Caching method using User’s Context based on Grouping for Enterprise and Urban Small Cell Environments

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Abstract—In this paper, we propose a caching method using grouping based on user’s context in an enterprise/urban small cell environment. In our method, we classify users into several user groups based on user’s contexts. After that, an edge server updates a cache storage size in proportion to the amount of the offered cache data to each group. As a performance metric, we use a cache efficiency that represents the ratio of traffic decreased by cache to total traffic. The results of performance analysis show that the proposed method can reduce data traffic toward core networks more than the existing method in the enterprise/urban small cell environment.

Keywords—Cache; small cell; user-context;

I. INTRODUCTION
In recent years, the proliferation of smart phones and various smart devices, mobile data traffic is increasing rapidly. One of solutions for exploding mobile data traffic is deployments of small cells. Many telecommunications companies in the world are studying on small cells as a solution for exploding mobile data traffic[1]. Deployments of small cells have benefits of cell coverage extension and improvement of efficiency for frequency but core networks should have capability to accommodate mobile data traffic. Thus, it is important to reduce data traffic to core networks for the accommodation of rapidly increasing mobile data traffic.

It is reported that to cache in a small cell base station is one of the solutions to reduce mobile data traffic toward core networks. There are many studies about small cell caching. In a Shim’s paper, it proposed effective way to pre-fetch popular video contents in small cells[2]. ElBamby studied on content-aware user clustering and caching method in small cell networks[3]. In addition Jung proposed a local caching method under user’s context in small cell networks that pre-fetch suitable files using regional characteristics and user’s personalities[4]. However, Shim and ElBamby considered effective methods to bring popularity contents closely to users without considering user’s contexts and Jung assumed that users in a single small cell (i.e., home small cell environment). Thus there is a limitation to apply their method to large coverage small cells which serve various users (i.e., enterprise/urban small cell environments). Therefore, we propose a caching method based on various user’s contexts in enterprise/urban small cell environments using a concept of mobile edge computing that can control base stations.

II. PROPOSED METHOD
Fig 1 shows the reference network architecture. Each small cell base stations is connected to edge server. The edge server has a data storage to pre-fetch popular contents based on user’s contexts.

The proposed method consists of three phases as follows. First, a user grouping phase is to classify users into several groups based on users’ personalities. Users can select their own group or the edge server can select users’ group using analysis of users’ data traffic logs. Second is a storage allocation. In this phase, edge server allocates the storage for each group with same size. In the allocated storage, popular contents for each groups are pre-fetched. The final one is a storage and contents update phase. It is important to reallocate data storage for each group with different size because the amount of the offered cache data to each group is different. Cache data are contents in each cache storage. It is assume that there are two groups; A and B. If the amount of the offered cache data to group A is smaller than that of group B, the edge server reallocates the smaller cache storage to group A than group B, which makes the core network more efficient. In every time period \( t \), the edge server measures the amount of the offered cache data traffic of user groups.

\[
T_{\text{cache, tot}}(G, t) = N_{\text{G}} \times S_{\text{G}}(t) \times f \times P_{\text{hit}}(t),
\]

where \( N_{\text{G}} \), \( S_{\text{G}}(t) \), \( f \), and \( P_{\text{hit}}(t) \) denote the number of users...
in a group $G_i$, average number of requests, file size and average hit ratio.

### III. PERFORMANCE ANALYSIS

For performance analysis of proposed method, we collected real-time popular keywords for 3 days. Keywords are classified by target groups and provided by Naver portal service. Table 1 shows the simulation parameters [4]. It is assumed that there are 4 user groups. Each group has different number of users and makes different traffic volume. Target groups are single men, single women, university students, office workers. For the performance comparison, we considered the existing method in [4]. The existing caching method pre-fetches popular contents in small cells based on user’s contexts without changing the storage size. Also the existing method assumed that users associated with a same small cell have a same personality and cache storage is equipped in the edge server.

As a performance metric, we use a cache efficiency. It can be expressed as follows [4].

$$\text{Cache Efficiency} = \frac{T_{\text{total}} - (T_{\text{total}} + T_{\text{eff}})}{T_{\text{total}}} \times 100(\%)$$

where $T_{\text{total}}$, $T_{\text{total}}$, and $T_{\text{eff}}$ donate the amount of total data traffic occurred during simulations, the amount of data traffic for pre-fetching contents, and the amount of data traffic occurred during simulations due to cache miss.

Fig 2 shows that the average hit ratio for 2 methods, $G_i$, shows higher hit ratio than the existing method. On the other hand, the hit ratio of $G_i$ and $G_j$ is lower than that of the existing method. That is due to the change of storage size. The amount of the offered cache data traffic of $G_i$ is more than that of other groups. Thus, the cache storage size of $G_i$ is larger and hit ratio of $G_i$ is higher than other groups. In terms of average hit ratio, the proposed method has lower hit ratio than the existing method. However, as shown in Fig 3, in terms of average cache efficiency, the proposed method shows more efficient result. The existing method assumed that users associated with a same small cell ha-

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of small cells</td>
<td>Enterprise/Urban small cells</td>
</tr>
<tr>
<td>Number of small cells</td>
<td>4</td>
</tr>
<tr>
<td>Number of user’s groups</td>
<td>4</td>
</tr>
<tr>
<td>Number of users in each group</td>
<td>$G_1: 50, G_2: 30, G_3: 20, G_4: 20$</td>
</tr>
<tr>
<td>Size of Contents</td>
<td>7.8 MB</td>
</tr>
<tr>
<td>Probability to search a keyword</td>
<td>$1-10$ ranked keywords: 56.64% $11-100$ ranked keywords: 43.36%</td>
</tr>
<tr>
<td>Average number of requests of each users</td>
<td>10.8</td>
</tr>
<tr>
<td>Update cycle</td>
<td>1 hour</td>
</tr>
<tr>
<td>Total cache storage size</td>
<td>400 MB</td>
</tr>
</tbody>
</table>

![Fig. 2. Average hit ratio](image)

![Fig. 3. Cache efficiency](image)

### IV. CONCLUSION

We proposed a caching method based on user’s contexts in enterprise/urban small cell environments. We reflect users’ context mentioned in [4], however contrary to existing method, we make user groups using user’s contexts and change a cache storage size using offered data traffic through cache storage. The simulation results show that the proposed method can improve the performance by about 3% compared to the existing method. Also by grouping users, it can be applied to various small cell environments to reduce data traffic to core networks.

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### REFERENCES


