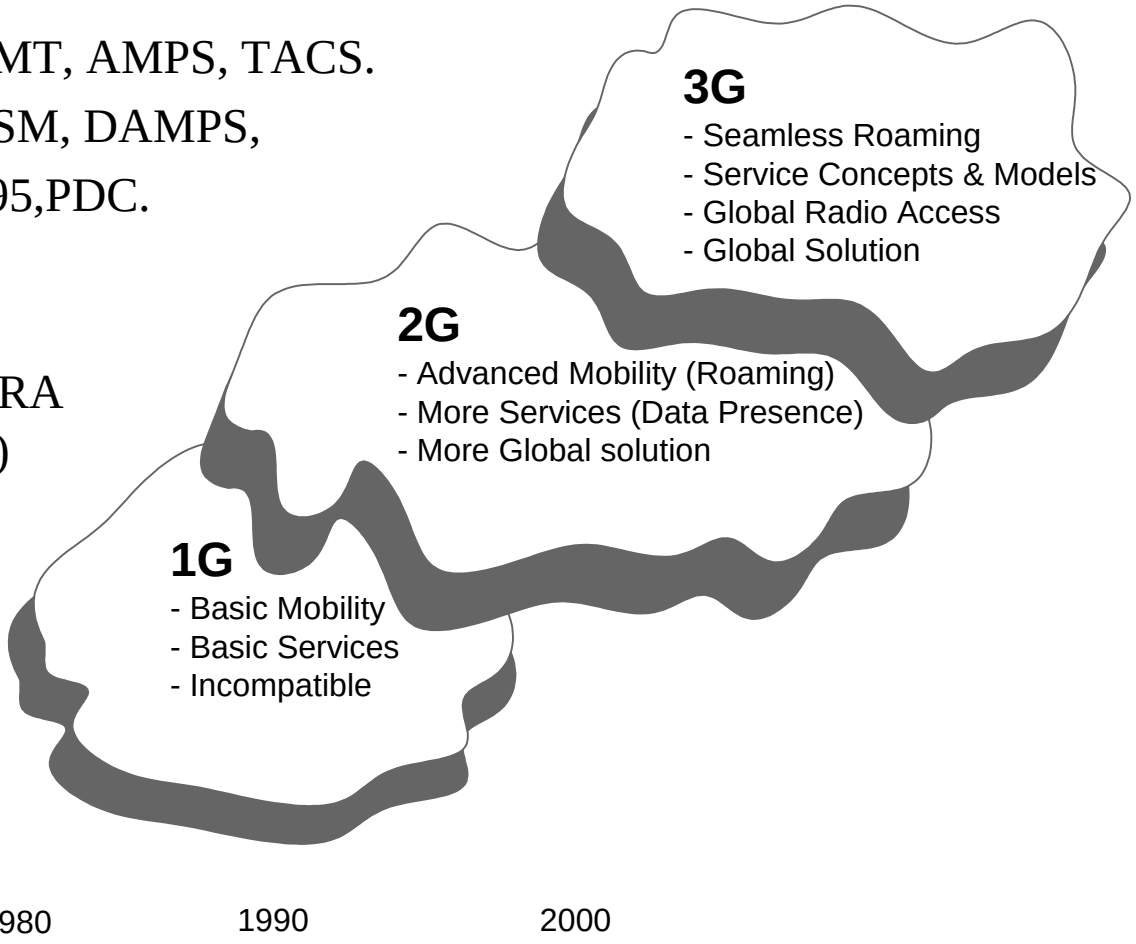
2G Systems: GSM, DAMPS,
IS-136, IS-95,PDC.

3G Systems:

WCDMA
(UMTS,UTRA
FDD+TDD)

cdma2000

EDGE



Vision for UMTS

- Well specified system with major interfaces open and standardised. The specifications generated should be valid world-wide.
- Added value to the GSM. However, in the beginning the system must be backward compatible at least with GSM and ISDN.
- Multimedia and all of its components must be supported throughout the system
- The radio access of the 3G must provide wideband capacity be generic enough in order to become available world-wide. The term “wideband” was adopted to reflect the capacity requirements between 2G narrowband capacity and the broadband capacity of the fixed communications media.
- The services for end-users must be independent from radio access technology details an the network infrastructure must not limit the services to be generated. That is, the technology platform is one issue and the services using the platform are totally another issue.

User aspects of UMTS

- reaching mass market
- common standards enabling
  - low cost mass production
  - open interfaces
- global standards
- public and private networks
- ubiquitous services

Mobile aspects of UMTS

- terminal mobility
- personal mobility
- service mobility

Telecommunication aspects of UMTS

- System providers:
  - connection everywhere
  - interconnection between networks
  - billing and accounting functions for all various interest
  - security
  - Network management is cost efficient and spectrum efficient manner
- Service choice and flexibility thorough a large variety of service providers and network operators.
- Simple and user friendly access.
- Personalised of user service profiles and user interfaces.
- Transparent services.
- Universal accessibility.
- Convergence of telecommunications, computer technology, and content provision
- Multimedia services

Examples of new services or applications

Information services:

- Interactive shopping,
- On-line equivalents of printed media,
- Location based broadcasting,
- services.

Educational services:

- Virtual schools,
- On-line library,
- Training.

Entertainment services:

- audio on demand,
- games on demand.

Community services

- emergency services,
- governmental procedures.

Business information:

- mobile office,
- virtual workshop.

Special services:

- tele-medicine,
- security monitoring,
- instant help line,
- personal administration.

Communication services:

- video telephony,
- video conference,
- personal location.

Business and financial services

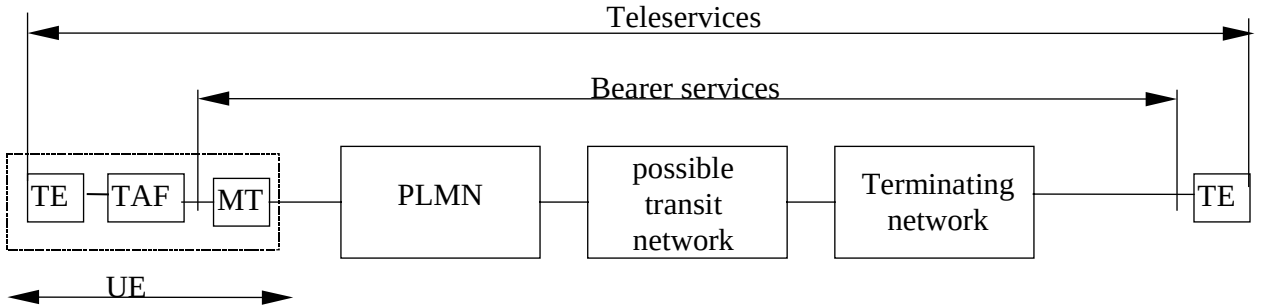
- virtual banking,
- on-line billing.

3G technical requirements

- Bit Rate:
  - Rural outdoor 144 kbps (500 km/h).
  - Suburban outdoor 384 kbps (120 km/h) .
  - Indoor 2 Mbps (10 km/h).
- Variable bit rate capability: granularity, circuit and packet bearers.
- Service Multiplexing.
- Varying delay and quality of service requirements. (priorities of traffic).
- Handover: seamless between the cells and different operators. Co-existence with and handover to 2G systems (with WCDMA to GSM).
- Support of asymmetric traffic.
- High spectrum efficiency.
- Coexistence of FDD and TDD modes.

Basic telecommunication services

- **Bearer services**: which are telecommunication services providing the capability of transmission of signals between access points.
- **Teleservices**: which are telecommunication services providing the complete capability, including terminal equipment functions, for communication between users according to protocols established by agreement between network operators.
  - Some teleservices are standardised because that interworking with other systems have been recognised as a requirement.
- **Supplementary services:** A supplementary service modifies or supplements a basic telecommunication service. Consequently, it cannot be offered to a user as a stand alone service.



UE: User Equipment
MT: Mobile Termination
TE: Terminal Equipment
TAF: Teminal Adaption Function

Definitions (1)

- **Basic telecommunication service :** this term is used as a common reference to both bearer services and teleservices.
- **Bearer service :** is a type of telecommunication service that provides the capability of transmission of signals between access points.
- **Call :** a logical association between several users (this could be connection oriented or connection less).
- **Connection :** is a communication channel between two or more end-points (e.g. terminal, server etc.).
- **Multimedia service :** Multimedia services are services that handle several types of media. For some services, synchronisation between the media is necessary (e.g. synchronised audio and video). A multimedia service may involve multiple parties, multiple connections, and the addition or deletion of resources and users within a single call.
- **Quality of Service :** the collective effect of service performances which determine the degree of satisfaction of a user of a service. It is characterised by the combined aspects of performance factors applicable to all services, such as;
  - service operability performance:
  - service accessibility performance;
  - service retention performance;
  - service integrity performance;
  - other factors specific to each service.

Definitions (2)

- **Service Capabilities:** Bearers defined by parameters, and/or mechanisms needed to realise services. These are within networks and under network control.
- **Service Capability Feature:** Functionality offered by service capabilities that are accessible via the standardised application interface
- **Services:** Services are made up of different service capability features.
- **Supplementary service :** is a service which modifies or supplements a basic telecommunication service. Consequently, it cannot be offered to a user as a standalone service. It shall be offered together with or in association with a basic telecommunication service. The same supplementary service may be common to a number of basic telecommunication services.
- **Teleservice;** is a type of telecommunication service that provides the complete capability, including terminal equipment functions, for communication between users according to standardised protocols and transmission capabilities established by agreement between operators.

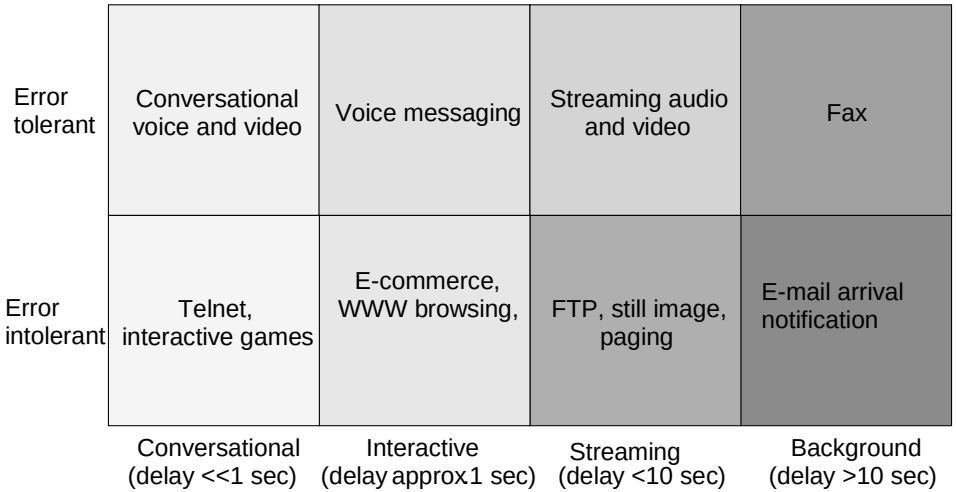
Bearer Services

- Bearer services provide the capability for information transfer between access points and involve only low layer functions.
- The user may choose any set of high layer protocols for his communication.
- A communication link between access points provides a general service for information transport.
- The communication link may span over different networks.
- Bearer services are characterised by a set of end-to-end characteristics with requirements on QoS. QoS is the end-to-end quality of a requested service as perceived by the customer.
- Requirements on the Bearer Services
  - Information transfer:
    - Traffic type: quaranteed/constant bit rate, non-quaranteed/dynamic variable bit rate, real time dynamic variable bit rate with a minimum guaranteed bit rate.
  - Traffic characteristics: the user can require on of the following configurations
    - Pont-to-point: uni-directional, bi-directional: symmetric, assymmetric.
    - Uni-directional point-to-multipoint: multicast,broadcast.

Information quality

- **Maximum transfer delay:** Transfer delay is the time between the request to transfer the information at one access point to its delivery at the other access point.
- **Delay variation:** The delay variation of the information received information over the bearer has to be controlled to support real-time services.
- **Bit error ratio:** The ratio between incorrect and total transferred information bits.
- **Data rate:** The data rate is the amount of data transferred between the two access points in a given period of time.

UMTS QoS Classes



- Conversational: end-to-end delay is low and the traffic is symmetric of nearly symmetric.
  - Speech, Video telephony, … .
- Streaming: data is transferred such that it can be processed as a steady continuous stream.
  - Video, audio, … .
- Interactive: interaction between human or machine and remote equipment.
  - Web browsing, tele-mechanics, ...
- Background: non real time data traffic.
  - email … .

QoS requirements

	Real Time (Constant Delay)	Non Real Time (Variable Delay)
Operating environment	**BER/Max Transfer Delay**	**BER/Max Transfer Delay**
Satellite (Terminal relative speed to ground up to 1000 km/h for plane)	Max Transfer Delay less than 400 ms BER 10-3 - 10-7 (Note 1)	Max Transfer Delay 1200 ms or more (Note 2) BER = 10-5 to 10-8
Rural outdoor (Terminal relative speed to ground up to 500 km/h) (Note 3)	Max Transfer Delay 20 - 300 ms BER 10-3 - 10-7 (Note 1)	Max Transfer Delay 150 ms or more (Note 2) BER = 10-5 to 10-8
Urban/ Suburban outdoor (Terminal relative speed to ground up to 120 km/h)	Max Transfer Delay 20 - 300 ms BER 10-3 - 10-7 (Note 1)	Max Transfer Delay 150 ms or more (Note 2) BER = 10-5 to 10-8
Indoor/ Low range outdoor (Terminal relative speed to ground up to 10 km/h)	Max Transfer Delay 20 - 300 ms BER 10-3 - 10-7 (Note 1)	Max Transfer Delay 150 ms or more (Note 2) BER = 10-5 to 10-8
NOTE 1; There is likely to be a compromise between BER and delay. NOTE 2; The Max Transfer Delay should be here regarded as the target value for 95% of the data. NOTE 3; The value of 500 km/h as the maximum speed to be supported in the rural outdoor environment was selected in order to provide service on high speed vehicles (e.g. trains). This is not meant to be the typical value for this environment (250 km/h is more typical).		

End-user performance expectation conversational/real time traffic

Medium	**Application**	**Degree of symmetry**	**Data rate**	**Key performance parameters and target values**		
				End-to-end One-way Delay	Delay Variation within a call	Information loss
Audio	Conversational voice	Two-way	4-25 kb/s	<150 msec preferred <400 msec limit Note 1	< 1 msec	< 3% FER
Video	Videophone	Two-way	32-384 kb/s	< 150 msec preferred <400 msec limit Lip-synch : < 100 msec		< 1% FER
Data	Telemetry - two-way control	Two-way	<28.8 kb/s	< 250 msec	N.A	Zero
Data	Interactive games	Two-way	< 1 KB	< 250 msec	N.A	Zero
Data	Telnet	Two-way (asymmetric)	< 1 KB	< 250 msec	N.A	Zero

End-user Performance Expectations - Interactive Services

Medium	**Application**	**Degree of symmetry**	**Data rate**	**Key performance parameters and target values**		
				One-way Delay	Delay Variation	Information loss
Audio	Voice messaging	Primarily one-way	4-13 kb/s	< 1 sec for playback < 2 sec for record	< 1 msec	< 3% FER
Data	Web-browsing - HTML	Primarily one-way		< 4 sec /page	N.A	Zero
Data	Transaction services – high priority e.g. e-commerce, ATM	Two-way		< 4 sec	N.A	Zero
Data	E-mail (server access)	Primarily One-way		< 4 sec	N.A	Zero

End-user Performance Expectations - Streaming Services

Medium	**Application**	**Degree of symmetry**	**Data rate**	**Key performance parameters and target values**		
				One-way Delay	Delay Variation	Information loss
Audio	High quality streaming audio	Primarily one-way	32-128 kb/s	< 10 sec	< 1 msec	< 1% FER
Video	One-way	One-way	32-384 kb/s	< 10 sec		< 1% FER
Data	Bulk data transfer/retrieval	Primarily one-way		< 10 sec	N.A	Zero
Data	Still image	One-way		< 10 sec	N.A	Zero
Data	Telemetry - monitoring	One-way	<28.8 kb/s	< 10 sec	N.A	Zero

Teleservices

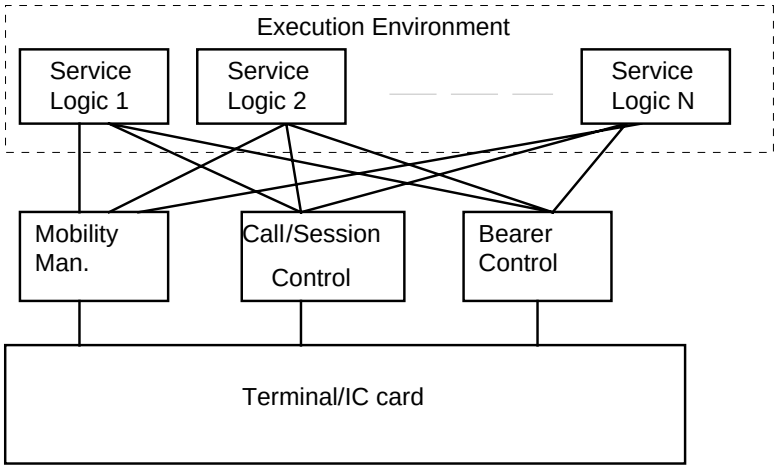
- A teleservice can be viewed as set of upper layer capabilities utilising the lower layer capabilities.
- Teleservices can be single media or multimedia services.
- Multimedia services are classified:
  - multimedia conference services,
  - multimedia conversational services,
  - multimedia distribution services,
  - multimedia retrieval services,
  - multimedia messaging services,
  - multimedia collection services.
- The terminal and network should support the service.
- The principle of the network design has been that upper layer and lower layer are made as independent as possible. (Layers are understood accordingly OSI model).

Service Capability features

- **Services Capability Features** are open, technology independent building blocks accessible via a standardised application interface.
- Application/Clients access the service capability features via the standardised application interface.
- **Framework service capability features**: these shall provide commonly used utilities, necessary for the non-framework service capability features to be accessible, secure, resilient and manageable.
  - Authentication, User-Network Authentication, Application-Network Authentication, User-Application Authentication, Authorisation, Application-Network Authorisation, User-Application Authorisation, Registration, Discovery, Notification. TS22.121.
- **Non-Framework service capability features**: these shall enable the applications to make use of the functionality of the underlying network capabilities (e.g. User Location service capability features).
  - Session Control, Security/Privacy, Address Translation, Location, User Status, Terminal Capabilities, Messaging, Data Download, User Profile Management, Charging.
- When applications use the generic service capability features, these applications become independent of (portable over) underlying service capabilities.

Execution environment

- The execution environment is a set of standardised capabilities that shall allow the support of home environment/serving network (HE/SN) specific services (i.e. both applications, teleservices and supplementary services). The execution environment shall be distributed between the IC card, terminal and network nodes
- Building blocks of execution environment:
  - A standardised content description language for support of HE/SN specific user interfaces (both for information output and user input).
  - A standardised procedural language for support of HE/SN specific scripts. This language shall be common to all types of platforms.
    - The scripts could be used for e.g. improving the user interface, adding new features to the terminal like the latest version of a codec, controlling the execution of a service.
  - Standardised application programming interfaces for opening platform resources and capabilities to the scripts written with the standardised procedural language.



3GPP standardised user service capabilities

UMTS R99 will standardise the technical means by which a UE may implement the following UE Service Capabilities.

- Tele services:
  - Speech.
  - Emergency call.
  - Short Message Service.
  - Cell Broadcast service CBS.
- Bearer Services:
  - Circuit-switched data.
  - Packet-switched data.
  - Defined by their attributes:
    - Information transfer attributes.
      - Information transfer rate, Information transfer characteristics … .
    - Information quality attributes.
      - Bit error ratio, Maximum transfer delay Delay variation … .
- Supplementary services:
  - Defined in GSM R'99. Examples:
    - Call Forwarding
    - Advice of Charge.
    - Explicit Call transfer.
- Service capabilities:
  - Mobile Service Execution Environment.
  - Location Services.
  - SIM application toolkit.
- GSM systems features:
  - Network identity and time zone.
  - Unstructures supplementary service data.

Regulation

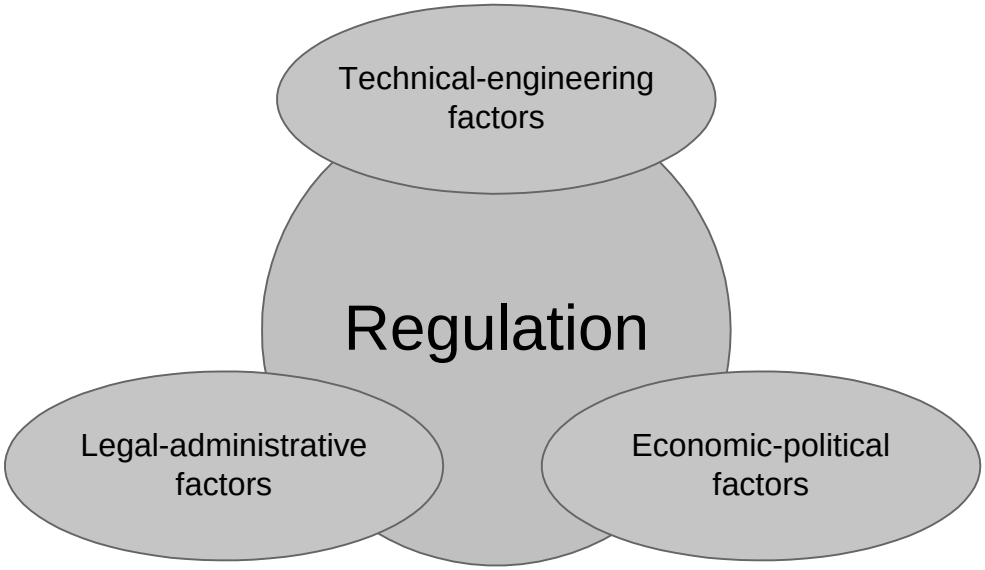
Legal-administrative aspects:

- Spectrum allocation.
- Technical standardisation.

Economic-political aspects:

The spectrum made available such that:

- System providers and users are satisfied.
- Spectrum efficiently used.

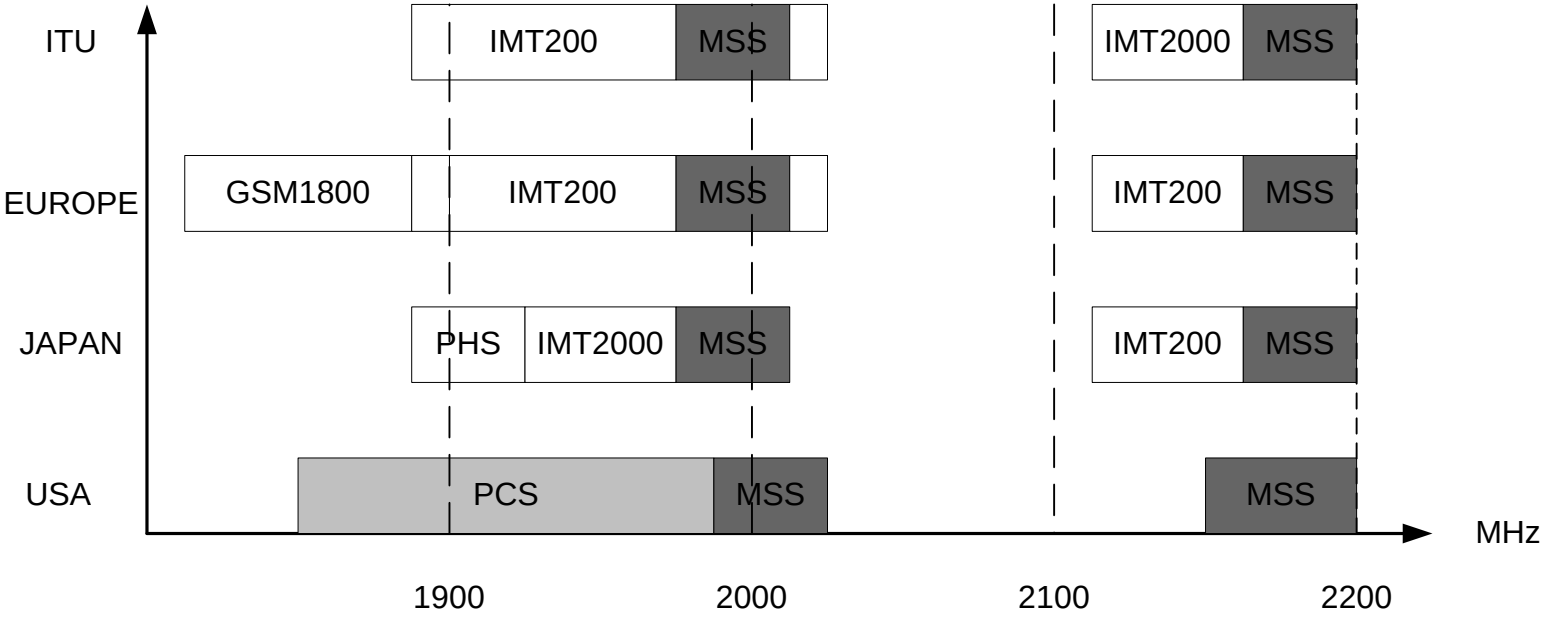


Factors in the regulation process

Specification process for 3G

- In Europe 3G has become UMTS (Universal Mobile Telecommunication System), following the ETSI perspective.
- In Japan and US IMT-2000 (International Mobile Telephony 2000). The name comes from the International Telecommunication Union (ITU) development projects.
- Evolution of IS-95 system is covered under the name CDMA2000.
- ITU FPLMTS project - promotion of common architectural principles among the family of IMT-2000 systems.
- Different short-term targets.
  - Europe: need for commercial mobile data service.
  - Far East: need for additional spectrum for speech services.

3G Spectrum



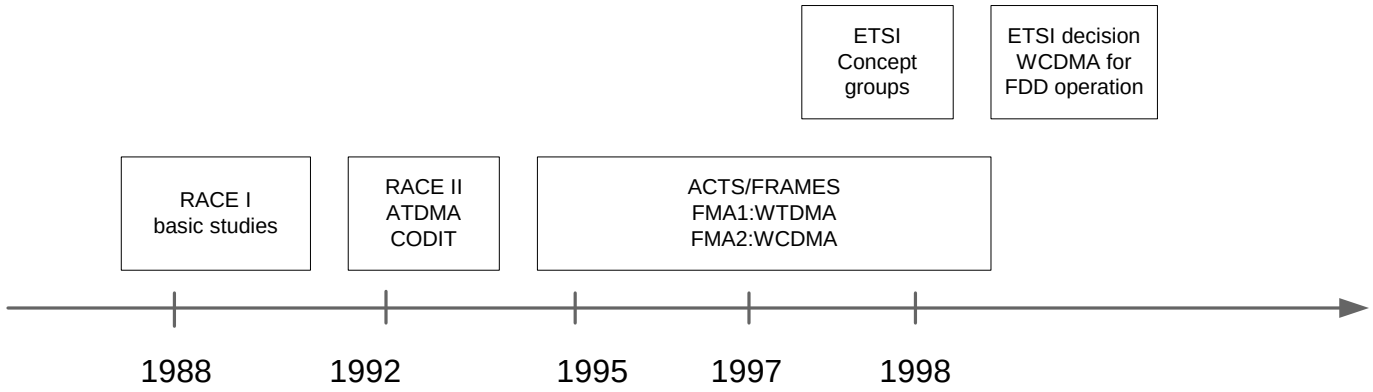
In Europe:

WCDMA-FDD 2110-2170 MHz downlink. 1920-1980 MHz uplink,

WCDMA-TDD 1900-1920 and 2020-2025.

EU projects

- Several pre-standardisation research projects:
  - 1992-1995 RACE MoNet project (financed by EU)
    - System Techniques.
    - System integration
    - Modelling methods for describing function allocation between the radio access and core parts of network.
  - 1995-1998 ACTS FRAMES project.
    - Multiple access method.
- Participants: Nokia, Siemens, Ericsson, Universities …
- Single air interference proposal for ETSI: input 13 proposals, output 2 modes.



ETSI Technology selection (1)

- WCDMA
  - The basic system features considered
    - Wideband CDMA operation with 5 MHz,
    - Physical layer flexibility for integration of all data rates on a single carrier,
    - Frequency reuse 1.
  - The enhancements covered
    - Transmit diversity,
    - Adaptive antennae operations,
    - Support for advanced receiver structures.
- WB-TDMA/CDMA
  - The basic system features considered
    - Equalisation with training sequences in TDMA bursts,
    - Interference averaging with frequence hopping,
    - Link adaptation,
    - Two basic burst types,
    - Low reuse size.
  - The enhancements covered
    - Inter-cell interference supression,
    - Support of adaptive antennas,
    - TDD operation,
    - Less complex equalisers for large delay spread environment.

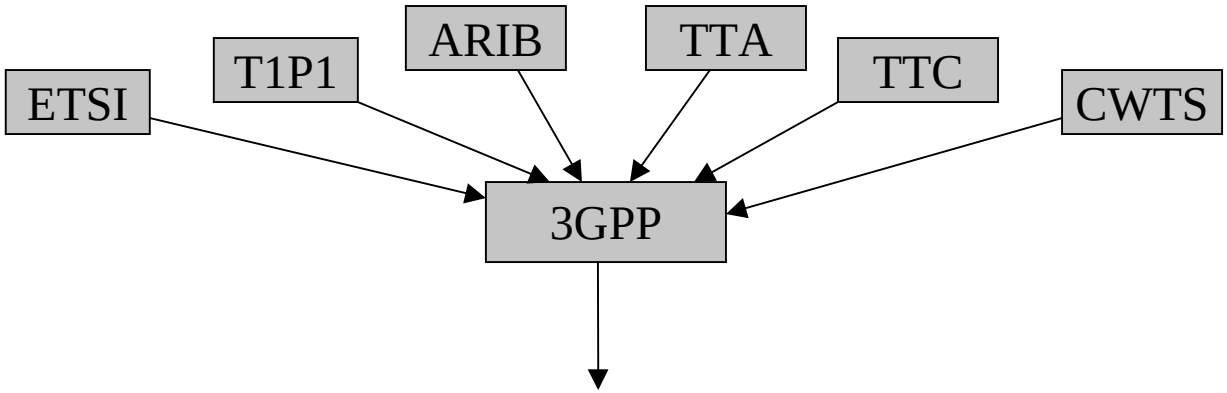
ETSI Technology selection (2)

- WB-TDMA/CDMA
  - The basic system features considered
    - TDMA burst structure with midamble for channel estimation,
    - CDMA concept applied on top of the TDMA structure for additional flexibility,
    - Reduction of intracell interference with multiuser detection,
    - Low reuse size (< 3)
  - The enhancement covered included
    - Frequency hopping,
    - Inter-cell interference cancellation,
    - Support of adaptive antennas
    - Operation in TDD mode,
    - Dynamic Channel Allocation.
- OFDMA
  - The basic system features considered
    - Operation with slow frequency hopping with TDMA and OFDM multiplexing,
    - A 100kHz wide bandslot from the OFDM signal as the basic resource unit,
    - Higher rates build by allocating several bandslots, creating a wideband signal,
    - Diversy by dividing information over several bandslots.
  - The enhancement covered included
    - Transmit diversity,
    - MUD,
    - Adaptive antennas solution.
- ODMA (opportunity driven MA)
  - terminal outside of cell coverage use other terminals as retransmitters.

UMTS standardisation procedure

3GPP is a “umbrella” aiming to form compromised standards by taking into account, political, industrial, and commercial pressures from local specification bodies:

ETSI	European Telecommunication Standard Institute /Europe
ARIB	Association of Radio Industries and Business /Japan
CWTS	China Wireless Telecommunication Standard group /China
T1	Standardisation Committee T1 Telecommunications /US
TTA	Telecommunication Technology Association /Korea
TTC	Telecommunication Technology Committee /Japan



3GPP evolvement

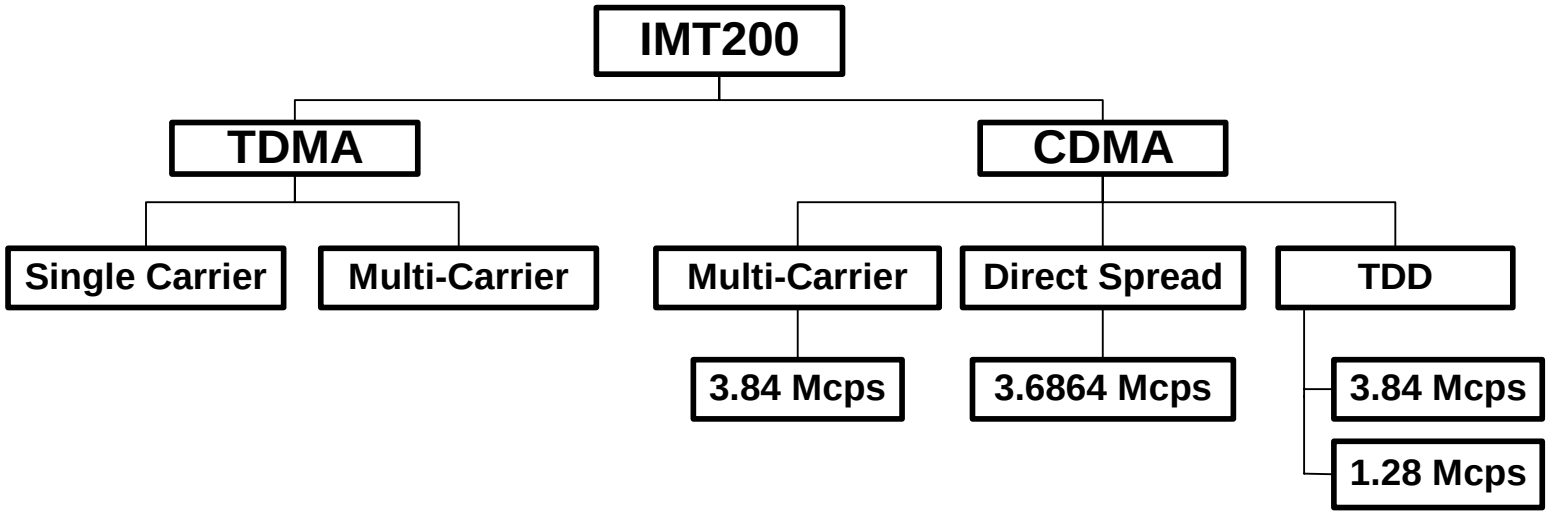
Different switching systems can be combined with different radio access parts.

Variant	Radio access	Switching	2G Basis
3G (US)	WCDMA, EDGE,	IS 41	IS-95, GSM1900,
	CDMA2000		TDMA
3G (Europe)	WCDMA, GSM, E	Advanced GSM N	GSM900/1800
		and packet core	
3G (Japan)	WCDMA	Advanced GSM N	PDC
		and packet core	

- Release 99:
  - strong GSM presence:
    - Backward compatibility with GSM,
    - Interoperation between UMTS and GSM.
  - UTRAN
- Release 4:
  - Separation of user data flows and control mechanisms,
  - Narrowband TDD with 1.28 Mchips/s,
  - Position location functionality.
- Release 5:
  - End-to-end packet switched cellular network using IP,
  - Downlink data rate more than 10 Mbits/s.
  - GERAN.

WCDMA in ITU IMT 2000

- 3GPP covers CDMA direct spread and TDD
- ITU provides references to 3GPP specifications and does not make specifications of its own.
- Based on the standardisation ITU has the following grouping:



2G (GSM) vs 3G (WCDMA)

	WCDMA	**GSM**
Carrier spacing	5 MHz	200 kHz
Frequency reuse factor	1	1-18
Power control frequency	1500 Hz	2 Hz or lower
Quality control	Radio resource management algorithms	Network planning (Frequency planning)
Frequency diversity	5 MHz bandwidth gives multipath diversity with RAKE receiver	Frequency hopping
Packet data	Load based packet scheduling	Time slot based scheduling with GPRS
Dowlink transmit diversity.	Supported for improving downlink capacity.	Not supported by the standard but can be applied.