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Dynamic Transition of Bandwidth and Power Saving Mechanism to Support Multimedia Streaming Using H.264/SVC over the Wireless Networks

G.Rohini
Assistant Professor , Dept.of IT
Adhiyamaan College of Engineering, India, Hosur

Dr. A.Srinivasan
Professor and Head ,Dept of IT
MNM Jain Engineering College ,India, Chennai

Abstract – Nowadays Internet and bandwidth is an extremely valuable and scarce resource in remote networks. Consequently, efficient bandwidth management is necessary to support service stability, good Quality of service and ensure steady quality of experience for users of handheld multimedia streaming services. certainly, the support of uniform streaming rate during the entire course of a streaming videos, where the user is in mobility is one of the demanding issue and may not have high resolution or video quality due to the limited 3G/3.5G/4G bandwidth to the Internet as well as changing of bandwidth . Popular iOS and Android based handheld devices, accessing more Internet video services typically involves about 10%–80% redundant traffic and low battery life. This work proposes the Service transition protocol and Session transition protocol using H.264/SCV over the wireless network. This paper enables dynamic voltage and frequency Scaling Power control mechanism for better battery life. Simulation results shows that the proposed approach outperforms existing bandwidth management schemes in better supporting mobile multimedia services with better life time of battery.

Index Terms – Efficient bandwidth management, Streaming videos, ioS and Android, Wireless Network, redundant traffic.

1. INTRODUCTION

AS wireless services become ever more ubiquitous, there is a growing demand for the provisioning of multimedia services with diverse quality-of-service (QoS) requirements; QoS is defined as the ability of the network to provide a service at an assured service level while QoE is how a user perceives the usability/quality of a service when in use; more specifically, how satisfied the user is with a service in terms of usability, accessibility, retainability and integrity of the service. Mobile users may experience performance degradations during multimedia request due to limited bandwidth and mobility.

In this paper, we intend extending our schemes [1, 2] making them scale with the number of users, by developing

- Aggregate path and neighbors bandwidth discovery model (APNBD)
- Integrated boundary range estimation scheme called (IBRES)
- Network transition and handover framework model called (NTHFM)
- Aggregated Bandwidth reservation scheme (ABRS)
- Streaming task assignment scheme (STAS)
- Dynamic voltage and frequency scaling(DVFS)

APNBD estimates paths to destinations for groups of users (not only for a single user) and takes into account (a) road intersections(i.e., junctions of two or more roads) and road segments (i.e., a segment is a road portion between two adjacent road intersections or between a road intersection and finding neighbors network bandwidth location, i.e., a location at which the user exits/enters a multimedia request);(b) preferences of users in terms of road characteristics (e.g., highway, multi-lane, one-way, without traffic light and without stop sign);(c) spatial conceptual maps; (d) current locations of users ; and (e) estimated request ; these are determined by the Aggregated Path Prediction Model [2] and Destination Prediction Model (DPM) proposed in [5].IBRES the Controller (SDN) located in the network system (NS) estimate the user multimedia request and bandwidth requirement. CTL identifies the neighbor's networks bandwidth and estimate the status of current available bandwidth 3G/3.5G/4G/5G [1NTHFM during multimedia streaming degrades in bandwidth due to moving user equipment (UE) (i.e., mobile smart devices) .SDN activate the session transition and network transition states to hand over the available neighbors bandwidth [4] (i.e., dynamic adjustment bandwidth) [1].NTHFS are the first framework takes into network service transition. ABRS integrates mobility and bandwidth reservation models to better support user request (e.g., multimedia streaming sessions) from source to destination. To the best of our knowledge; this ABRS allows reducing the amount of exchanged messages between UE and the network (SDN) and thus improves scalability and shortens response time.STAS after user request for multimedia data the

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streaming required video data to package all video data into multiple assignment units. Each assignment unit is the basic unit of a streaming task. We named the Assignment Unit as an AU which is proposed in [4]. After partitioning the required video data into multiple AUs, each units starts buffering in UE. Adaptive streaming adjustment mechanisms select the optimal or corresponding bit rate media segment for streaming play according to the variance in bandwidth using H.264/SVC codec.

DVFS Systems in a general embedded system operate at a fixed frequency and power voltage state if no specific power saving mechanism is available for iOS and Android smart devices. In this case, a system in idle state supports the same CPU frequency and voltage, but consumes excessive power. DVFS algorithm [6] is used to reduce power consumption. The DVFS is mainly used in embedded systems for dynamic adjustment of CPU frequency and power voltage .The DVFS algorithm can extend system lifetime. Furthermore, if the proposed solution is efficiently used for users without much constraint in energy consumption, the optimization and savings achieved in the network resources can be used to accommodate more mobile users with energy consumption constraints.

The remainder of this paper is structured as follows. Section II presents some related work. Section III describes the proposed framework along with the envisioned mobile network bandwidth transition architecture. Section IV evaluates the performance of the proposed framework and showcases its potential in achieving its design objectives. Section V concludes this paper.

2. RELATED WORK

In this section, we survey existing research issues in the (a) Bandwidth predictive b) K-hop cooperative video streaming (c) Power consumption in iOS and android smart devices.

2.1. Bandwidth predictive

Apollinaire Nadembega *et al[2]* proposed a integrated predictive mobile-oriented bandwidth reservation framework(IPMBRF)[2] is to satisfy the requirements, in terms of bandwidth, of each mobile user along his/her movement path across cells towards destination. For this purpose, the framework predicts (a) the mobile user path to destination; (b) the entry/exit times of the mobile user to/from cells along the path to destination; and (c) the available bandwidth in each cell that will be transited by the user to destination. It then accepts the user request, if there is sufficient available bandwidth along the path to accommodate the request; otherwise, it rejects the user request. Jun *et al.* [8] proposed a CAC and bandwidth reservation scheme which is cell-oriented, distributed and supports prioritized handoff based on the historical available bandwidth data while Wu *et al.* [9] proposed a CAC and bandwidth reservation scheme based on the load and the ratio of high speed users in the next cell as input variables of fuzzy inference system (FIS).Many aggregate CAC and bandwidth reservation schemes have been proposed in the literature [1, 3, 8, 9, 10]; however, they are not predictive mobile-oriented schemes; These predictive mechanism degrades the usage of multimedia. Our proposed system considers the handover bandwidth mechanism which improves the usage of multimedia.

2.2. K-hop cooperative video streaming

How to speed up the video streaming and QoS in moving user equipment is one of the critical issues in wireless network. Chao-Hsien Lee *et al* [3] proposed a K-hop Cooperative Video Streaming (KCVS) in order to increase the video quality during the travelling path, one vehicle would ask other vehicles belonging to the same fleet to download video data using their redundant 3G/3.5G bandwidth. Once other vehicles download video data from the Internet, they forward the downloaded video data to the requested vehicle through the ad-hoc transmission among vehicles, in which Dedicated Short-Range Communications (DSRC) is designed for automotive to have one-way or two-way short to medium-range wireless communication specifically in the highly dynamic mobile environment.

2.3. Power consumption in iOS and android Smart devices

The rapid growth of mobile multimedia services makes power endurance for hand-held devices an important issue. Android and iOS provides a power management mechanism at the Linux Kernel to reduce system power consumption and to extend standby time. Yi-Wei Ma et al., [7] proposed a dynamic voltage and frequency scaling power control mechanisms.

3. DYNAMIC TRANSITION OF BANDWIDTH FRAMEWORK

The objective of the proposed DTBF is to satisfy the requirements, in terms of bandwidth, of each mobile user along his/her movement path across cells towards destination. For this purpose, the framework predicts (a) the mobile user multimedia request (b) the request time /response times of the mobile user to/from cells along the path to destination; and (c) the available bandwidth(d) identifying other network bandwidth range .It then accepts the user request, if there is sufficient available bandwidth along the path to accommodate the request; otherwise, it calls to the SDN controller located in NS to identify the other available bandwidth ;if its available controller handover the service request to other available network service providers .In proposed framework there is no rejection of request services . In the following section, we present the architecture of DTBF and the DTBF operations in processing new multimedia requests. Then, after stating our assumptions, we present the Aggregate path and neighbors bandwidth discovery model (APNBD), Integrated boundary range estimation scheme called (IBRES), Network transition

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and handover framework model called(NTHFM),Aggregated Bandwidth reservation scheme (ABRS);and Streaming task assignment scheme (STAS).

3.1. Architecture

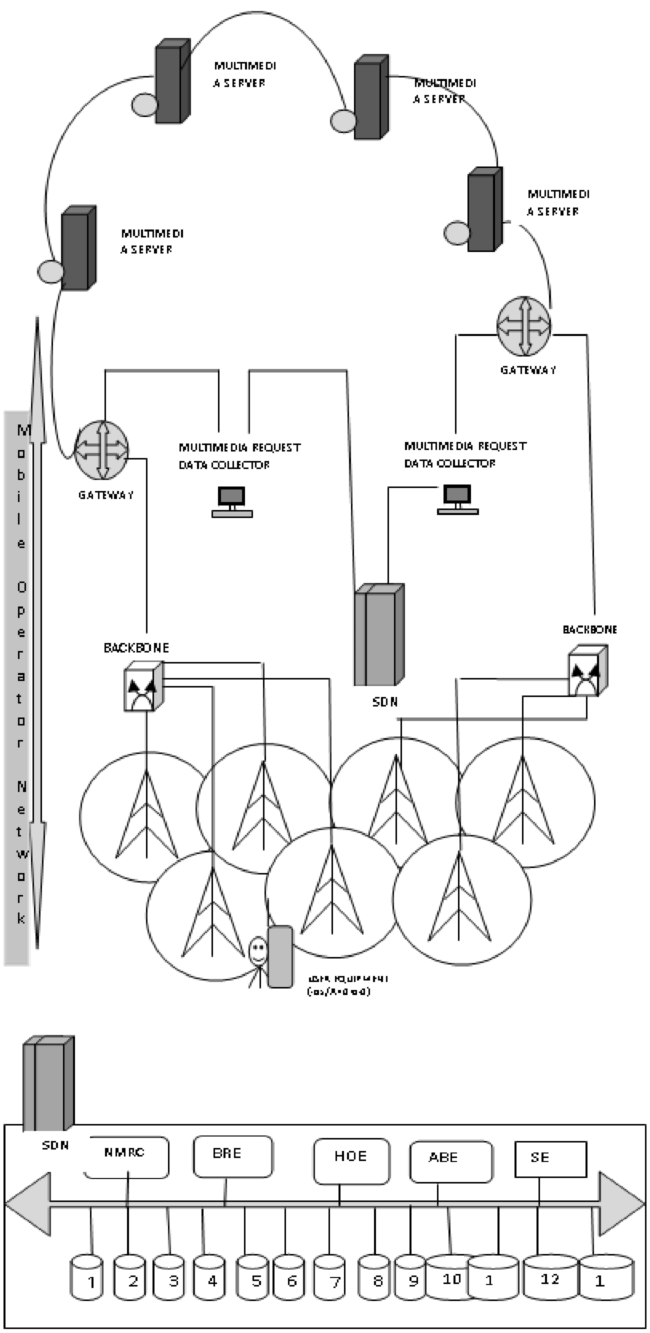

Figure 1 Envisioned

NMRC: New Multimedia Request Controller
BRE : Bandwidth Range Estimator
HOE: Handover Time Estimator
ABE: Available Bandwidth Estimator
SE: Streaming Estimator

1: Available Bandwidth Amount Register (ABAR)
2: Data Of Diving Behavior Register (DDBR)
3: Data Of Stopping Times Register (DSTR)
4: Earlier Request Call (ERC)
5: Transition Register (TR)
6: Traffic Light Cycle Register (TLCR)
7: User Request Data (URD)
8: User Handover Times Register (UHTR)
9: Profile Based Path Register (PBPR)
10: User Trajectories Register (UTR)
11: Bandwidth Register Boundary Range (BRBR)
12: Assignment Unit (AU) 13: Multiple Assignment Unit (MAU)

Figure. 1 shows a network configuration that consists of wireless networks which are inter-connected via gateways. . The wireless network operator administrates a new entity, called SDN Controller, that performs bandwidth management and request admission control. A number of multimedia calls data collectors are deployed over the entire network to collect data about request data and forward them to the SDN Controller for processing. The backbone (see Figure. 1) allows cell towers and gateways to be inter-connected.

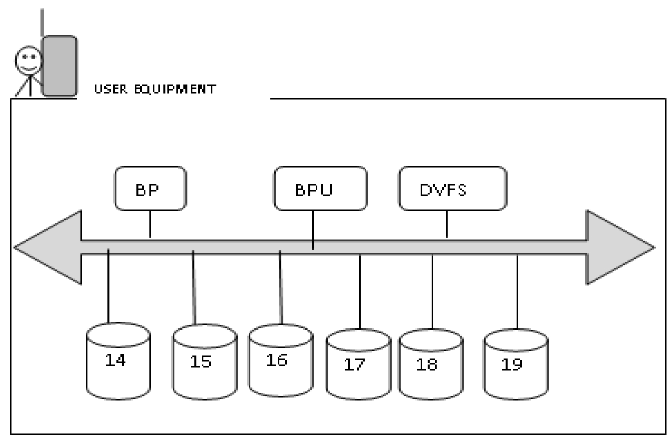

Figure 2 DTBF Architecture (SDN and User Equipment)

BP:Bandwidth Predictor(BP)
BPU:Bandwidth Predictor User(BP-U)
DVFS: Dynamic Voltage and frequency Scalling
14: Navigation Map
15: User Content
16: User Frequency visited Location Trace
17: User Movement trace
18: Frequency and Voltage Domain
19: Power Domain

Figure.2 shows the architecture of DTBF whose operation is performed by User Equipment (UE) and the SDN Controller Figure.1.Envisioned. Figure.2. DTBF Architecture, which is located in the network system (NS). UE is responsible for predicting the mobile user multimedia request and navigation zone is lightly dense while SDN controller is responsible for predicting the path and discovery the neighbors' network range is high dense.SDN controller is also responsible for predicting the request time /response times of the mobile user to/from cells along the path to destination and other available bandwidth. In the rest of the paper, current user and the person who uses the UE are used interchangeably. UE consists of four modules, namely Bandwidth Predictor (BP) and bandwidth Predictor-User side (BP-U). BP (resp. BP-U) predicts the user's bandwidth (resp. the user's path to the predicted bandwidth), streaming estimator (SE), H.264/SVC codec is used to stream the multimedia content, voltage and scaling estimator (VSE) which monitors the batter usage and CPU utilization . Figure. 2 shows SDN controller that consists of four main modules namely path and neighbor bandwidth discovery model (PNBDM), boundary range estimator (BRE), Network transition and handover model (NTHM), Bandwidth reservation estimator (BRE).

3.2. New multimedia request /service transition

The role of DTBF is to decide on whether to accept the request in same service or transition of services based on the available bandwidth along the path to destination. Figure.3 illustrates the process of new multimedia acceptance/transition that consists of (1) Bandwidth prediction (BP): indeed, upon receipt of a multimedia request, DTBF determines the current user's bandwidth using IBRES [1]; this operation is performed by bandwidth prediction module (BP) of UE. Then, UE creates a message that contains the predicted bandwidth, the reference of current user's new multimedia request (i.e., request ID or name and multimedia server where the request is located which allows identifying the multimedia application in order to get the required bandwidth and boundary range) and his/her ID, and sends it to SDN located in NS; (2) Boundary range estimation:

DTBF uses the user's bandwidth (forwarded by his UE) and information about users' locations, to compute the density of the current user identify the boundary range (i.e.,E current_location/ bandwidth_BRE) using (1); this operation is performed by SDN (3)Service Transition according to the boundary range density: if the current bandwidth is lightly dense, SDN sends a message to UE that determines, by using BP-U (implements BPM [2]), the predicted bandwidth and sends it back to SDN; otherwise, SDN determines, by using PNBDM the predicted bandwidth. The predicted bandwidth and boundary range is stored in database BBRR of SDN (4) handover times' estimation: With the knowledge of the bandwidth boundary range, DBTF determines the user's service handover when the bandwidth is low (resp. not lightly) dense; this operation is performed by service handover estimation module (HOE of SDN); HOE output is stored in UHTR; (5) available bandwidth estimation: SDN (via IBRES) determines available bandwidth in each cell along the user's path to destination; the results of IBRES are stored in ABAR; and (6) new multimedia request admission control; SDN (via RAI) checks whether there is sufficient available bandwidth along the path to accommodate the user's new request; if the response is no, it predict the bandwidth for a while and transfers to the neighbors bandwidth (via NTHFM) the user's new multimedia request. In the following sections, after we present, Streaming task assignment scheme (STAS), Dynamic voltage and frequency scaling (DVFS).

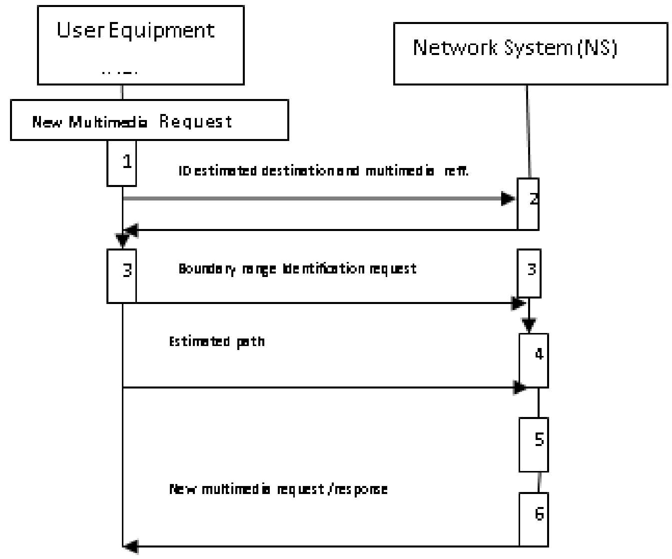

Figure 3. DTBF process for new multimedia acceptance/transition

3.3. Streaming task assignment scheme (STAS)

In the video streaming scenario, the scalable video coding technique, i.e., H.264/SVC, used to encode video into one base layer and multiple enhancement layers. The base layer is downloaded by the user by using Greedy approach proposed in [4]. After the SDN provide the redundant 3G/3.5G/4G bandwidth for downloading required video data. However, before downloading it undergoes STAS mechanism that, (1) how to partition the video into multiple streaming tasks for user to download and forward video data to other requester and (2) how to decide appropriate workload for each user because different user are characterized with different capabilities, e.g., different 3G/3.5G /4Gbandwidth .At the beginning, STAS will refer the profile of the required video data to package all video data into multiple assignment units. Each assignment unit is the basic unit of a streaming task. In other words, the assigned streaming task is composed into multiple assignment units. We named the Assignment Unit as an AU which is proposed in [11]. After partitioning the required video data into multiple AUs, the SDN then can start the assigning procedure of streaming tasks. First, the SDN will do the initial scheduling and determine an assignment interval. The assignment interval is used to decide when the next streaming tasks assignment process is triggered again to assign streaming tasks to user. Next, the SDN will send requests of initially required video data to user through 3G/3.5G/4G network and forwarding video data during the assignment interval. When the timer of

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the assignment interval expires, the SDN then estimates the appropriate amount of AUs for each user as the workload of the streaming task for a user in the next assignment interval. This procedure will be repeated until all AUs of the video data have been downloaded. At the beginning, we assume that the user will start video playback when the buffered video data can playback 7 seconds, and those 7seconds' buffered video data are assigned to requested user only. Let the estimated spending time of 1 user transmitting these 7 seconds' video data is represented as *Tinitial*. We can approximately estimate *Tinitial* in Equation (3), where *Sizei* , *BWi*3G/3.5*G/4G*, and *BWi* stand for the data size of initially downloaded streaming task of user i, 3G/3.5G bandwidth of user irrespectively.

$Ti = max(size_i / BW^i \;\; , size_i / BW^i \; 3G/3.5G/4G \;), \;\; \forall i \in$ n-user (1)

$Tinitial = max(T1, T2, . . . , Ti) \;, \forall i \in$ n-user (2)

Since the processes of transmitting video data from the server using 3G/3.5G/4G and forwarding by SDN using wireless networks are concurrent, we estimate the maximum transmitted time between downloading and forwarding time of each user. Then, we let the maximum time of transmitting video data from the server to the user as *Tinitial*. However, during 1user, transmitting these initial 7 seconds video data, n -user (n > 1) can also use their 3G/3.5G/4G resource to download video data. Therefore, after getting *Tinitial*, the total throughput of n user (n>1), *ThH, can* be calculated as Equation (3).

$THH = \sum_i BWi3G/3.5G/4G * Tinitial, \forall i \in$ n-user (3)

3.4. Dynamic voltage and frequency scaling (DVFS)

DVFS power saving module in proposed system located in UE. This module supports three functions: frequency domain, voltage domain, and power domain. The DVFS supports the developments in completing power saving functions. Therefore, the implementation based on this module adjusts the CPU frequency and the power supply [12]. Each functional control has the following characteristics: This module controls the ARM chip and DSP chip frequency. It decreases system state according to ARM chip and DSP chip frequency.1. In multimedia state, the system uses the proposed DSP multimedia architecture for processing multimedia packets. In this state, it increases DSP chip frequency to support user high-quality multimedia service.2 in idle state, the system adjusts the ARM chip and DSP chip to the lowest frequency to minimize power consumption.

Function	Description
DVFS-OPP1	Set CPU Frequency (ARM:125MHz,DSP:90MHz)
DVFS-OPP2	Set CPU Frequency (ARM:260MHz,DSP:180MHz)
DVFS-OPP3	Set CPU Frequency (ARM:500MHz,DSP:360MHz)
DVFS-OPP4	Set CPU Frequency (ARM:550MHz,DSP:400MHz)
DVFS-OPP5	Set CPU Frequency (ARM:600MHz,DSP:430MHz)
LCD1	Turn LCD off
LCD2	Turn LCD on

Table 1 POWER SAVING FUNCITON MODULE

DSP chip frequency

(1) In multimedia state, the system uses the proposed DSP multimedia architecture for processing multimedia packets. In this state; it increases DSP chip frequency to support user high-quality multimedia service.

(2) In idle state, the system adjusts the ARM chip and DSP chip to the lowest frequency to minimize power consumption. The operating performance point in the CPU domain adjusts CPU frequency in the five stages shown in Table 1. Developers can refer to the system states to adjust ARM and DSP frequency. This module divides ARM, DSP, and other device voltages into five main functions to control different parts of the hardware.

- VDD1: Processor voltage.
- VDD2: Core voltage.
- VDD3: Wake-up voltage.
- VDD4: Processor SRAM voltage.
- VDD5: CORE SRAM voltage.

The TI Company released VDD1 and VDD2 resource code. The developer can adapt the system states to control voltage, including VDD1 region ARM and DSP voltage. The VDD2 region includes that various hardware for controlling voltage. The architecture proposed in this paper is used to realize a voltage control mechanism. [7] Power domain controls the power switch supply of the device. Depending on device state, the power supply is turned on or off. This architecture is usually in idle state. When the system reaches this state, the system automatically turns off power and records it in memory. At the same time, the system provides support power to memory. The proposed architecture is used as a power control mechanism. However, in the current Android architecture, DVFS power saving mechanism is not recognized on an embedded hardware platform. The APK cannot get power saving service from application framework layer .This paper, therefore, imports the DVFS power saving mechanism shown in Figure 5 on the Linux Kernel so that the bottom of power management can recognize the wake lock information needed for power management by the application framework layer. The developer can get wake lock and control CPU frequency

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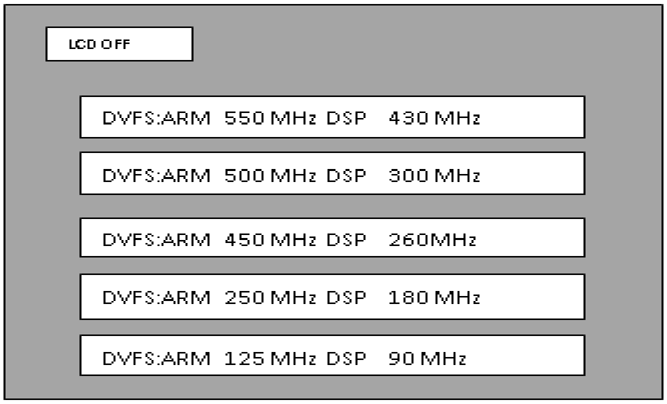

FIGURE 5. Power saving controller

4. PERFORMANCE EVALUTION

In this Section, we evaluate, via simulations, the performance of APNBD, IBRES, ABRS and DTBS.

4.1. Service transition and session transition Performance Evaluation

We evaluate the performance of APNBD and DTBS using two parameters: accuracy *Ap* and computational complexity *Ct*. *Ap* of DTBS is defined as follows:

$$Ap(Eact,Epred)=2*|Eact\cap Epred|/|Eact|+|Epred| \quad (4)$$

Where Eact is the actual available bandwidth and Epred is the set of the session predicted bandwidth; Eact and Epred are computed during simulation time *dt*. *Ap* of APNBD is defined as follows:

$$Ap = 1- \left(\sum_{i=0}^{NU} E_i / NU\right) / 180 \quad (5)$$

where *NU* and Ei denote the number of users and the average hand over time prediction error gap (i.e., difference between session and predicted handover time instants) of user *i* respectively; we assume that the average handover time prediction error gap of 180 seconds (i.e., 3 minutes) represents an accuracy of 0%. *Ct* is defined as follows:

$$C_t=\sum_{i=0}^{NU} T/N_U \quad (6)$$

Where *Ti* denotes the transition /estimation computation time of user *i* and the number of users respectively.

4.2. Multimedia Streaming Performance Evaluation

Figure. 6(a) and (b) show the goodput of different interval among various speed and user. In Figure. 6(a) and(b), vertical lines indicate the calculated assignment intervals proposed in our work and each forwarder adopts the FIFO transmission strategy to forward packets. From Figure. 6(a) and (b), we can see that the duration of the assignment interval does have impact to the video streaming quality. When the assignment interval is set to be 1 second, the obtained streaming quality is generally good. Since the amount of NAL units that can be transmitted back by user even in limited short interval, the total amount of NAL units that can be assigned by the user is small. Hence, NAL units cannot be transmitted back before the decoding deadline. Even the duration is getting smaller, the streaming quality is getting improved. However, the improved degree is decreasing as the duration is getting longer and finally the obtained goodput will be limited at a bound. The reason for this phenomenon is that (1) even the duration of the assignment interval is getting smaller, assigned streaming tasks are almost transmitted to the requester in time and (2) enlarging the duration of the interval cannot get obvious improvement anymore.

Goodput = Numdec_NAL / Numtotal_NAL (7)

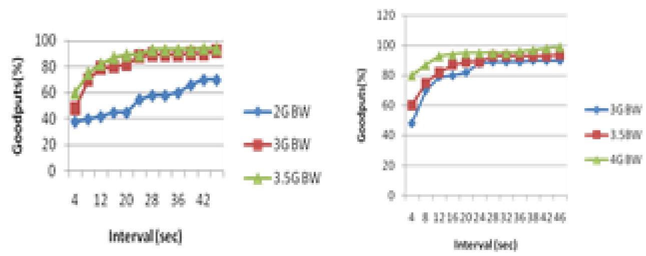

Figure 6 (a) (b) Good puts of different in Intervals in different Bandwidth

4.3. Power consumption in iOS and android Smart devices

To enhance the efficiency in developing embedded systems and to reduce burning kernel time, Android file system and ioS is mounted by network file system (NFS) sharing multimedia file. In this case, NFS uses Transmission Control Protocol/ Internet Protocol (TCP/IP) to mount an Android file system and ioS catalog on local network server. Through remote control, the developer can add, modify, and remove applications and files. The advantages of NFS are the reduced time needed to burn image files to memory and the reduced development time. The design method of power control provides five CPU frequencies and selects LCD on/off as shown in Figure. 5. The DVFS power saving mechanism is effective for all video files. The performance of the hardware platform is tested on video files. Figure.7 compares the performance between ARM chip and mixed ARM and DSP chip system operation state.

Table 2 compares average FPS between ARM multimedia architecture and ARM plus DSP multimedia architecture. The table shows that the average FPS in the proposed ARM with DSP decoding architecture is about 30, which provides high quality multimedia services**.** The test video in this paper was run ten times for performance testing .Figure.7 shows that, because the ARM chip must support the memory for system operation and video playing, the frame per second (FPS) is about 24.

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CPU Frequency	Range (Average)FPS	Play video with LCD Range (Average)Current	Power saving Rate	Play video with LCD Range (Average)Current	Power saving Rate
ARM 550 MHz+ DSP 430 MHz	27-29FPS	0.636-0.638A	-	0.324-0.326A	-
ARM 500 MHz+ DSP 300 MHz	22-24 FPS	0.634-0.636A	1.51%	0.319-0.322A	1.32%
ARM 450 MHz+ DSP 260MHz	20-15 FPS	0.583-0.567A	1.82%	0.313-0.316A	1.77%
ARM 250 MHz+ DSP 180 MHz	16-18 FPS	0.567-0.570A	12.21%	0.267-0.269A	14.51%
ARM 125 MHz +DSP 90 MHz	5-7 FPS	0.527-0.529A	18.42%	0.243-0.249A	20.12%

Table 2 The FPS and Current for Each CPU frequency

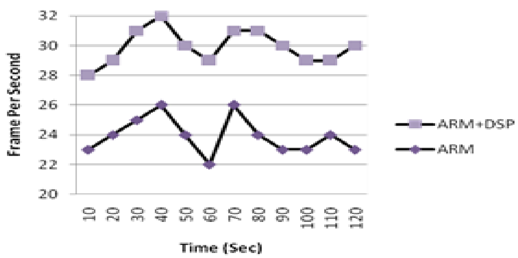

Figure 7 ARM and DSP FPS Performance analysis comparison

5. CONCLUSION

The calculated Performance evaluation results did show that our scheme maintains a well-balanced network performance between bandwidth utilization, hand over mechanism and new multimedia request rates while other schemes cannot offer such an attractive performance balance; indeed, our scheme will achieves considerably better handover and 0.5% error gap and efficient bandwidth transition and utilization rate irrespective of cells capacities and request arrival rates with high quality of multimedia content with fast streaming performance in smart devices. Our scheme improves the life time of hand held devices using DVFS power control mechanism CPU frequency and controlling the power supply of the device to optimize power consumption, and to achieve the goal of power saving for hand-held devices.

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Authors

Mrs.G.Rohini received B.E in Computer Science & Engineering from Bharathidasan Engineering College in 2008, The Master degree in Computer Science & Engineering from PSN College of Engineering and Technology in 2011 and the pursing Ph.D in Information & Communication Engineering in Anna University and she is working as an Assistant Professor in Information Technology at Adhiyamaan College of Engineering. Her research interest lies in the field of Cloud Computing, Multimedia Streaming and Mobile Bandwidth Management.

Dr.A.Srinivasan completed his ME, PhD in Computer Science and Engineering field at the Madras Institute of Technology, Anna University, Chennai. He has finished his Post Doctorate at Nan yang Technological University, Singapore. He has 21 years of Teaching and Research Experience in the Computer Science and Engineering field and one year of Industrial Experience. He is a recognized Ph.D Supervisor in the faculty of computer science and engineering, Anna University and other Engineering Universities in the southern part of our country. Currently he is guiding 06 Ph.D scholars and one has successfully completed Ph.D. He has published 52 Research papers in National and International journals and conferences and one book work published in Pearson Education in Cloud computing techniques in the year 2013. He successfully filed a patent for one of his research works in the Indian patent office. He is on the editorial board in Journal of Computer Science and Information Technology [JCSIT] and Review Board Member to 12 reputed International Journals in Computer Science and Engineering field. Currently he is working as Senior Professor and Head in Information Technology Department, Misrimal Navajee Munoth Jain Engineering College, Anna University, Chennai, India. He is a Senior Member IEEE, ACM and Life Member CSI, ISTE. His fields of interests are Digital Image processing, Face Recognition and Distributed Systems.