Next Generation Network
Soft Switch
Long-Term Evolution
Worldwide Interoperability for Microwave Access

Course Number : TTH2A3
CLO : 2
Week : 6-7
Next Generation Network (NGN)
Next Generation Network

• Previous Network: TDM (Time Division Multiplex)
  (question: why do we need to use multiplex?)

• NGN: packet-based network

• Benefits:
  – Better QoS
  – Carrie any type of information
  – Accommodate future needs

ITU-T Study Group 13 defined an NGN in Recommendation Y.2001, as “A packet-based network able to provide telecommunication services and able to make use of multiple broadband, QoS-enabled transport technologies, and in which service-related functions are independent from underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and/or services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.”
Quality of Service

- QoS is a measurement on how well a network behaves to provide a service
- QoS parameters:
  - Delay
    Total time needed to deliver a packet from sender to receiver
  - Jitter
    Variant on packet arrival delay
  - Bandwidth
    Maximum transfer rate a transmission channel able to accommodate
  - Throughput
    Real transfer rate (successful packet delivered) after packet loss
NGN Architecture
Basic concept of Next Generation Network. Monolithic networks evolve towards a layered NGN architecture with open interfaces.

- **Application Plane**: Enables the provisioning of services and provides the control and logic for the execution of services.
- **Control Plane**: Controls the elements of the network, establishes and tears down media connections.
- **Transport Plane**: Responsible for the transport of media and signaling messages.
- **Management Plane**: Covers network management ensuring service fulfillment, service assurance, and billing.
- **Access Networks**: Connect customer networks or terminals with the components of the NGN network and aggregate the dedicated traffic type.
# Comparison between PSTN and NGN

<table>
<thead>
<tr>
<th>Features</th>
<th>PSTN/IN</th>
<th>Internet</th>
<th>NGN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multimedia services</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>QoS-enabled</td>
<td>Yes (voice)</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Network intelligence</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Intelligent CPE</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Underlying transport network</td>
<td>TDM</td>
<td>Packet</td>
<td>Packet</td>
</tr>
<tr>
<td>Service architecture</td>
<td>Semi-distinct</td>
<td>Ad hoc</td>
<td>Distinct</td>
</tr>
<tr>
<td>Integrated control and management</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Service reliability</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Service creation</td>
<td>Complex</td>
<td>Ad-hoc</td>
<td>Systematic</td>
</tr>
<tr>
<td>Ease of use of services</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Evolvability/modularity</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Time to market of services</td>
<td>Long</td>
<td>Short</td>
<td>Short</td>
</tr>
<tr>
<td>Architecture openness</td>
<td>Low</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>
Media Gateway on NGN

- **Media Gateway (MG)**
  - On Transport plane that connects different type of network
  - Trunk Gateway, connects packet-based network with trunk network from PSTN or ISDN
  - Access Gateway, provides services to CPE
  - Residential Gateway, connects packet-based network with analog network

- **Signaling Gateway (SG)**
  - Transforming signaling format, ex. SIP ↔ SS7

- **Media Gateway Controller (MGC)**
  - Control Media Gateway and Signaling Gateway
  - aka. **Soft Switch** (call setup for multimedia communication, detect and manage events, and manage media gateway based on configuration)
  - Use MGCP (MGC Protocol) from ITU-T or Megaco from IETF
Soft Switch (SS)
Definition

• Soft Switch = Software Switch
• Switching using software (program)
• Task: call processing, call routing
• Processor to control circuit switch (which switch connects and when)
• Basically it handles IP to IP phone calls
Soft Switch Sample Architecture #1
Soft Switch Sample Architecture #2
Benefits

• **Less Cost**
  – Network management works efficiently
  – Easy to initiate service development
  – Better network capacity using offloading mechanism

• **Better Quality of Service**
  – Provides flexibility on offering value added services
  – Faster installation
  – Provides capability for self-management by end user

• **Facilitate IP Migration**
  – Support transparent migration from PSTN to IP-based network
Call Scenario on Soft Switch

1. Analog phone to analog phone (PSTN-to-PSTN) over IP using Class 4 Softswitch
2. Analog phone to analog phone over IP using Class 5 Softswitch
3. IP phone to IP phone (LAN-to-LAN)
Some Features using Soft Switch

• Voice VPN, create a virtual (and private) network which connects several (and dispersed) users
• Centrex (Virtual PBX), create a group of users as if they are in secluded PBX, with features such as call transfer, Direct Inward Dialling (DID), Direct Outward Dialling (DOD), etc.
• Prepaid Services, provides calls using pre-paid card
• Web Base Services, provides special services via web such as web call center, corporate directory, collect call, hotline, etc.
• Unified Messaging Service (UMS), provides messaging service between users or from content provider
• Multimedia Conferencing, provides multimedia teleconference
Long-Term Evolution (LTE)
## What? When?

<table>
<thead>
<tr>
<th>1G</th>
<th>2G</th>
<th>3G (IMT-2000)</th>
<th>4G (IMT-Advanced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid 80’s</td>
<td>Mid 90’s</td>
<td>2001</td>
<td>2010</td>
</tr>
<tr>
<td>• Analog AMPS</td>
<td>• GSM</td>
<td>• UMTS</td>
<td>• SAE, EPC</td>
</tr>
<tr>
<td>• NMT</td>
<td>• IS-54/136 TDMA</td>
<td>• WCDMA (UTRA)</td>
<td>• LTE-Advanced</td>
</tr>
<tr>
<td>• TACS</td>
<td>• PDC</td>
<td>• HSDPA, HSUPA,</td>
<td>• IEEE 802.16m</td>
</tr>
<tr>
<td></td>
<td>• IS-95 cdmaOne</td>
<td>LTE, EDGE, EDGE+</td>
<td>• Interworking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>with all wireless</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and fixed access</td>
</tr>
</tbody>
</table>

- **1G**: What? When?  
- **2G**: What? When?  
- **3G (IMT-2000)**: What? When?  
- **4G (IMT-Advanced)**: What? When?
Bandwidth Evolution

- **GPRS/EDGE**
  - ~200kbps

- **GREAN**
  - ~600kbps

- **B3G**
  - ITU IMT-Advanced(4G)

- **WCDMA**
  - 384Kbps

- **HSDPA**
  - 1.8/3.6Mbps

- **HSUPA**
  - 1.4~5.8Mbps

- **HSPA+**
  - DL>40Mbps; UL>10Mbps

- **LTE-FDD**
  - DL:100Mbps
  - UL:50Mbps

- **LTE-TDD**
  - DL:100Mbps
  - UL:50Mbps

- **TD-HSDPA**
  - 2.8~8.4Mbps

- **TD-HSUPA**
  - 2.2~6.6Mbps

- **Mobile WiMAX Wave1**
  - 15Mbps

- **Mobile WiMAX Wave2**
  - 30Mbps

- **cdma2000 1x**
  - 153.6kbps

- **EV-DO Rel. 0**
  - DL: 2.4Mbps
  - UL: 153.6kbps

- **D0 Rel. A**
  - DL: 3.1Mbps
  - UL: 1.8Mbps

- **Do Rev B**
  - DL: 46.5Mbps
  - UL: 27Mbps

- **UMB**
  - DL: 100Mbps
  - UL: 50Mbps

- **UMB+**
  - 100Mbps~1Gbps
1 Generation

- Advance Mobile Phone System (AMPS)
- Bell Labs, America, 1978, FDMA, 800MHz, 1.9 kbps
- Nordic Mobile Telephony (NMT)
- Finland, Sweden, Denmark, Norway 1981. NMT-450, NMT-900.
- Total Access Communication System (TACS)
- UK, Ireland, 1983.
## 2 Generation

<table>
<thead>
<tr>
<th>System</th>
<th>GSM Global System for Mobile Communication</th>
<th>IS-95 cdmaOne</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where</td>
<td>Europe</td>
<td>America</td>
</tr>
<tr>
<td>Who</td>
<td>ETSI (3GPP)</td>
<td>TIA</td>
</tr>
<tr>
<td>Modulation</td>
<td>FDMA, TDMA</td>
<td>DSSS</td>
</tr>
<tr>
<td>Spectrum</td>
<td>900 MHz</td>
<td>1800 MHz</td>
</tr>
<tr>
<td>Max data rate</td>
<td>9,6 kbps</td>
<td>14,4 kbps</td>
</tr>
</tbody>
</table>
2,5 Generation

- General Packet Radio Service (GPRS)
- Theoretically 115 kbps with throughput 20 – 30 kbps
- MMS
## 2.75 Generation

<table>
<thead>
<tr>
<th>System</th>
<th>EDGE Enhanced Data rate for GSM Evolution</th>
<th>CDMA2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where</td>
<td>Europe</td>
<td>America</td>
</tr>
<tr>
<td>Who</td>
<td>ETSI (3GPP)</td>
<td>TIA</td>
</tr>
<tr>
<td>Modulation</td>
<td>FDMA, TDMA</td>
<td>DSSS</td>
</tr>
<tr>
<td>Spectrum</td>
<td>900 MHz</td>
<td>1800 MHz</td>
</tr>
<tr>
<td>Max data rate</td>
<td>384 kbps</td>
<td>153.6 kbps</td>
</tr>
</tbody>
</table>
# 3 Generation

<table>
<thead>
<tr>
<th>System</th>
<th>UMTS Universal Mobile Telecommunication Service</th>
<th>EV-DO Evolution-Data Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where</td>
<td>Europe</td>
<td>America</td>
</tr>
<tr>
<td>Who</td>
<td>ETSI (3GPP)</td>
<td>TIA</td>
</tr>
<tr>
<td>Modulation</td>
<td>WCDMA</td>
<td>DSSS</td>
</tr>
<tr>
<td>Spectrum</td>
<td>1900 MHz</td>
<td>1800 MHz</td>
</tr>
<tr>
<td>Max data rate</td>
<td>384 kbps</td>
<td>2.4 Mbps</td>
</tr>
</tbody>
</table>
# 3,5 Generation

<table>
<thead>
<tr>
<th>System</th>
<th>HSPA High Speed Packet Access</th>
<th>EV-DO Rev.A Evolution-Data Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where</td>
<td>Europe</td>
<td>America</td>
</tr>
<tr>
<td>Who</td>
<td>ETSI (3GPP)</td>
<td>TIA</td>
</tr>
<tr>
<td>Modulation</td>
<td>WCDMA</td>
<td>DSSS</td>
</tr>
<tr>
<td>Spectrum</td>
<td>1900 MHz</td>
<td>1800 MHz</td>
</tr>
<tr>
<td>Max data rate</td>
<td>HSDPA 14 Mbps</td>
<td>3,1 Mbps</td>
</tr>
<tr>
<td></td>
<td>HSUPA 5.76 Mbps</td>
<td></td>
</tr>
</tbody>
</table>
### 3.75 Generation

<table>
<thead>
<tr>
<th>System</th>
<th>HSPA+ High Speed Packet Access+</th>
<th>EV-DO Rev.B Evolution-Data Optimized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where</td>
<td>Europe</td>
<td>America</td>
</tr>
<tr>
<td>Who</td>
<td>ETSI (3GPP)</td>
<td>TIA</td>
</tr>
<tr>
<td>Modulation</td>
<td>WCDMA</td>
<td>DSSS</td>
</tr>
<tr>
<td>Spectrum</td>
<td>1900 MHz</td>
<td>1800 MHz</td>
</tr>
<tr>
<td>Max data rate</td>
<td>HSDPA 84 Mbps</td>
<td>14.7 Mbps</td>
</tr>
<tr>
<td></td>
<td>HSUPA 10.8 Mbps</td>
<td></td>
</tr>
</tbody>
</table>
3.9 Generation

- Long Term Evolution (LTE) 3GPP 2004-2005
- Technical Report (TR) 25.913 “Requirements for Evolved UTRA and Evolved UTRAN (E-UTRAN)”:  
  - Peak data rate up to 100 Mbps DL and 50 Mbps UL  
  - Less latency on Control-Plane and User-Plane  
  - Better data throughput 3-4 times DL and 2-3 times UL  
  - Better spectrum efficiency  
  - Better mobility (user can have mobility up to 350 km/hr.)  
  - Better coverage radius, up to 100 km
Long Term Evolution (LTE) was given by 3gpp project to advance 3G mobile standard

Why do we need LTE?
– Need faster data rate
– Need more efficient frequency spectrum
– More and more subscribers
– Limited and expensive frequency spectrum
– Better QoS
– Better, simpler, and cheaper infrastructure
Requirements

• Based on all Internet Protocol (IP) network
• Interoperability with existing wireless standards
• A nominal data rate of 100 Mbps (user mobiles at high speeds) and 1 Gbps (user relatively at fixed positions)
• Dynamically share and use the network resources to support more simultaneous users per cell.
• Scalable channel bandwidth 5–20 MHz, optionally up to 40 MHz
Evolution on LTE Release

Note:
In radio, MIMO (multiple-input and multiple-output) is a method for multiplying the capacity of a radio link using multiple transmit and receive antennas
SU = Single User, MU = Multi User
# Main Specification of LTE release-8

## Peak rate Mbps

<table>
<thead>
<tr>
<th>Category</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL</td>
<td>10</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>UL</td>
<td>5</td>
<td>25</td>
<td>50</td>
<td>50</td>
<td>75</td>
</tr>
</tbody>
</table>

## Capability for physical functionalities

<table>
<thead>
<tr>
<th>RF bandwidth</th>
<th>20MHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulation</td>
<td>QPSK, 16QAM, 64QAM</td>
</tr>
</tbody>
</table>

## Multi-antenna

<table>
<thead>
<tr>
<th>2 Rx diversity</th>
<th>Assumed in performance requirements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x2 MIMO</td>
<td>Not supported</td>
</tr>
<tr>
<td>4x4 MIMO</td>
<td>Not supported</td>
</tr>
</tbody>
</table>
## Improvement from LTE release-8 to LTE release-10

<table>
<thead>
<tr>
<th>Key downlink MIMO techniques</th>
<th>802.16m</th>
<th>3GPP E-UTRA</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>LTE</td>
<td>Release 8</td>
<td>Release 9</td>
</tr>
<tr>
<td>DL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SU-MIMO</td>
<td>Up to 8 streams</td>
<td>Up to 4 streams</td>
<td>Up to 4 streams</td>
<td>Up to 8 streams</td>
</tr>
<tr>
<td>MU-MIMO</td>
<td>Up to 4 users (non-unitary precoding)</td>
<td>Up to 2 users (unitary precoding)</td>
<td>Up to 4 users (non-unitary precoding)*</td>
<td>Under development</td>
</tr>
<tr>
<td>UL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SU-MIMO</td>
<td>Up to 4 streams</td>
<td>1 stream</td>
<td>1 stream</td>
<td>Up to 4 streams</td>
</tr>
<tr>
<td>MU-MIMO</td>
<td>Up to 4 users</td>
<td>Up to 8 users</td>
<td>Up to 8 users</td>
<td>Under development</td>
</tr>
</tbody>
</table>

*Release 8 unitary precoding for up to 2 users is still supported in Releases 9 and 10.

**Table 2. MIMO capabilities.**
Evolution Directions

- Evolution directions to further enhance network capacity

**Spectrum efficiency**
- Radio access technologies including multi-antenna transmission and receiver processing techniques
- All-time issue for researchers and engineers in this area

**Bandwidth extension**
- Efficient way to reduce cost per bit
- Depends on future spectrum allocation and UE capability

**Network density**
- Technical trend such as heterogeneous deployments
- Network architecture to reduce cost per bit highly required

**Traffic offloading**
- Offloading strategies tuned to applications and scenarios

**Emerging solutions that need more focus**

**Required network capacity**

**Conventional approach for capacity improvement**
Worldwide Interoperability for Microwave Access
WiMAX
What is WiMAX?

• created by the WiMAX Forum
• a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL
• IEEE 802.16m or WirelessMAN-Advanced is a candidate for the 4G, in competition with the LTE Advanced standard
• WiMAX was initially designed to provide 30-40 Mbps data rates, with the 2011 update providing up to 1 Gbps for fixed stations
See you on next class