IP Multimedia Subsystem (IMS) in 3G Mobile Networking

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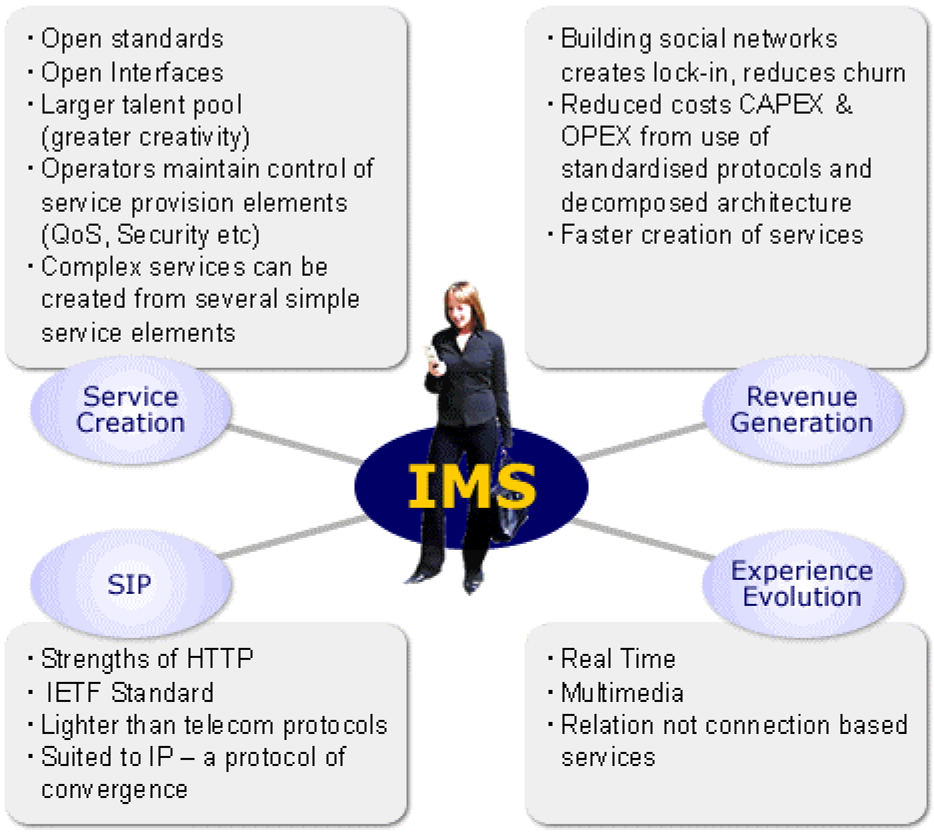
Abstract. *IP-based systems offer network operators the opportunity to expand their services, integrating voice and multimedia communications and delivering them into new environments. This is what the industry calls convergence. The 3rd Generation Partnership Project (3GPP)'s UMTS networks promise to deliver an abundance of advanced and feature rich applications to end-users in the 3G wireless environment. An IP Multimedia core network Subsystem is being introduced as part of this which aims to enable the convergence of, and access to, voice, video, messaging, data and web based technologies for the wireless user. The goal is to combine the growth of the Internet with the growth in mobile communications.*

Introduction

The 3rd Generation Partnership Project (3GPP), European Telecommunications Standards Institute (ETSI) and Parlay Forum have defined a services architecture, the IP Multimedia Subsystem (IMS). IMS is introduced in the UMTS core network of as an extension to the existing Circuit Switched (CS) and Packet Switched (PS) domains. The CS domain supports voice and data services based on GSM protocols. The PS domain serves as the core network for GPRS services. To delver the plethora of advanced, innovative, feature-rich, high quality IP-based Multimedia Services in Mobile Networks applications, IMS is established to provide IP Multimedia services on PS domain. For users, it delivers an entirely new, but intuitively right experience; for operators it provides solutions for fundamental problems such as reducing churn and creating new revenue streams.

IMS standardization is proceeding within the mobile industry's standardization body, 3GPP, and the first stage has been completed with the freezing of Release 5 standards. Within these standards, 3GPP has created a clear roadmap for how to introduce the IMS to the packet switched network and begin the migration away from circuit switched services.

IMS services are based on the Session Initiation Protocol (SIP) that has been developed within the IETF. SIP is firmly grounded in the culture of the Internet and has drawn heavily from the experiences of developing protocols such as HTTP and SMTP. It is specified that its services must be independent of the access media.



[Figure: The IMS Revolution]

IMS Services

If IMS is about one thing it is about services. Real-time multimedia services that easily integrate with each other and telephone services is the main aim for IMS as a service platform. By bringing together call control and service provision into a horizontally integrated system, IMS enables new combinations of services and service elements. This new service structure not only makes it easier to combine services but also to develop and deploy new services in shorter time cycles.

Service Examples:

Presence List, Rich Call, Group chat, Push-to-talk, Multimedia Advertising, Teleconferencing, Instant Messaging, Multiparty Gaming and Personalized Information Services

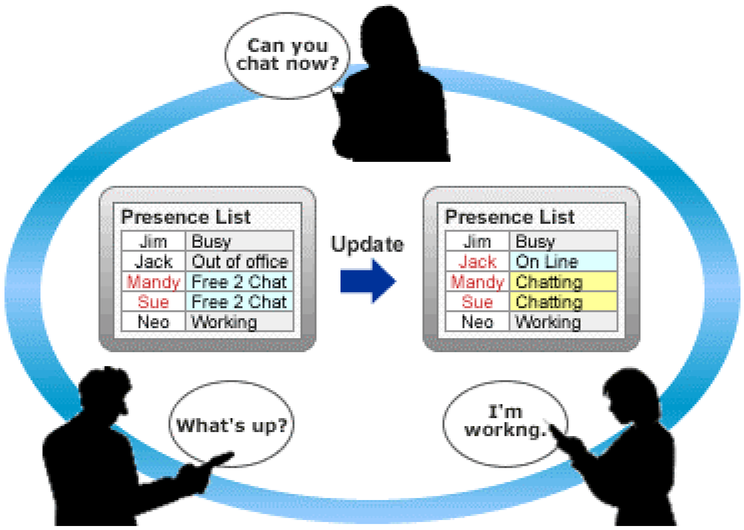


Figure: Presence List Service

While the technology is interesting for operators and vendors, more often than not it is unseen by users. It is very likely that the details of IMS will be more or less unknown to the end user, but what will be noticed is the change in services that they are able to use and access. These services will no longer be constructed under the one-to-one model of traditional voice services, but will see services being built around the concept of groups that form on the basis of common interest/need to communicate and exchange information. The individual will also have a much greater choice for ways to communicate with others and to mange and personalize those communications.

The IMS (IP Multimedia Subsystem) Network Architecture

The main elements within the logical architecture of the IMS are:

Serving Call Session Control Function (S-CSCF) - The main SIP server that maintains session state for IMS services

Proxy Call Session Control Function (P-CSCF)- Whether in a home network or visited network the P-CSCF will be the first point of contact for the UE and forward SIP messages to the user's home S-CSCF.

Interrogating Call Session Control Function (I-CSCF) - Optional within 3GPP, this CSCF will be the contact point for a network when other networks need to make contact

Home Subscriber Server (HSS) - Evolved from the HLR this handles subscriber profile information for the IMS

Multimedia Resource Function (MRF) - Multimedia Resource Function Server which enables conference bridging or Interactive Voice Response Services (IVR).

Application Servers- Application Servers that provides SIP based application services such as presence and group chat.

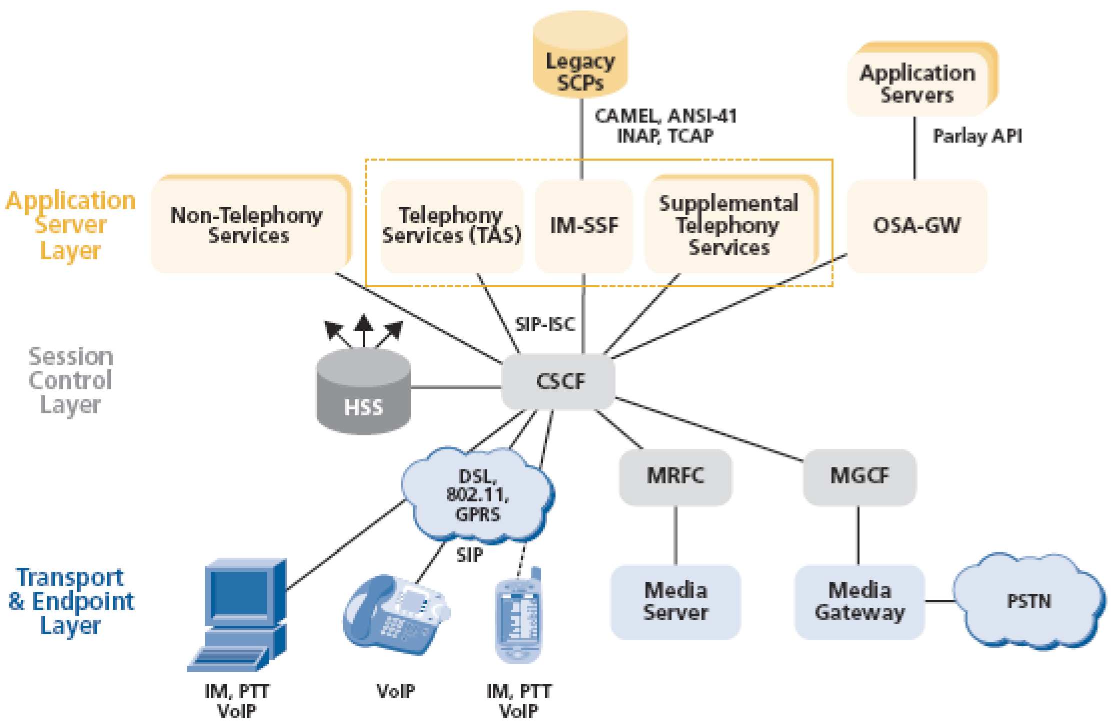


Figure: Simplified View of the IP Multimedia Subsystem (IMS)

SIP IN IMS

SIP is the protocol of choice for the support of IP multimedia services in the IMS of the 3GPP UMTS. The IMS allows peer-to-peer connectivity for services such as VoIP and rich calls (i.e., calls with multiple media including data transfer).

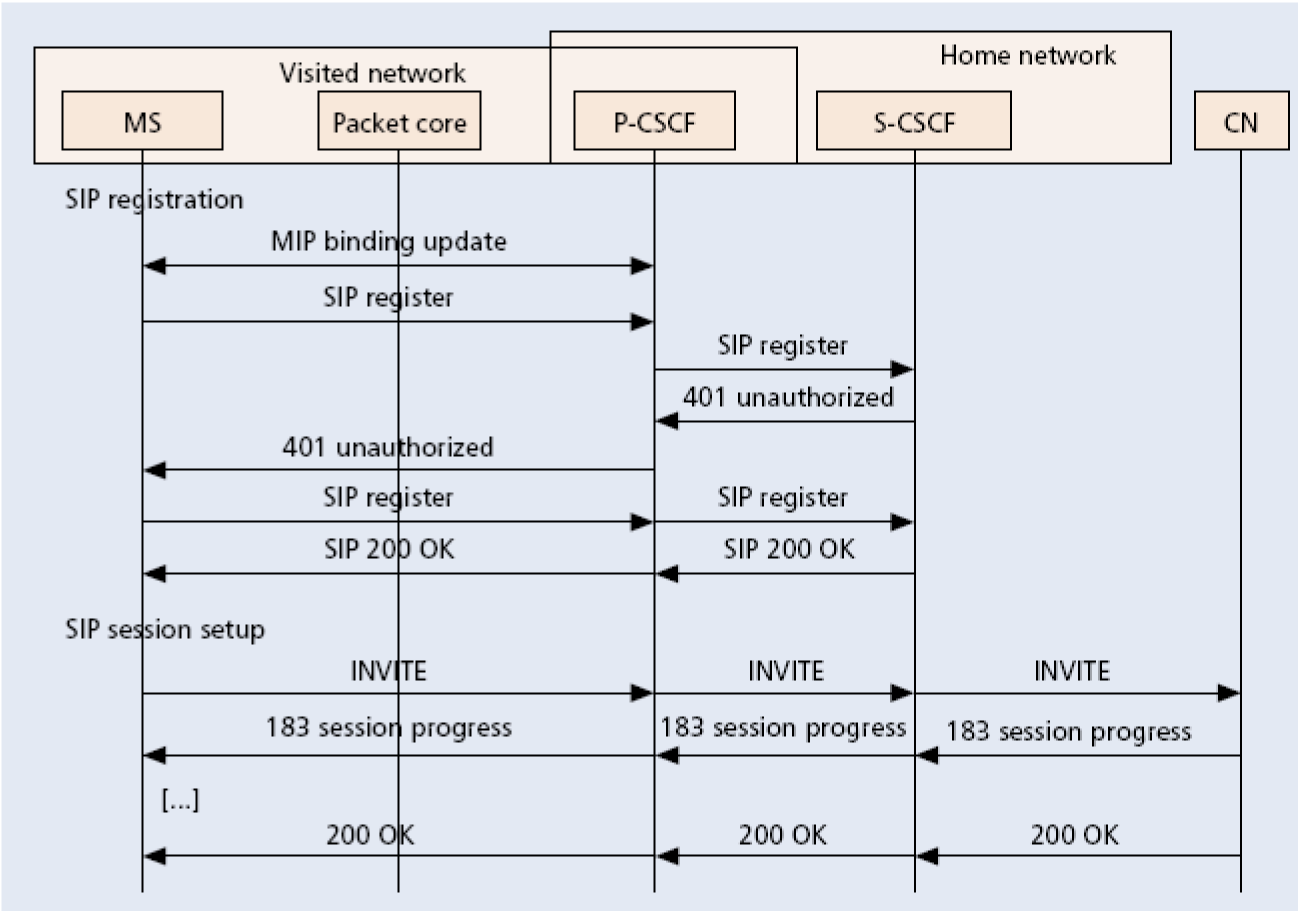


Figure: SIP registration and session establishment in the IMS.

The P-CSCF acts as a SIP proxy between the MN and the I-CSCF/S-CSCF. The S-CSCF implements the actual SIP registrar functionality and session control, including service triggering. After gaining IP connectivity through the packet network (e.g. GPRS in 3GPP), the MN registers with the S-CSCF (Fig.). The registration request is forwarded via the P-CSCF. SCSCF authenticates the MN and retrieves the user profile. After successful authentication, the MN is registered and ready to set up or receive SIP calls. To set up a SIP call, the MN sends an INVITE to the SIP infrastructure and addressed to the correspondent node. The P-CSCF forwards the request to the S-CSCF based on the setup service route information. The P-CSCF verifies that the request was coming on a valid security association, whereas the S-CSCF trusts the requests coming from the P-CSCF since they are in the same trust domain. The call setup requires a series of round-trips in order to allow the two end nodes to exchange information on the media components of the call (e.g. voice, video) and to set up the corresponding quality of service. It is relevant to note that the MN always exchanges SIP signaling with the P-CSCF, and direct communication with the S-CSCF is not allowed. There are two main reasons for this: first, the P-CSCF is the endpoint of the security association with the user and takes care of integrity protection of SIP signaling. Second, the SIP signaling exchanged between the user and the PCSCF is compressed in order to optimize the usage of wireless resources, and the P-CSCF handles SIP signaling compression (SigComp). In addition, this allows the visited service provider to monitor and apply policies and local services to the SIP services the MN accesses, since the PCSCF (if in the visited network) can inspect all SIP signaling exchanged by the MN and SIP infrastructure. The IETF SIP specifications define SIP extensions on top of the basic SIP RFC, therefore 3GPP has specified a profile of SIP extensions to be mandatorily implemented by IMS networks, i.e. which options of SIP are used and how. In particular, since in 3GPP mobility is supported by the packet core network functions such as GPRS, SIP mobility is not supported in IMS. In fact, in GPRS/UMTS the MS never changes the point of attachment to the network, and therefore never changes the IP address.

Policy-Based Networking (PBN) in IMS

While current Mobile Networks are limited to “best effort” packet transport, new services including multimedia applications, Real-Time Services, interactive gaming, and mission critical business applications require *end-to-end QoS* guarantees from the network. Policy Based Networking (PBN) is a novel, domain independent approach to facilitate the operation of IP based networks and to introduce a concept for dynamic network control. Policy-Based mechanisms are applied to support *end-to-end QoS* control in the IP Multimedia Subsystem (IMS) of the 3G UMTS networks.

The end-user of a policy-enabled network can benefit by getting access to high-quality transport whenever needed for mission critical services. It also means, that the user will only pay for the service quality level used. For the operator, PBN can provide a wealth of options for introducing new “personalized” transport features and real-time services based on IP, while network resources are allocated and used most efficiently.

The Policy Decision Function (PDF) that is currently being standardized in the 3GPP as part of the UMTS IP Multimedia Subsystem (IMS) exploits policy based technology for provisioning of IP QoS services.

Further on, policy based QoS management provides complete network control, like traffic congestion management, traffic shaping and policing, bandwidth control and traffic balancing.

In a Policy Based Network the behavior of the system is specified by high-level policy rules in a declarative way and not by explicit configuration of individual system elements as in traditional networks. Policies are the links between a high-level business specification of desired services and low-level network element (NE) configurations that provide those services. The high-level business rules are mapped to low-level NE configurations. Policies can handle network configuration, including Quality of Service (QoS), Service Level Agreement (SLA), Virtual Private Network (VPN), and security issues.

Policy-based networking offers a powerful basis for building an "intelligent" network automating many of the management and operational tasks.

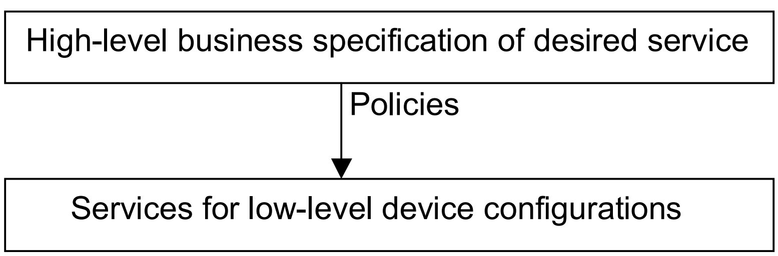


Figure: Purpose of Policies

The IETF has defined a policy framework to transform sets of policy rules to network device configurations in an administrative domain. Figure is one possible instantiation of the policy framework that includes two elements, the Policy Repository and Policy Management Tool that are explicitly described in but nonetheless are important in a practical system. The sets of policy rules are described in the form of policy models that are stored in the Policy Repository through the Policy Management Tool. The Policy Decision Point (PDP) retrieves the appropriate policy rules from the Policy Repository in response to policy events triggered by the contracted IP QoS services, such as the reception of a Resource Reservation Protocol (RSVP) message by the Policy Enforcement point (PEP). It translates the acquired policy rules in to a set of QoS mechanism configuration actions that is communicated to the PEP as policy decisions. The PEP then executes the actions spelled out in the supplied decisions to handle the triggering policy rules mat be returned to the PEP, which is capable of translating them into configuration actions. These policy rules can be cached in the PEP so that similar future triggering policy events can be serviced locally without further interactions with the PDP.

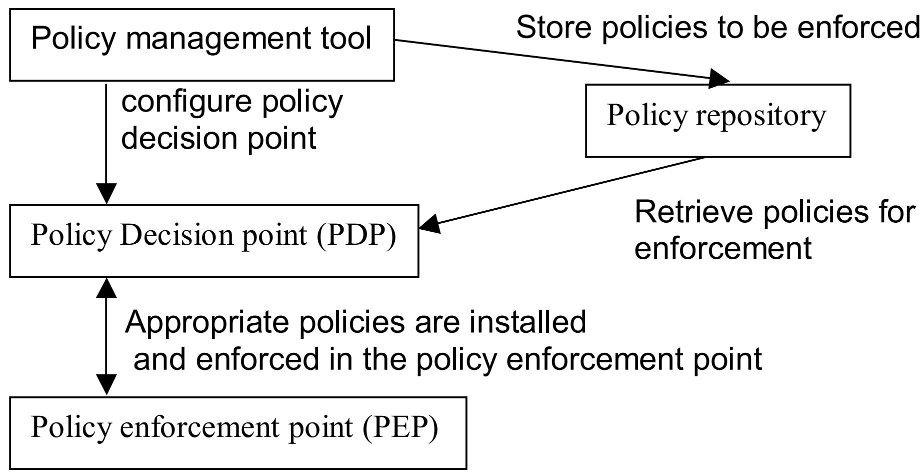


Figure. A PBN architecture that is derived from the policy framework specified by the IETF.

UMTS IMS Policy Architecture

As described in the IETF's reference model, PBN consists of two main elements PDP and PEP. PEPs often reside in the policy-aware network nodes that carry out actions stipulated bye policy rules. The actions taken are based on the decisions of a PDP, which retrieves the policy rules from the repository. The PDP is the final authority the PEP needs to refer to for actions to be taken. In IMS, the policy control function (PCF) plays the role of the PDP. The PCF can be a logical component of a P-CSCF or a separate entity altogether. Since the gateway GPRS serving node (GGSN) is the data path, it is the logical location for the PEP. The policy repository can be an entity external to the PCE. A Lightweight Directory Access Protocol (LDAP) capable data store is likely to be used for this purpose. The PCF communicates with the PEP via the Go interface. It allows two modes of operation. In the push mode, the PCF initiates communication with the PEP and sends the PEP its decision. In the pull mode, the PEP initiates communication with the PCF to request a decision for a particular IP flow. Figure depicts the relationship between these entities.

PCF: During the establishment of a SIP Session, a P-CSCF is the first contact point in the IMS domain for a UE. Hence it is the natural place to *authorize* usage of network resources such as the BW required by UE. The QoS requirements of the UE are carried in the Session Description Protocol (SDP) description within a SIP message. PCF examines the source and destination IP addresses and port numbers in its decision making. The PCF refers to the policy rules stored in the repository and generates an *authorization* token that uniquely identifies the SIP session across multiple Packet Data Protocol (PDP) contexts terminated by a GSN. This token is sent to UE via SIP messages so that UE can use it to identify the associated session flows to the PEP in the GGSN in subsequent transmissions of IP packets. This mechanism is consistent with the specification on the supporting media authorization in the SIP protocol.

PEP: In the PS domain, a GGSN maintains connectivity to other PS external networks such as the Internet. From the service point of view, the GGSN controls which IP flows are permitted into the external IP network by policing the IP packets based on their destination and source IP addresses and port number. The role of PEP is to ensure that only authorized IP flows area allowed to use network resources that have been reserved and allocated to them.

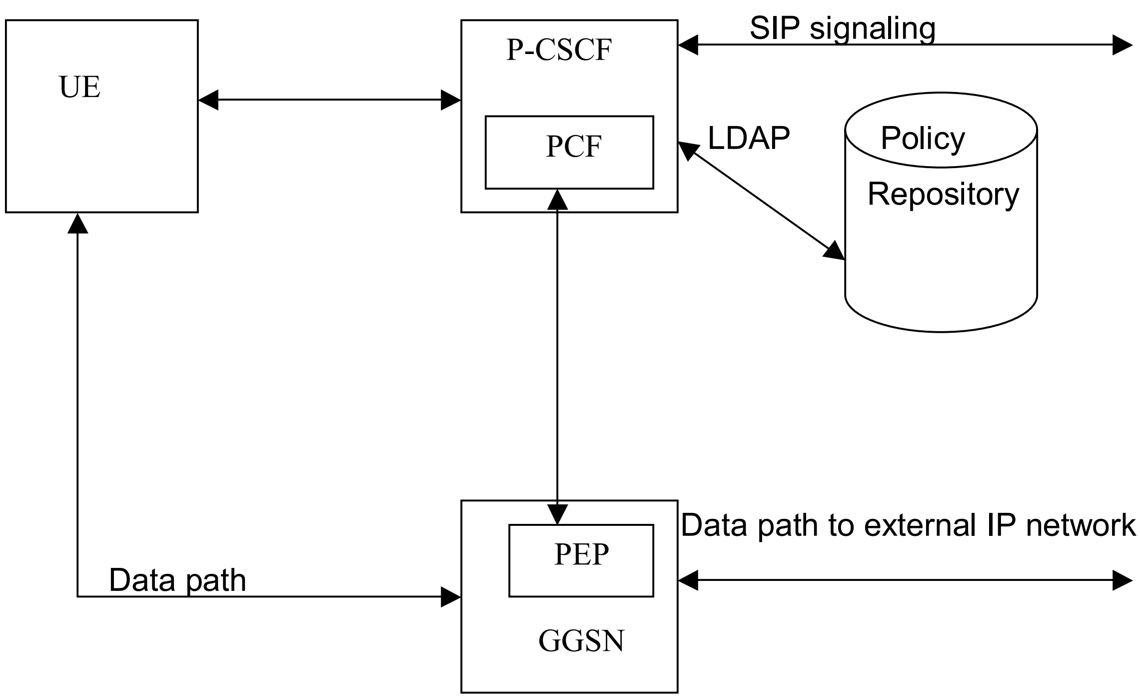


Figure: UMTS's IMS Policy Architecture

The policy enforcement function in the GGSN is called gate. A gate comprises a packet classifier, a traffic meter and the relevant packet handling mechanisms. When an IP flow is authorized by the PCF, the PEP opens the gate for the flow by allowing it to pass though the packet handling mechanisms. But if the IP flow is not permitted by PCF, PEP closes the gate and drops IP packets. This is called *policy-based admission control.* It ensures that an IP flow is only allowed to use resources that have been approved by policy rules. This process takes place at the IP bearer service (BS) level.

3GPP Go Interface and Protocol: In IMS, the session setup signaling is separated from the data path of the session. The PCF resides on the signaling path while GGSN resides on the data path. The role of PCF is to authorize then establishment of session at the policy level. To actually establish the data path of the session, the GGSN must reserve the proper level of QoS resources. To tie policy-level authorization to the corresponding QoS resource reservation, the PEP component of the GGSN must validate the reservation request with the PCF. Go interface facilitates the necessary communication between the PDF and the PEP to realize this validation.

The 3GPP has chosen to use the Common Open Policy Service – Policy Provisioning (COPS-PR) as the communication protocol on the Go interface. It provides a simple request-response framework to transport policy information reliably between the PEP and the PDF over a TCP connection. The PEP hereby acts as a client that sends requests, updates and deletes to the PDF. The PDF returns decisions to the PEP in response to these requests. Finally, the PEP completes the transaction by replying with reports on the execution status of the decisions. The message content, i.e. the information model of the COPS-PR messages of the Go interface – is specified by the Go Policy Information Base (PIB)
The PEP and the PDF maintain state information for every request initiated by the PEP. Therefore, the PDF can track the status of the PEP and potentially initiate a policy information transaction for an existing request state by sending unsolicited decisions to the PEP. In addition, the PDF can formulate decisions to new requests by referencing previously installed request states that are related to the new requests. The stateful nature of the COPS-PR protocol permits the PDF to push configuration information to the PEP and remove this information when it is no longer needed. The set of policy events that will trigger the PEP to solicit decisions from the PDF are specified in the policy information installed in the PEP

during the PEP configuration request transaction. The PEP may store decisions in a local policy decision point, thus allowing the GGSN to make the admission control decisions without additional interactions with the PDF. This will reduce the traffic over the Go interface and lessen the processing load on the PDF.

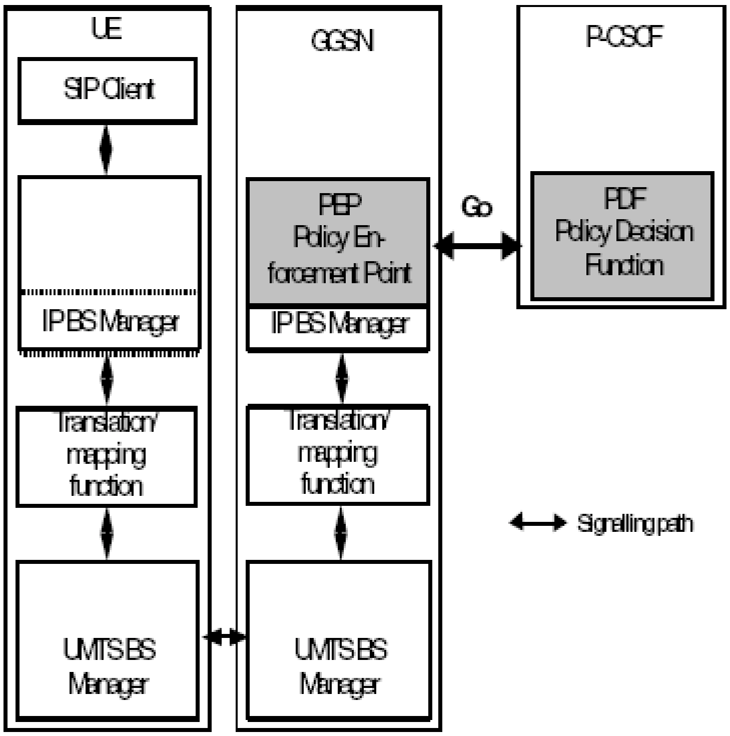


Figure: Go interface architecture model

IP VERSION FOR IMS

3GPP has selected IPv6 as the IP version supported by the IMS in order to benefit from the advantages of IPv6. In contrast, in 3GPP2 the question whether only IPv6 is supported by the IMS has just been settled, and IPv4 is allowed. Several parties support IPv6 only for the same reasons IPv6 was chosen for the IMS in 3GPP. However, wide deployment of IPv4 3GPP2 networks can be seen as an obstacle to an IPv6-only IMS solution, since operators are interested in reusing their investment in network architecture. Hence, for 3GPP2 networks IMS deployment over IPv4 and possibly MIPv4 needs to be studied.