Dynamic adaptive streaming over HTTP-based 3D resource allocation algorithm

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Abstract: With the improvement of people’s quality of life, the demand for three-dimensional (3D) video has gradually grown in recent years. However, there are many challenges to providing high-definition and high-fidelity 3D video services. The most difficult challenge for users to provide 3D video is a large amount of energy lost during 3D video transmission. In this study, the authors present a 3D resource allocation system architecture, which can effectively alleviate the problem of large transmission energy loss. They propose that multiple users in a small cell can share video resources in the downlink from the cloud to the client. In the cloud processing, multiple users can share part of the cloud computing work cycle. In the downlink, multiple users can share part of video resources. They presume that some share output bits can be multicast to overall users, and the other bits can be sent to every user in unicast. They model this and derive the simulation results. The simulation results show that the resource allocation scheme in this study achieves greater energy savings under certain conditions than the traditional case without sharing the resource.

1 Introduction

With the development of economy and technology, people are no longer satisfied with traditional visual enjoyment. Also, the demand for three-dimensional (3D) video has gradually grown in recent years [1]. 3D video supplies the true spatial depth of an object via recreating 3D scenes for both eyes [2]. When the 3D video appears more often in daily services, how to effectively transmit this kind of large data is a difficult challenge. The focus of this study is to propose an energy-efficient resource allocation scheme based on a dynamic adaptive 3D multi-view video rate control system [3], which can improve the quality of user experience very well when facing different network bandwidths. Also, the resource allocation scheme proposed in this study can greatly save the energy consumption of 3D video services. The most difficult challenge for users to provide 3D video via the internet is the strict bandwidth demands of transmitting 3D video and the huge energy consumption during transmission. The application of the new resource allocation algorithm of this study has alleviated this problem.

The following is a brief introduction to the dynamic adaptive 3D multi-view video rate control system.

For the purpose of improving the user’s quality of experience (QoE), the transmission components of the 3D video system on the high-speed internet should effectively deal with the changes in bandwidth. In this regard, we need actional accommodative rate control algorithms and compression encoders to handle different network conditions. The 3D multi-view video rate control system model is based on two most advanced key technologies: high efficiency video coding (HEVC) [4] and MPEG’s dynamic adaptive streaming over HTTP (DASH) [5]. HEVC doubles the compression efficiency of high resolution video images on the basis of H.264/AVC [6]. Moreover, HEVC can flexibly generate bit stream formats appropriate for diverse settings: from conventional 2D video to stereoscopic 3D video and 3D multi-view video. MPEG-DASH can distribute the video content into the same duration parts and saves them in the server. Copy of video clips is encoded by using diverse bit rates which indicates diverse resolutions and qualities. The user can access overall video parts saved in the server by means of an XML-based media presentation description (MPD) file.

The native video sequence captured by the camera is segmented into video sequences segmentation with the same period. In the cause of guaranteeing steady bit rate for every view and providing the greatest perceived quality for every particular bitrate level, every part of the diverse view numbers is decoded at diverse bitrates utilising the R-lambda model [7]. Moreover, the system uses the HEVC 3D extended test model [8] as an encoder so as to make the system have better compression performance. This system model runs under DASH. The client can manage overall streaming sessions in DASH. The client requests a particular MPD according to the network conditions and the decoding procedure to select the bit rate. The client is in charge of repackaging the data packets and decoding them before they are displayed to the user. The decoder is in charge of figuring statistics such as jitter, loss and delay and deciding the practicable network bandwidth. In addition, it sends appropriate requests to particular MPDs on the basis of practicable bandwidth. The bit stream adaptation portion of the client is in charge of determining which bit stream to use under specific network conditions. The model provides the best video quality by considering the combination of video quality and number of layers to produce diverse bit streams based on the available network bandwidth.

The focus is to study a resource-saving resource allocation scheme for transmitting 3D video resources on the downlink from the cloud to the client. The core idea is that in the downlink, part of video resources is shared by all users and another part of resources are received by users individually. Subsequent sections of this paper will study the proposed scheme and perform simulations. The rest of the paper is organised as follows: in the next section, the traditional resource allocation system model and the new resource allocation system model are introduced, respectively. Section 3 explains the simulation method. Section 4 presents the simulation results. Section 5 summarises the work. Finally, we acknowledge those who provided help and support for writing this paper.

2 System models

The resource allocation scheme proposed in this study can be applied between the cloud and the client theoretically. This study only focuses on the theoretical digital research of a new resource...
In the uplink, any user sends $B_k^1$ bits to the cloud separately. In cloud processing, part of the cloud computing work cycle needs to be spent to generate output bits that multiple users can share. We assume that $V_s \leq \min \{V_f \}$ the CPU cycle is shared, and $\Delta V_s = V_s - V_f$ the CPU cycle is performed exclusively by the user.

In the downlink, some output bits require to be shared to overall users. In order to model this, we presume that a subset of output bits $B_k^2 \leq \min \{B_k^1 \}$ can be multicast to overall users in the small cell, and $\Delta B_k^2 = B_k^1 - B_k^2$ bits require to be sent to every user in unicast.

2.2 Improved resource allocation

Based on the above considerations, this study has made improvements on the basis of the traditional network resource allocation method. The improved structure is shown in Fig. 2. We can see from the following figure that in the downlink, users can not only receive a part of resources from the cloud alone but also share some resources from the cloud with other users. At this time, part of the CPU’s computing cycle is for the user to perform tasks alone, and another part of the CPU’s calculation cycle is for multiple users to perform shared tasks.

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3 Methodology

3.1 Frame structure

The data frame structure is described in detail in Fig. 3. As shown in Fig. 3, the transmission task of the shared data is first performed, followed by the transmission of the conventional individual task, as described below.

3.2 Modelling

(1) Cloud processing: $F_C$ represents the capability of the cloud server in the light of the number of CPU cycles per second. In addition, let $f_s \geq 0$ and $f_s \geq 0$ be the fraction of the handling ability $F_C$ allocated to the user $k$ specific $V_s$ CPU cycles and $V_s$ shared CPU cycles, respectively, so that $\sum_{k} f_s \leq 1$ and $f_s \leq 1$.

As Fig. 3 shows, the shared CPU cycle execution time is $T_s^f = V_s/(f_s F_C)$, and the time of the CPU cycle performed by the user alone is $\Delta V_s/(f_s F_C)$.

(2) In the downlink: the common output bit $B_k^2$ is multicast to all users. Assume that $P_k^f$ is the multicast transmit power, $\gamma_k$ is the downlink channel power gain of user $k$. $N_0$ is the noise power spectrum density of the receiver. The available downlink rate is given by

$$ R_k^{dl}(P_k^f) = W_d l \log \left(1 + \frac{\gamma_k P_k^f}{N_0 W_d}\right) $$

where $W_d$ is the downlink bandwidth. Therefore, the multicast $B_k^2$ bit downlink transmission time can be calculated by $T_k^{dl} = B_k^2 / R_k^{dl}(P_k^f)$, the output bit $\Delta B_k^2$ dedicated to each user uses equal bandwidth allocation in the downlink and is transmitted in unicast mode at a rate of

$$ R_k^{dl}(P_k^c) = \frac{W_d}{K} \log \left(1 + \frac{\gamma_k P_k^c}{N_0 W_d/K}\right) $$
where $P_k^d$ is the BS transmitted power assigned to user $k$. The overall energy loss of user $k$ in the downlink is

$$E_k^d(P_k^d, P_k^o) = \left( \frac{\Delta B_k^o}{\eta B_k^o} + \frac{B_k^o}{\eta B_k^o} \right) \times \theta_k^d. \tag{3}$$

Here, $\theta_k^d$ is the argument that catches the downlink reception energy consumption per second.

### 4 Simulation results
In this segment, we offer numerical examples with the purpose of presenting the superiority that can be produced by the proposed resource allocation scheme compared to the traditional one. We set up a scene in which eight users are arranged in a small cell randomly. The wireless channel is Rayleigh fading, and the path loss coefficient is procured on the basis of the small cell model in [9] for a carrier frequency of 2 GHz. The distance from the user to the BS is selected between 100 and 1000 m at random, and the result is the average over multiple independent user locations and fading channels [10]. The noise power spectrum density is set as $N_0 = -147$ dBm/Hz [11]. The bandwidth in the downlink is $B_k^d = 10$ MHz and the downlink power budgets are limited to 60 dBm. Cloud server processing capacity of High Level Teachers in Beijing Municipal Universities (no. 6162010606) and the Science and Discipline construction project of Beijing Information Science and Technology University (no. 5121911006).

### 5 Conclusion
In this study, we propose a new energy-efficient resource allocation scheme based on a dynamic adaptive 3D multi-view video rate control system. We present how users share the resources in the downlink and cloudlet: part of video resources is shared by all users and another part of resources is received by users individually. The simulation results show that the new scheme achieves $\sim 56\%$ energy savings compared to the traditional case when the sharing factor $\eta = 0.4$. Also, the greater the proportion of users sharing resources, more energy is saved. In conclusion, the resource allocation scheme proposed in this study achieves greater energy savings under certain conditions than the traditional case.

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