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# Efficient Resource Management Method for IMS Services in Hybrid Wireless Networks

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***Abstract***

*This paper proposes an efficient resource management method for the IMS (IP Multimedia Subsystem) related mobile network services. Mobile wireless services associated with the IMS include multimedia telephony (MT), instant messaging (IM) and full browsing. To access those services the subscriber should register on the related system of the mobile wireless network. Even when the usage frequency is low for many cases, resources such as the session and the database are occupied by them. Those usage patterns could incur the overinvestment in the system build-up. Also it gets more important to manage the IMS related resource management especially in the next generation mobile network services. In this paper a cost effective IMS management method is proposed which is necessary for planning the network evolution. To reach an ultimate goal of the All-IP network, it is inevitable to have a transient period including both the circuit and the packet based data network. At the stage of those hybrid networks, it is required to establish them in an efficient manner in terms of resource usage which is deeply related with the TCO (Total Cost Ownership). The multimedia telephony is one of the essential services in the advanced packet based mobile networks. In this paper a cost effective resource management method is proposed for deploying the multimedia telephony service while the legacy network co-exists. Simulation results show that main system elements required for the multimedia telephony and the instant messaging services can be scaled down while maintaining compatible quality of service level.*

***Keywords:*** *Wireless multimedia service, IMS, resource management, mobile network*

## 1. Introduction

Mobile networks are being advanced and expanded to accommodate explosively increasing amount of data traffic. Major portions of the total traffic are being occupied by multimedia services due to the advancement of mobile devices and rapid increase of user expectation of the quality of mobile services. Mobile devices such as smart phone, tablet and laptop PC are already penetrated into almost everyone's daily life and now able to support various types of multimedia functions. This is possible due to the integration of various top-notch technologies into the mobile equipment which include advanced data processing and transmission unit, high-quality camera, high precision display and high capacity data storages. The increased

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bandwidth and versatile mobile terminals in turn attracts interests in new services from both service providers and end users sides. Various kinds of mobile wireless services are implemented in the IMS data network based on the IP (Internet Protocol). One of the main services is the Multimedia Telephony. In the process of the network evolution, the voice service has been provided in many cases through the separate channel by the carrier. This is because the operator launched the voice first and later the data networks were implemented by the mobile network providers. Therefore, it is possible to provide voice services via separate legacy networks. For example, in the series of the 3GPP2 network evolution, the voice is serviced by the CDMA 2000 network [1]. Many experts predict the next mobile wireless network migration paths merge to the 4G network including the LTE (Long Term Evolution) and finally into an All-IP network [2]. At that time, the voice service is also expected to be provided by the data network or VoIP. This paper focuses on the pre All-IP network since there might be relatively long interim period before the implementation of the ultimate goal. The proposed scheme is discussed assuming the 3GPP2 series networks evolved to EV-DO data network. However, it is possible to extend the application of the proposed method to other cases including 3GPP series networks which co-exist with other legacy network. This paper also discusses the related issues of present mobile networks which are in the fast changing evolution path and provides operators with the analysis and solutions of those issues. This will help them make an optimized decision in terms of technology, service level, and/or total cost ownership [3].

## 2. IMS Platform for Convergence Network

The overall IMS architecture for the MT service is shown in Figure 1 [4]. Some of the major blocks for subsystems implementing MT include the HSS (Home Subscriber Server) and the CSCF. A CSCF (Call Session Control Function) is one of standardized systems on the IMS that implements VoIP service based on the SIP. All the elements of the IMS with the brief functional descriptions are shown in Table 1 [5].

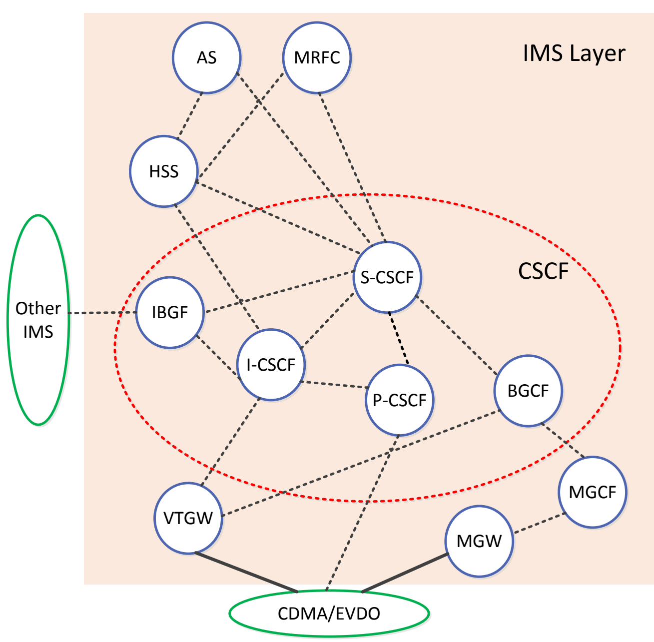


**Figure 1. IMS network elements in the MT service [TS23.228, 3GPP]**

**Table 1. Function of elements in the IMS [TS23.002, 3GPP]**

| Element | Full Name |
|---|---|
| S-CSCF | Serving Call Session Control Function |
| I-CSCF | Interrogating Call Session Control Function |
| IBCF | Interconnection Border Control Function |
| BGCF | Breakout Gateway Control Function |
| P-CSCF | Proxy Call Session Control Function |
| AS | Application Server |
| HSS | Home Subscriber Server |
| MRFC | Multimedia Resource Function Controller |
| VTGW | Video Telephony Gateway |
| MGW | Media Gateway |
| MGCF | Media Gateway Control Function |

# 3. Proposed Architecture for Efficient IMS Services

## 3.1. Resource management for the inactive user

To provide the MT service, a device should be registered by powering-on or connecting to the network. Even when subscribers do not use the MT service, resources are occupied which makes the efficiency level decrease. More specifically resources of the systems such as the HSS, CSCF, PDSN (Packet Data Serving Node), AAA (Authentication, Authorization, Accounting) and PCF (Packet Control Function) are being occupied [6]. This situation might lead to unnecessary investment for network capacity expansion. This problem is not only restricted to the MT but also associated with the IMS service such as the IM and full browsing. In the proposed scheme usage patterns of subscribers for the multimedia services are monitored. If the subscriber rarely uses the service within the monitoring window period, related systems delete the information of the corresponding subscriber. The proposed method can help the network handle the more subscribers with less system capacity.

The detailed signal flow for the proposed scheme can be described as follows. The HSS has the database storing the data associated with the last date of the service access. The CSCF is the call processing system in the IMS. Let us first take a look into the active state of the device. In the case of powering the device on or connecting to the network, a session of the device is connected by the PDSN. For checking the MT service usage, the CSCF periodically confirm the last date of usage associated with identifier (ID) of the device. This ID is unique for different user devices such as telephone number or serial number. If the last date is passed, the HSS deletes the device ID in the database and the CSCF takes controls on deleting the session related with the device ID. This last date includes not only the current date but also the specific time. I-CSCF and S-CSCF are checking the usage period of a device by interworking with the HSS. In the case of passing a designated time of the device ID, the CSCF sends a deleting SAR message to the HSS. Upon receipt of the message, the HSS responds with SAA to the CSCF. At that time, the HSS deletes a device ID in the database. Upon receiving the response message, the CSCF sends a session deleting message to the related UE (User Equipment). The UE responds with confirmation message to the CSCF. Also the UE sends a session deleting message to the PCF. After receiving a session deleting message from the UE, the PCF sends a received that message to the PDSN. At the final stage the PDSN deletes the UE session [7]. Secondly, let us consider a dormant mode of the device. If the device becomes that mode, the wireless resource is disconnected but keeping a data in the PDSN and HSS for reconnecting the session fast. In the end, that mode is the same status as the active mode. Therefore the same method above mentioned is applied. The overall signaling flow is summarized in Figure 2 which describes the step by step procedure for deleting the inactive MT subscriber.

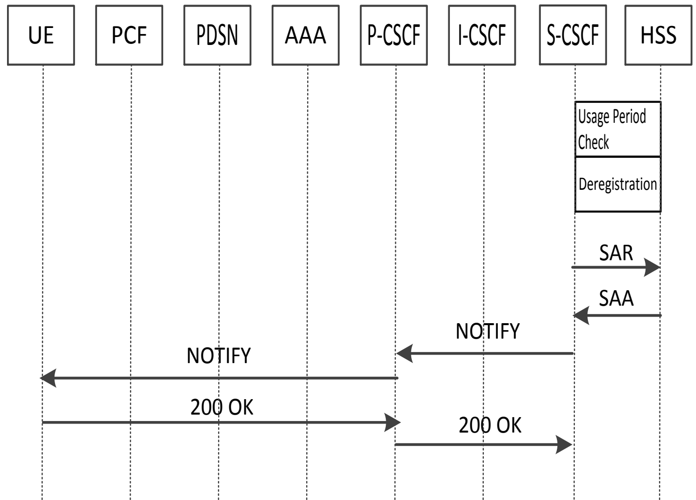


**Figure 2. Flow chart of the deleting procedure for the infrequent MT subscriber**

### 3.2. Efficient activation method for the deleted user

Although the information is deleted for infrequent users the proposed method still provides the way to handle the incoming call to them. If a multimedia call which has no information in the system is generated, a request message is sent to HSS. The HSS sends the registration message to the UE. The UE processes the registration and it also registers to the CSCF. The BSD (Billing Subdivision Device) has a function of analyzing data packets and the PCF is a policy control function system [8]. The block diagram for the multimedia data service subsystems are shown in Figure 3.

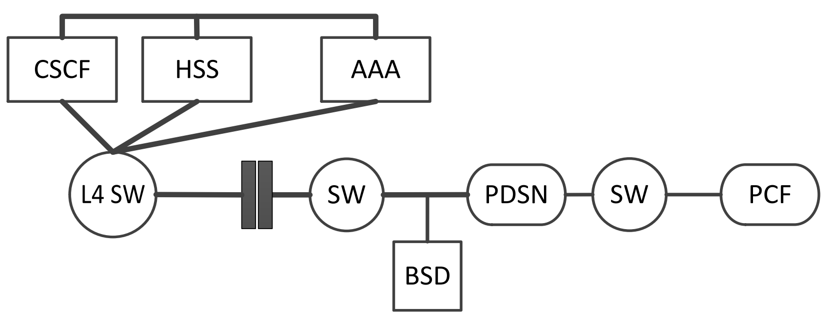


**Figure 3. Mobile wireless data network**

As mentioned above, this deleting information of the subscriber could cause a MT call unsuccessful. For a normal call processing, the information has to register in the HSS, CSCF, PCF, PDSN and AAA. Let us consider two kinds of cases which are the originating call and the termination call. First of all, for the originating MT call, there is no need to mention it because that call will be processed by the standard of the IMS. Secondly, for the purpose of terminating a MT call to a deleting subscriber, the subscriber information has to register in the

HSS, CSCF, PCF, PDSN and AAA. This means that the information needs to be registered for one time at the first incoming call. If the invitation message comes to the MT call through a VTGW (VT Gateway), AS (Application Server) sends a LIR message to the HSS and the MT service is registered [9]. After that the HSS sends a Registration Request message to a device. The device which received message processes the session registration. Completing the session registration up to the HSS, the HSS sends the LIA message to the CFS-AS. Finally, a normal call processing is done. In Figure 4 a part of the call flow is shown for the first incoming MT call [10]. Here various messages are communicated between the HSS and the CSCF. More detailed description of those commands shown in the figure is summarized in Table 2 [1].

**Table 2. Function of commands in the IMS**

| Command | Full Name | Function |
|---|---|---|
| UAR<br>UAA | User-Authorization-Request<br>User-Authorization-Answer | SIP registration/deregistration |
| SAR<br>SAA | Server-Assignment-Request<br>Server-Assignment-Answer | Update the S-CSCF name<br>and download the user profile data |
| LIR<br>LIA | Location-Info-Request<br>Location-Info-Answer | SIP session set-up and transactions |
| MAR<br>MAA | Registration-Termination-Request<br>Registration-Termination-Answer | Exchange information to support the authentication |

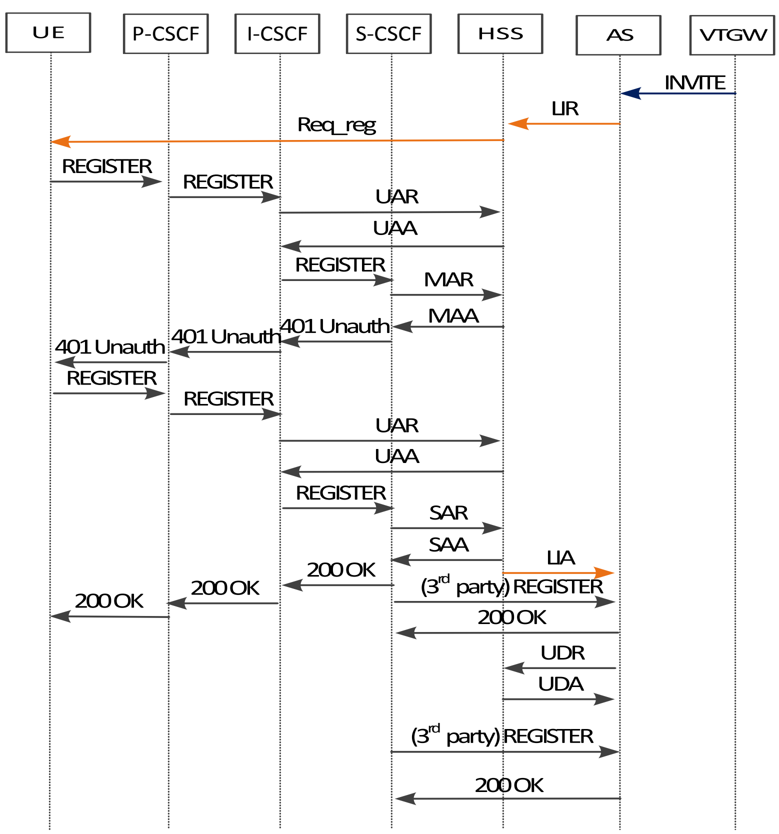


**Figure 4. Flow chart of the first incoming MT call**

## 4. Simulation Results

It is possible to manage a resource efficiently by deleting the information and the session for infrequent users among registered subscribers for MT services. In Figure 5 occupied resources are compared for the MT and IM cases applied to inactive subscriber for monthly basis. Results show that the proposed architecture could decrease the resource occupancy rate up to 24% and 4% for MT and IM, respectively.

Another simulation is done to assess the effectiveness of the proposed method. In this another simulation, the conventional and the proposed methods are compared based on planned investment costs to deploy the target service. The number of subscribers is assumed to grow from 8 million to 10 million and the capable device rate is 25%. Also the usage rate of the service is assumed 39% of maximum capacity which is equivalent to 0.8M for HSS, 2M for AAA, 0.5M for PDSN, 0.6M for CSCF and 0.5M for BSD. Here the operation rate is assumed to be in the range of 60~90% which varies depending on the subsystem. Quantitative results are summarized in Figure 6 which shows almost $29M cost savings with the proposed scheme. Although the reduction effect in absolute number might be varied for different subsystem price assumption due to price variations of system manufacturer, we expect similar results in the relative effect for each subsystem. In our simulation parameters are chosen to reflect the recent trend of mobile service networks. One thing that should be monitored is the first call delay associated with the subscriber who has been deleted from the system database. Laboratory tests show that it may take 2 to 7 seconds for the first terminated call while about one second delay for the first originated call. This effect should be considered when the proposed method is built up in the network as a trade-off between investment cost and the subscribers expectation on the service quality [11].

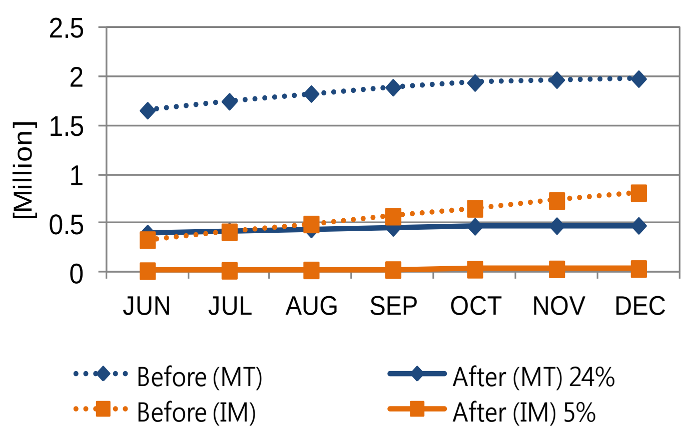


**Figure 5. Comparison of required resources for the proposed architecture**

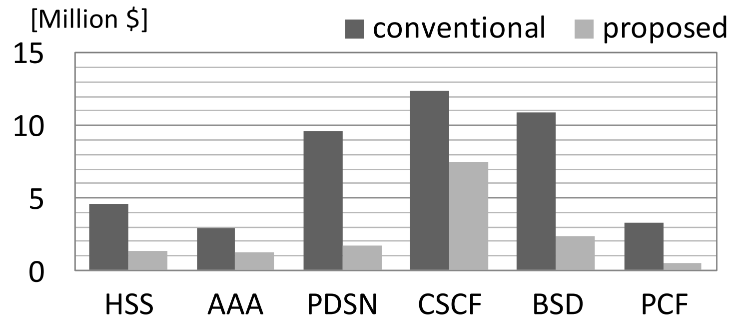


**Figure 6. Cost comparison with proposed and conventional method for each subsystem**

## 4. Conclusion

The uninterrupted service at anytime and anyplace is an essential requirement for mobile communication networks to accommodate various types of needs of mobile users. The IMS is one of the important network platforms to realize those requirements. This paper addresses some of key points for mobile carriers to consider when they deploy mobile networks which handle multimedia data traffics. We also discuss some trade-offs between mobile user experiences and cost-effectiveness of the network build-up for the proposed scheme. Finally a cost effective method is proposed for building up the multimedia telephony service. This scheme is especially effective in the transient stage where usage pattern of the subscriber are varied. In this scheme a detailed procedure is provided as a guideline for deleting dormant equipment database information. Also provided is the multimedia call process for those subscribers. From the operator's point of view this method helps them make gradual on-demand based investment on the new mobile services. Simulation results show that core building blocks required for the multimedia telephony service and instant messaging can be scaled down while maintaining compatible quality of service level. This includes some delay issues of initial call associated with the deletion of inactive users and the registration of initial call which requires some optimizations considering the trade-offs mentioned above. The proposed scheme is expected to be an effective solution for 3rd generation mobile systems which require further developments of interworking between IMS service equipments and new services. This scheme is still viable solution for the evolution periods towards more advanced 4th generation systems such as LTE and/or WiMax where VoIP in the IMS is the dominant service. The simulation result shows that the proposed method is a promising interim solution although further research is needed to satisfy the mobile users' needs and to minimize the power consumption which is expected to eventually realize the green systems and to increase the degree of effectiveness of network resource management.

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