
 Marmara University, 2021

Wireless and Mobile Networks


Subject 11
Cellular Network Technologies and Architectures

Mujdat Soyuturk, Ph.D.
Associate Professor


 Contents


- Evolution of the Cellular Network Architecture
- Radio Technologies of Next Generation Cellular Systems
- Core Networks of Next Generation Cellular Systems
- QoS in Cellular Networks

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 EVOLUTION OF THE CELLULAR NETWORK ARCHITECTURE


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 The 2G Cellular Network Architecture



Mobile Subscriber Unit


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 The 2G Cellular Network Architecture



Base Transceiver Stations

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MSU BTS Cellular Network

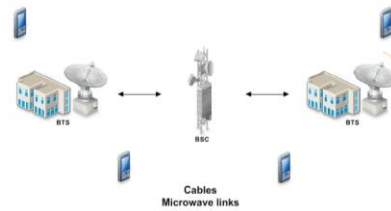
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The 2G Cellular Network Architecture



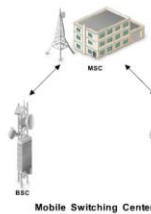
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The 2G Cellular Network Architecture



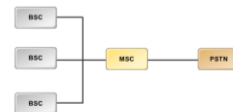
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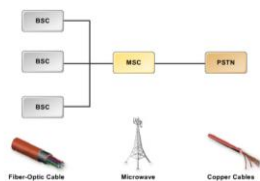
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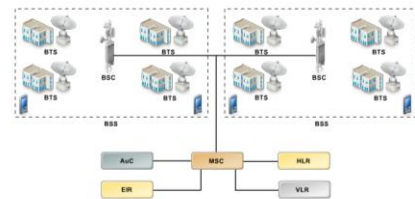
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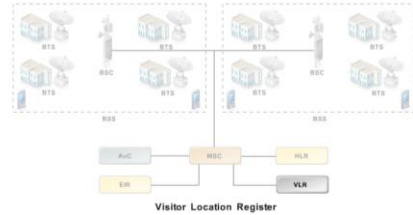
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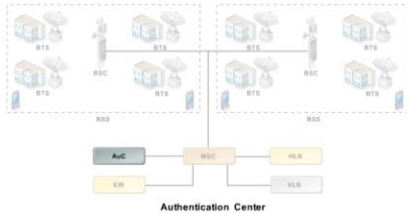
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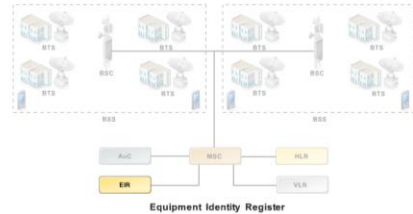
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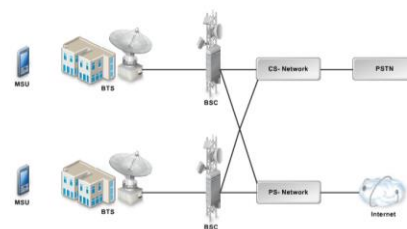
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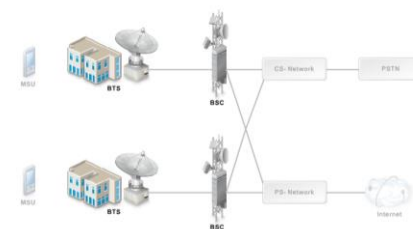
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The 2.5G Cellular Network Architecture



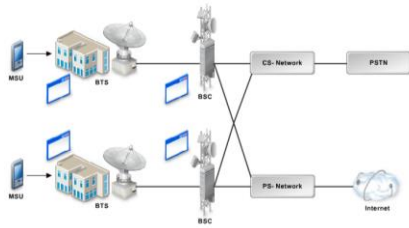
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The 2.5G Cellular Network Architecture



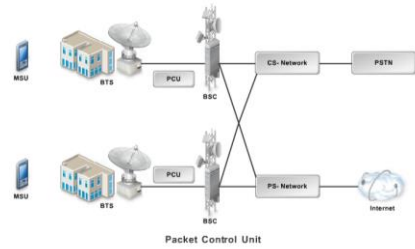
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The 2.5G Cellular Network Architecture



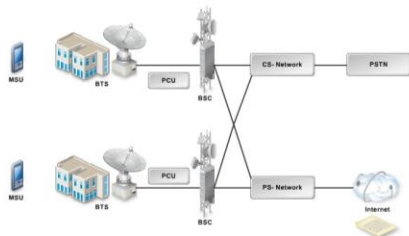
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The 2.5G Cellular Network Architecture



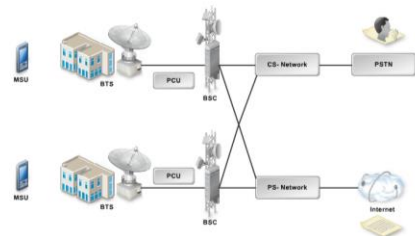
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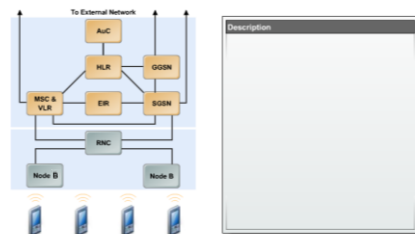
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The 2.5G Cellular Network Architecture



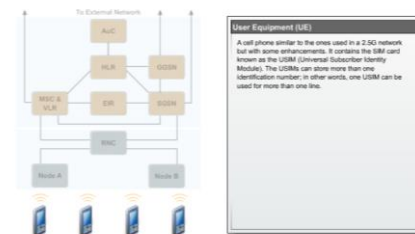
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The 3G Cellular Network Architecture



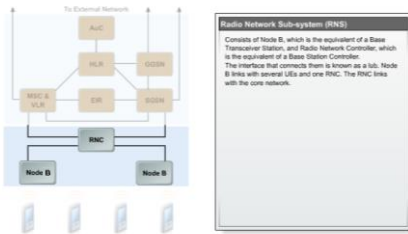
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The 3G Cellular Network Architecture



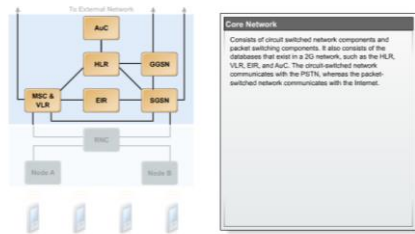
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The 3G Cellular Network Architecture



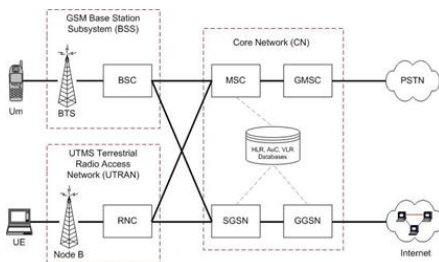
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The 3G Cellular Network Architecture



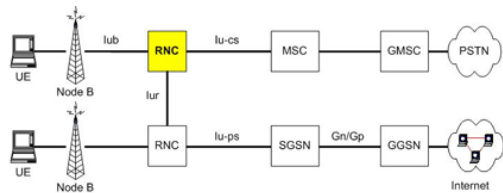
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The 3G Cellular Network Architecture



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The 3G Cellular Network Architecture



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The 4G Cellular Network Architecture



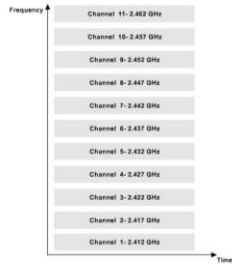
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The 4G Cellular Network Architecture



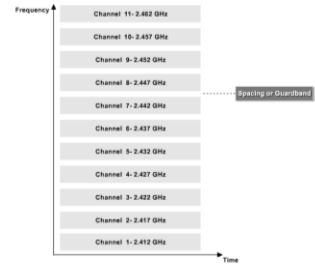
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Frequency Division Multiplexing



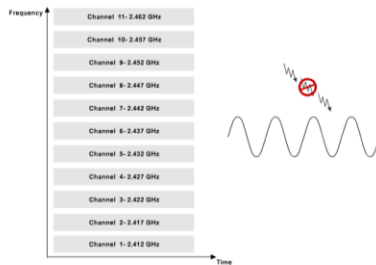
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Frequency Division Multiplexing



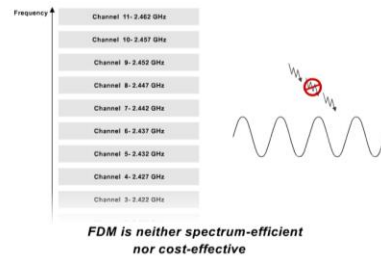
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Frequency Division Multiplexing



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Frequency Division Multiplexing



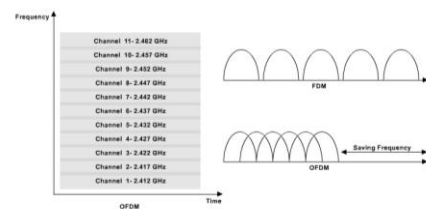
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Orthogonal Frequency Division Multiplexing

Orthogonal Frequency Division Multiplexing

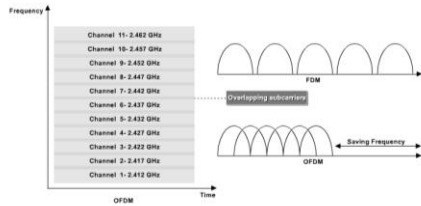
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Orthogonal Frequency Division Multiplexing



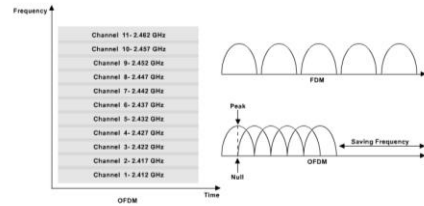
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Orthogonal Frequency Division Multiplexing



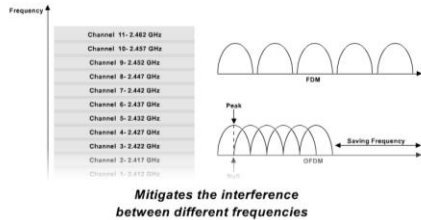
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Orthogonal Frequency Division Multiplexing



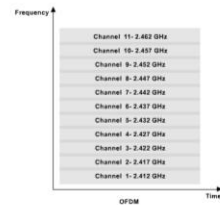
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Orthogonal Frequency Division Multiplexing



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Orthogonal Frequency Division Multiplexing



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Orthogonal Frequency Division Multiplexing



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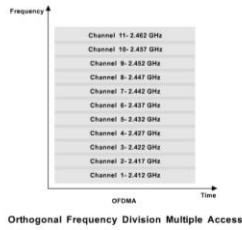
Orthogonal Frequency Division Multiplexing



OFDM offers resistance to interference and degradation

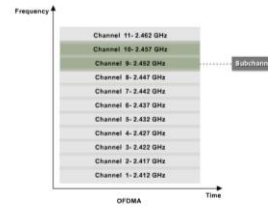
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Orthogonal Frequency Division Multiple Access



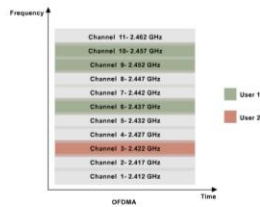
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Orthogonal Frequency Division Multiple Access



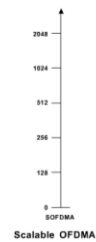
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Orthogonal Frequency Division Multiple Access



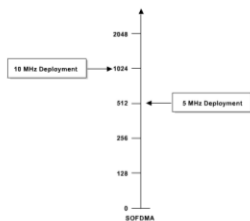
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Orthogonal Frequency Division Multiple Access



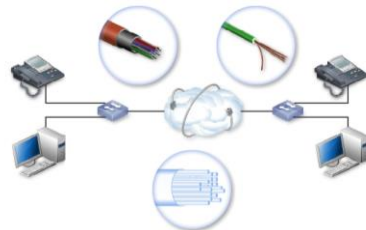
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Orthogonal Frequency Division Multiple Access



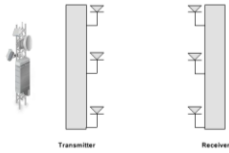
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Spatial Diversity



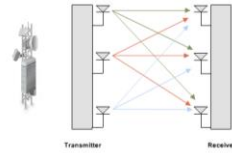
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Spatial Diversity



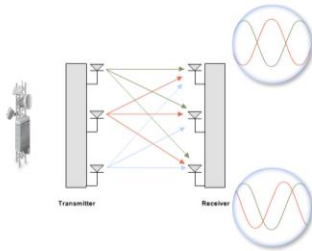
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Spatial Diversity



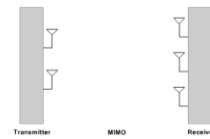
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Spatial Diversity



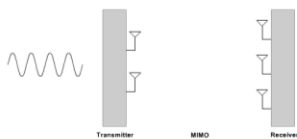
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Spatial Multiplexing



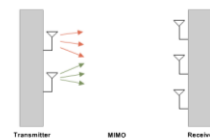
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Spatial Multiplexing



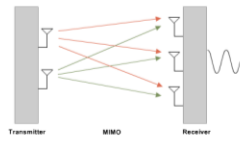
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Spatial Multiplexing



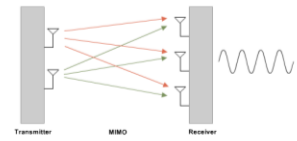
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Spatial Multiplexing



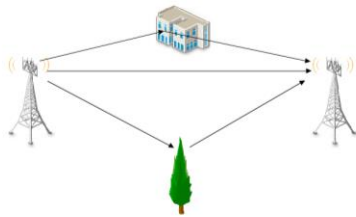
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Spatial Multiplexing



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Spatial Multiplexing



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Spatial Multiplexing



Total Rate Capacity ☐ Number of Antennas

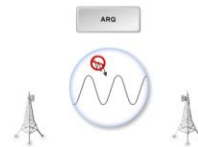
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Radio Layer Error Recovery Techniques



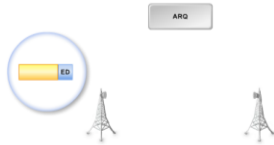
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Radio Layer Error Recovery Techniques



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Radio Layer Error Recovery Techniques



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Radio Layer Error Recovery Techniques



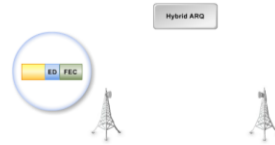
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Radio Layer Error Recovery Techniques



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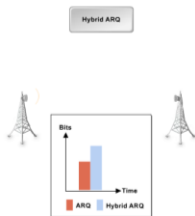
Radio Layer Error Recovery Techniques



Forward Error Correction

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Radio Layer Error Recovery Techniques



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Cognitive Radio



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Cognitive Radio

The diagram shows a 'Cognitive Radio' box, an 'IEEE SCC 41 Working Group' logo, and a table of user categories:

Licensed User	Amateur Radio
TV	Unlicensed User
Cellular Services	Pager Services

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A smartphone icon is shown to the right of the table.

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Licensed User	Amateur Radio
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A laptop and a smartphone icon are shown to the right of the table.

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Cognitive Radio

The diagram shows a 'Cognitive Radio' box, an 'IEEE SCC 41 Working Group' logo, and a table of user categories:

Licensed User	Amateur Radio
TV	Unlicensed User
Cellular Services	Pager Services

A laptop and a smartphone icon are shown to the right of the table. Below the table, the text reads: "Studies in various countries have shown that radio frequency spectrum is not being utilized efficiently".

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Cognitive Radio

The diagram shows a 'Cognitive Radio' box, an 'IEEE SCC 41 Working Group' logo, and a table of user categories:

Licensed User	Amateur Radio
TV	Unlicensed User
Cellular Services	Pager Services

Two circular charts labeled 'Frequency Usage' are shown. The left chart shows a bar for 'Frequency Usage' and a bar for 'Unused Spectrum'. The right chart shows a bar for 'Frequency Usage' and a bar for 'Unused Spectrum'.

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Cognitive Radio

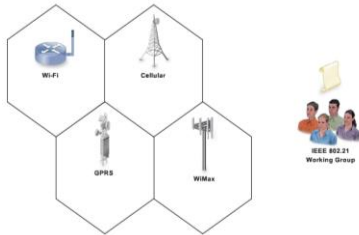
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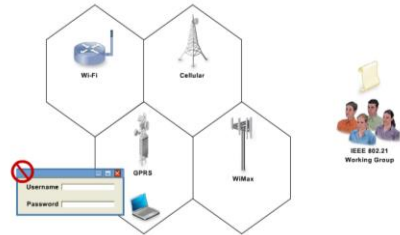
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Inter-Technology Handover



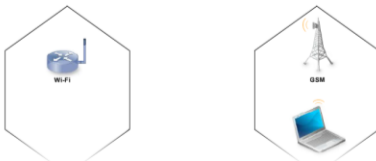
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Inter-Technology Handover



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Inter-Technology Handover



*Inter-technology handover provides
data session continuity for video
streaming applications*

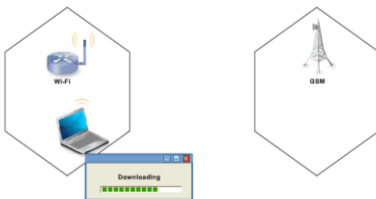
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Inter-Technology Handover



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Inter-Technology Handover



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Inter-Technology Handover



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CORE NETWORKS OF NEXT GENERATION CELLULAR SYSTEMS

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- Mobile IP
- IP Multimedia Subsystem
- Fixed Mobile Convergence
- Femtocells

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Mobile IP



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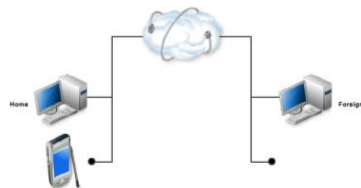
Mobile IP



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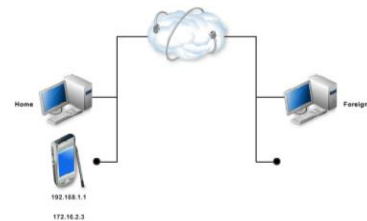
Mobile IP



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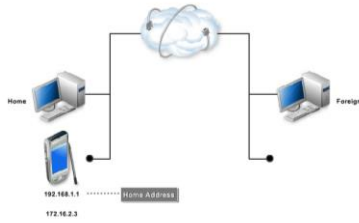


Mobile IP



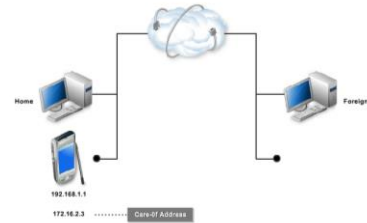
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Mobile IP



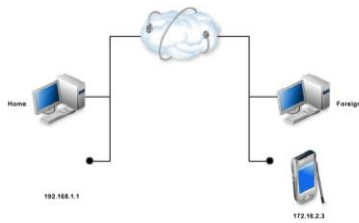
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Mobile IP



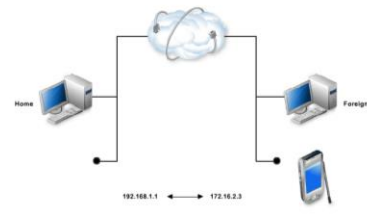
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Mobile IP



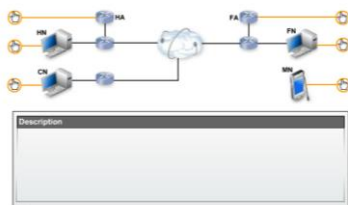
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Mobile IP



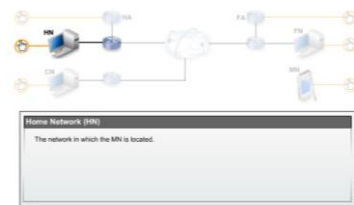
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Mobile IP



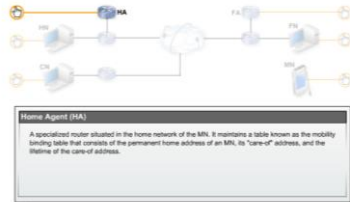
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Mobile IP



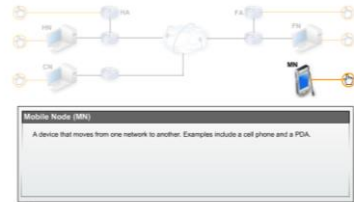
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Mobile IP



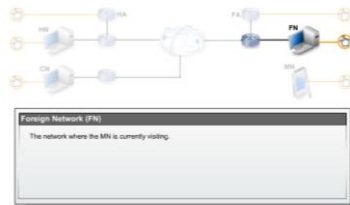
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Mobile IP



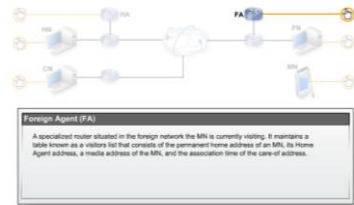
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Mobile IP



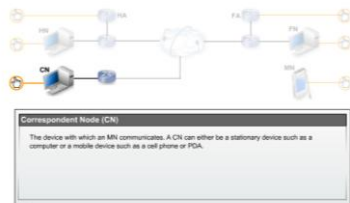
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Mobile IP



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Mobile IP



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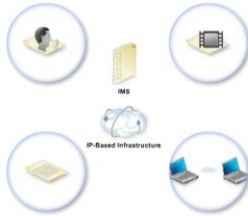
IP Multimedia Subsystem



IP Multimedia Subsystem

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IP Multimedia Subsystem



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IP Multimedia Subsystem



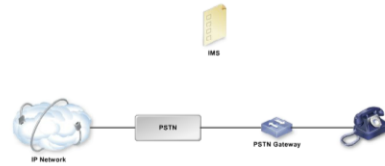
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IP Multimedia Subsystem



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IP Multimedia Subsystem



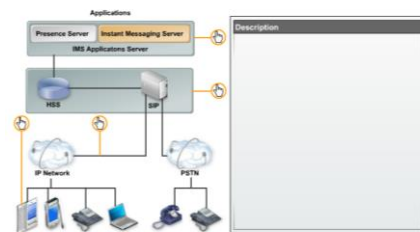
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IP Multimedia Subsystem



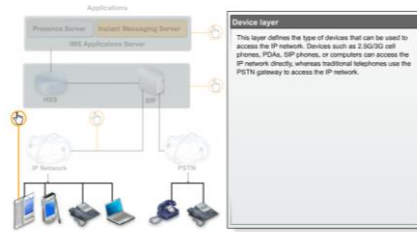
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IP Multimedia Subsystem



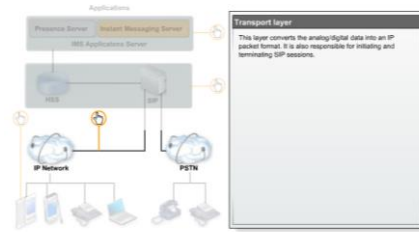
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IP Multimedia Subsystem



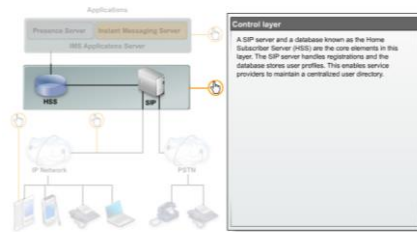
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IP Multimedia Subsystem



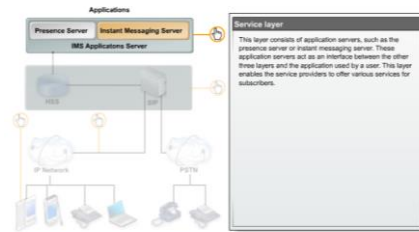
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IP Multimedia Subsystem



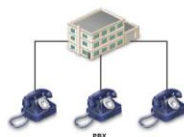
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IP Multimedia Subsystem



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Fixed Mobile Convergence




Fixed Mobile Convergence

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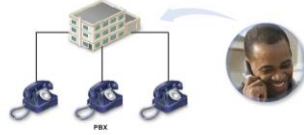
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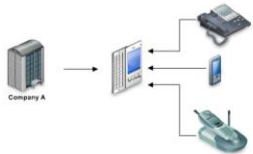
Features supported by FMC:

- Three- or four-digit extension dialing
- Access to corporate voice mail
- Call transfer to a mobile device


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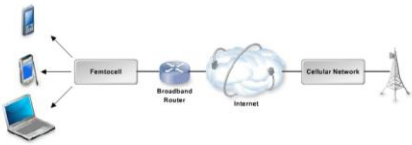


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Femtocells



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Femtocells



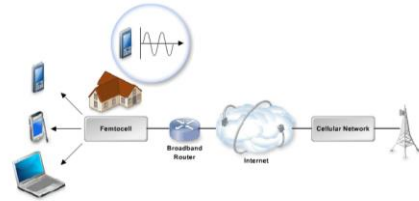
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Femtocells



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Femtocells



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Femtocells



*Femtocells use a licensed spectrum,
reducing the risk of interference*

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Femtocells



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Femtocells



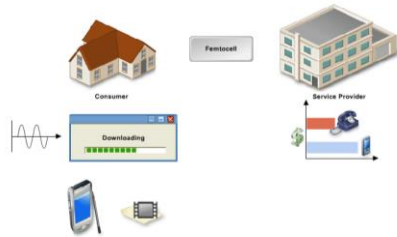
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Femtocells



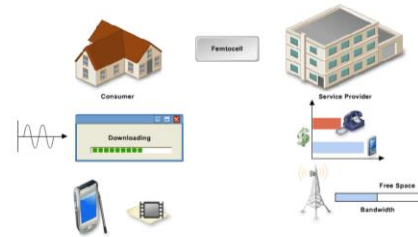
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Femtocells



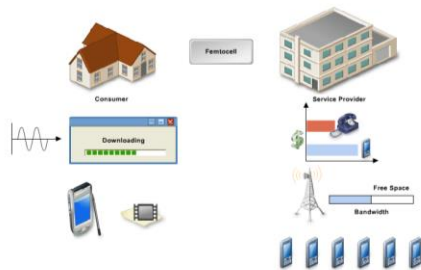
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Femtocells



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Femtocells

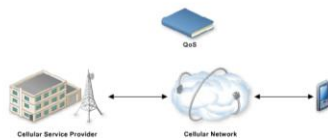


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QoS IN CELLULAR NETWORKS

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Cellular Network QoS



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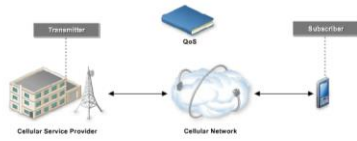
Cellular Network QoS



- QoS parameters for voice calls include:**
- Voice quality
 - Signal strength
 - Service availability
 - Frequency of call drops
 - Break in signal transmission

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Cellular Network QoS



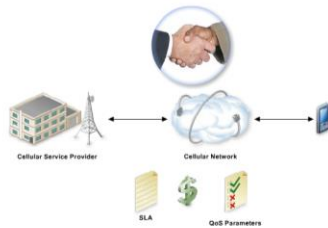
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Cellular Network QoS



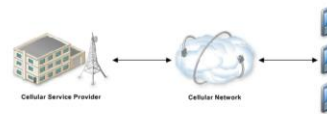
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Cellular Network QoS



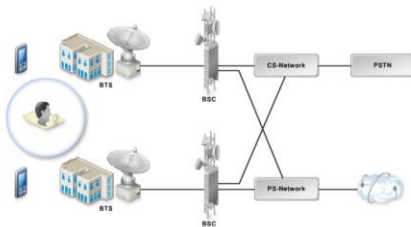
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Need for QoS in Cellular Networks



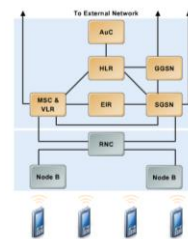
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Need for QoS in Cellular Networks



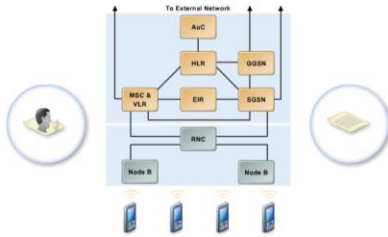
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Need for QoS in Cellular Networks



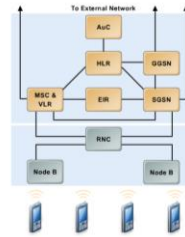
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Need for QoS in Cellular Networks



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Need for QoS in Cellular Networks

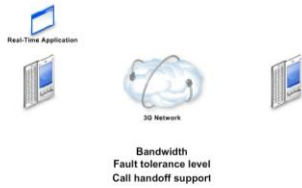


Primary concern for all subscribers is to enjoy:

- Good transmission quality
- Service availability
- Minimal delay

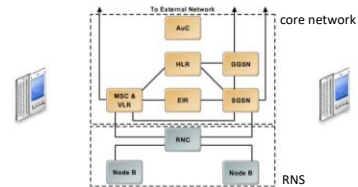
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QoS Principles



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QoS Principles



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QoS Principles

QoS Principle	Description
Packet classification	
Policing	
Appropriate resource allocation	
Call admission	

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QoS Principles

QoS Principle	Description
Packet classification	Each packet coming to a network element is classified based on its QoS requirements. This classification enables the network element to process the packet based on its resource requirement. For example, a packet classified as data will need less bandwidth than a packet classified as voice.
Policing	
Appropriate resource allocation	
Call admission	

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QoS Principles



QoS Principle	Description
Packet classification	An application requests the required amount of network resources, and it must always adhere to this request. An application must not send packets at a rate more than what was requested. In order to make sure the application is adhering to the parameters, policing of packets is implemented in the network.
Policing	
Appropriate resource allocation	
Call admission	

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QoS Principles



QoS Principle	Description
Packet classification	A network may receive both data and voice packets simultaneously. It is the network device's responsibility to appropriately allocate resources, such as channels to communicate to both these types of data.
Policing	
Appropriate resource allocation	
Call admission	

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QoS Principles



QoS Principle	Description
Packet classification	Once a network receives a QoS request, it verifies the available network resources to see if it can provide the required quality. In case of unavailability of network resources, the network can deny the request.
Policing	
Appropriate resource allocation	
Call admission	

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QoS Classes



QoS Class	Description
Conversational	
Streaming	
Interactive	
Background	

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QoS Classes



QoS Class	Description
Conversational	Applications that are most delay sensitive are part of this class. These include real-time voice applications, such as voice calls, VoIP, or video conferencing. QoS levels in this class are mostly defined by user-generated data—that is, how much delay a person can tolerate for audio or video signals.
Streaming	
Interactive	
Background	

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QoS Classes



QoS Class	Description
Conversational	Applications, such as audio and video streaming, are part of this class. The delay between subsequent packets should be maintained below an acceptable limit. If the time variation between two subsequent packets is large, the quality of streaming applications goes down.
Streaming	
Interactive	
Background	

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QoS Classes



QoS Class	Description
Conversational	Web browsing applications are part of this class. They are not very delay sensitive, but are sensitive to data loss.
Streaming	
Interactive	
Background	

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QoS Classes



QoS Class	Description
Conversational	SMS applications are part of this class. These applications become active only on the arrival of an SMS; otherwise, they run in the background. These applications are not very delay sensitive, but are sensitive to data loss.
Streaming	
Interactive	
Background	

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QoS Attributes



QoS Attribute	Description
Maximum bit rate (kbps)	
Guaranteed bit rate (kbps)	
Delivery order (yn)	
Transfer delay (ms)	
Traffic handling priority	

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QoS Attributes



QoS Attribute	Description
Maximum bit rate (kbps)	Maximum number of bits delivered within a period of time.
Guaranteed bit rate (kbps)	
Delivery order (yn)	
Transfer delay (ms)	
Traffic handling priority	

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QoS Attributes



QoS Attribute	Description
Maximum bit rate (kbps)	Guaranteed number of bits delivered within a period of time by the cellular network.
Guaranteed bit rate (kbps)	
Delivery order (yn)	
Transfer delay (ms)	
Traffic handling priority	

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QoS Attributes



QoS Attribute	Description
Maximum bit rate (kbps)	The order in which the data units are delivered. Indicates whether the delivery is sequential or not.
Guaranteed bit rate (kbps)	
Delivery order (yn)	
Transfer delay (ms)	
Traffic handling priority	

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QoS Attributes



QoS Attribute	Description
Maximum bit rate (kbps)	Defines the maximum amount of delay.
Guaranteed bit rate (kbps)	
Delivery order (yn)	
Transfer delay (ms)	
Traffic handling priority	

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QoS Attributes



QoS Attribute	Description
Maximum bit rate (kbps)	Indicates the priority level of packets.
Guaranteed bit rate (kbps)	
Delivery order (yn)	
Transfer delay (ms)	
Traffic handling priority	

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QoS Schemes



QoS Scheme	Description
Dynamic channel allocation	
Call Admission Control (CAC)	
Mobility prediction	
Individual QoS (IQoS)	

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QoS Schemes



QoS Scheme	Description
Dynamic channel allocation	In this scheme, channels are allocated to subscribers dynamically, either using a central controller or a Mobile Service Station (MSS). In the central dynamic channel allocation scheme, requests for channels are sent to a central controller. In a distributed channel allocation scheme, requests are sent to MSSs, which are present in each cell. These MSS take care of channel allocations in their cell. Better channel allocation means better utilization of resources, which in turn provides better QoS.
Call Admission Control (CAC)	
Mobility prediction	
Individual QoS (IQoS)	

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QoS Schemes



QoS Scheme	Description
Dynamic channel allocation	Call Admission Control (CAC) is a set of actions taken by a network during the call setup or call re-negotiation phase to determine whether a connection request can be accepted or rejected before the source information is admitted to the cellular network. When a connection is requested by an application, the application indicates to the network the type of service required, a set of parameters describing the source traffic characteristics, and the quality of service parameters requested in each direction. CAC uses this information to assess the required quality of service for the connection and determines whether it has sufficient resources and channels to accept the requested connection based on the current network status.
Call Admission Control (CAC)	
Mobility prediction	
Individual QoS (IQoS)	

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QoS Schemes



QoS Scheme	Description
Dynamic channel allocation	The path a mobile takes is studied over a period of time and stored in a database. Using this data, resources are blocked or prioritized so as to facilitate a proper handoff.
Call Admission Control (CAC)	
Mobility prediction	
Individual QoS (IQoS)	

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QoS Schemes



QoS Scheme	Description
Dynamic channel allocation	It is the user perceived QoS level. QoS is the satisfaction level of each subscriber for the full duration of a call. There maybe times when the overall QoS in a network is good, but subscribers having lesser coverage may experience drop in calls. Therefore, it is necessary to measure the QoS at user terminals.
Call Admission Control (CAC)	
Mobility prediction	
Individual QoS (IQoS)	

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