Quality of Service

- QoS for a network: different parameters such as bandwidth, latency, jitter, packet loss, packet delay
- for video applications: QoS is based on the bandwidth
- for VoIP: QoS is based on latency (end to end delay not larger than 200 ms)
- => optimize delay, bandwidth, packet loss… but not all
- CoS (Classes of Service) classify the services in different classes.
• CoS manage each type of traffic with a particular way
• ETSI (European Telecommunications Standards Institute has introduced 4 CoS (Classe 1 : Best Effort, Classe 4: QoS guaranteed)
• Many SLA offers 3 CoS: Premium (max 15% of network resources), Olympic (max 80% of network resources) and BE
• Bandwidth broker reserve the resources
• IP network set of owned and rented links

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• QoS can be linked to the
  – network level: QoS depend of the network policy. Mechanisms such as filters, rerouting in the core of the network and control access at the corners of the network. Intelligence in the routers. (OSPF, RIP, SNMP, BGP)
  – application level: applications which improve the QoS. No link with the network infrastructure. (NFS, …)

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• Internet is increasing exponentially:
  – 2001: 180 million users
  – 2005: 500 millions users
• Internet traffic and the bandwidth will double every 6 months
• The bandwidth will be about 35 Tbits/s by 2001
• In 2005, the data traffic will be 20 times the voice traffic
• More wireless voice traffic than wired traffic

• 2 types of applications: elastic (TCP) or streaming (RTP/UDP)

• 90% TCP - 10% UDP (no congestion control mechanisms)
• WWW: 75% Email: 3%
• FTP: 4% News: 7%
• Best Effort: provide a fair service
• Max-min allocation of bandwidth: maximize the bandwidth allocation to the source receiving the smallest allocation
  => decrease the bandwidth allocated to other source
• Packets are dropped when congestion occurs in routers
  – when the buffer is full (tail drop)
  – when the buffer occupancy increases too much (RED Random Early Detection)

• Congestion control mechanisms in end systems
  – Inform the source about network congestion with ICMP or tagged packets with ECN (Explicit Congestion Notification) => all routers should implement the congestion control mechanisms
• Divide the output buffers in N queues and introduce a scheduler (processor sharing, round robin)
- Classification of the IP flows at different layers: edge router perform classification/marking and backbone router relies on marking
- Weighted RED: n RED algorithms in parallel. Support n drop priorities to offer minimum bandwidth service
- Generalized Processor Sharing/Weighted Round Robin: introduce a weight to each queue

- New communications network must offer:
  - QoS
  - Mobility
- => necessary to introduce
  - QoS mechanisms with signalization and route (telecommunication world)
  - overprovisioning the network for new applications such as TV on demand, telephony IP
- Routing: giga/tera routers or priority mechanisms
- Switching (optical, temporal, space): centralized signalization (policy control) or decentralized signalization (MPLS).
• Overprovisioning is not a global solution but is an asset for traffic engineering and QoS in Internet

• Reservation of resources
  – hard state: complex because signalization is necessary, modification is complex
  – soft state: destruction of the route is done automatically, refreshment to keep a route, easy to change the route

• 1st generation Internet: Best Effort
• 2nd generation Internet: QoS, mobility, security
  – all IP with terarouter
  – Use the networks providing QoS (ATM, MPLS, …):VC, switching environment

• 3rd generation: common architecture for wire and wireless communications

• Core of the network: alternation of architectures with signalization and with no signalization (SS7, Arpanet, X25/ATM, Internet 1st generation, Internet/Telecom)
• Growth of the networks capacity:
  Wavelength Division Multiplexing (WDM)
  – 2005: 1000 Wavelength / 1000 Tbit
  – optical switching
  – ATM cannot work with these rate
  – IP packet => IP frame (code violation)
  – IP over ATM over IP
  – all IP in the future?
• 3rd generation
  – Intelligent platform with several IP
  WDM network

Mechanisms for QoS:
• ATM or IP. Each solution has his own advantage
  and offer different QoS guaranties
• IP networks are technically and economically
  reliable
• 2nd generation of Internet introduce signalization
  and QoS (IntServ, DiffServ, MPLS, IPv6, …)
• Need of metrics for QoS
  – Necessary for SLA (Service Level Agreements)
    between a provider and a client)
• IPPM (IP Performance Metric)
ATM networks

• Connection oriented protocol
• offer real QoS guaranty
• QoS is negotiated during the establishment of the connection and depend of the available resources
• 6 CoS:
  – CBR (Constant Bit Rate): guarantee a constant rate: videoconferencing, telephony
  – RT-VBR (Real-Time Variable Bit Rate): transmission with a variable rate for application requiring real-time constraints: MPEG transmission
  – NRT-VBR (Non-Real-Time Variable Bit Rate): transmission with a variable rate for application requiring no real-time constraints: multimedia transfer
  – ABR (Available Bit Rate): transmission of traffic using remaining bandwidth or bursty traffic. ABR guaranty always a minimum rate.
– GFR (Guaranteed Frame Rate): accept to loose sometime some services
– UBR (Unspecified Bit rate): no rate guaranty and no congestion indication. Best Effort.
For theses CoS, 5 AAL (ATM Adaptation layer) have been defined:

- AAL1: for real-time traffic. Oriented connection. CBR
- AAL2: variable real time traffic. VBR
- AAL3/4: variable real-time traffic. ABR, GFR
- AAL5: user can choose between reliable or non-reliable services, can do unicast or multicast traffic

Parameters

- QOS comes from the signalization mechanisms and stream controls

- QoS parameters are:
  - CTD: Cell Transfer Delay
  - CMR: Cell Misinsertion Ratio
  - CLR: Cell Loss Ratio
  - CER: Cell Error Ratio
  - PCR: Peak Cell Rate
  - MCR: Minimum Cell Rate
  - CVDT: Cell variation Delay Tolerance
  - SCR: Sustainable Cell Rate
  - BT: Burst Tolerance
  - CDV: Cell Delay Variation
Stream control

• CAC (Connection Admission Control) determines if a connection can be accepted or not
• UPC/NPC: Usage Parameter Control/Network Parameter control. Manage and control the traffic and the conformity of a connection
• RM: Resource Management. Optimize the traffic
IP over ATM

- LANE: LAN Emulation
- Classical IP
- MPOA: Multi Protocol Over ATM
Classical IP

• Defined by IETF
• Introduce the notion of LIS (Logical IP Subnetwork): emulation of a IP subnetwork
• each IP station registers a connection with an ARP (Address Resolution Protocol) Server.
• The ARP server do the translation between IP and ATM addresses
• Multicast traffic: MARS (Multicast Address Resolution Server)

• Problems:
  – Only IP is supported
  – the connections between 2 ARP servers must be done through protocols such as NHRP (Next Hop Resolution Protocol)
LANE

- Support all types of protocol (IP, IPX, …)
- Problem: cannot be used for wide area networks, routers are always necessary
- Composed by 3 servers and 1 client:
  - LEC (LAN Emulation Client): station with an ATM address and a MAC address
  - LES (LAN Emulation Server): for the translation between the 6 octets of the IP address and the 20 octets of the ATM address
  - LECS (LAN Emulation Configuration Server): automatic configuration. Allow to know the LES ATM address
  - BUS: Broadband Unknown Server. Management of multicast, broadcast and unknown frames.
MPOA

- avoid the router bottleneck problem
- introduce a route server used for the ATM address resolution
- can be considered as a virtual router which divide data transmission from computation functions
- I-PNNI is used instead of RIP and OSPF
- MPOA can be used in wide area network
WATM (Wireless ATM)

- management of the QoS is difficult because the way change continually
- new model such as MPOWA (Multi Protocol Over Wireless ATM)
- introduce mechanisms such as FEC (Forward Error Correction), ARQ (Automatic Repeat Request)

Mobile and Wireless ATM (MWATM)

- Require ATM switches with mobility features. (Mobility enhanced ATM switches).
- Mobility specific: Signaling, Location management, mobility management, security management and connection admission control
- Issues: Mobile phones are increasing, fixed phones keep steady and even decreasing. Mobility specific issues should be taken into account.
• ATM is necessary when a very good QoS is needed
• Disadvantage of ATM
  – Big overhead
  – Complex and expensive
  – expensive support of VC (time, grow exponentially)
  – support of IP is complex
New Communication architecture

• Challenge: offer QoS in the Internet network
• Multimedia applications (voice and video) for Internet will be developed and used when QoS mechanisms will exist
• New functions must be developed to guarantee performance, offer security, avoid jitter, allow the respect of time-constraints, ...

Mechanisms allowing QoS

• 1996: proprietary solutions such as Tag Switching (Ipsilon), IP Switching and Net Flow Switching (Cisco), ARIS (IBM), IP Navigator (Cascade), ...
• Signalization (control, management) -> routers
• Data -> switches
Switch IP

ATM Link

Router

First IP Packet

Other IP Packets

Router fct

Switch

Router fct

Switch

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• The control plane of ATM has been transferred to the IP layers
• IP: routing, signaling and the management of switching tables (20% traffic)
• ATM or Ethernet: only the fast forwarding at level 2 (80% traffic)
MPLS (Multi Protocol Label Switching)

- Packet forwarding is based on labels
- Labels (4 octets) are assigned when the packets enter into the network
- The assignment of a packet to a FEC (Forwarding Equivalence Class) is done just once when the packet enters in the network at the ingress node, all packets with the same destination use a common route
- At the egress node, the label is removed
- The label is inserted between the layer 2 header and the IP header
• Existing protocols (BGP, RSVP, …) are extended to enable to piggyback the MPLS labels
• Label switching enables better IP/ATM integration
  – Can encode one or two labels into the VPI/VCI field when 2 ATM-LSR are connected
  – IP protocols are switched instead of routed
  – IP can keep RIP, OSPF or BGP protocols

• MPLS nodes (LSR or Label Switching Router) forward packet/cell based on the label value.
• LSR: only switching and no more routing
• Label switching is a packet forwarding
• MPLS combines L3 routing (IP) and L2 forwarding (ATM with VPI/VCI or Ethernet with a shim label between the MAC and the VLAN addresses (switched Ethernet))
• LSR can implemented DiffServ: DiffServ over MPLS
A LSP (Label Switched Paths) is a sequence of routers
LDP (signalization protocol): manages the information exchange between the LSR to establish the LSP and associates a FEC to each LSP
A LSR sent periodically a LDP Hello Message
Can introduce path protection/restoration: alternate route

Can use RSVP as Label Distribution Protocol
CR-LDP (Constraint-based Routing LDP): the LSR establish LSPs satisfying to a set of constraints
MPLS supports IP QoS models
Can be used to build VPN
Support all types of traffic
Can define a trunk for each pair of ingress/egress router OR for each CoS
MPLS is able to any IP-compatible link layer technology
- GMPLS: integrate ATM, Ethernet, FR, TDM, optical networks. Networks which have references.
- Can do traffic engineering (enable to control the network resources and not only the input load to enable the performance optimization): network, structural, behavioral and simulation models are necessary => CR-LDP
- Traffic engineering must be implemented as an automatic control system

Real time Transport Protocol and Real Time Control Protocol
- RTP: functions for real time applications
- RTCP: used for supervision and control information
- => QoS for voice and movies without jitter
**Reservation of Resource**

- First Internet generation: RSVP (supervision packet via a routing algorithm)

- IP generation of UMTS: COPS (supervision packet via a central command site)

**Ressource ReSerVation Protocol**

- Signalization protocol to establish unidirectional flows in IP networks

- RSVP is used by routers to deliver QoS

- RSVP request: reserve resources in each node along a path

- RSVP sends periodic refresh message to maintain the state along the reserved paths(s)

- The bandwidth is reserved for a given flow

- Require resources reservation and releasing at regular intervals
• Establishment/maintain of unidirectional flows in IP networks through the messages PATH and RESV
• RSVP messages are encapsulated inside IP packets
• Refresh regularly the flow (soft state solution). Default refresh period = 30 seconds
• Supports MPLS and layer 4 flows
• Support multicast and unicast traffics

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• Signalization transport can be done by COPS (Common Open Policy Service):
  – exchange between a policy server (Policy Decision Point) and a edge router (Policy Enforcement Point): RAP (Resource Allocation Protocol) IETF Standard
  – SNMP ->COPS
  – MIB->PIB (Policy Information Base): set of classes
    – variable->object
    – UDP->TCP
• In the PEP, we can found LPDP (Local PDP)
• Consult the PDP of the operators: to know the best network, best price of the communication

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• 2 policy management:
  – outsourcing policy model: PDP decides if a request can be accepted or not (ex RSVP request)
  – provisioning policy model: PDP decides what politic should be installed in routers
• PDP include bandwidth, security and mobility brokers, authentication servers, billing …
• COPS can use IPsec for authentication and secure communications

• PDP is connected to
  – LDAP server (accept or not a new user)
  – PIB (base with all politics)
  – Bandwidth broker (manage the available resources)
  – Mobility broker
  – Security broker
• For example: can give a priority to Web access, high priority for Email and video, prohibit the access to some URL at give time, …
  ⇒ Email is premium, Web is BE
IntServ

- Based on traffic control mechanisms
- Signalization protocol: RSVP
- Reservation at the router level
- Poor scalability: the amount of state increase proportionally with the number of flows
- Problems:
  - all routers must have RSVP
  - there is no policy for the reservation control
  - stations must support signalization

=> small networks

Classes of Service for IntServ

- Guaranteed Service (Premium service): application required fixed delay bound (CBR, RT-VBR)
- Controlled-Load Service (Olympic service): applications requiring reliable and enhanced best-effort service (NRT-VBR, GFR, ABR)
- Null service: no respect of time constraints (UBR), but a better best-effort service
DiffServ

- DiffServ is a relative-priority scheme
- Signalization protocol: SLA
- Specify contracts for few traffic classes
- IP Packets are classified and marked at the network ingress routers to create several packet classes
- Type of service is marked inside each IP packet
- DiffServ scalability comes from the aggregation of the traffic
- Utilize aggregate classification state in the core of the network
- Share the bandwidth => hierarchy of the different flows

- Work with existing applications
- Similar as MPLS, but more adapted for MAN
- Complex mechanisms are implemented only on boundary nodes
- Complexity depends on the number of different services
- SLA between the client and the provider which specifies for each service the amount of traffic that can be sent
Classes of Service for DiffServ

• Expedited Forwarding (Premium service): fixed bit rate between source and destination -> CBR, rt-VBR
• Assured Forwarding (Olympic service): bursty service, no QoS guaranteed but low loss probability -> ABR, GFR, nrt-VBR
• Bulk Handling: service such as file transfer or mail when no other packets needs to be transmitted -> UBR
  Ex: Priority: Voice, VPN+OSPF, BGP, BE

• DiffServ is more easy (less complex) to be implemented than IntServ, but give less accurately (less QoS flow differentiation) to the flows
• DiffServ: located in the core of the network between the routers
• IntServ: periphery of the networks. Work on micro-flows. Complex, "hard" approach for QoS.
• LAN: IntServ
• MAN: DiffServ (or IntServ)
• WAN: MPLS
• DiffServ is an evolution of IP service: load control at aggregate level by the network and not at flow level by TCP
• MPLS is another evolution of IP service: generic connection orientation, increase of routing functionalities

CORBA (Common Object Request Broker Architecture)
• QOS needs to take into account heterogeneous systems
• Middlewares hide the heterogeneity of platforms having each own:
  – network protocol
  – Operating System
  – programmation language
• IDL (Interface Definition Language) is used by CORBA to define the objects and their interfaces
• integration of QoS mechanisms is more easy in small networks, because large networks integrate a lot of heterogeneous domains
• Internet 1: will still exist
• Internet 2: QoS during all the communication. MPLS ??
• IPv4: introduce intelligence in the nodes
• IPv6: use the intelligence of the PC

• CTI (Computer telephony Integration)
  – PC: intelligence in the PC
  – telephony: intelligence in the network
  – => to reach a compromise
QoS in Wireless Networks

- Cellular networks
- Mobile and Wireless networks
- Data transmission networks
- Satellites networks
- wave radio-electrical: large distances, penetrate the buildings.
- wave infrared: small distance, do not penetrate the buildings.
- micro-wave: frequency upper to 100 MHz, distances 80 km, do not penetrate the buildings.
- light wave: lasers are quickly absorbed by the rain or the snow

What is Wireless Internet?

- U.S. Federal Networking Council resolution, October 24 1995, defines the Internet in terms of:
  – Globally unique address space
  – Support for TCP/IP communications
  – Enabling of high level services
- Systems that don’t do this are not “the Internet”
- Wireless Internet is just that part of the Internet that sends data over wireless links (same for satellites)
Bringing the Internet to the RF world and vice-versa

- Long and valuable history of “pre-internet” wireless engineering of applications solving problems like mobility, scale, location, real-time transport
- Long and valuable history of Internet of wired systems with applications solving problems like routing, addressing, multimedia transmission

What Are The Drivers?

- **Transparent Access**
  - End to end access to the Internet through a number of different end systems (PC, handhelds, cellular devices, palm pilot, etc.)
- **Quality of Service (QoS)**
  - IP QoS essential for next generation services
  - Multimedia content over the Internet necessitates differentiation of traffic classes
  - Creates a need for different delivery mechanisms:
    - consumers
    - commercial users
    - content providers
**Mobile Internet Applications**

- **Financial**
  - Stock quotes and notification
  - Financial news
  - Stock trade engine
  - Banking engine
- **Mobile travelers**
  - Weather services
  - Address finder
  - Route planner
  - Restaurant and hotel finder
  - City guide and Air/Train/Bus information

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**Mobile Internet Applications (Cont.)**

- **Mobile Community**
  - Community chat
  - Secrets sharing engine
- **Mobile entertainment**
  - Games
  - Music sharing
  - Picture messaging
- **Mobile Personal Internet management**
  - E-mail
  - Net meeting
  - Calendar and address book
Internet Protocols
What are the problems?

• A standards problem?
• An implementation problem?
  – Code length?
  – Algorithm Options?
• An analytical Problem?
  – Queuing analysis?
  – System behavior?
• Bottleneck problem?
  – It is not where you think it is

Internet Protocols
What are the Problems? (cont.)

• A hardware problem?
• A software problem?
  – Too many errors and too many versions?
• A network engineering problem?
  – Design and implementation?
• Wrong selections of multiple vendors’ products?
• Interoperability in multi-vendors environment?
• Surprise! It’s all of these
What are the Issues?

• Why the existing networks don’t go so fast?
  – Protocol design
  – Current perception of protocols
    • Hard to design and document
    • Hard to understand and code
    • They run slow
• Whose fault is this?

What is a good Performance?

• A cell phone is only as good as the network it is on
• Speed?
• Effective use of costly resources
• Meeting users expectation
• Keeping users happy
• Educate users and yourself
• Think of quality of Service (QoS)
  – e.g., Speed, Delay, Loss rate
Who Cares About These Problems?

- There are many parts to good performance
- Network and protocol designers must design good standards
- Implementers of networks and products must develop and ship good hardware and software
- Network operators must observe and manage the network
- The users must be educated consumers
- There is something for everyone us

Mobile, Satellite and Personal Communications - 4th Generation

- Satellite Broadband
  - Satellite Universal Mobile telecommunication System (S - UMTS)
  - S - DVB
- Broadcasting
  - Digital Video Broadcast (DVB - T)
  - Digital Audio Broadcast (DAB)
- Cellular
  - Enhanced Data rates for GSM Evolution (EDGE)
  - General Packet Radio System (GPRS)
  - GSM
  - UMTS and UMTS++
Mobile, Satellite and Personal Communications - 4th Generation

(CONT.)

• Semi - Cellular
  – MBS
• Wireless in Local Loop (WiLL)
  – Wireless Fixed Access (WFA)
  – MWS
  – xMDS
• Local Area Networks
  – LANs
  – Personal Networks
• Broadband W - LAN
• Bluetooth
• IR
• Home - Cell
  Home Networking

Mobile, Satellite and Personal Communications
Research Projects - 4th Generation

• ADAMAS - ADAptive Multicarrier Access System
• ASILUM - Advanced Signal processing schemes for Link capacity increase in UMTS
• BRAHMS - Broadband Access for High Speed multimedia via Satellite
• BRAIN - Broadband Radio Access for IP based Network
• CAST - Configurable radio with Advanced Software Technology
• DRY - Dynamic Radio for IP-Services in Vehicular Environments
• EMBRACE - Efficient Millimetre Broadband Radio Access for Convergence and Evolution
• MCP - Multimedia Car Platform
• METRA - Multi-Element Transmit and Receive Antennas
• MORIVAS - Downloadable MOBIle Value Added Services through Software Radio & Switching Integrated Platforms
• MULTIKARA - Multibeam Ka-band Receiving antenna for future “multimedia via satellite, direct to home” systems
• PLATFORM - Platform And Software for Terminal: Operationally Re-configurable
• R-FIELDBUS - High Performance Wireless Fieldbus In Industrial Related Multi-Media Environment
Research Projects
4th Generation (Cont.)

• SATURN - Smart Antenna Technology in Universal bRoadband wireless Networks
• SODERA - Re-configurable Radio for Software DEfined RA dio for 3rd Generation mobile terminals
• SUITED - Multi-Segment System for Broadband Ubiquitous Access to Internet Services and Demonstrator
• TRUST - Transparent Re-configurable Ubiquitous Terminal
• VIRTUOUS - Virtual Home UMTS on Satellite

• WIND-FLEX - Wireless Indoor Flexible High Bit rate Modem Architecture
• WINE GLASS - Wireless IP Network as a Generic Platform for Location Aware Service Support
• WSI - Wireless Strategic Initiative
• WINE - Wireless Internet Networks http://www.cordis.lu/ist/ka4/mobile/barc_tab.htm

Broadband Radio Access IP based Networks Projects

• Access network is based on end - to - end IP real time and non real time services
• Application is in Suburban, Urban, in buildings and home cells
• Provides higher rates up to 20 Mbps for cellular systems
• Coverage is in campus areas, conference centers, railway stations and airports.
• Its radio interface is based on HIPERLAN type 2 physical and MAC layers
• Provides local and global mobility management and QoS through IP services

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Dynamic radio IP - Services in Vehicular Environments

Projects

• Delivery of high QoS multimedia to cars, buses and trains and supports for education and entertainment
• High quality wireless IP use common frequency range and dynamic frequency allocation

Mobile and Wireless Standardization Forums

• ITU - UMTS (www.itu.org)
• 3rd Generation Partnership Project (3GPP) - http://www.3gpp.org/
• European Telecommunications Standards Institute (ETSI)
• Wireless Application Protocol (WAP) - www.wapforum.org
• HTML --> WML --> WAP

• Mobile Wireless Internet Forum (MWIF) (www.mwif.org)
• Information Society Technologies (IST), Wireless Information Society 4th generation
• http://www.cordis.lu/ist/ka4/mobile/barc_tab.htm
• http://www.infowin.org/ACTS/IST/
• http://www.etsi.org
• http://www.iert.org
• http://www.ipv6forum.com/
• Cellular IP < draft-ietf-mobileip-cellularip-00.txt>
• Requirements on mobile IP from a cellular perspective < draft-ietf-mobileip-cellular-requirements-02.txt>
• http://www.atmforum.com
Multiple Access Techniques

• Fixed assignments
  – FDMA (analogical), TDMA (numerical) and CDMA (3G)
• Random Access
  – Contention resolution process has large delay
• Demand assignment (Reservation)
  – No waste of bandwidth. It minimizes wasted bandwidth by assigning BW on demand and avoid BW wasted due to collisions.
  – Most appropriate for integrated wired and wireless networks.

Demands for all IP Networks

• Satellite and Wireless Networks now seen as inherent sub-nets of the internet
• Internet Performance is key to market success:
  – Support asymmetrical traffic
  – Support IP QoS for real time applications
  – Support IP/MPLS and ATM over DWDM for ISP providers
• Efficient mechanisms
  • Avoid inefficient mechanisms except when driven by other essential requirements (Security, availability, cost and complexity)
Satellite Transponders

- LEO (Low Earth Orbit) use the Ka band

- MEO (Medium Earth Orbit),

- GEO (Geo-synchronous Earth Orbit).

- LEO at 800 MHz offer 300 kbit/s rate: send messages and for localization.
  GPS (Global Positioning System).

- LEO at 2 GHz offer 10 kbit/s rate: telephony.

- LEO at 20 to 30 GHz offer 155 Mbit/s rate: multimedia applications.
Satellites:
- Ku band (10 GHz to 18 GHz),
- C band (4 GHz to 6 GHz) for the connections between terrestrial stations and satellites.
- Ka band (20 GHz to 30 GHz) not very used
- V band (40 GHz to 50 GHz) futures applications

LEO (Low Earth Orbit), between 500 and 2000 km.
Communication delay: 0.01 second and rate of 155 Mbit/s.

To cover the world: 50 satellites, one satellite covers the skylink in 15 minutes.
- Iridium (Motorola) is composed by 66 satellites located at an altitude of 780 km and by 6 emergency satellites (since 1998, out of service).
- Globalstar (France Telecom, Daimler-Benz Aérospase) is composed by 48 satellites located at an altitude of 1414 km and by 8 emergency satellites.

- Teledesic (Microsoft and de Craig McCaw) is planned for 2004. It will be composed by 288 satellites located at an altitude of 1375 km with a download rate of 64 Mbit/s and an upload rate of 2 Mbit/s.
- Integrate bandwidth allocation functions, switching, inter-satellites communication
- Skybridge (Alcatel Space) is scheduled for 2002. It will be composed by 80 satellites located at an altitude of 1469 km and will offer a rate of 200 Gbit/s.
- will use the Ku band.

- MEO are located at an altitude of between 5000 and 20000 km and the communications delay are 0.1 second.
- A communication can remain one hour. 12 satellites are necessary to cover all the earth. (ICO systems)
- GEO:
36600 km and the delay are 0.27 second (round).
Duration: 15 to 20 years and 3 satellites can cover all the world.
- Spoofing: send a quick acknowledgement, equipment continue the transmission. The errors management are done later.
- VSAT (Very Small Aperture Terminal) rate of 50 Mbit/s.
Antenna has 1 meter diameter.

- Pico-satellite: 1 kilo, 340 km
- HEO (Highly elliptical Earth Orbit)
- HAPS (High Altitude Stratospheric Platform):
  + Proteus airplane (Awacs) will offer a bandwidth of 164 bit/s for a 100 km diameter
  + Airship at an altitude of 23 km (Sky Station project). Rate of 10 Mbit/s in the 48 GHz band.
Internet Goes Mobile

- Satellites create an orbiting Internet
- Mobile IP (different from Roaming) will be used in Cellular Networks
  - Mobile IP should be independent of access protocols
  - Interconnection to existing devices
  - Deploy IP security with mobility features
  - Provide QoS for mobile users
    - Handover (Europe) / Handoff (US)
      - Soft-handover, hard-handover (cell and frequency change)
    - Route optimization
- Mobile IP over 802.11

Mobile IP in Cellular Networks (Cont.)

- Mobility need to be included in QoS architecture, Differentiated and integrated services
- There is a need for a uniform service delivering across broadband wireless access technologies
- 2G (HLR and VLR) => Mobile IP in Internet Telecom
- (Cellular IP + Mobile IP) or (Mobile IP + AdHoc networks) will compete with 3G
- Basic Mechanisms
  - Authentication, Authorization, accounting (AAA)
  - QoS and policy control
  - Directory and gateway services
- Pico-cells for communications with distances between 5 and 50 meter
- micro-cells for communications with distances between 50 and 500 meter,
- macro-cells for communications with distances between 0.5 and 10 km.

USA technologies:
- D-AMPS (Advanced Mobile Phone System) 800 MHz or 1900 MHz and based on TDMA,
- PCS 1900 (Personal Communication Services) 1900 MHz and based on TDMA,
- IS-95 based on CDMA.
- IS-136 based on TDMA
Japan - PDC (Personal Digital Cellular) numerical technology
Europe - numerical technology GSM, DCS and PCS

15 billions SMS per month (2000)
200 billions SMS per month (2001)
=> MMS (Multimedia Messaging Service)

GSM (Global System for Mobile Communication). Rate of 10 kbit/s.
220 million of users
- 900 MHz (France : Itinéris and SFR) or
- 1800 MHz (Bouygues Telecom) which use the DSC (Digital Cellular System) standards. Two-bands (GSM and DSC), three-bands (900, 1800 and 1900 MHz)
Public Land Mobile Network (PLMN)
- Base Station Subsystem (BSS): manage radio resources
  * Mobile Station,
  * Base Transceiver Station (BTS)
  * Base Station Controller (BSC)
- Network and Switching Subsystem (NSS): manage network resources
  * Visitor Location Register (VLR) manage the localization of the mobiles
  * Home Location Register (HLR) contain the information about the subscription
  * Mobile Switching Center (MSC)

• Operation Sub-System (OSS): administration and management of the network and the local administration of the equipment

• Mobile: search of the control channels sent by the different Base Transceiver Station or BTS

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• BSC establish the communication with the Mobile services Switching Center or MSC

• When the best BTS is chosen, the mobile asks for a logical signalling channel to the BSC which manage the communication synchronization

- GPRS (General Packet Radio Service): rate of 170 kbit/s
  - packet switching
  - cost of the communication is based on the amount of data
  - without modification of the BSS: same frequency of the GSM
  - reuse the BTS and the BSC
- NSS: add a gateway GSM and the packet mode
- 2 additional routers:
  - SGSN (Serving GPRS Support Node): manage the resources, the sessions, the taxation and the mobility,
  - GGSN (Gateway GPRS Service Node) manage the connections with the IP networks

EDGE (Enhanced Data rate for GSM Evolution): rate of 384 kbit/s

E-GPRS (Enhanced GPRS): apply EDGE to GPRS

=> Services comparable to UMTS (Universal Mobile Telecommunication System) services
IMT2000 (International Mobile Telecommunication 2000): 

- l’UMTS (Universal Mobile Telecommunication System): 3GPP (Third Generation Partnership Project):

+ SMG (Special Mobile Group) of ETSI (European Telecommunication Standard Institute),
+ Japanese organizations ARIB (Association of Radio Industries and Business) and TTC (Telecommunication Technology Association),
+ Korean organization TTA (Telecommunication Technology Association),
+ American committee T1P1.
- CDMA 2000 (USA) is an evolution of the American IS-95 standard,
- UWC-136 (USA) based on the GPRS and EDGE technologies and is an evolution of the American IS-136 standard.
- UMTS (Europe) -> UMTS TDD (TD-CDMA)
- W-CDMA (Japan) -> UMTS FDD

- BTS -> node B
- BSC -> RNC (Radio Network Controller)
- MSC -> UMSC (UMTS MSC)
- BSS -> RNS (Radio Network Subsystem)
- MS (Mobile Station) -> UE (User Equipment)
UTRAN (Universal Terrestrial Radio Access Network) uses the modes:
- TDD (Time Division Duplex):
  + temporal multiplexing and 2 Mbit/s rate (dense traffic)
  + asymmetrical traffic
- FDD (Frequency Division Duplex)
  + frequency and codes multiplexing
  + 380 bit/s rate: large network.
  + upload and download traffic use different frequencies
  + symmetrical traffic

IMT 2000:
- integrate in a same network, the cellular network, the wireless network and the data transmission networks.
- services and intelligent terminals (unique number and universal)
- multimedia services: bandwidth on demand.

2 billions users in 2010
- VHE (Virtual Home Environment) to obtain their services and his usual environment with use of smart card
- rate 2 Mbit/s (City), 144 kbit/s (countryside), de 30 kbit/s (global mobility for satellites)
- 1885 MHz to 2030 MHz band
- 2110 MHz to 2200 MHz band

- New frequency and new infrastructures
- Fourth generation networks for 2010 will use the 30 GHz frequency
ETSI (European Telecoms Standards Institute) has defined standards for the wireless networks in the 5 GHz frequency, Hiperlan (High Performance Radio Lan): rate of 25 Mbit/s, small distances.

Wireless LAN (WLAN)

- IEEE 802.11b : frequency 2.4 GHz, rate 11 Mbit/s, 100 meter, 2 walls
- CDMA/CA
- IEEE 802.11a : 5Ghz, 54 Mbit/s
- IEEE 802.11d : introduction of a MIB
- IEEE 802.11e : 802.11.a + security
- IEEE 802.11e : interchangeability
- IEEE 802.15.1: Wireless Personal Area Network (Bluetooth). Rate 433 kbit/s, 2400MHz. 3 meters (WPAN: Wireless Personal Area Networks)
- IEEE 802.15.4: 200 kb/s, communications between toys, sensors
- HomeRF: home automation, 1,6 Mbit/s

• Bluetooth and Home RF: phone + computer
• 802.11: only computer

• DECT (Digital European Cordless Telephone): 100 m, rate of 500 kbit/s, frequency of 1880 MHz to 1900 MHz.
Wireless Local Loop (WLL)
IEEE 802.16
- LMDS (Local Multi-point Distribution Service): + bi-directional transmissions point to multi-points
  + rate of 1 Gbit/s in the 28 GHz to 31 GHz band
  + 1 to 2 km distances
  + directive antenna without shadow area, Rain Fading

MMDS (Multi-channel Multi-point Distribution Service):
+ unidirectional video
+ distances 10 km in the 2.5 GHz to 2.7 GHz band
+ rural areas without CATV.

IEEE 802.16:
+ 1 and 66 GHz
• GSM -> ISDN
• GPRS -> Frame Relay
• UMTS -> ATM (AAL2)
• 2nd generation of UMTS and CDMA 2000 -> IP

THANK YOU - Question ??