

UMTS Architecture

Kimmo Raatikainen
kimmo.raatikainen@cs.helsinki.fi

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Lesson Outline

- What is it?
- Standardization fora
- Radio Evolution
- UMTS Architecture
- UMTS Protocols
- QoS Issues
- Domains
- Services
- Backup Material

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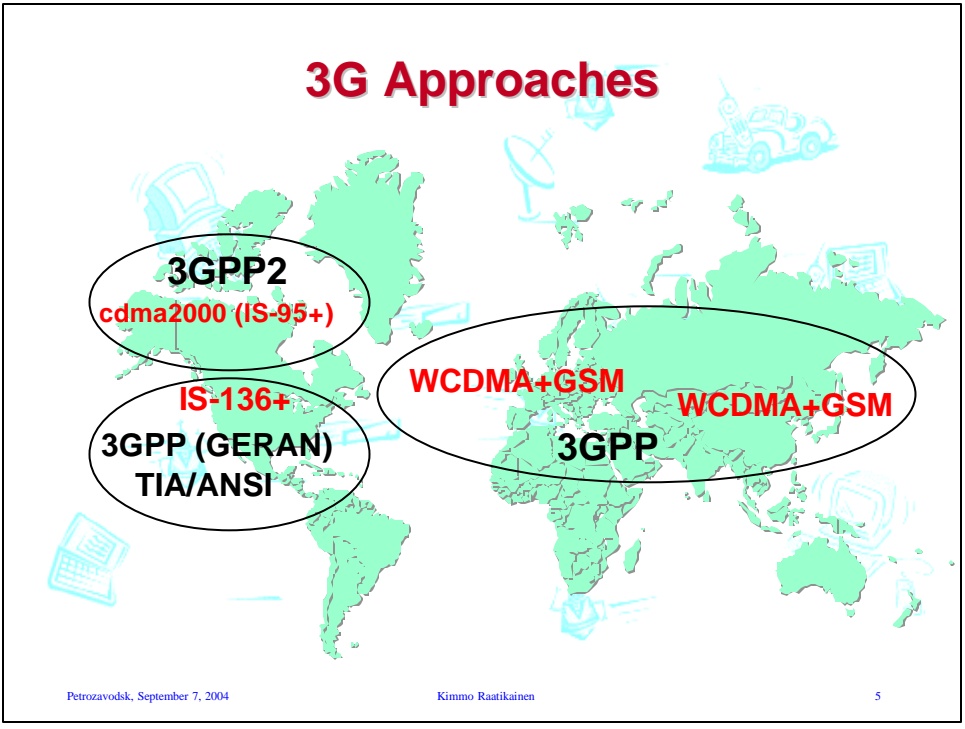
What is it?

- IP multimedia and realtime services support within the UMTS system
- IP Multimedia network elements in addition to Packet-Switched and Circuit-Switched domains
- Two different radio access technologies connected to the same core network
 - GERAN (GPRS/EDGE RAN)
 - UTRAN (WCDMA RAN)
 - other access technologies should be enabled as well; e.g. fixed access, cable modems, WLAN, etc.
- Network architecture and elements based on Internet protocols

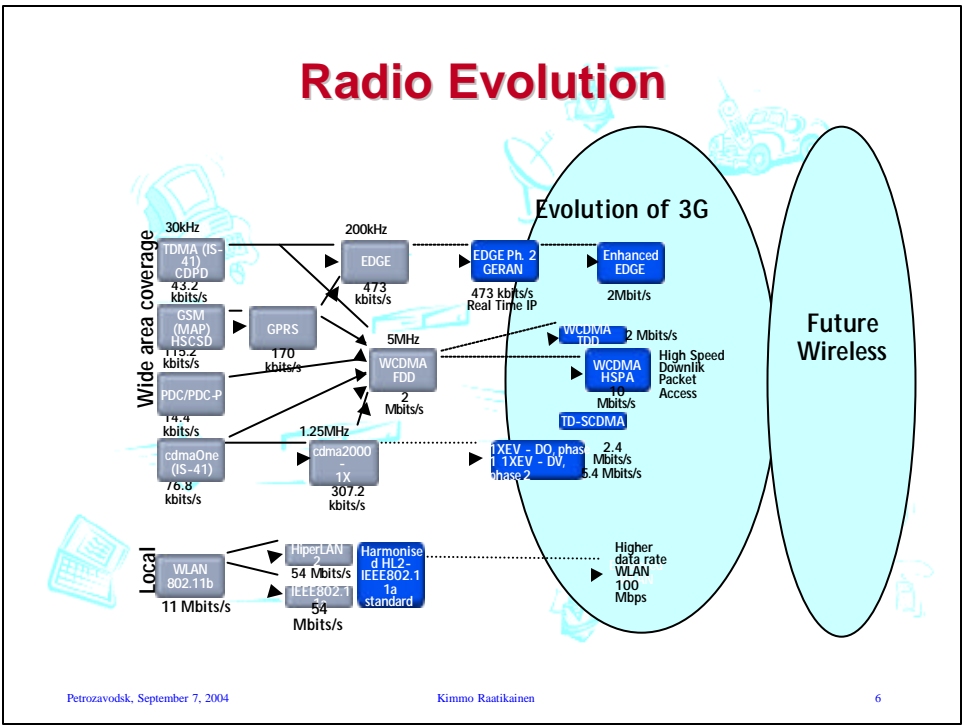
Relevant fora

- 3G.IP - closed forum
 - Initial founding members:
 - Operators: AT&T, British Telecom, CSELT, Rogers Cantel, Telenor
 - Vendors: Nokia, Ericsson, Lucent, Nortel
 - Current member status: a lot of new members
- Mobile Wireless Internet Forum - open forum
 - Initiators: Vodafone/Airtouch, Orange, Motorola, Cisco, etc.
- Both driving for a definition of a more IP-based UMTS system and attempting to affect standardisation bodies
 - 3GPP - making the standards for UMTS Release 2000
 - Tiphon - IP telephony related standardisation group within ETSI
 - IETF - Internet related standards

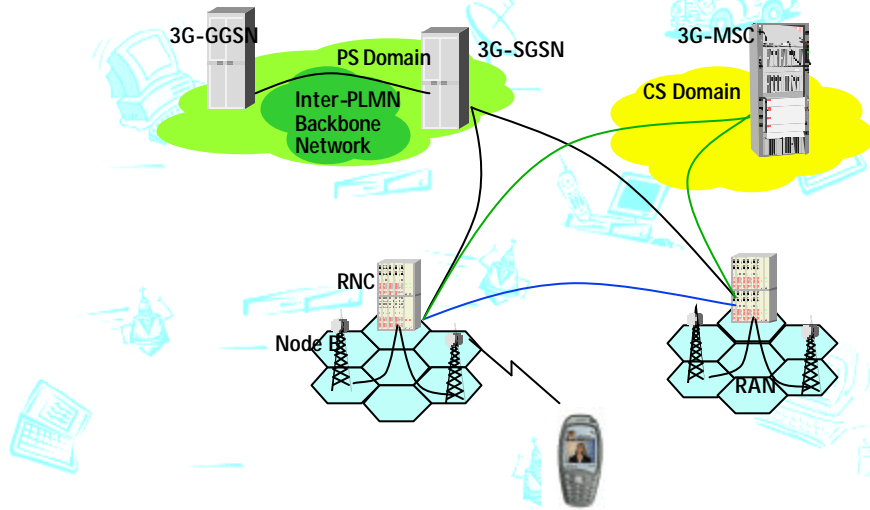
3G Approaches



Radio Evolution



UMTS Network Architecture

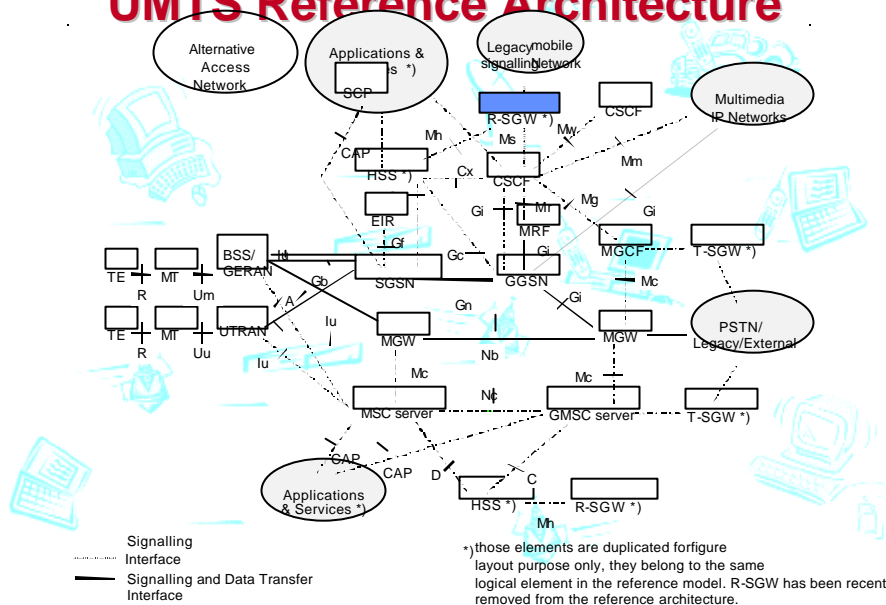


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UMTS Reference Architecture



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UMTS Abbreviations – 1/4

AAL2	ATM adaptation layer 2	CSCF	Call services control function
ANSI	American National Standards Institute	CWTS	China's Wireless Telecommunications Standard
ARIB	Association of radio industries and businesses	EDGE	Enhanced data rates for GSM evolution
ASN.1	Abstract Syntax Notation One	ETSI	European Telecommunication standardisation institute
ATM	Asynchronous transfer mode	FDD	Frequency division duplex
BER	Bit error rate	GERAN	Global system for mobile communications enhanced data rates for GSM evolution radio access network
BS	Base station	GGSN	Gateway GPRS support node
BSAP	Base Station application part	GMM	GPRS MM
BSC	Base station controller	GMSC	Gateway MSC
BSSGP	Base Station Sub-System GPRS Protocol	GPRS	General packet access
CC	Call control	GSM	Global system for mobile communication
cdma	code division multiple access		
CDPD	Cellular Digital Packet Data		
CN	Core network		
CS	Circuit switched		

UMTS Abbreviations – 2/4

GTP	GPRS tunneling protocol	MGW	Media gateway
HLR	Home location register	MPLS	Multiprotocol label switching
HSCSD	High speed circuit switched data	MSC	Mobile services switching center
HSS	Home subscriber server	MMS	Multimedia messaging
IETF	Internet engineering task force	MWIF	Mobile wireless interest forum
IM	Internet multimedia	OHG	Operator harmonisation group
IP	Internet protocol	OSA	Open services architecture
ISDN	Integrated services digital network	P-CSCF	Proxy-CSCF
ITU	International telecommunications union	PDC	Personal digital communication
LLC	Link layer control	PDCP	Packet data convergence protocol
MAC	Medium access control	PDP	Packet data protocol
MAP	Mobile application part	PHB	Per hop behaviour
MM	Mobility management	PLMN	Public land mobile network
MGCF	Media gateway control function		

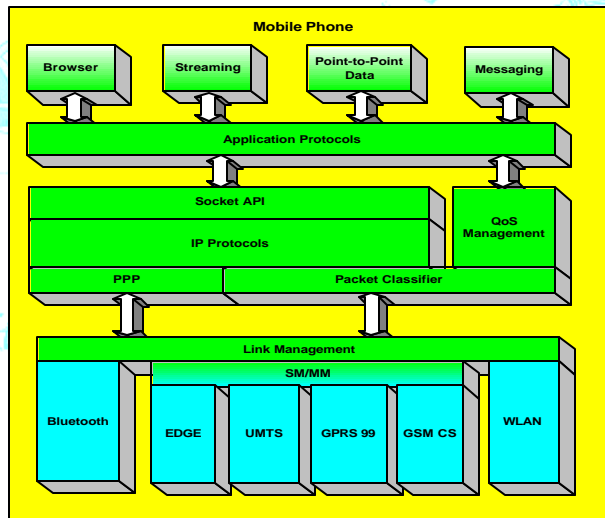
UMTS Abbreviations – 3/4

PPP	Point-to-point protocol	SMG	Special mobile group
PS	Packet switched	SNDCP	Sub-network dependent convergence protocol
PSTN	Public switched telephony network	T	Terminal
QoS	Quality of service	TCP	Transmission control protocol
RAN	Radio access network	TD-CDMA	Time division-CDMA
RANAP	RAN application part	TDD	Time division duplex
RF	Radio frequency	TDMA	Time division multiple access
RLC	Radio link control	TFT	Traffic flow template
RNC	Radio network controller	TIA	Telecommunications industry association
RRC	Radio resource control	TTA	Telecommunications technology association
RSVP	Resource reservation protocol	TTC	Telecommunications technology committee
SCP	Services control point	TSG	Technical specification group
SA	Services and System Aspects	UDP	User datagram protocol
SDL	Specification and description language		
SDU	Serving data unit		
SGSN	Serving GPRS support node		
SGW	Signalling gateway		
SM	Session management		

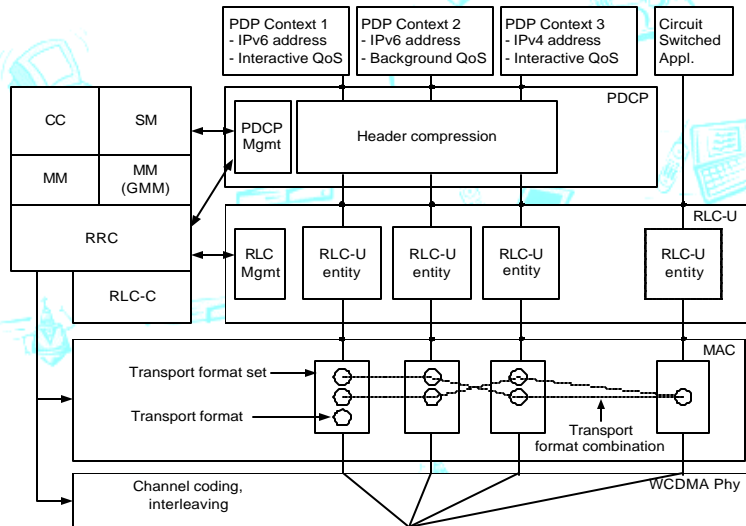
UMTS Abbreviations – 4/4

UMTS	Universal mobile telecommunication system
UWCC	Universal wireless communications consortium
UTRAN	UMTS terrestrial RAN
VHE	Virtual home environment
VLR	Visitor location register
VoIP	Voice over IP
WAP	Wireless application protocol
WLAN	Wireless local area network
WCDMA	Wideband CDMA
3GPP	3rd generation partnership project
3GPP2	3rd generation partnership project 2

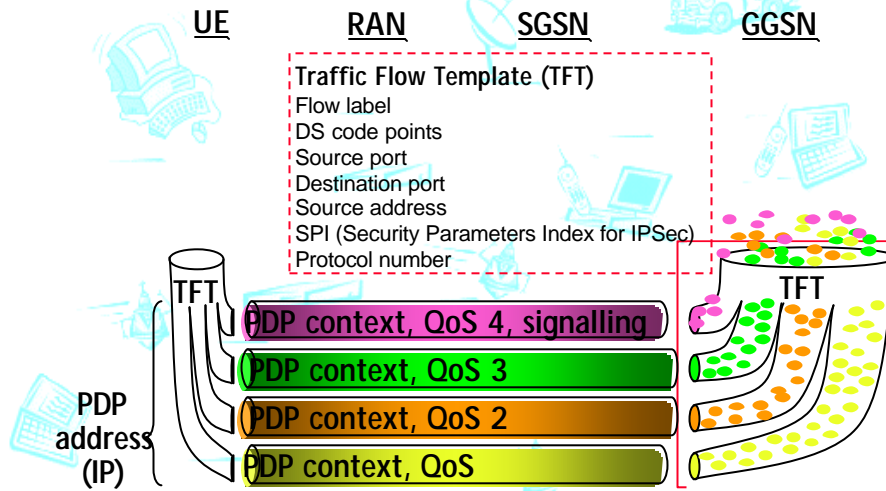
Mobile Functional Model



Data Protocol Functionality (simplified)



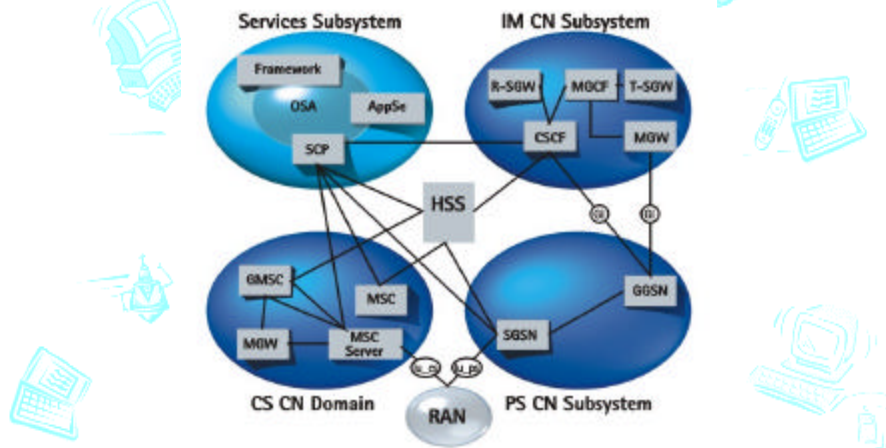
Evolution of Mechanisms to Enable QoS



QoS Parameters

GPRS rel'97, '98	GPRS/UMTS rel'99, 4, 5			
	Conversational	Streaming	Interactive	Background
Precedence class	Telephony	Streaming video	Signalling	Calendar update
Delay class				
Reliability class	VoIP	Streaming audio	Interactive games	Mail download
Peak throughput class				
Mean throughput class	Video telephony	Video surveillance	Web browsing	Background

Domain definitions



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Domain and Subsystem Definitions

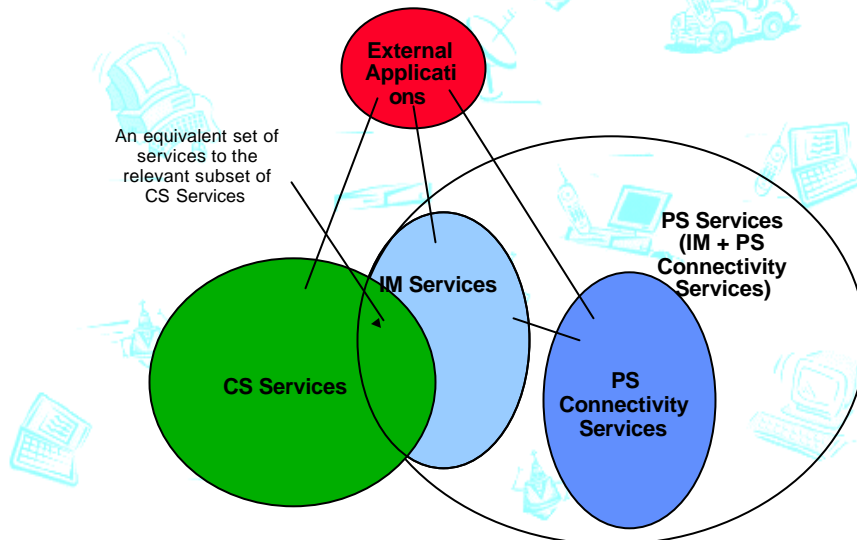
- **CS CN domain:** comprises all core network elements for provision of CS services.
- **PS CN domain:** comprises all core network elements for provision of PS connectivity services.
- **IM CN subsystem:** (IP Multimedia CN subsystem) comprises all CN elements for provision of IM services
- **Service Subsystem:** Comprises all elements providing capabilities to support operator specific services (e.g. IN and OSA)
- **External Applications:** Applications on an external Host.
- The **Radio Access Network domain** consists of the physical entities, which manage the resources of the radio access network, and provides the user with a mechanism to access the core network.

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UMTS Service Definitions



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Service-related Definitions

- **CS Services:** Telecommunication services provided to "GSM/ISDN" clients via 24.008 CC.
- **PS Connectivity Services:** IP connectivity service provided to IP clients via 24.008 SM.
- **IM Services:** IP Multimedia Services that require support on the Call Control level carried on top of the PS connectivity services (this may include an equivalent set of services to the relevant subset of CS Services).
- **PS services:** The superset of IM services and PS connectivity Services.

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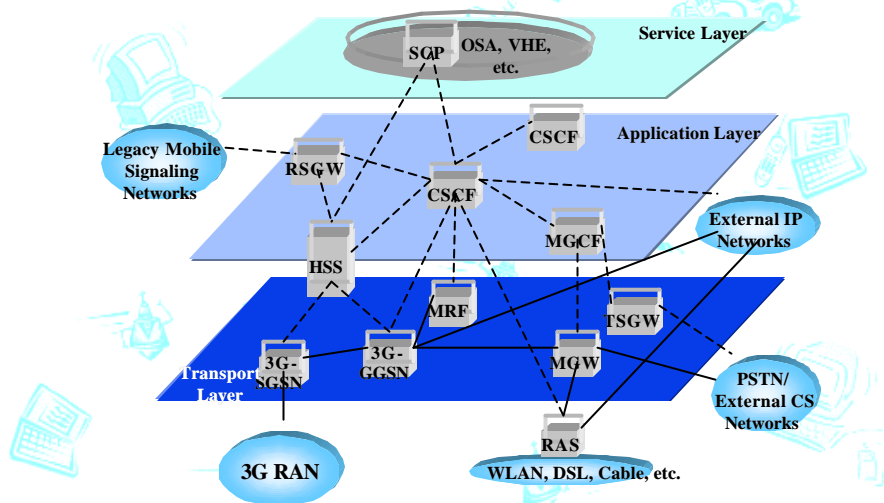
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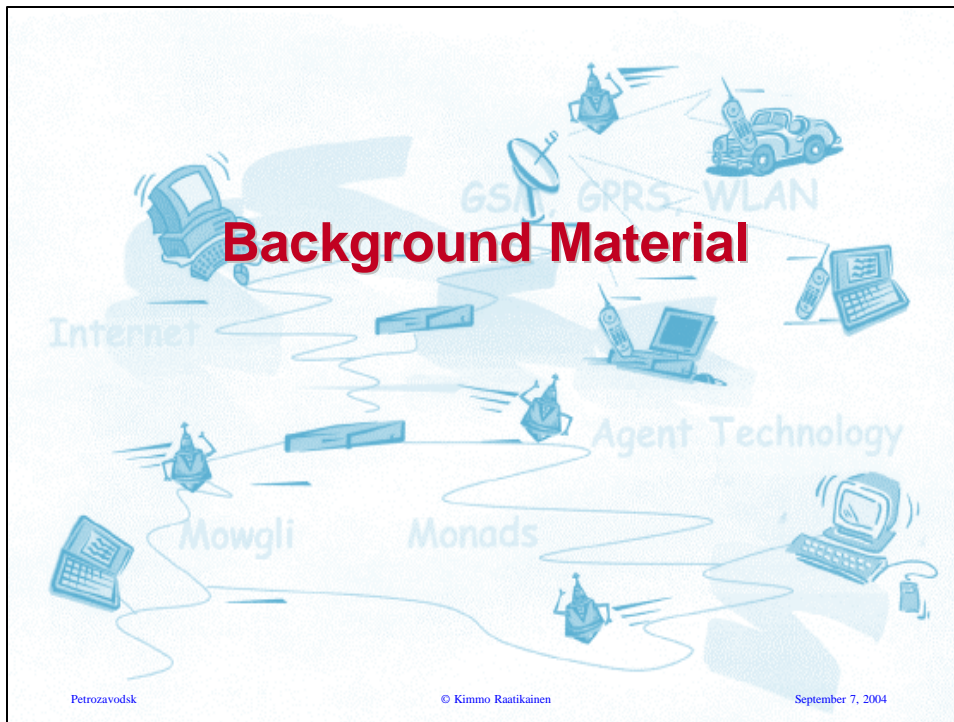
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Multimedia and speech support

- SIP or H.323 instead of cellular network specific call control
 - SIP defined by IETF for IP multimedia services; to be used in the Internet
 - H.323 defined by ITU; part of the H-protocol family; to be used over IP networks
- Both provide session and call establishment capabilities, among other capabilities & features
- Both probably need enhancements in order to be suitable for the mobile network environment and cellular systems

UMTS Layered Approach for the PS services





Technical Requirements

- Equal or better quality for voice transmission
- Backwards compatibility vs. revolution (e.g. old phones should work in the new networks due to the large installed customer base)
- Roaming to/from legacy and UMTS R99 networks should be possible
- Interworking necessary with telephony networks, GSM & other cellular networks, IP networks, etc.
- Realtime handovers: which cases must be supported? Intra RAN, inter RAN, inter-SGSN, inter-operator, inter-GGSN, inter-system, ...
- Easy service creation and execution environment. Possible components:
 - Mobile Station Execution Environment (MExE), SIM Application Toolkit (SAT), Open Service Architecture (OSA), Virtual Home Environment (VHE), CAMEL, WAP, etc.

Technical Key Issues

- Call control protocol: SIP (or H.323 or ...)
- Addressing & Identifiers
- Roaming models and handovers
- Legacy networks: roaming, handovers, etc.
- New header compression algorithms, especially suited for realtime traffic: IETF ROHC
- End-to-end QoS negotiation? Enough guarantees on the call quality? Role of RSVP?
- IP version to be used
- Etc etc...

Requirements for Future All-IP Systems – 1/2

- Mobility Handling
 - Determined by, and optimised for, mobile terminals
- Multiservice
 - Common Network for real time and non real time services
 - Rapid, flexible and easy creation of new services
- Layered Network Functionality
 - For independence of access, transport, applications and service creation
 - For system flexibility and future evolution
- Multiaccess & Access Independence
 - Several accesses including WCDMA, EDGE, WLAN, Cable etc.
 - Mobility between accesses (Global IP Mobility)

Requirements for Future All-IP Systems – 2/2

- IPv6-Based
 - For scalability and address space
 - For mobility between accesses (Global IP mobility)
- Evolution and Legacy Support
 - For utilisation of existing investments
 - For service continuity
- Shared Transport and Network Management
 - For cost efficiency

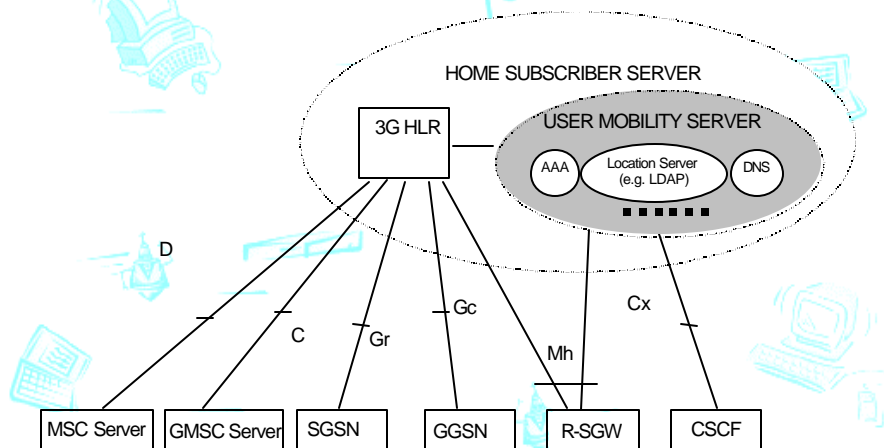
Functional Elements: Call State Control Function (CSCF)

- Logical, i.e. internal, components:
- **ICGW (Incoming call gateway):** Acts as a first entry point and performs routing of incoming calls, Communicates with HSS, Incoming call service triggering (e.g. call screening/call forwarding unconditional) may need to reside for optimisation purposes, Query Address Handling (implies administrative dependency with other entities), Communicates with HSS
- **CCF (Call Control Function):** Call set-up/termination and state/event management, Interact with MRF in order to support multi-party and other services, Reports call events for billing, auditing, intercept or other purpose, Receives and process application level registration, Query Address Handling (implies administrative dependency), May provide service trigger mechanisms (service capabilities features) towards Application & services network (VHE/OSA), May invoke location based services relevant to the serving network, May check whether the requested outgoing communication is allowed given the current subscription.
- **SPD (Serving Profile Database):** Interacts with HSS in the home domain to receive profile information for the R00 all-IP network user and may store them depending on the SLA with the home domain, Notifies the home domain of initial user's access (includes e.g. CSCF signalling transport address, user ID etc. needs further study), May cache access related information (e.g. terminal IP address(es) where the user may be reached etc.)
- **AH (Address Handling):** Analysis, translation, modification if required, address portability, mapping of alias addresses, May do temporary address handling for inter-network routing.

Functional Elements: Home Subscriber Server

- The Home Subscriber Server (HSS) is the master database for a given user. It is responsible for keeping a master list of features and services (either directly or via servers) associated with a user, and for tracking of location of and means of access for its users. It provides user profile information, either directly or via servers. It is a superset of the Home Location Register (HLR) functionality. The HSS shall support a subscription profile which identifies for a given user for example:
 - 1) user identities; 2) subscribed services and profiles; 3) service specific information; 4) mobility management information; and 5) authorization information
- Like the HLR, the HSS contains or has access to the authentication centers/servers (e.g. AUC, AAA).
- HSS structure:
 - User Mobility Server (UMS): it stores Service Profile for the Multimedia domain and stores Service Mobility or Serving CSCF related information for the users. UMS might also generate, store and/or manage security data and policies (e.g. IETF features). UMS should provide logical name to transport address translation in order to provide answer to DNS queries.
 - 3G HLR: A UMTS HLR enhanced to support Release 2000 access specific information.

Functional Elements: HSS structure



Functional Elements: Transport Signalling Gateway

- This component in the Rel 4/5 network is PSTN/PLMN termination point for a defined network.
 - Maps call related signalling from/to PSTN/PLMN on an IP bearer and sends it to/from the MGCF.
 - Needs to provide PSTN/PLMN <=> IP transport level address mapping.

Functional Elements: Roaming Signalling Gateway

- The role of the R-SGW described in the following bullets is related only to roaming to/from 2G/R99 CS and GPRS domain to/from R00 UMTS Teleservices domain and UMTS GPRS domain and is not involving the Multimedia domain.
 - In order to ensure proper roaming, the R-SGW performs the signaling conversion at transport level (conversion: Sigtran SCTP/IP versus SS7 MTP) between the legacy SS7 based transport of signaling and the IP based transport of signaling. The R-SGW does not interpret the MAP / CAP messages but may have to interpret the underlying SCCP layer to ensure proper routing of the signaling.
 - (For the support of 2G / R99 CS terminals): The services of the R_SGW are used to ensure transport interworking between the SS7 and the IP transport of MAP_E and MAP_G signalling interfaces with a 2G / R99 MSC/LR

Functional Elements: Media Gateway Control Function

- This component is PSTN/PLMN termination point for a defined network.
 - Controls the parts of the call state that pertain to connection control for media channels in a MGW.
 - Communicates with CSCF.
 - MGCF selects the CSCF depending on the routing number for incoming calls from legacy networks.
 - Performs protocol conversion between the Legacy (e.g. ISUP, R1/R2 etc.) and the R00 network call control protocols.
 - Out of band information assumed to be received in MGCF and may be forwarded to CSCF/MGW.

Functional Elements: Media Gateway

- This component is PSTN/PLMN transport termination point for a defined network and interfaces UTRAN with the core network over Iu.
- A MGW may terminate bearer channels from a switched circuit network and media streams from a packet network (e.g., RTP streams in an IP network). Over Iu MGW may support media conversion, bearer control and payload processing (e.g. codec, echo canceller, conference bridge) for support of different Iu options for CS services: AAL2/ATM based as well as RTP/UDP/IP based.
 - Interacts with MGCF, MSC server and GMSC server for resource control; Owns and handles resources such as echo cancellers etc.; May need to have codecs.
- Tailoring (i.e packages) of the H.248 may be required to support additional codecs and framing protocols, and support of mobile specific functions

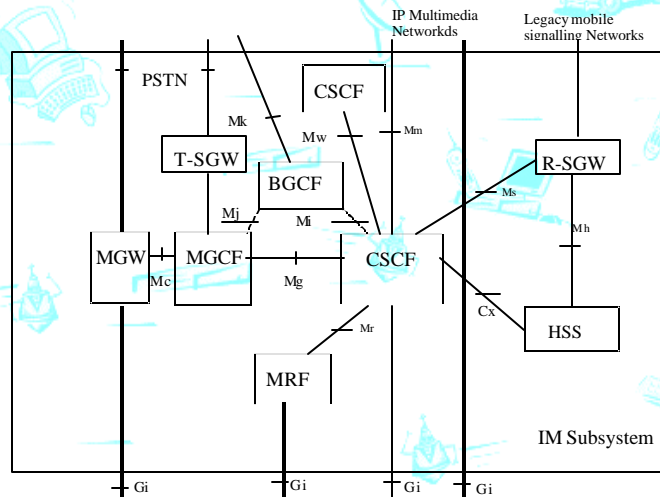
Functional Elements: Multimedia Resource Function

- This component:
 - performs multiparty call and multimedia conferencing functions. MRF would have the same functions of an MCU in an H.323 network.
 - Is responsible for bearer control (with GGSN and MGW) in case of multi party/multi media conference
 - may communicate with CSCF for service validation for multiparty/multimedia sessions.

Functional Elements: (G)MSCs, (G)MSC servers

- MSC server: comprises the call control and mobility control parts of a GSM/UMTS MSC and is responsible for the control of mobile originated and mobile terminated CS Domain calls. It terminates the user-network signalling (04.08+CC+MM) and translates it into the relevant network – network signalling. The MSC Server also contains a VLR to hold the mobile subscriber's service data and CAMEL related data.
- MSC server controls the parts of the call state that pertain to connection control for media channels in a MGW.
- Gateway MSC Server: The GMSC server mainly comprises the call control and mobility control parts of a GSM/UMTS GMSC.
- MSC: A MSC server and a MGW make up the full functionality of a MSC as defined in 23.002
- Gateway MSC: A GMSC server and a MGW make up the full functionality of a GMSC as defined in 23.002

Release 5: Basic IMS Configuration



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Proxy-CSCF

- Proxy-CSCF (P-CSCF) is the first contact point within the IM subsystem. Its address is discovered by "Procedures related to Local CSCF Discovery". The P-CSCF behaves like a proxy (as defined in RFC2543). The functions performed by the P-CSCF are:
 - Forward the SIP register request received from the UE to an I-CSCF determined using the home domain name, as provided by the UE.
 - Forward SIP messages received from the UE to the SIP server (e.g. S-CSCF) whose name the P-CSCF has received as a result of the registration procedure.
 - As part of processing of the request and before forwarding, the P-CSCF may modify the Request URI of outgoing requests according to a set of provisioned rules defined by the network operator (e.g. Number analysis and potential modification such as translation from local to international format.)
 - Forward the SIP request or response to the UE.
 - Detect an emergency call and select a S-CSCF in the visited network to handle emergency calls.
 - The generation of CDRs.
 - Authorization of bearer resources and QoS management and Security issues are FFS.

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Interrogating-CSCF

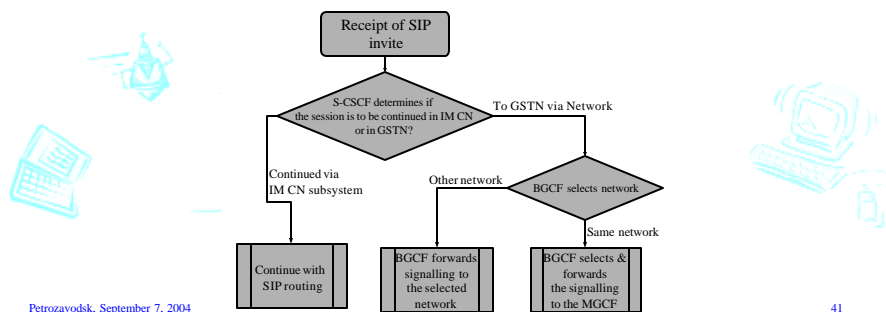
- Interrogating-CSCF (**I-CSCF**) is the contact point within an operator's network for all connections destined to a subscriber of that network operator, or a roaming subscriber currently located within that network operator's service area. There may be multiple I-CSCFs within an operator's network. The functions performed by the I-CSCF are:
- Registration: Assigning a S-CSCF to a user performing SIP registration (see section on Procedures related to Serving CSCF assignment); Cryptography mechanisms may be used by I-CSCF to hide the S-CSCF when S-CSCF name is provided to the P-CSCF in the Visited network
- Session Flows: Route a SIP request received from another network towards the S-CSCF; Obtain from HSS the Address of the S-CSCF; Forward the SIP request or response to the S-CSCF determined by the step above;
- Charging and resource utilisation: Generation of CDRs.
- In performing the above functions the operator may use I-CSCF to hide the configuration, capacity, and topology of the its network from the outside
- Editor's Note: Additional functions related to inter-operator security are for further study.

Serving-CSCF

- Serving-CSCF (**S-CSCF**) performs the session control services for the endpoint. It maintains session state. Within an operator's network, different S-CSCFs may have different functionalities. The functions performed by the S-CSCF during a session are:
- Registration: Acts like a Registrar defined in the RFC2543, i.e. it accepts Register requests and makes its information available through the location server (eg. HSS).
- Session flows: Session control for the registered endpoint's sessions; Interaction with Services Platforms for the support of Services;
 - On behalf of an originating endpoint (i.e. the originating subscriber/UE); Forward the SIP request or response to the I-CSCF
 - On behalf of a destination endpoint (i.e. the terminating subscriber/UE): Forward the SIP request or response to a P-CSCF for a MT session to a home subscriber within the home network, or for a subscriber roaming within a visited network where the home network operator has chosen not to have an I-CSCF in the path; Forward the SIP request or response to an I-CSCF for a MT session for a roaming subscriber within a visited network where the home network operator has chosen to have an I-CSCF in the path.
- Charging and resource utilisation: Generation of CDRs.
- Security issues are FFS

BGCF

- The S-CSCF, possibly in conjunction with an application server, shall determine that the session should be forwarded to the PSTN. The S-CSCF will forward the Invite information flow to the BGCF in the same network.
- The BGCF selects the network in which the interworking should occur based on local policy
- If the BGCF determines that the interworking should occur in the same network, then the BGCF selects the MGCF which will perform the interworking, otherwise the BGCF forward the invite information flow to the BGCF in the selected network. The MGCF will perform the interworking to the PSTN and control the MG for the media conversions.



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Identities

- Private User identities
 - Every IM subsystem subscriber shall have a private user identity. The private identity is assigned by the home network operator, and used, for example, for Registration, Authorization, Administration, and Accounting purposes. This identity shall take the form of a Network Access Identifier (NAI) as defined in RFC2486. Note: It is possible for a representation of the IMSI to be contained within the NAI for the private identity.
 - The Private User Identity is not used for routing of SIP messages
- Public user identities
 - Every IM subsystem subscriber shall have one or more public user identities [Ref 22.228]. The public user identity/identities are used by any user for requesting communications to other users. Note: For example, this might be included on a business card.
 - Both telecom numbering and internet naming schemes can be used to address users depending on the Public User identities that the user's have.
 - The public user identity/identities shall take the form of SIP URL (as defined in RFC2543 and RFC2396) or E.164 numbers.

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New Reference points (1)

- **Cx Reference Point (HSS – CSCF):** the transfer of data between the HSS and the CSCF. When a UE has registered with a CSCF, the CSCF can update its location towards HSS. This will allow the HSS to determine which CSCF to direct incoming calls to. On this update towards the HSS, the HSS sends the subscriber data (application related) to CSCF. For a MT call, CSCF asks the HSS for call routing information.
- **Gm Reference Point (CSCF – UE):** allow UE to communicate with the CSCF e.g.
 - Register with a CSCF,
 - Call origination and termination
 - Supplementary services control

New reference points (2)

- **Mc Reference Point (MGCF – MGW):** describes the interfaces between the MGCF and MGW, between the MSC Server and MGW, and between the GMSC Server and MGW. It has the following properties:
 - full compliance with the H.248 standard.
 - flexible connection handling which allows support of different call models and different media processing purposes not restricted to H.323 usage.
 - dynamic sharing of MGW physical node resources. A physical MGW can be partitioned into logically separate virtual MGWs/domains consisting of a set of statically allocated Terminations.
 - dynamic sharing of transmission resources between the domains as the MGW controls bearers and manage resources according to the H.248 protocols.
 - The functionality across the Mc reference point will need to support mobile specific functions such as SRNS relocation/handover and anchoring. It is expected that current H.248/IETF Megaco standard mechanisms can be applied to enable this.

New reference points (3)

- Mg Reference Point (MGCF – CSCF): The Mg reference point is based on external specifications, e.g. H.323 or SIP.
- Mh Reference Point (HSS – R-SGW): supports the exchange of mobility management and subscription data information between HSS and R99 and 2G networks. This is required to support Release 2000 network users who are roaming in R99 and 2G networks.
- Mm Reference Point (CSCF – Multimedia IP networks): an IP interface between CSCF and IP networks. This interface is used, for example, to receive a call request from another VoIP call control server or terminal.
- Mr Reference Point (CSCF - MRF): Allows the CSCF to control the resources within the MRF.
- Ms Reference Point (CSCF – R-SGW): This is an interface between the CSCF and R-SGW.

New reference points (4)

- Mw Reference Point (CSCF – CSCF): The interface allows one CSCF (e.g. home CSCF) to relay the call request to another CSCF (e.g. serving CSCF).
- Nc Reference Point (MSC Server – GMSC Server): Over the Nc reference point the Network-Network based call control is performed. Examples of this are ISUP or an evolution of ISUP for bearer independent call control (BICC). In the R'00 architecture different options for signalling transport on Nc shall be possible including IP.
- Nb Reference Point (MGW-MGW): Over the Nb reference point the bearer control and transport are performed. The transport may be RTP/UDP/IP or AAL2 for transport of user data. In the R00 architecture different options for user data transport and bearer control shall be possible on Nb, for example: AAL2/Q.AAL2, STM/none, RTP/H.245.

New reference points (5): CAP towards SCP

- This includes the interfaces from the SGSN to the SCP, from the MSC Server to the SCP, and the GMSC Server to the SCP.

CAP		
TCAP		
SCCP		
M3UA SCTP (1)	MTP-3B SAAL	Narrow-band SS7
IP (2)	ATM(2)	STM (2)

New reference points (6): MAP-based

- This includes the interfaces from the GGSN to the HSS (Gc reference point), from the SGSN to the HSS (Gr reference point), from the GMSC Server to the HSS (C reference point), and the MSC Server to the HSS (D reference point).
- The MAP based interfaces may be implemented using MAP transported over IP, or MAP over SS7.
- MAP can be transported on the same protocol stacks as CAP

New reference points (7): lu ref point

- This is the reference point between UTRAN and the R00 core network. This reference point is realized by one or more interfaces:
 - Between UTRAN and SGSN, transport of user data is IP based.
 - Between UTRAN and SGSN, transport of signalling is based on IP or SS#7.
 - Between UTRAN and MGW, transport of user data is based on different technologies (e.g., IP, AAL2), and includes the relevant bearer control protocol in the interface.
 - Between UTRAN and MSC server, transport of signalling is based on IP or SS#7.
- When the lu_cs is ATM based, then the protocols used can be based on R99 protocols or an evolved version. When lu_cs is IP based, new IP transport related protocols need to be added as part of the lu protocols. It shall be possible to have R99 lu interface with MSCs compliant to R99 specifications in the network. It shall be possible to have a R99 CS domain with R99 lu_cs reference point coexisting with a R00 lu reference point.