



## Episode 5: Cellular Networks (GSM and UMTS)

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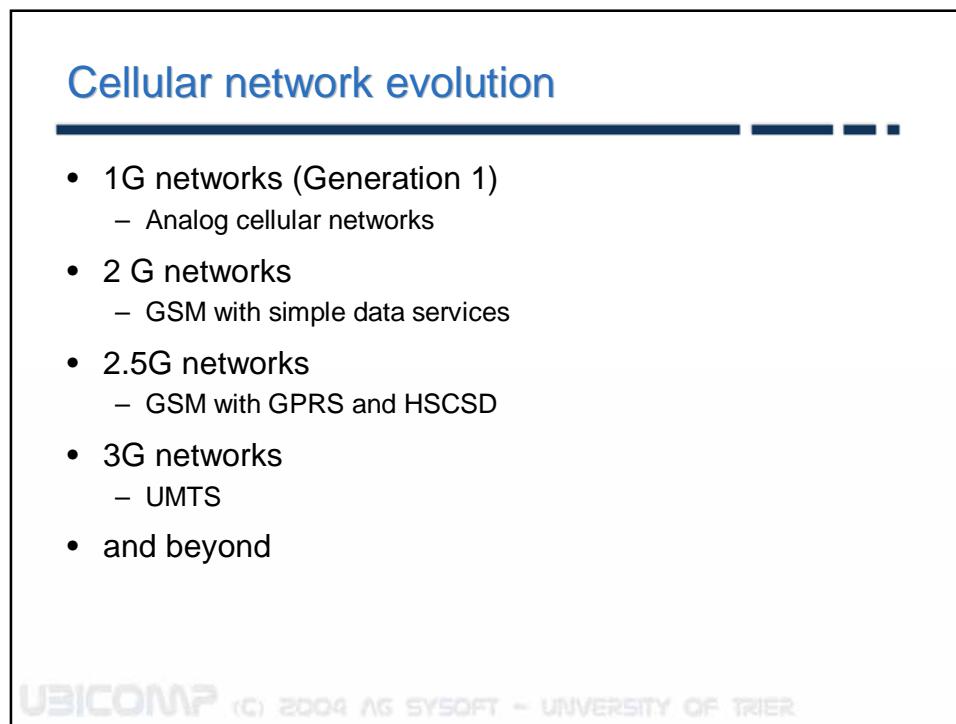
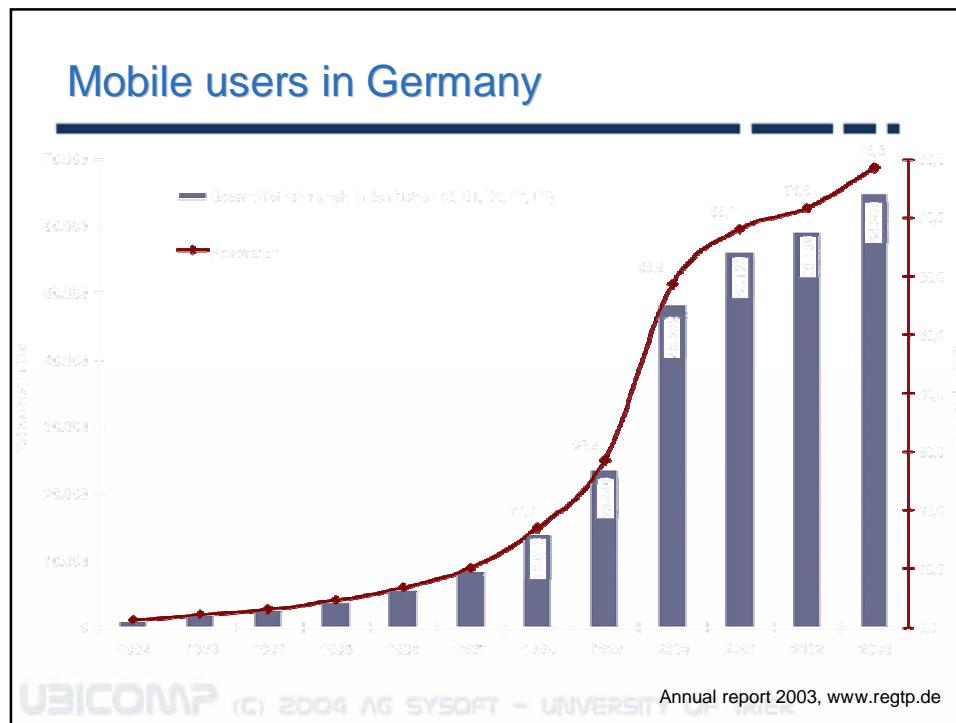
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### Motivation

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- Mobile telephone networks are nearly ubiquitous
- Still basic client/server architecture
  - Only “last mile” wireless
  - Wired backbone structure
- From voice to data

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## GSM (1982-)



- = Global System for Mobile Communication  
(Groupe Speciale Mobile by CEPT)
- Goals
  - Good speech quality
  - Low cost for terminals and services
  - International roaming
  - Handheld terminals
  - Spectral efficiency
  - Compatibility with ISDN
- Primary usage
  - Voice calls
  - Short message service (SMS)
- First commercial services 1991

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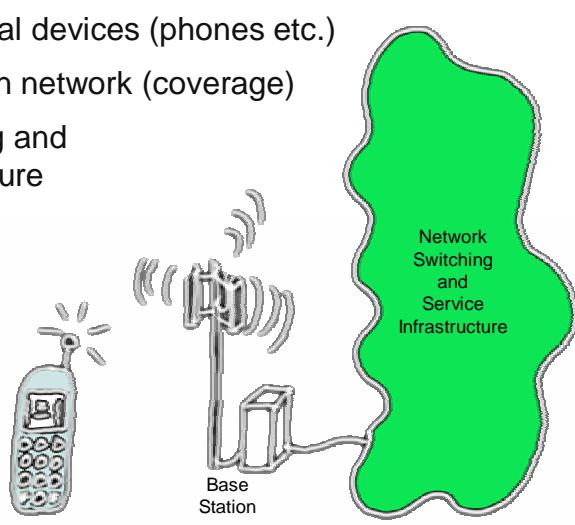
## Characteristics

- Circuit switched network
- Three major frequency bands
  - 900 MHz and 1800 MHz (Europe and Asia)
  - 1900 MHz (North America)
- 200 kHz wide radio channels
  - Data rate appr. 270 kbps
- TDMA division of channel into 8 time slots
- Frequency division duplex
  - Separate channels for mobile devices to base station and
  - Base station to mobile devices

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## Basic structure

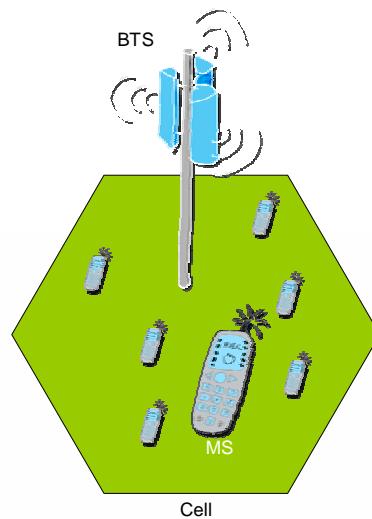
- Subscriber terminal devices (phones etc.)
- Radio base station network (coverage)
- Network switching and service infrastructure



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## MS and BTS

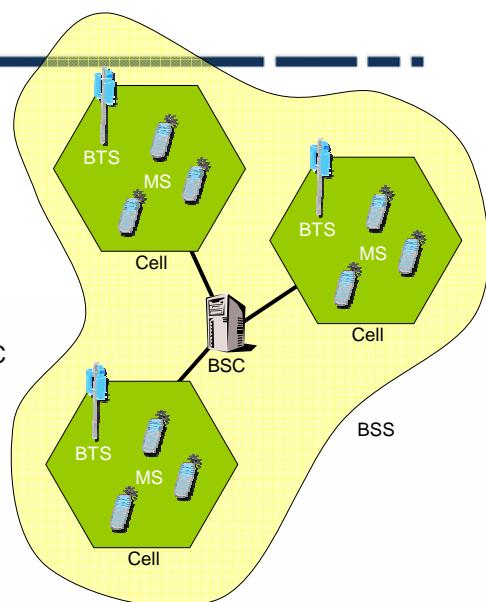
- Mobile station (MS)
  - Mobile terminal (MT)
    - Cellular handset
  - Terminal equipment (TE)
    - PC or PDA
- BTS
  - Radio equipment
    - Antennas
    - Signal processing devices
    - Amplifiers
  - Link establishment
  - Modulation and demodulation of radio signals between MS and BTS



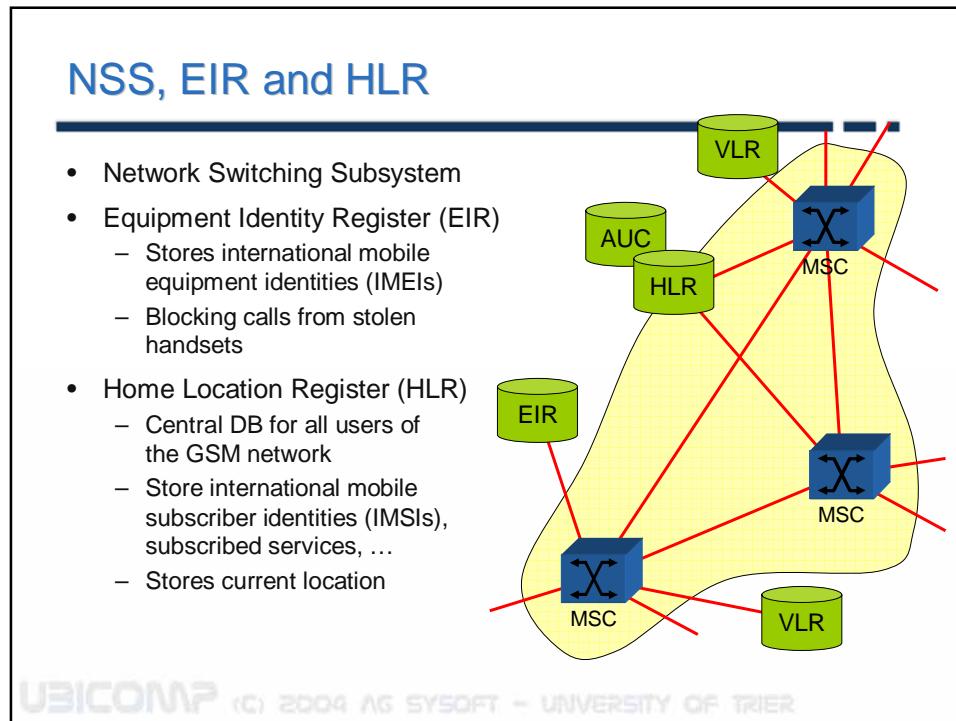
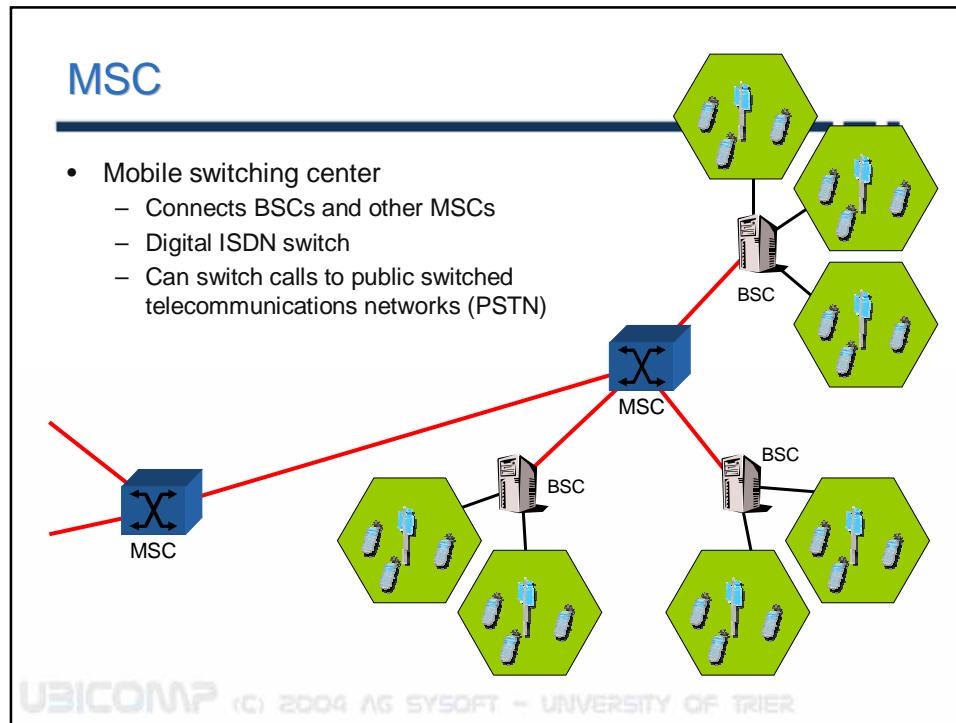
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## BSC and BSS

- Base station controller
  - Manages BTSs
  - Reserves radio frequencies for communication between BTSs
  - Handles handoffs
  - Pages MS for incoming calls
- Base station subsystem
  - Set of cells controlled by a BSC
  - Monitoring

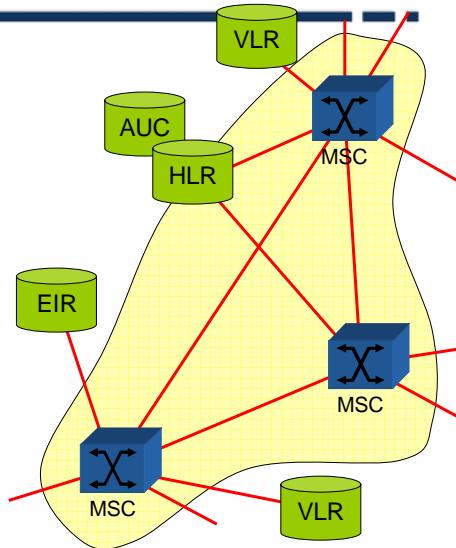


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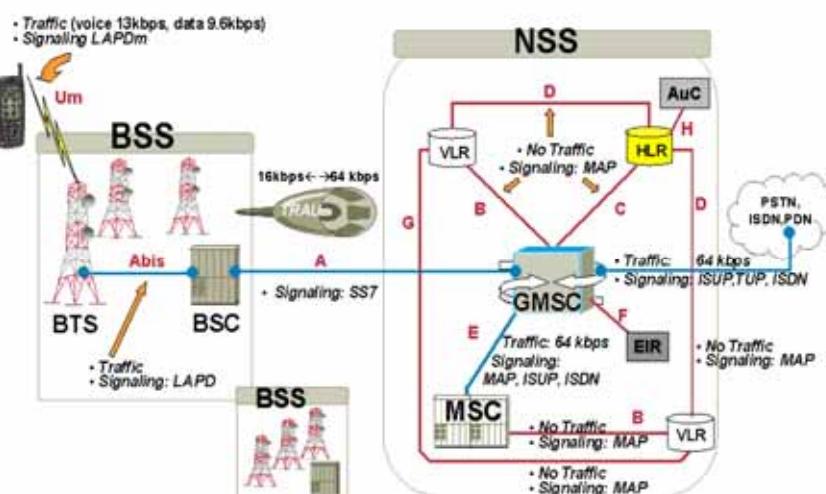
## AUC and VLR

- Authentication Center (AUC)
  - Associated with HLR
  - DB stores algorithms for authenticating subscribers
  - Encryption keys
- Visitor Location Register (VLR)
  - Distributed DB
  - Temporary information about mobile stations active in a given geographic area
  - Copies data from HLR



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## GSM interfaces



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## Signaling and traffic

- GMSC = Gateway MSC
  - Connects to the PSTN
- Between MS and BTS
  - ISDN Link Access Procedure-D mobile (LAP-Dm)
  - Channel carries speech (13 kbps) and data (9.6 kbps)
- Between BTS and BSC
  - ISDN LAP-D
- Between BSC and MSC (GMSC)
  - SS7 and TRAU (Translation between 16 kbps and 64 kbps)
- Inside the NSS
  - MAP = Mobile Application Part of SS7 (Signaling System 7)
  - ISUP = ISDN User Part (call traffic at 64 kbps) (part of SS7)

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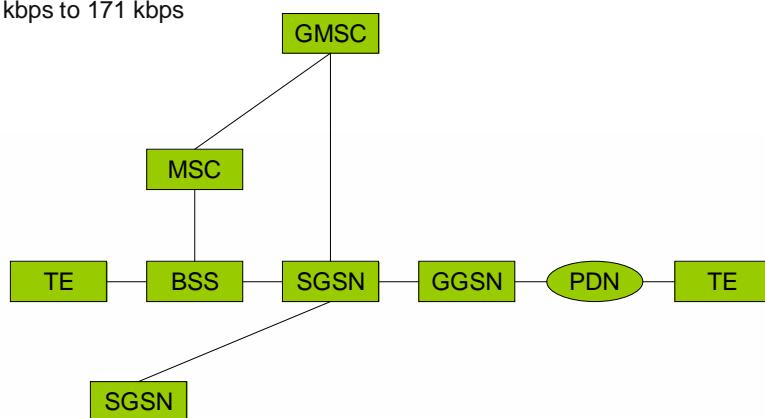
## GPRS (General Packet Radio Service)

- GSM offers circuit switched data
  - Dedicated channel between MS and provider
  - Charging based on the duration
- GPRS implements packet switched data
  - Overlay on existing GSM network
  - Always On
  - Supports bursty applications such as email, web, ...
- Applications
  - Communication (intranet, internet, mail, unified messaging)
  - Information services, games
  - E-Commerce
  - Location-based applications
  - Vertical applications (freight delivery, fleet management)
  - Advertising

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## GPRS Architecture

- Overlays 2G GSM network
  - Packet data transport
  - 9.6 kbps to 171 kbps



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## GPRS Support Nodes

- Serving GPRS Support Node (SGSN)
  - Delivers packets to mobile stations
  - Queries HLR etc.
  - Detects new GPRS MS
  - Performs mobility management (handoff)
  - Connects to PCUs in the BSC
- Gateway GPRS Support Node (GGSN)
  - Interfaces to external IP networks
  - Maintain routing information to tunnel protocol data units (PDU) to the SGSN serving the particular MS

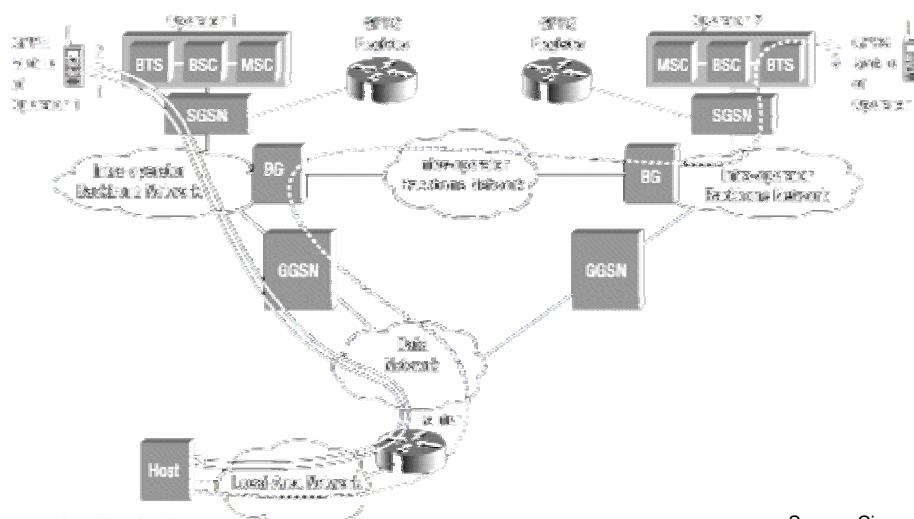
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## GPRS terminals

- Class A
  - Supports GPRS and GSM in parallel
  - Simultaneous attach, activation, monitor, and traffic
  - GPRS virtual circuits are placed on hold in the presence of circuit-switched GSM services
- Class B
  - Monitors GPRS and GSM in parallel
  - Simultaneous attach, activation, and monitor
  - Sequential traffic
  - GPRS virtual circuits are kept busy
- Class C
  - Sequential attach (selected by user)

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## Packet routing



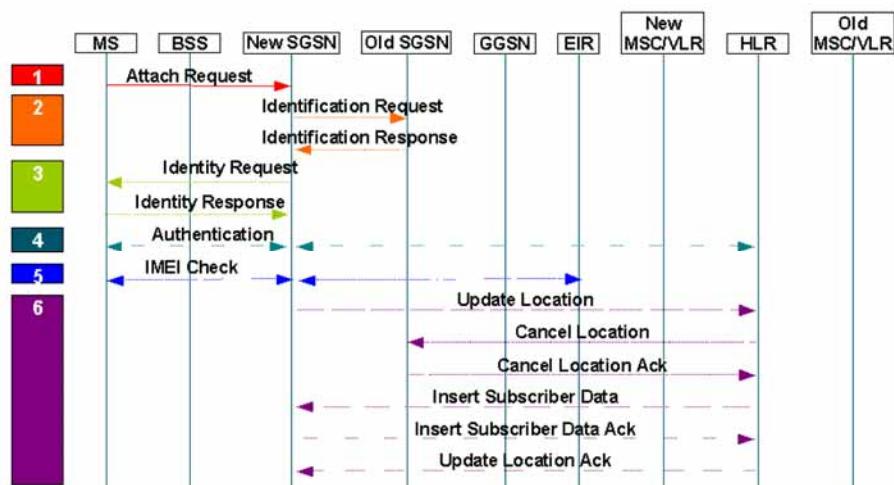
Source: Cisco

## States of MS

- Active state
  - SGSN knows cell location of MS
  - Exchange of packets between MS and GPRS network
  - Uplink and downlink channel shared with other MS (BSS resp. BSC serve as arbiter)
  - MS is notified about incoming pages
  - MS request uplink slot
- Standby state
  - Only routing area is known by SGSN (one or more cells)
  - SGSN can page MS to determine cell location
- Idle state

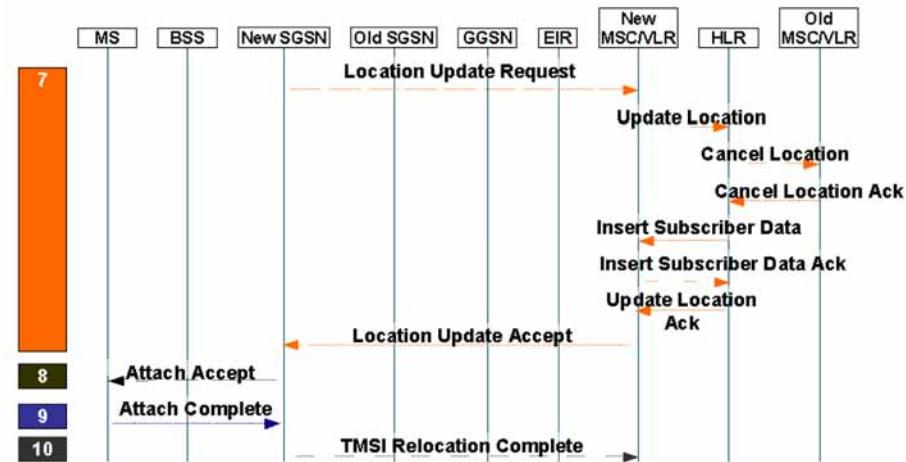
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## GPRS attach request (1)



Source: Cisco

## GPRS attach request (2)



Source: Cisco



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## Universal Mobile Telecommunication System

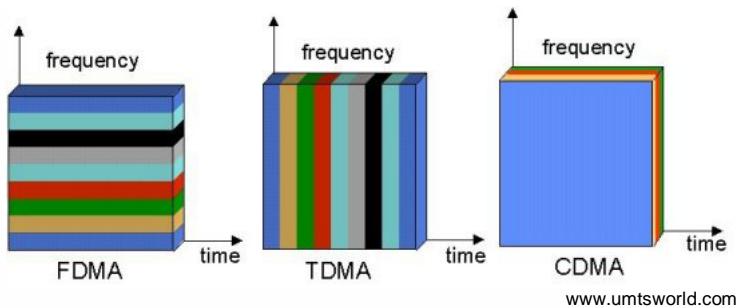
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- 3G mobile network
- Supports voice and data services
  - 144 kbps – Satellite and rural outdoor
  - 384 kbps – Urban outdoor
  - 2048 kbps – Indoor and low range outdoor
- Provides different QoS
  - Conversational class
  - Streaming class
  - Interactive class
  - Background class

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## Difference GSM and UMTS

- Major difference is air interface
  - GSM: TDMA and FDMA
  - UMTS
    - Wide-band code division multiple access (WCDMA)
    - Power control



## In the future

- HSCSD
  - High Speed Circuit Switched Data
  - Using multiple channels
  - Reliable data connection with QoS
- EDGE
  - Enhanced GPRS and CSD (Circuit Switched Data)
  - Higher bitrates
- Migration to completely ip-based networks
  - Voice over IP

## References

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- Cisco Mobile Exchange (CMX) Solutions Guide