Protocol Analysis for the 3G IP Multimedia Subsystem

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INTRODUCTION

In the past few years, the evolution of cellular networks has reflected the success and growth the Internet has experienced in the last decade. This leads to networks where IP connectivity is provided to mobile nodes. The result is third-generation (3G) networks where IP services such as voiceover IP (VoIP) and instant messaging (IM) are provided to mobile nodes (MNs) in addition to connectivity. IP multimedia subsystem (IMS) is a new framework, basically specified for mobile networks, for providing Internet protocol (IP) telecommunication services. It has been introduced by the Third-Generation Partnership Project (3GPP) in two phases (release 5 and release 6) for Universal Mobile Telecommunications System (UMTS) networks. 3GPP was born in 1998 as a collaboration agreement between a number of regional telecommunication standards bodies, known as *organizational partners.* The current 3GPP organizational partners are:

- ARIB (Association of Radio Industries and Business) in Japan,
- CCSA (China Communications Standards Associations) in China,
- ETSI (European Telecommunications Standards Institute) in Europe,
- Committee T1 in the United States of America
- TTA (Telecommunications Technology Association) of Korea, and
- TTC (Telecommunication Technology Committee) in Japan.

Besides the organizational partners, *market representation partners* (the UMTS Forum, 3G Americas, the IPv6 Forum, the Global Mobile Suppliers Association, etc.) provide the partnership with market requirements. 3GPP maintains an up-to-date Web site at http://www.3gpp.org.

3GPP working groups do not provide standards. Instead, they produce technical specifications (TSs) and technical reports (TRs). 3G PP Release 5 contains the first version of the IMS. 3GPP release 6 contains enhancements to the IMS. The Third Generation Partnership Project 2 (3GPP2) was born to evolve North American and Asian cellular networks based on ANSI/TIA/EIA-41 standards and CDMA2000 radio access into a third-generation system. An IP multimedia framework was later introduced by 3GPP2 as the Multimedia Domain (MMD) for third-generation Code Division Multiple Access 2000 (CDMA2000) networks, and finally harmonized with IMS. IMS aims to use Internet protocols. The 3GPP and 3GPP2 established collaboration with the IETF to make sure that the protocols developed there meet their requirements. In this article, we aim to discuss a few potential areas of the IMS that could be improved to provide better quality of service (QoS).

BACKGROUND

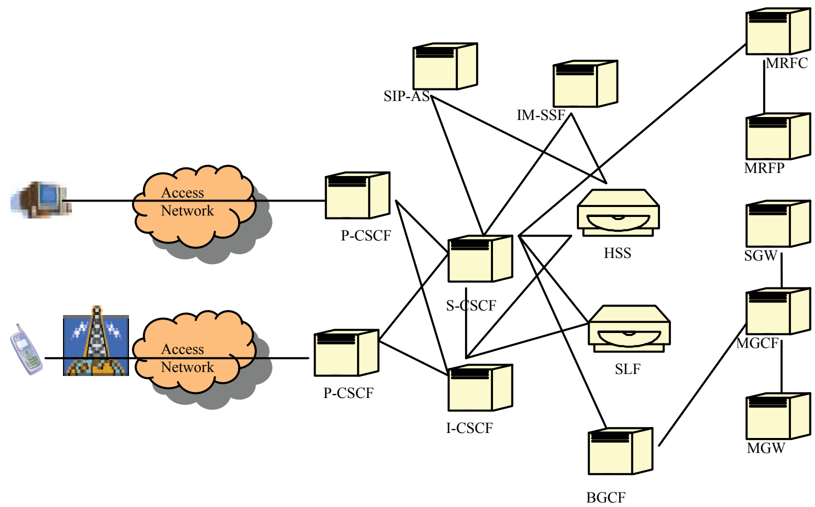
The IMS is the technology that will merge the Internet (packet switching) with the cellular world (circuit switching). It will make Internet technologies, such as the Web, e-mail, instant messaging, presence, and videoconferencing- available nearly everywhere.

In brief the IMS concept was introduced to address the following network and user requirements:

- Deliver person-to-person, real-time, IP-based multimedia communications (e.g., voice or video-telephony) as well as person-to-machine communications (e.g., gaming service).
- Fully integrate real-time with non-real-time multimedia communications (e.g., live streaming and chat).
- Enable different services and applications to interact (e.g., combined use of presence and instant messaging).
- Easy user setup of multiple services in a single session or multiple simultaneous synchronized sessions.

Figure 1 depicts an overview of the IMS architecture. The definitions and functions of the common nodes included in the IMS are furnished in the Key Terms section. There are plenty of ways to improve the existing infrastructure and protocols in the IMS. Previously, the performance of the critical protocol SIP (Session Initiation Protocol, Rosenberg et al., 2002) in an IMS environment had never been evaluated. The signaling overhead reaches its peak when a massive number of IMS terminals joins the network at the same time. The minimal discovery time of different CSCFs are crucial for system performance.

Figure 1. 3GPP IMS architecture overview



Session Establishment Scenario for a Mobile Terminal

Every mobile node must register with the visited network in IMS. Re-registration takes place once the timeout occurs. The SIP INVITE request is sent from the UE (user equipment) to S-CSCF#1 (serving call session control function) by the procedures of the originating flow to initiate a session between two nodes. This message may contain the initial media description in the SDP (session description protocol). S-CSCF#1 performs an analysis and passes the request to I-CSCF#1 (interrogating CSCF) and so on. Thus the intermediate nodes analyze and forward the request to the next node until it reaches the destination node. The detail of IMS SIP session set up procedures with MIPv6 can be found in Technical Specification 23.228 of IP Multimedia Subsystems.

If a mobile terminal moves away from its current visited network, it needs to send a binding update (BU) message to the corresponding node. It may move away during the session set up. The issue of sending the BU to achieve better mobility management needs to be addressed thoroughly.

In the existing scenario, the mobile node sends the BU to the corresponding node after the session is set up. This implies that traffic will be routed through the HA (home agent) before being routed directly to the MN (mobile node), even if for a limited amount of time. This can have implications on quality of service, since quality of service (QoS) is initially established only for the route from the MN to the HA and to the CN (correspondent node), whereas QoS for the optimized route is not established.

Presence Service in the IMS

Presence is one of the basic services that is likely to become omnipresent in IMS. It is the service that allows a user to be informed about the reachability, availability, and willingness of communication of another user.

The presence framework defines various roles as shown in Figure 2. The person who is providing presence information to the presence service is called a presence entity, or for short a presentity. In the figure, Alice plays the role of a presentity. The presentity is supplying presence information such as status, capabilities, communication address, and so forth. A given presentity has several devices known as presence user agents (PUAs) which provide information about her presence. All PUAs send their pieces of information to a presence agent (PA). A presence agent can be an integral part of a presence server (PS). A PS is a functional entity that acts as either a PA or as a proxy server for SUBSCRIBE requests. Figure 3 also shows two watchers: Bob and Cynthia. A watcher is an entity that requests (from the PA) presence information about a presentity or watcher information about his/her watchers. A subscribed watcher asks to be notified about future changes in the presentity's presence information, so that the subscribed watcher has an updated view of the presentity's presence information.

3GPP defined in 3GPP TS 23.141 provides the architecture to support the presence service in the IMS. The architecture indicates that the flow of messages will be massive for a large amount of publishers and watchers joining an IMS system.

P-CSCF Discovery

P-CSCF discovery is the procedure by which an IMS terminal obtains the IP address of a P-CSCF. This is the P-CSCF that acts as an outbound/inbound SIP proxy server toward the IMS terminal (i.e., all the SIP signaling sent by or destined for the IMS terminal traverses the P-CSCF). P-CSCF discovery may take place in two different ways: