Resource Management over Interworking of 3G and Digital Broadcasting Networks

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Abstract
A resource management (RM) framework is proposed for the efficient delivery of the mobile multimedia-on-demand services in a Beyond 3G (B3G) environment where the enhanced version of the third generation mobile terrestrial network for multicast and broadcast multimedia service (MBMS), and the digital video broadcasting transmission system for handheld terminals (DVB-H) work together cooperatively and complementarily. Their inherent “one-to-many” transmission capabilities are exploited to stream multimedia services to a group of users. Furthermore, network selection and qualities of service (QoS) adaptation are developed to allocate radio resources adaptively to network conditions and users’ personalities to benefit overall utility of the system and loss probability. Simulation results confirm the benefit of the proposed RM framework.

Keywords
Resource management, multimedia, multicast, interworking, QoS

1. Introduction
A recent effort of infrastructure enhancement is towards B3G [1]. These concepts envision a heterogeneous network infrastructure comprising different wireless access systems, which is believed to achieve more efficient service provisioning. In addition, multicast transmission is attracting attentions from mobile networks operators because it is an efficient way to deliver high bit rate services over bandwidth-limited system by sending one copy of data to a group of users. In this context, the interworking of MBMS [2] and DVB-H [3] is the research target in our study, due to their inherent multicast transmission capabilities. This paper proposes a RM framework over the interworking of MBMS and DVB-H, to provide mobile multimedia on-demand services. Considering that the multimedia transmission is asymmetrical and the big resource bottleneck is on the wireless part, we focus on the wireless downlink. This paper is structured as follows. In Section 2, the RM framework is introduced. The results from simulation are then presented in Section 3. Section 4 concludes the paper and suggests the directions for future work.
2. Resource Management Framework

We assume that the multimedia source traffic has a multi-level and discrete bit rate, each corresponding to a different QoS requirement. The proposed RM framework is presented in Figure 1. It is applied to both of MBMS and DVB-H networks.

This framework comprises three functions: service scheduling (SS), network selection (NS) and QoS adaptation (QoSA). The arrival of a request for a new service triggers the RM. First of all, requests stay in the system for a period that is determined by SS. When time is up, NS is triggered and cooperates with QoSA in order to provide the service with the best QoS desired by users. The interaction between SS and NS will happen again if no QoS supportable in either of networks. The request then goes back to the system until either it is served or reneges due to the long delay of the service display. All the functions involved are explained in detail below.

The objective of SS is to accommodate as many users as possible in one multicast channel by postponing the service display for a batching duration. The SS works based on following rules:

- Requests for different contents are batched in separate batching queues.
- Requests for the same content are batched in the same queue and are forced to wait for a specific batching duration.
- Timer is set upon the arrival of the first request and timer is expired when there is a request reneging from the batching queue.

QoSA chooses the best QoS level (of all the discrete levels supported by the specific application) that is not only supportable by the network but also acceptable by the users. NS decides the access network when both networks can support the service with the same QoS. This is done by comparing the “profit quotes” given by each network and the network that provides the highest “profit quote” is chosen. The profit quote of the service s with a particular QoS level over the service area R has been derived and is given as follows.
\[
\text{profit}_i = \sum_{s=1}^{N} \frac{n_{i,s}}{L_{s,i} \cdot R} \quad (L_{s,i} = \sum_{i=1}^{N} \frac{r_{i,s} \cdot c_{i,s}}{f_{i}})
\]  

where, \( N \) is the number of cells covered by service area \( R \); \( n_{i,s} \) is the number of interested users in the service \( s \) in cell \( i \); \( L_{s,i} \) is the load indicator corresponding to a particular QoS level of service \( s \) in cell \( i \); \( r_{i,s} \) is the required resource corresponding to a particular QoS level of service \( s \) in cell \( i \); \( c_i \) is the available resource in cell \( i \); \( f_{i} \) is the assigned frequency bandwidth in cell \( i \). Note that, different networks user different unit in resource, i.e., power in MBMS and throughput in DVB-H. In addition, MBMS does not use the fast power control as in UMTS. Instead, the proportion of the available Node B power allocated to a particular service will essentially be fixed to cover certain coverage.

3. Simulation Model and Results

To evaluate the performance of the proposed RM framework, the simulation has been performed in OPNET. In the simulation, MBMS with 7 cells and DVB-H with one cell overlap covering one service area \( R \). Two services are modeled with exponentially distributed duration. Requests for each service are generated with Poisson distribution. A fluid flow mobility model is adopted [4]. The reneging model in [5] is adopted. After waiting an amount of time given by the waiting threshold, the user’s remaining time until departure is given by an exponential distribution with a mean waiting time. Two performance measures are evaluated:

- Overall utility: the utility is the degree of user satisfaction with service quality, given by a concave function with the service bit rate received [6].
- Overall loss probability: it is the percentage of users who renege before service display and are dropped during horizontal handover over the total users.

Table 1: Simulation parameters

<table>
<thead>
<tr>
<th>Simulation Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>s1 request arrival rate</td>
<td>30 requests/hour/cell</td>
</tr>
<tr>
<td>s2 request arrival rate</td>
<td>210 requests/hour/cell</td>
</tr>
<tr>
<td>s1 mean duration</td>
<td>10 minutes</td>
</tr>
<tr>
<td>s2 mean duration</td>
<td>10 minutes</td>
</tr>
<tr>
<td>s1 QoS range acceptable by users</td>
<td>128,64,32 kbps</td>
</tr>
<tr>
<td>s2 QoS range acceptable by users</td>
<td>384,256,128,64,32 kbps</td>
</tr>
<tr>
<td>s1 operator</td>
<td>MBMS</td>
</tr>
<tr>
<td>s2 operator</td>
<td>DVB-H</td>
</tr>
<tr>
<td>MBMS cell radius</td>
<td>1400m</td>
</tr>
<tr>
<td>BS total transmit power</td>
<td>20W</td>
</tr>
<tr>
<td>Mobility speed</td>
<td>3 km/hour</td>
</tr>
<tr>
<td>Waiting threshold</td>
<td>2 minutes</td>
</tr>
<tr>
<td>Available resource in MBMS</td>
<td>18W</td>
</tr>
<tr>
<td>Available resource in DVB-H</td>
<td>2Mbps</td>
</tr>
<tr>
<td>Mean waiting time</td>
<td>Variable</td>
</tr>
</tbody>
</table>

We show in Figure 2 and Figure 3 performances with the variable mean waiting
time. To evaluate the efficiency of our RM including functions of SS, NS and QoSA, three combinations of them have been compared to the case without RM.

![Figure 2: Overall utility](image1)

![Figure 3: Overall loss probability](image2)

The benefits of our RM can be seen in overall utility and overall loss probability. However, considering that there is no delay suffered for the service display in the case of without RM, it comes to the conclusion that the benefit of our RM is achieved at the price of the service display delay that nevertheless could not become a big suffering if we utilize user’s patience on waiting.

4. Conclusions
This paper presented a resource management framework that enables the efficient provisioning of multimedia on-demand services over the interworking of MBMS and DVB-H. The results from simulation confirm the benefits of this framework. The issue to be considered further is the impact of the signaling loads required by this framework for the information exchange between users and system as well as within network entities. The frequent information exchange could reduce the efficiency of our framework. This will be left for the future study.

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REFERENCES