1 NGN

1.1 Introduction

Opinions on NGN definition may differ in some ways, but the main principles of the **NGN**s (*Next Generation Network*s) were formed when the idea of NGN itself emerged. The next two definitions from ETSI and ITU-T describe NGN in substance.

According to ETSI NGN is a concept for the defining and establishing of the networks, allowing a formal distribution of functionalities into separate layers and planes by using open interfaces, making it possible for the service providers and operators to create a platform which can be gradually developed thanks to creation, implementation and effective management of innovative services [1], [2]. ITU-T defines NGN as a network based on packet transfer, enabling to provide services, including telecommunication services, and is capable of using several broadband transmission technologies allowing guaranteeing QoS [1], [2]. The functions related to services are at the same time independent of the basic transmission technologies. NGN provides unlimited user access to different service providers. It supports general mobility providing the users with consistency and availability of services.

1.2 Requirements for NGN

That is what definitions say, but probably eventual NGN advantages are of bigger importance. Worth mentioning are some requirements for NGN it should conform to [3]:

- High-capacity packet transfer within the transmission infrastructure, however, with a possibility to connect existing and future networks (be it the networks with packet switching, circuit switching, connection-oriented or connectionless, fixed or mobile).
- Separation of managing functions from transmission features. Separation of service provisioning from the network and ensuring the access via an open interface and thus a flexible, open and distributed architecture.
- Support for a wide range of services and applications by using the mechanisms based on the modular and flexible structure of elementary service building blocks
- Broadband capabilities, while complying with the requirements for **QoS** (*Quality of Services*) and transparency. Possibility of a complex network management should be available.
- Various types of mobility (users, terminals, services). Unlimited access to a variety of service providers.
- Various identification schemes and addressing which can be translated to the target IP address for the purposes of routing in the IP network. (Flexible addressing and identification, authentication).
- Converged services between fixed and mobile networks (as well as voice, data and video convergence). Various categories of services with the need of different QoS and *classes of services* (**CoS**).
- Conformance to the regulation requirements, such as emergency calls and security requirements in terms of personal data protection.
- Cheaper and more effective technologies if compared to the current technologies.

1.3 Next Generation Network Concept

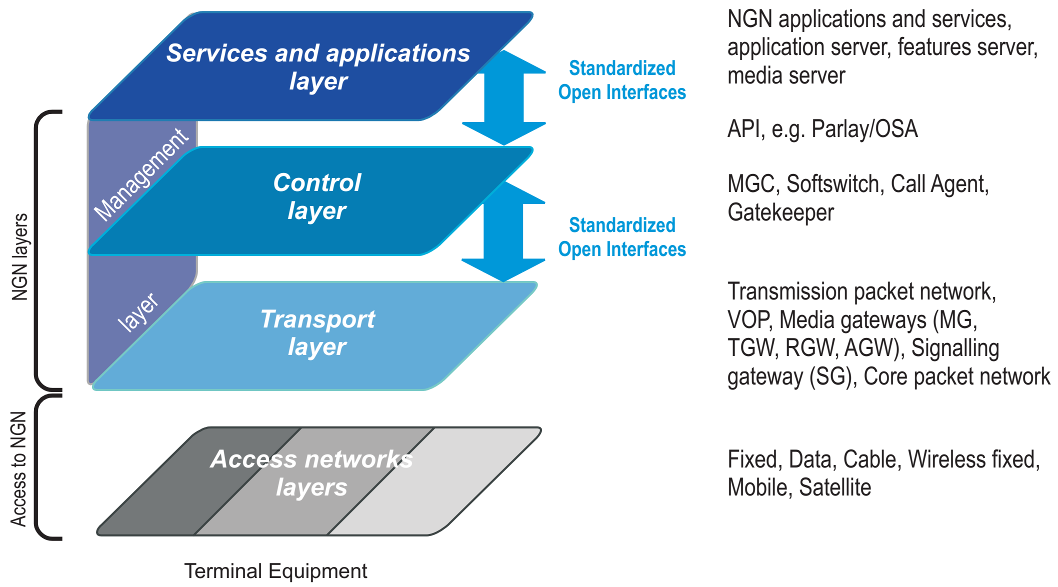
Within the NGN concepts the standardization institutions are solving the following issues and problems:

- existing networks migration towards NGN,
- development in the field of access technologies,
- connection of other networks to IP networks,
- provision of services and development of new ones,
- interworking in the area of addressing,
- interworking of signaling systems,
- roaming a mobility.

There are many conceptual models and reference architectures for both the converged networks and VoIP architectures. Therefore, we have tried to find common features and to define a suitable conceptual model for NGN.

An objective of the **conceptual model** [4] is to determine functional layers (covering similar functionalities), their entities, reference points (interfaces) and information flows between them. Such a model then can be mapped more easily into the physical reference architecture (and it is independent of the physical entities, i.e. components of the architecture).

In most analyzed cases the NGN conceptual model layers are from the point of view of functionalities divided into independent parts as follows: access (some reference architectures do not include it directly into the NGN model or replace it by the adaptation one), transport (transmission, switching), control (call/sessions control) and application (services).



NGN conceptual model and its functional layers

Conceptual model layers

The access layer provides the infrastructure, for example an access network between the end user and the transport network. The access network can be both wireless and fixed and it can be based on various transport media.

The transport layer ensures the transport between the individual nodes (points) of the network, to which are connected access networks. It connects physical elements deployed in the individual layers It also enables the transport of different types of traffic, media (signaling, interactive data, real-time video, voice communication, etc.)

The control layer includes the control of services and network elements. This layer is responsible for set-up/establishing, control and cancelling of the multimedia session. It ensures the control of sources as well, depending on the service requirements. One of the fundamental NGN principles is the separation of control logic from the switching hardware.

The service layer offers the basic service functions, which can be used to create more complex and sophisticated services and applications. It controls the progress of the service based on its logic.

In the NGN it is required that the network control is not determined only by the terminal equipment applications, but that the network intelligence may carry out control over the network at all levels of the reference model. The network management reference model implies the following tasks for the network intelligence it has to ensure:

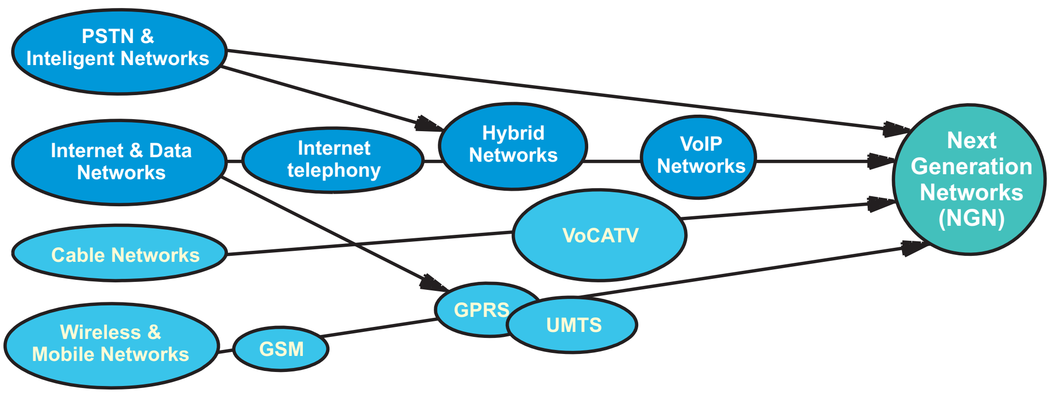
- Resource management (capacity, ports, and physical elements) and QoS in access to the network and in the transport network, as necessary.

- Various media processing, encoding, data transfer (information flows).
- Management of calls and connection. Management and interworking of all elements of the reference architecture.
- Service control.

NGN evolutional scenarios and multimedia services

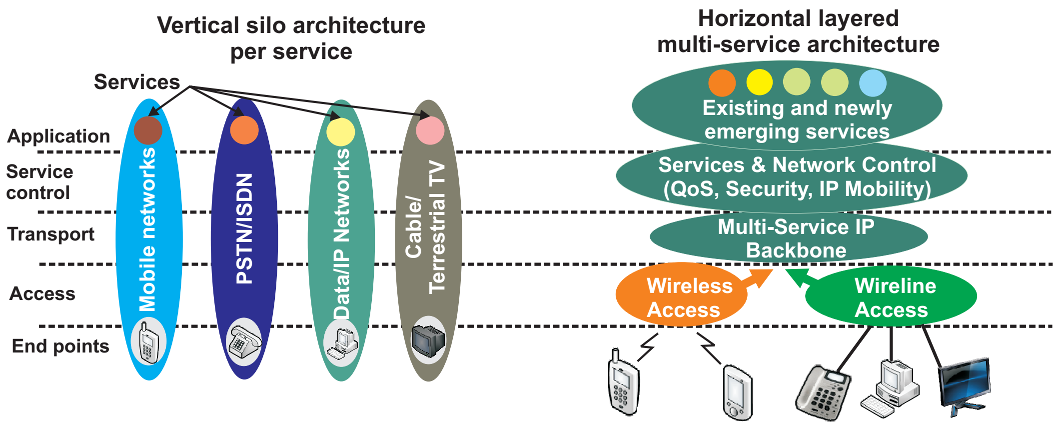
As it has already been stated, the next generation networks are a vision of a converged network, meeting all the requirements for a converged universal packet network of the future. The main aim is to explain the deployment and functions of the individual components within the network intelligence and to give a brief characteristic of the individual layers of an NGN conceptual model. After introducing the first real solutions, the next generation networks are becoming a reality, not just a concept. That is why it is appropriate to look into their evolution and to outline their future trends and the open issues to be solved as well. Migration scenarios of different types of networks platforms are based on the idea to integrate **TDM** (*Time Division Multiplexing*) and **IP** (*Internet Protocol*) platforms into one converged NGN platform (from the point of network infrastructure, as well as services, Figure below) [4], [5]. The separation of processes of service control and providing from the physical network architecture and extension of telephone and multimedia services are two different NGN aspects.

+ New concepts and architectures of new generation of **ICT** (*Information and Communication Technology*) based on converged ICT and NGN offer to operators new opportunities to implement and provide wide spectrum of multimedia services and applications [6].



Migration scenarios

Therefore operators can move from vertical silo architecture where each type of service has dedicated access, transport, control and application infrastructure per service to horizontally oriented architecture more independent from provided services. The main idea of NGN based IPTV is to include functionalities and infrastructure required for any of multimedia NGN services specially here the IPTV type of services to NGN architecture.



From vertical silos to horizontal NGN architecture

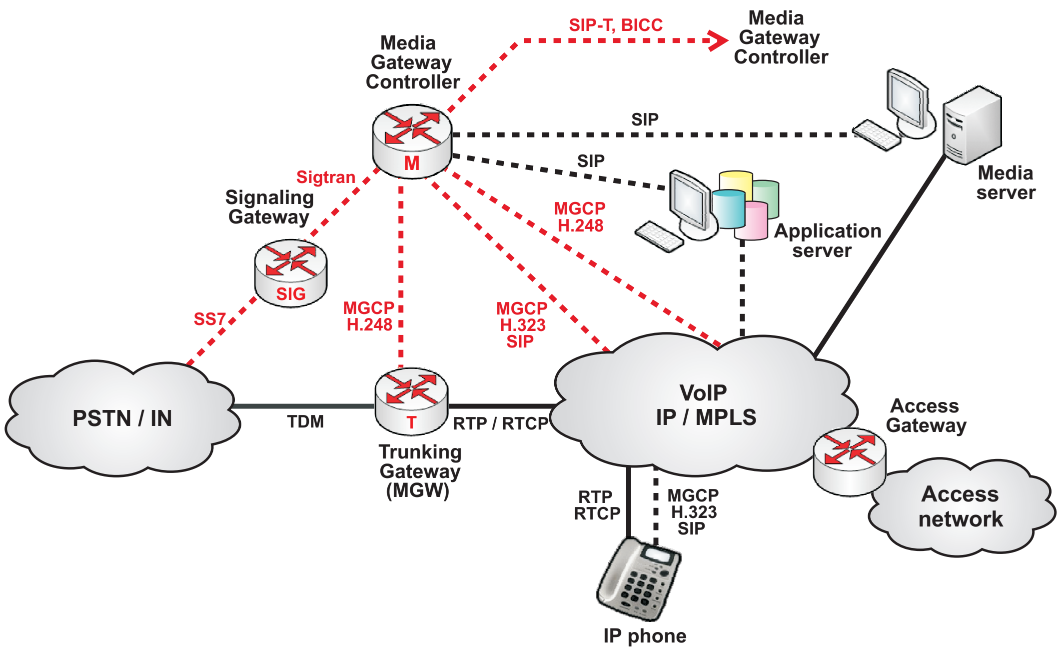
Table shows some of the main parameters and features of network concepts: NGN, **PSTN/IN** (*Public Switched Telephone Network/Intelligent Network*) and Internet (simplified and generalized interpretation).

Comparing the features of PSTN/IN, Internet and NGN

	PSTN/IN	**Internet**	**NGN**
Multimedia services	NO	YES	YES
QoS support	YES (Voice)	NO	YES
Network intelligence	YES	NO	YES
Intelligent terminal equipment	NO	YES	YES
Integrated supervision and control	YES	NO	YES
Reliability	high	low	high
Service creation	complex	ad-hoc	systematic
Simplicity of services use	medium	high	high
Modularity	low	medium	high
Time of service introduction	long	short	short
Openness of architecture	small	high	high

1.4 NGN Softswitch Based Architectures

NGN architecture based on software switching technology (softswitch) can be supposed as first and unique evolution step in NGN, although there are more modern architecture available nowadays (for example see chapter IMS based architecture). However, it has built up philosophy of building of new NGN networks and validated principles and features of NGN architecture and its components towards its next evolution [3]. This architecture was the first which drive was significantly motivated by telecommunication vendors, naturally reflecting on massive development of VoIP protocol family and by telecommunication providers demand to implement services more modern and more efficient way. Due to this fact it is not strictly standardized and we can see there several different attitudes of telecommunication vendors how to provide some features, how to distribute components across network including distribution of functional entities inside control element plane. Knowledge of this architectural approach is important for understanding of next evolved architectures and principles. Components of softswitch based architecture you can see in next Figure.



Components of softswitch based architecture

Media Gateway Controller/call agent/softswitch: generally serves as components for controlling of communication relations of users and other network components; provides call routing, network signaling, billing, and other logical functions.

Media Gateway: operate within transport plane, perform all function related to media physical transport between different networks, media processing functions (transcoding, echo cancellation, jitter managing), tones processing and management of information transport

- Trunking gateways: interface between the PSTN/PLMN and VoIP network
- Residential gateways: provide traditional analog (RJ11) interface to VoIP network
- Access gateways: provide traditional analog or PBX interface to VoIP network
- Signaling network: provide change of signalization systems between PSTN or **PLMN** (*Public Land Mobile Network*) network to VoIP network

Application Server: it is obviously implemented to perform functionalities specific to certain service, perform specialized service logic call control, also includes more functionalities in terms of user web interface, end-points management, etc. For example it can provide specific videoconferencing service, Call Centre service or IP Centrex service.

Media Server: provides functionalities allow interaction between calling party and application using end-point device. It provides Media Resource Functions (tones detection, speech synthesis and recognition, compressions, media mixing, etc.) and Media Control Functions – control of media functions (voice message play management, conference bridge, fax messages management, etc.).

1.5 IMS Based Architecture

The initiative of organization institutions 3GPP within the specifications of **UMTS** (*Universal Mobile Telecommunications System*) architecture (3GPP within the UMTS architecture 5/6) has defined two domains:

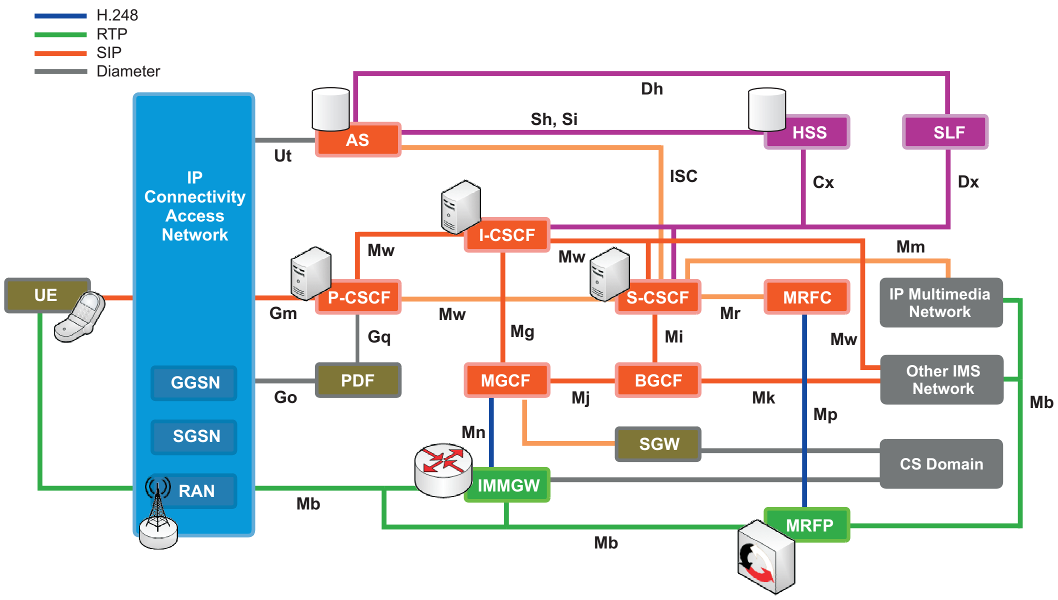
- Circuit switching domain,
- Packet switching domain.

The packet switching domain extends the existing GSM network and other mobile *2nd generation* (**2G**) networks by the CDMA-based access, while the packet switching domain extends the abilities of the GPRS and other systems of 2.5 generation.

The subsystem for supporting multimedia services, telephony and IP-based message sending, designed in the framework of the packet switching domain is called **IMS** (*IP Multimedia Subsystem*). IMS is based on the IP architecture for multimedia and it was placed as a supporting network element to provide standardized and universal services for mobile users. As it was one of the first concepts on which all the standardizations institutions agreed and which conformed to the NGN principles, it is becoming one of the reference concepts for the fixed networks as well.

The 3GPP adopted **SIP** (*Session Initiation Protocol*) [7], which was originally standardized by the IETF. In time, the 3GPP discovered that there were gaps between the SIP, as initially defined by the IETF, and the features that were required to provide full support for IMS networks. Because SIP did not address all the requirements of IMS networks, the 3GPP subsequently defined dozens of new SIP extensions that are specific to IMS networks, e.g. [8]. Collectively, these extensions comprise the IMS SIP protocol, which is defined in the 3GPP TS.24.229 standard. IMS SIP extensions, such as extended call control, presence and instant messaging, extend the functionality of SIP on IMS networks.

By definition, SIP is not a protocol designed for a specific network or application. To use SIP, you can define the usage profile. Usage profiles work much like templates, and provide a varied, flexible environment for application development in which you can easily develop an application suited to your particular requirements can be easily developed. In effect, this is what IMS SIP did. The IMS SIP usage profile is the most important in the telecommunications industry, as it affects the entire telecom industry and not only mobile networks. The usage profile used by IMS SIP is actually the most appropriate for NGN networks. There are numerous IMS SIP extensions. The figure below illustrates a typical IMS network. Note that all SIP interfaces are shown in orange and specify the name of the interface between two adjoining entities. For example, the AS uses the ISC interface.


H.248
RTP
SIP
Diameter
IP Connectivity Access Network
GGSN
SGSN
RAN
UE
AS
HSS
SLF
Dh
Sh, Si
Ut
ISC
Cx
Dx
I-CSCF
P-CSCF
S-CSCF
MRFC
IP Multimedia Network
Other IMS Network
CS Domain
PDF
MGCF
BGCF
SGW
IMMGW
MRFP
Mw
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Mb

SIP in IMS

1.6 IMS Based Architecture – P-CSCF

Proxy Call State Control Function (**P-CSCF**) performs the following functions:

- is the first contact point for UE within IM CN subsystem, forwards the registration to the I-CSCF to find the S-CSCF and after that forwards the SIP messages between UE and I-CSCF/S-CSCF,
- behaves as like a proxy in RFC 2543, i.e. accepts requests and services the internally or forwards them possibly after translation,
- may behave also like a user agent (in RFC 2543), i.e. in abnormal conditions it may terminate and independently generate SIP transactions,
- is discovered using DHCP during registration or the address is sent with PDP context activation,
- may modify the URI of outgoing requests according to the local operator rules (e.g. perform number analysis, detect local service numbers),
- detect and forward emergency calls to local S-CSCF,
- generation of charging information,
- maintains security association between itself and **UE** (*User Equipment*), also provides security towards S-CSCF,
- provides the *policy control function* (**PCF**),
- authorization of bearer resources, QoS management and Security issues are currently open in standardization.

1.7 IMS Based Architecture – I-CSCF

Interrogating Call State Control Function (**I-CSCF**) performs the following functions:

- 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. It can be regarded as a kind of firewall between the external IMSS and the operator's internal IMSS network. There may be multiple I-CSCFs within an operator's network.
- assigns a S-CSCF to a user performing SIP registration,
- routes a SIP request received from another network towards the S-CSCF,
- obtains from HSS the Address of the S-CSCF,
- charging and resource utilization,
- 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,
- additional functions related to inter-operator security are for further study.

1.8 IMS Based Architecture – S-CSCF

Serving Call State Control Function (**S-CSCF**) performs the following functions:

- performs the session control services for the terminal. Within an operator's network, different S-CSCFs may have different functionality.
- maintains session state and has the session control for the registered endpoint's sessions,
- acts like a Registrar defined in the RFC2543, i.e. it accepts Register requests and makes its information available through the location server (e.g. HSS),
- may also behave as a proxy or as a user agent as defined by RFC 2543,
- interacts with services platforms for the support of services,
- obtain the address of the destination I-CSCF based on the dialed number or SIP URL,
- on behalf of a UE forward the SIP requests or responses to a P-CSCF or an I-CSCF if an I-CSCF is used in the path in the roaming case,
- generates charging information,
- security issues are currently open in standardization.

1.9 IMS Based Architecture – Other Entities

Media Gateway Control Function (**MGCF**) provides the following functions:

- protocol conversion between ISUP and SIP,
- routes incoming calls to appropriate CSCF,
- controls MGW resources.

Media Gateway (**MGW**) provides the following functions:

- transcoding between PSTN and 3G voice codecs,
- termination of SCN bearer channels,
- termination of RTP streams.

Transport Signaling Gateway (**TSG**) provides the following functions:

- maps call related signaling from/to PSTN/PLMN on an IP bearer,
- provides PSTN/PLMN <-> IP transport level address mapping.

Multimedia Resource Function (**MRF**) provides the following functions:

- performs multiparty call and multimedia conferencing functions.

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 *Breakout Gateway control function* (**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 MGW for the media conversions.

1.10 IMS Based Architecture – Self-SIP in IMS

SIP and SDP as a protocol has been selected to some and IPv6 as the only solution to all of the IP Multimedia Subsystem interfaces.

As shown by the figure below the basic SIP has been selected as the main protocol on the following interfaces:

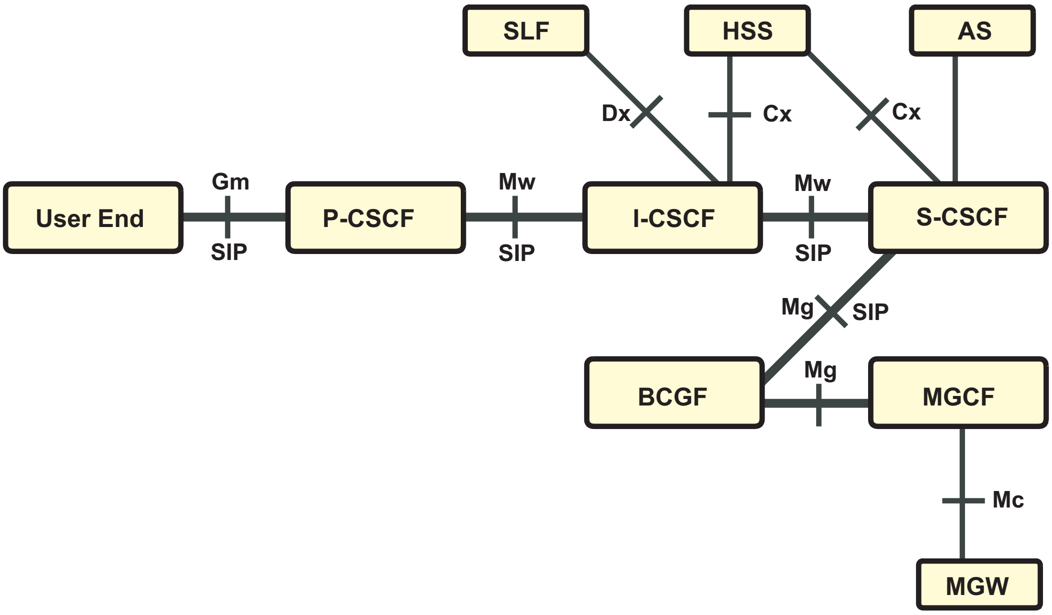
- Gm: P-CSCF – UE
- Mw: P-CSCF – S-CSCF and P-CSCF – I-CSCF
- Mm: S/I-CSCF – external IP networks & other IMS networks
- Mg: S-CSCF – BCGF Mk: BCGF – external IP networks & other IMS networks

Eventually there may be differences in the SIP procedures of Gm and Mw reference points. This implies that there is a difference in UNI and NNI interfaces.

The following procedures have been defined for the 3GPP IM subsystem in:

- Local P-CSCF discovery: Either using **DHCP** (*Dynamic Host Configuration Protocol*) or carrying address in the PDP context
- S-CSCF assignment and cancel
- S-CSCF registration
- S-CSCF re-registration
- S-CSCF de-registration (UE or network initiated)
- Call establishment procedures separated for
    - Mobile origination; roaming, home and PSTN
    - Mobile termination; roaming, home and PSTN
- S-CSCF/MGCF – S-CSCF/MGCF; between and within operators, PSTN in the same and different network
- Routing information interrogation
- Session release
- Session hold and resume
- Anonymous session establishment
- Codec and media flow negotiation (Initial and changes)
- Called ID procedures

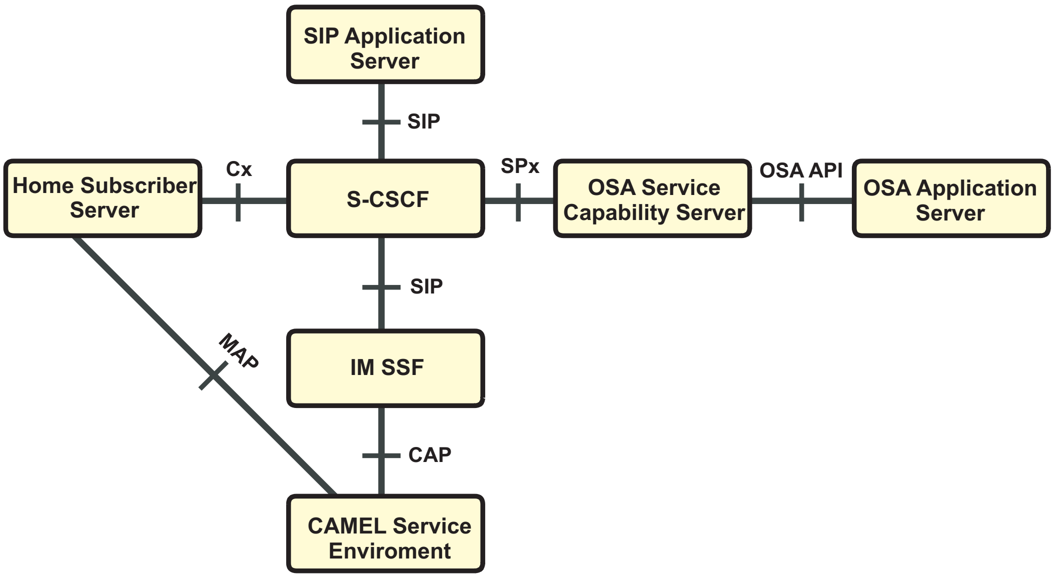
- Session redirect
- Session Transfer



SIP protocol in IMS

1.11 SIP in Service SS

The service subsystem and its connections to IM subsystem is shown in the Figure. The S-CSCF interfaces the application development servers with SIP+ protocols. The SIP application server can reside either outside or within operator's network. The OSA capability server and Camel refer to already standardized 3G and GSM based service generation elements.



Service Subsystem connections with IMS