Self-Networking and Replaceable Structure for Ubiquitous Multimedia Contents

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Abstract

In this paper, we propose a novel technique for the ubiquitous multimedia which is self-networking and replaceable structure. As the content in the ubiquitous multimedia should be realistic and continuously updated in the real-time manner, an efficient scheme of a self-networking and replaceable structure is necessary. In the proposed method, the content itself connects to the server or corresponding devices and updates itself autonomously. Also, we can reduce the total amount of data transmission comparing to the cases where the whole content should be downloaded. A Markov chain model is introduced for the proposed structure in order to perform the throughput analysis. The whole mechanism is implemented in the wireless handset and also, various applications of the scheme are discussed.

1. Introduction

Various technologies are being developed toward the concept of ubiquitous computing [1]. For the services in the ubiquitous network, there also need various contents. Recently, many researches have been performed for the ubiquitous multimedia content [2]–[6], which should provide user-specific, context-aware, real-time, interactive information to the user.

Basically, ubiquitous multimedia content focuses on the technologies based on the virtual reality, context-awareness based service or the multimedia streaming technologies for the ubiquitous network.

Different from these, in this paper, we propose an effective *self-networking and replaceable structure* to provide real-time information to the user and save the bandwidth of the network. Based on the proposed concept, the content itself connects to the server or other digital devices in the ubiquitous network and updates itself autonomously according to the predefined user context. Usually, the content is static, and cannot be changed after downloading. However, in the ubiquitous network, the content must be dynamic, real-time, and can be updated autonomously to provide user-centric and context-aware information.

Using the proposed scheme, we can provide real-time, user-specific and context-aware information to the user. Also, the network bandwidth can be saved since there is no need to download the whole amount of content. The gain of the proposed method over the conventional schemes is analyzed based on the Markov chain model [7].

Since wireless handset is one of the possible candidate for ubiquitous device, we design and implement these functions in wireless handset with mobile vector graphics solution [8]–[10]. Combined with the portability and mobility of the wireless handset, numerous ubiquitous multimedia applications can be developed by the self-networking functions.

The remaining part of this paper is organized as follows. In Section 2, the basic concept of the proposed method is introduced. In Section 3, the design and implementation of the proposed method are presented using mobile vector graphics in wireless handset. In Section 4, the throughput analysis of the proposed structure is given based on the Markov chain. In Section 5, services using the proposed method are discussed and the conclusion follows in Section 6.

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2. Concept of Self-networking and Replaceable Structure for Ubiquitous Multimedia

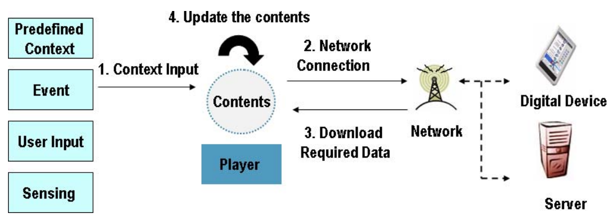


Figure 1. Self-networking and Replaceable Structure for Ubiquitous Multimedia

Fig. 1 shows the basic concept of self-networking and replaceable structure for ubiquitous multimedia. Based on the analysis of user context, the content itself connects to the network, downloads some required data and updates itself. The sequence can be summarized as follows :

1. Analyze user context and send the input to the content
2. Connect to the specified server or device.
3. Download the required data.
4. Update the content.

We can provide the real-time and context-aware information to the user using the proposed method. Also, the network bandwidth can be saved since there is no need to download the whole materials.

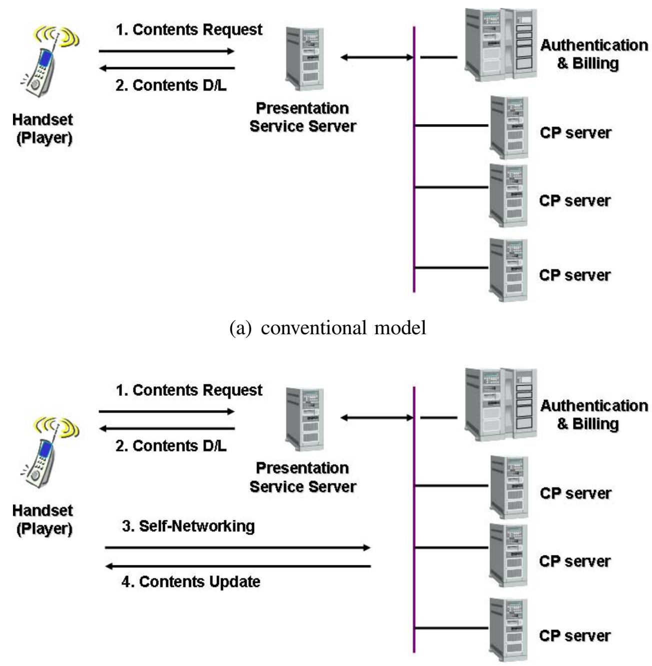
As an illustrative design, we implement the proposed concept in wireless handset with mobile vector graphics. Fig. 2 shows the differences of the service models between conventional methods and the proposed method.

3 Design and Implementation of Self-networking and Replaceable Structure in Wireless Handset

3.1 Overview

We design and implement the proposed concept in wireless handset. We use the CDMA 1x-EVDO network and CDMA handset. Also, for the service, we implement the self-networking and replaceable structure with mobile vector graphics solution VIS which is developed by NeoMtel, Korea [8]–[10].

The conventional multimedia content cannot be modified once downloaded. In contrast, the self-networking and replaceable structure functions can overcome this problem.



(a) conventional model

(b) Service model using proposed method

Figure 2. Service models

The user needs to download only the modified part of the content and consequently the waste of bandwidth is prevented. By combined with the RTOS in the handset, numerous kinds of applications can be developed.

3.2 Implementation of the proposed method in Wireless Handset

The self-networking function means that using the network information in content, the content or player connects to the server or device.

In order to request the data from server and download it, some script functions are implemented such as **loadVariables**(), **importImage**(), **importSound**() and **importMovie**(). Table 1.(a) shows the explanations for the action scripts corresponding to content request. For event handling such as key pressing or timer handling, some scripts as in Table 1.(b) are implemented. These action scripts need to connect to the context analysis.

Once the script function runs, the VIS player connects to the server and requests data. In downloading data, the progress of VIS content is holding and the player should notify the user of the downloading status. In case of failure, failure notice should be sent to the user after the transmission of data. In case of success, the operation related to the data are processed. Usually, the data request is done by VIS

Table 1. Action Scripts

(a) Action scripts examples for the content request

Action Script	Explanation
loadVariable (url,target)	url : http://server.com/data/data.txt target : target path to a movie clip
importImage (url,resource)	url : http://server.com/image/image.txt resource : identifier of image resource
importSound (url,resource)	url : http://server.com/sound/sound.snd resource : identifier of sound resource
importMovie (url,resource)	url : http://server.com/vis/a.vis resource : identifier of VIS file

(b) Action scripts examples for event handling

Usage example : Pressing key "1"
on(keyPress "1"){ importMovie(http://server.com/vis/a.vis,"new movie"); }
Usage example : Timer function
function getData(){ importMovie(http://server.com/vis/a.vis,"new movie"); } setInterval(getData, 2000); //Execute setInterval() at every 2 seconds

player. But in the special case, such as **PUSH**, external data is downloaded without the request of VIS player. For example, in broadcasting, transmission of data from web site or data transmission using SMS, the request and download are done by **PUSH**. Also in **PUSH**, the downloaded data is included in VIS files using appropriate functions.

The downloaded data can be divided into two parts, control data and resource data. Using control data, VIS player can change the play of content. Mainly, the control data changes the values of script variables, which are scene variation in the display or value setting of the size and position. In case of resource data, it changes the resource in content such as text, sound, image or VIS file. For text, the news or SMS data can be displayed on the screen.

After the downloaded data is applied to the content, the current state is recorded in the handset. In replaying the content, the status information is considered and the changes by the network can be adopted. Fig. 3 shows the brief concept of component setting using **replaceResource()**.

4 Analysis of throughput improvement

Here, the throughput of the proposed technique is derived based on a Markov chain model. Assume that there

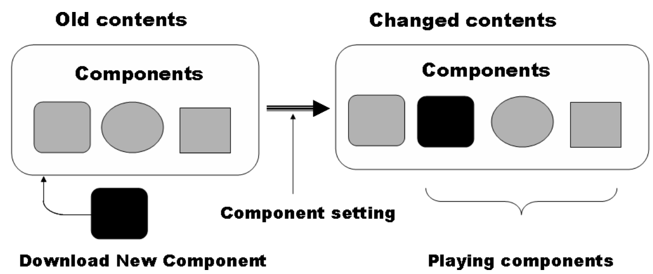


Figure 3. Playing component setting in content

are total of $N+1$ states and each i-th state has D_i amount of data to send where $i = 0, 1, \cdots, N$. Also, without loss of generality, for any given i and j with $i \leq j$, assume that $D_i \leq D_j$ and D_j includes D_i, i.e., the data in i-th state is included in that in j-th state. Note that the states of the self-networking and nested structure are discrete and further, the entire past history is summarized in the present state, which is referred to as the *memoryless* property [7]. Consequently, we adopt a continuous-time Markov chain (CTMC) in order to derive the throughput analysis.

Based on the CTMC model, the average data transferred for the conventional technique in VIS is as $T_0 = \sum_{j=0}^{N} \pi_j D_j$, where π_i denotes the steady-state probability of the i-th state.

Now consider the throughput of the proposed technique. At every transition from state i to state j, the proposed technique only transmit additional data in D_j, which is not included in D_i. Hence, the average transmitted data of the proposed technique is as follows:

$$\begin{aligned} T_{prop} &= \sum_{i=0}^{N}\sum_{j=0}^{N} P(X(t)=i) \quad (1)\\ &\quad \times P(X(t+1)=j \mid X(t)=i)[D_j - D_i]^+ \\ &= \sum_{j=0}^{N}\sum_{i=0}^{N} \pi_i P_{ij}[D_j - D_i]^+ \\ &= \sum_{j=0}^{N}\sum_{i=0,i<j}^{N} \pi_i P_{ij}(D_j - D_i), \end{aligned}$$

where $X(t)$ is the state of the system at time t, P_{ij} is the transition probability, i.e., $P_{ij} = P(X(t+1) = j \mid X(t) = i)$, and $[x]^+ = x$ if $x \geq 0$ and $[x]^+ = 0$ otherwise.

Here, we can easily show that $T_0 > T_{prop}$.

$$T_0 - T_{prop} = \sum_{j=0}^{N}\big(\pi_j D_j - \sum_{i=0,i<j}^{N} \pi_i P_{ij}(D_j - D_i)\big)$$

$$\geq \sum_{i=0}^{N} D_j \big[\pi_j - \sum_{i=0,i<j}^{N} \pi_i P_{ij}\big].$$

Note that

$$\pi_j = \sum_{i=0}^{N} \pi_i P_{ij} \geq \sum_{j=0,j<i}^{N} \pi_j P_{ji}.$$

Hence, we always have

$$T_0 \geq T_{prop}. \tag{2}$$

The throughput gain, i.e., $G_T := T_0 - T_{prop}$ depends on the transition probabilities P_{ij} and the amount of data D_i of each state. Actually, this is very intuitive since the proposed technique only transmits the additional data which is not included in the present state while the conventional method sends all the redundant data. To enhance the understanding of the throughput analysis, let us consider the following two cases of a birth-death process.

Example 1. As the first example, assume that the overall process in VIS is a birth-death process with $\pi_i = \frac{1}{N+1}$, $D_i = iD$, $i = 0, 1, \cdots, N$. Then, the following relation are obtained.

$$\begin{aligned} T_0 &= \sum_{i=0}^{N} \pi_i D_i = \frac{D}{N+1} \sum_{i=0}^{N} i = \frac{ND}{2}. \\ T_{prop} &= \sum_{i=0}^{N} \sum_{j=0,j<i}^{N} \pi_j P_{ji} (D_i - D_j) \\ &= \sum_{i=1}^{N} \pi_{i-1} D = (1 - \pi_0) D = \frac{ND}{N+1}. \end{aligned}$$

Hence, the throughput gain G_T is as follows.

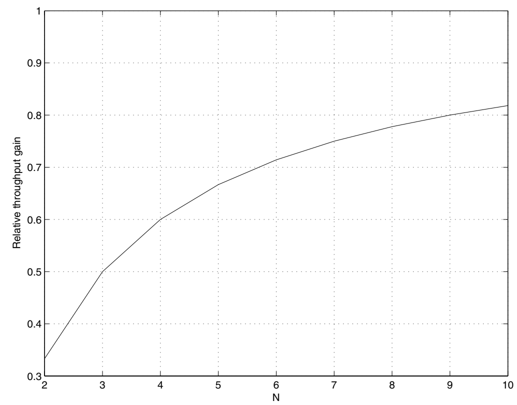
$$G_T = T_0 - T_{prop} = \frac{(N-1)ND}{2(N+1)}.$$

Finally, the relative throughput gain R_T is as follows.

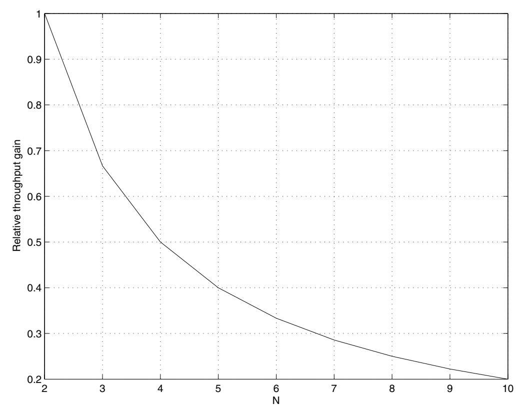
$$R_T =: \frac{G_T}{T_0} = \frac{N-1}{N+1}. \tag{3}$$

Note that the relative throughput gain R_T is a measure which shows the amount of data transmission that can be saved by the proposed technique, hence, the following always holds: $0 \leq R_T \leq 1$ and as R_T becomes larger, more bandwidth can be saved.

We can know from (3) that the amount of data transferred in the proposed technique will be greatly reduced, especially as the number of states increases. This can be verified from Fig. 4(a). Note that we can obtain the actual value of the throughput gain only when P_{ij}'s and D_i's are known priori.



(a) R_T vs. N in Example 1.



(b) R_T vs. N in Example 2.

Figure 4. R_T vs. N

Example 2. If π_i is linearly decreasing and $D_i = iD$, which is more realistic since the bigger the data, the smaller the probability in this case. If π_i is linearly decreasing with $\pi_i = \frac{2}{(N+1)(N+2)}(N+1-i)$,

$$\begin{aligned} T_0 &= \sum_{i=0}^{N} \pi_i D_i = \frac{2D}{(N+1)(N+2)} \sum_{i=0}^{N} (N+1-i) = D \\ T_{prop} &= \sum_{i=1}^{N} \pi_{i-1} D = \frac{N}{N+2} D. \end{aligned}$$

Hence, the relative throughput gain is

$$R_T = \frac{G_T}{T_0} = \frac{T_0 - T_{prop}}{T_0} = \frac{2}{N}. \tag{4}$$

It can be known from (4) that the relative throughput gain of the proposed technique compared to the conventional scheme will be reduced as the number of states increases. This is shown in Fig. 4(b).

Example 1 and 2 can be summarized as follows: The throughput gain from the proposed technique will vary according to the distribution of $\pi_i, i = 0, 1, \cdots, N$. If π_i's become similar to each other (Example 1 is the extreme case when all the π_i's are equal), R_T will become very get larger, and if π_i's decrease with i as in Example 2, R_2 will not be as much significant as the case when π_i are similar to each other.

5 Application examples of the proposed method

5.1 Application examples without context awareness

The proposed concepts are implemented in wireless handset and now serviced in Korea. We can provide real-time news, mobile avatar, handset user interface design, and so on. Some example applications can be seen in [10]. Fig. 5 and Fig. 6 show examples of baseball game broadcasting service and mobile photo application.

Figure 5. Baseball game broadcasting

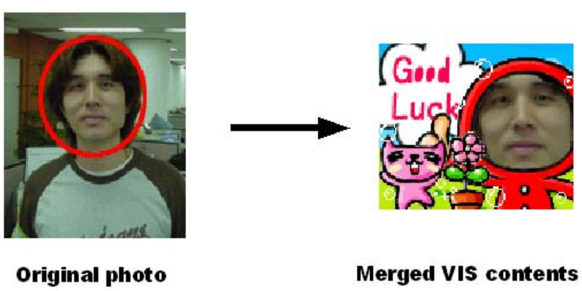


Figure 6. Photo application

5.2 Application examples with context awareness

If the context awareness functions are added to the current implementation as in Fig. 1, various ubiquitous multimedia applications can be provided to the user. Fig. 7 shows a location based service. Entering into a zone, a user can download some applications for his location. In this case, using the proposed method, user can enjoy various services saving network bandwidth. Also, in WPAN based connection between digital devices as in Fig. 8, several applications can be developed [6]. The context aware functions are under developing.

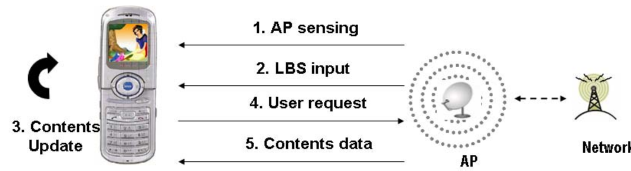


Figure 7. An example of LBS

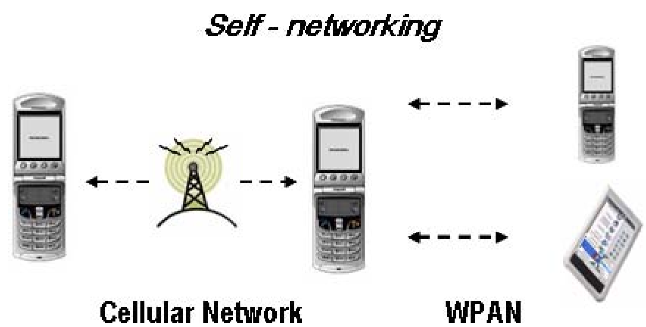


Figure 8. Self-networking between devices

6 Conclusion

In this paper, a novel self-networking and replaceable structure has been proposed for the ubiquitous multimedia services. In the proposed method, content itself connects to the server and updates autonomously. Through this, the overall network bandwidth can be reduced and cost effective real time multimedia services can be provided to the user.

The basic mechanism has been implemented in the wireless handset with mobile vector graphics. The detailed implementation has been explained. The characteristics of the proposed self-networking and replaceable structure can make various applications in the wireless handset combining with the portability and mobility. Also, the throughput analysis of the proposed method shows that the proposed technique is effective in transmission of data in the wireless network.

The implementation is now being serviced in Korea. Various ubiquitous applications are being expected. If there are the functions of context awareness and WPAN connection API's, various ubiquitous applications can be developed. They remain future work.

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