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MMKP B&B Based Heterogeneous Handover for the Next Generation Network's

Ms.P. Nirmala, Ms. S. Swarna Parvathi
Department of IT
Sri Venkateswara College of Engineering
Pennalur, India

ABSTRACT

Growing consumer demand for access to communication services anywhere and anytime is accelerating the technological development towards the integration of various wireless access technologies, nowadays called as Fourth Generation (4G) wireless systems. 4G wireless systems will provide significantly higher data rates, offer a variety of services and applications previously not possible due to speed limitations, and allow global roaming among a diverse range of mobile access networks. In a typical 4G networking scenario, handsets or mobile terminals with multiple interfaces will be able to choose the most appropriate access link among the available alternatives .Future network devices will need to roam seamlessly across heterogeneous access technologies such as 802.l1, Wi MAX, CDMA, GSM etc., between wired networks such as xDSL and cable, as well as between packet switched and circuit switched (PSTN) networks. The movement of user within or among different types of networks is called vertical mobility. In the deployment of multimedia services with real -time requirements, the hand off process can significantly degrade the QoS from the user's perspective. Since video data can be lost due to latency caused by vertical hand off (VH), video quality degradation is a critical problem in video streaming. In order to solve the above issues, a channel-adaptive video transmission method using H.264 Scalable Video Coding (SVC) can be used, which better adapts to mobile environments with heterogeneous clients and time varying available capacity. In this paper we propose a mechanism for radio access network selection based on Multidimensional Multiple choice knapsack problem (MMKP).We also devise our own heuristic to solve the above network selection problem. We prove that the runtime complexity of our heuristic is O(log n).

Keywords: MMKP (Multi-dimensional Multiple Choice Knapsack Problem), B&B (Branch and Bound), Vertical Handover, BBMVHO (Branch and Bound based MMKP Vertical Handover)

2. INTRODUCTION

The 4G technology promises faster data rates opening up avenues for application that needs high data rates like video streaming .The next generation networks promise to bring together heterogeneous networks like Wi-Fi, Wi-Max and cellular networks to make it one ecosystem. All of these networks will be treated as one family of packed switched networks. The demands for streaming video, Internet radio and other internet access have increased in the recent. The user has the luxury of roaming through the heterogeneous networks while the streaming is going on. The handoffs take place between the different networks. When the network characteristics are different the handoff is called a vertical handoff. To facilitate streaming while the user roams through different networks, the content has to be adapted to maintain the streaming presentable to the user. The adaptation process must be capable of maintaining the streaming content's quality to ensure that the handoff seems as seamless as possible to the user. The adaptation of the content is done according to the transmission characteristics of the end-to-end communication path and to the capabilities of the displaying device.

Adaptation is a process which repackages the content being streamed according to the present eco-system characteristics. Here the eco-system consists of the end-user device, network characteristics, content requested for streaming and the intermediate nodes like proxy. Different combinations of these entities would affect the QOE (Quality of Experience) of the user. There are a couple of efficient methods, namely scalable media delivery and trans coding, to achieve the video adaptation to varying network characteristics, device capabilities and end-user preferences. In an ongoing streaming application when a user roams from one network to another network the network parameters change and the session has to be transferred seamlessly. When the user wanders through heterogeneous networks vertical handoff takes place. The transfer of Session must be done seamlessly such that the user does not experience an interruption with the service.

Trans coding is a process where the content is re-coded into new format. The transcoded video streams can have a lower spatial resolution, a lower temporal resolution, a lower quality, or even a different compression standard. The new format is decided based on the target devices capability and constraints that are present in the network connection. In transcoding the content is decompressed completely or to an intermediate form and again recoded into a form that is decodable by the client's device. A single source sequence is kept in the video storage and different versions are created on the-fly upon request using transcoding methods. The major downside of transcoding is the additional complexity needed to re-encode the video sequence in its new form.

The Scalable Video Coding (SVC) was developed in response to the growing need for higher compression of moving pictures for various applications such as videoconferencing, digital storage media, television broadcasting, Internet streaming, and communication. It is also designed to enable the use of the coded video representation in a flexible manner for a wide variety of network environments .Here in SVC the content is encoded once and can be decoded in several layers to suit the requirements of the target device and network conditions. It is a coding standard in which the video is coded with a base layer video stream meant for connections with basic terminal capabilities or low bandwidth network conditions. The residual information between the base layer and the original content is then encoded to form one or more enhancement layers. Additional enhancement layers can be integrated with the base layer for scaling up the quality of stream. Thus giving the user the flexibility to choose the quality of stream that can be received. SVC extension of the H.264/AVC standard has achieved significant improvements in coding efficiency with an increased degree of supported scalability relative to the scalable profiles of prior video coding standards. MPEG-4/AVC outperformed MPEG-2 in terms of throughput, packet delays, packet loss and jitter. Hence SVC can be used to optimally adapt video stream over heterogeneous networks.

3. RELATED WORK

Reference [1] analyzed various existing vertical handover decision mechanisms that aim at providing ubiquitous connectivity to the mobile users. This paper categorized the vertical handover measurement and decision schemes on the basis of their employed techniques and parameters. Also, presented a comprehensive summary of their advantages and drawbacks. [6] Showed the streaming of scalable video streams from a server to a client and the in-network adaption of the video at the Wi-Fi router. The core element of the demonstration is the H.264/SVC adaptation proxy that runs on the Wi-Fi router. The proxy implementation is based on the RTSP/RTP protocol suite which is commonly used in unicast video streaming applications. By applying certain firewall rules on the router, each RTSP request of a client located in the LAN/WLAN for a media resource on the Internet is redirected to the adaptation proxy instead of being forwarded directly to the media server. The proxy itself connects to the actual media server and forwards the RTSP requests of the client and the corresponding RTP stream sent by the server.

Since the quality of video transmission over mobile worldwide interoperability for microwave access (WiMAX) network can be severely degraded due to the effect of fading and handoff [3] proposed a channel-adaptive video transmission method using H.264 scalable video coding (SVC) which not only dynamically extracts the layer of bit stream based on the available channel bandwidth (ACBW), but also minimizes the error propagation during handoff. Firstly, the ACBW and the handoff in the mobile WiMAX are estimated by analyzing channel parameters including the carrier to interference and noise ratio (CINR). Secondly, the streaming server extracts the next transmission layer according to the estimated ACBW to support the better quality and controls the smart frame skipping adaptively based on the handoff detection. [4] explains the basic concepts of SVC and proposes how scalable video coding can be obtained by leveraging on different features, like the image quality, the frame size, the frame rate or a combination thereof.SVC provides functionalities such as graceful degradation in lossy transmission environments as well as bit rate, format, and power adaptation. However, in order to optimally tailor scalable video content along the temporal, spatial, or perceptual quality axis, a metric is needed that reliably models subjective video quality. [5] Developed a novel full-reference quality metric for scalable video bit streams that are compliant with the H.264/AVC Scalable Video Coding (SVC) standard. These metrics include the temporal and spatial variance of the video content, the frame rate, the spatial resolution, and PSNR values.

4. AVC VERSUS SVC ENCODING

H.264/AVC is the most widely used video coding standards. It consists of two coordinated layers, the Video Coding Layer (VLC) and the Network Abstraction Layer (NAL). The former produces the coded representation of the video. The latter is responsible for the encoded video data in a convenient form for transmission. H.264/AVC exploits both block-based temporal and spatial prediction coding over groups of picture. Within each picture, group of pixels called Macro Blocks (MBs) are encoded using the aforementioned coding schemes. The standard specifies three main types of frames depending on the encoding process: I frames, P frames and B frames. The frames of a video sequence are usually arranged in a sequence form of ”IBBPBBPBBPBB”, known as a Group of Pictures (GOP). The encoded video is transformed to bit stream that is organized in NAL units and Access Units (AU). Each NAL Unit consists of a header and payload coded data. Each AU contains a number of NALs. NAL units are encapsulated in RTP packets in order to be transmitted over the Internet. IETF has specified the following mechanisms for the encapsulation of NAL units to RTP packets: Non- Fragmented NAL Units and Fragmented NAL Units.

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5. SEAMLESS MOBILITY BASED ON IEEE802.21

[7] In the vision of the 4G wireless communications, it is requisite to provide seamless mobility support across heterogeneous access networks using wireless technologies such as 802.11 (Wi-Fi), 802.16 (WiMax), CDMA, and wired access technologies like LAN, xDSL. Handover performance is a vital part in the end-to-end delay and packet loss control for the QoS provisioning of real time services in heterogeneous networks. When a handover process is initiated, the Mobile Node (MN) will acquire a new address, called Care-of-Address (CoA), and use Binding Update messages (BUs) to register the CoA with its Home Agent (HA) and Correspondent Node (CN) which will then communicate with the MN directly through the CoA. Handover

delay will occur due to the processes of neighbor network discovery, CoA configuration, mobility binding updates, and sometimes through the network-specific authentication and authorization.

The IEEE802.21 - Media Independent Handover (MIH) Service, which was formed in 2003 is a draft standard to enable handover and interoperability between heterogeneous networks including both 802 and non 802 networks. The main purpose of IEEE 802.21 is to enable handovers between heterogeneous technologies including IEEE 802 and cellular technologies without service interruption, hence improving the user experience of mobile terminals. Much functionality required to provide session continuity depend on complex interactions that are specific to each particular technology. IEEE 802.21 provides a framework that allows higher levels to interact with lower layers to provide session continuity without dealing with the specifics of each technology.

In the mobility management protocol stack of both mobile node and network element, the Media Independent Handover Function (MIHF) is logically defined as a shim layer between the L2 data link layer and L3 network layer. The upper layers are provided services by the MIH function through a unified interface. The services exposed by the unified interface are independent of access technologies. This unified interface is known as Service Access Point (SAP). The lower layer protocols communicate with the MIHF via media dependent SAP.

MIHF defines three main services that facilitate handovers between heterogeneous networks: Media Independent Event Service (MIES), Media Independent Command Service (MICS) and Media Independent Information Service (MIIS). Detailed discussions of each of the services are given below.

Media Independent Event Service

Media Independent Event Services (MIES) provide event reporting, event filtering and event classification corresponding to the dynamic changes in link characteristics, link quality and link status. The MIES report both local and remote events to the upper layers. The upper layers perform registration to receive events from the MIHF using a request/response primitive. Some of the events that have been specified by IEEE 802.21 are “Link Up”, “Link Down”, “Link Detect”,” “Link Parameter Reports” and “Link Going Down”.

Media Independent Command Service

Media Independent Command Service (MICS) use the MIHF primitives to send commands from higher layers to lower layers. The MICS command are utilized to determine the status of the connected links and also to execute mobile and connectivity decisions of the higher layers to the lower layers. MIH Commands are identified as either being local or remote. Local MIH commands flows from upper layers to the MIH function, and then to lower layers in the local stack. Remote commands, messages propagate from upper layer to the MIHF in one stack to the MIHF in a peer stack (with usage of the MIH protocol). Messages are further propagated to lower layer.

Media Independent Information Service

Media Independent Information Service (MIIS) provides a framework and mechanism for an MIHF entity to discover available neighboring network information within a geographical area to facilitate the handover process. The primary idea is for the MIIS to provide a set of information elements, the information structure and its representation and a query/response type mechanism for information transfer. Both static and dynamic information is provided by the MIIS. Examples of Static information would include the names and service providers of the mobile terminal’s exiting network neighborhood. Dynamic information would include link layer parameters such as channel information, MAC addresses, security make intelligent handover decision. The information could be made available through lower layers as well as higher layers. In cases where layer 2 information is not available or sufficient to make efficient handover decisions, then higher layer information services may be required. In order to represent the information across different technologies, the MIIS specifies a common way of representing this information by using a standardized format such as XML or ASN.1.

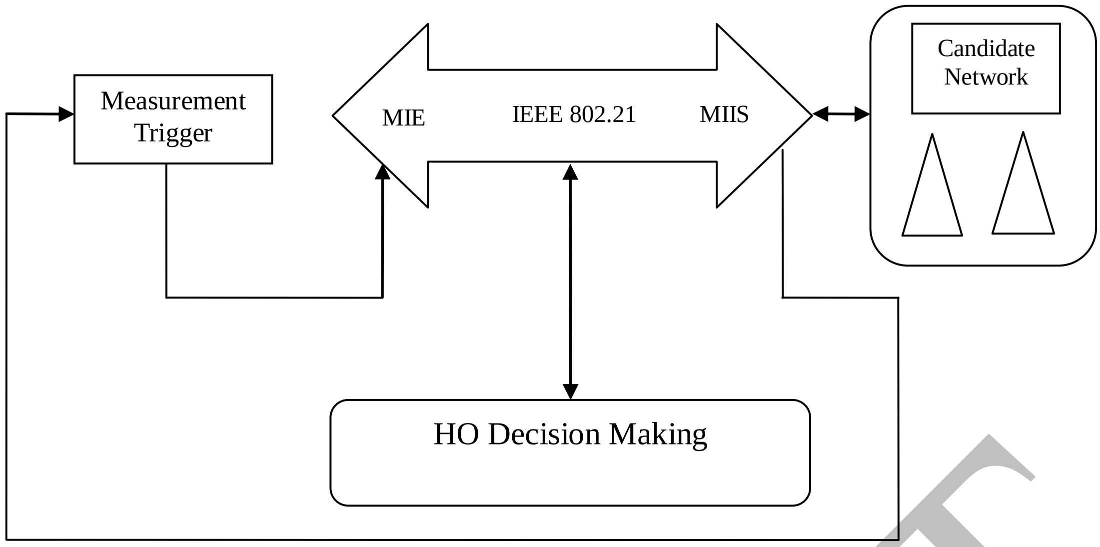

Fig.1 Overview of IEEE802.21 based Vertical Handover

According to MIH framework, a co-operative decision- making is defined, between MTs and wireless networks to optimize network selection, as illustrated in **Fig. 1.** The vertical handover is actually executed by Mobile IP. There is a synergy between IEEE 802.21 and any kind of IP mobility protocol (e.g., Mobile IP, Fast Mobile IP with handoffs, Proxy Mobile IP, etc) for maintaining QoE under varying physical and network conditions. In order to realize the co-operative decision making for vertical handover in IEEE 802.21, two functionalities are defined namely network selection and vertical handover. These functionalities are executed at the core network in order to control all neighboring access technologies. The former function is responsible for selecting the best candidate network for handover based on certain parameters (throughput, delay, jitter, packet loss) collected from the wireless network in the vicinity of the mobile terminal. The latter function is responsible for deciding and initiating the vertical handover.

5.1 Network Selection

Network selection decision is part of the handover execution process. The network selection decision may be invoked at the initiation of service connectivity or as part of the handover execution during the service call when the current RAN characteristics are worse than expected or degrade considerably, any of the other available RAN's characteristics improve, a new better RAN becomes available, the user changes their preferences or the service requirements, an imminent handover situation is predicted and triggered by any predictive algorithms running on the terminal. Network selection is to rank networks and find the best one, while VHO decision is to decide whether it is worth the handover to the best network or a network better than the current one.

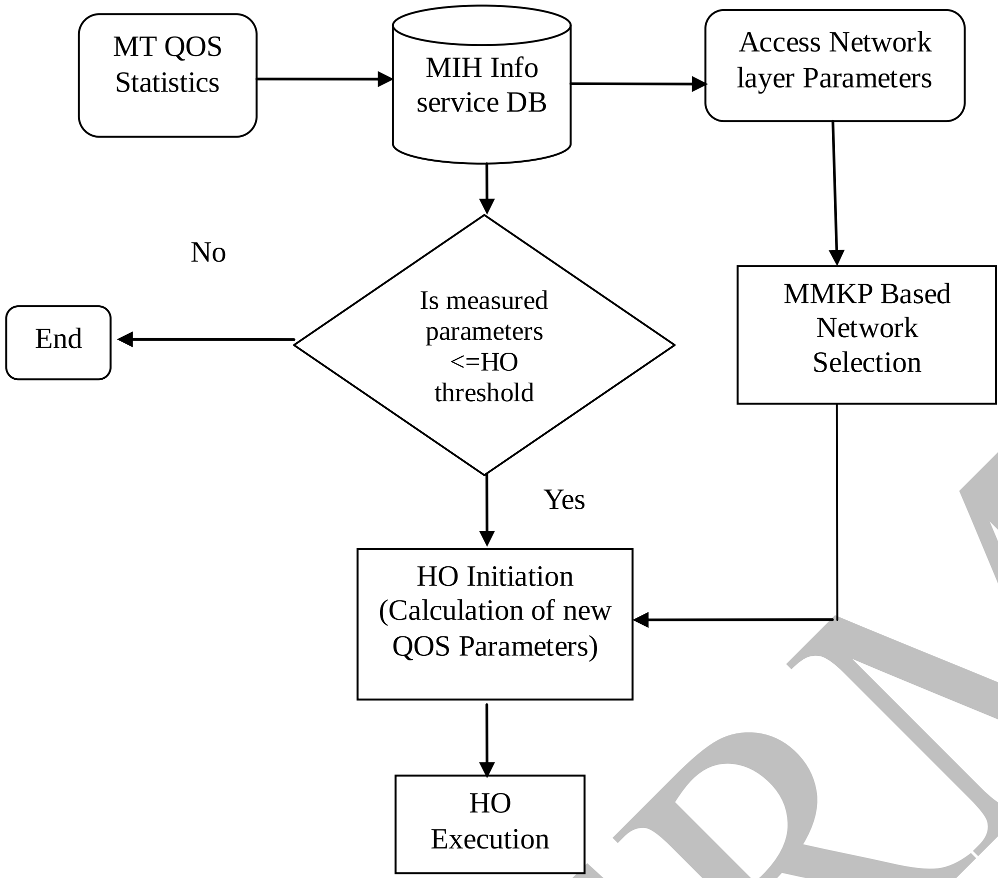

Fig. 2 Vertical handover and network selection functionalities

Fig. 2 illustrates the states of initiation and execution of a vertical handover according to the vertical handover function.[8] The vertical handover function is responsible for deciding whether a handover is needed based on physical, network and application layer statistics ,collected from both the mobile terminal and the access networks. Within the context of MIH, handover policy consists of three phases.

Decision phase–the collected information from MT (PSNR, packet loss, delay, bit rate) and access networks(e.g., network load ,packet loss) are stored in the MIH database in order to be retrieved by the handover decision algorithm.

Initiation phase–the collected parameters are evaluated and compared against a set of predetermined threshold values. During this phase, the MMKP based network selection function, running independently, informs the vertical handover about the best candidate network and its corresponding network and physical layer statistics.

Execution phase–the MIH triggers the IP Mobility platform (e.g., MobileIP) which is responsible for performing the actual handover and bidding with the new point of attachment, ensuring seamless service continuity.

5.1.1 problem formulation

We formulate our problem of performing vertical handover while streaming SVC over wireless networks by indicating a MMKP based approach for network selection which uses Branch and Bound technique. We devise our own heuristic to solve the above mentioned MMKP based video streaming procedure. A

H.264/SVC video stream may be represented using an essential base layer (also called the main profile) and one or more optional enhancement layers (called scalability profiles). The base layer constructs the coarse or base representation of the stream, and the enhancement layers successively improve it.

Formally, MMKP is expressed as follows :(specified in equations 1 through 4)

$V_{max}=$ Maximize,

$$\sum_{i=1}^{n}\sum_{j=1}^{l_i} x_{ij} v_{ij} \quad ;i=1,2,......n;\ j=1,2,.....l_i \qquad (1)$$

Such that,

$$\sum_{i=1}^{n}\sum_{j=1}^{l_i} x_{ij} r_{ijk} \le R_k \quad ;k=1,2,......m. \qquad (2)$$

$$\sum_{i=1}^{n} x_{ij}=1 \qquad (3)$$

$$x_{ij} \in \{0,1\} \qquad (4)$$

Let there be 'N' applications & 'M' networks. The objective is to find the best way of allocating applications into networks in order to maximize the user utility (i.e.,) maximizing the whole system capacity.

$$\text{Max } U = \sum_{k=1}^{N}\sum_{i=1}^{M} x_{ki} z_{ki}, \quad k=1......N, \quad i=1......M$$

such that

$$\sum c_{ki} z_{ki} \le c_i, \quad i=1......M, \quad k=1.......N$$

$$\sum_{k=1}^{N}\sum_{i=1}^{M} z_{ki}=1$$

$$z_{ki} \in \{0,1\}$$

Symbol	Description
U	User utility
x_{ki}	Utility of applications 'k' being placed in network 'i'
z_{ki}	Binary variable represents the placement of applications 'k' in network 'i'
c_i	Capacity of the network 'i' and it is a function of QOS attributes f(1/D,1/J,PSNR,B),where 'D' refers to delay, 'J' refers to Jitter,' PSNR' refers to Peak Signal to Noise Ratio and 'B' is the bit rate.

Table 1: Table of Symbols

6. HEURISTIC FOR BBMVHO OVER WIRELESS NETWORKS

In this section, we present our main contribution, BBMVHO (Branch and Bound based MMKP Vertical Handover), a new heuristic for vertical handover in heterogeneous wireless networks. The Pseudo code for the heuristic is presented in Table 2.

Branch and bound is based on the construction of a 'state space tree'. A state space tree is a rooted tree where each level represents a choice in the solution space that depends on the level above and any possible solution is represented by some path starting out at the root and ending at a leaf. The root, by definition, has level zero and represents the state where no partial solution has been made. A leaf has no children and represents the state where all choices making up a solution have been made. In the context of the Knapsack problem, if there are N possible items to choose from, then the kth level represents the state where it has been decided which of the first k items have or have not been included in the knapsack. In this case, there are 2k nodes on the kth level and the state space tree's leaves are all on level N [9].

In the state space tree, a branch going to the left indicates the inclusion of the next item while a branch to the right indicates its exclusion. In each node of the state space tree, we record the following information:

level - indicates which level is the node at,

cumValue – the cumulative value of all items that have been selected on this branch,

cumWeight – the cumulative weight of all items that have been selected on this branch,

nodeBound – used as a key for the priority queue.

We compute the upper bound on the value of any subset by adding the cumulative value of the items already selected in the subset, v, and the product of the remaining capacity of the knapsack (Capacity minus the cumulative weight of the items already selected in the subset, w,) and the best per unit payoff among the remaining items, which is vi+1 / wi+1[9].

Upper Bound = v + (Capacity – w)*(vi+1 / wi+1) (5)

BBMVHO (Branch and Bound based MMKP Vertical Handover) defines configuration set 'l' of 'M' attributes and Step 2 is used to compute 'p[n]' matrix elements which satisfy the resource constraints 'b'. Initialize the root node and compute its upper bound using eqn (5),a branch going to the left indicates inclusion of root node while a branch to the right indicates exclusion of root node. Then select the next item from p[n] and compute its bound. Continue to iterate this procedure until all items of p[n] added to the space tree. The path form the leaf node to the root contains the resultant set(rs).Compute the maximun value from the resultant set which returns the optimum value of the MMKP instance.

Table2: Pseudo code for BBMVHO

Procedure 1: BBMVHO
I/p: 'l' configuration sets of size 'M' I,e network's attributes , 'b', a set of vector resource constraints .
O/p: 'result', highest value of MMKP instance
for all k=1 to N
//read the resource constraints b from MIH DB store
rs=B&B(b)
result=max(rs)
end
Procedure 2: BBMVHO algorithm to compute best candidate network B&B(b)
I/p: 'b', a set of vector resource constraints, 'p[n]', a set of all attributes obtained from MIH DB store which do not violate the resource constraints.
O/p: result set 'rs', a minimized, combined configuration set with only feasible configurations.

```
    1. Initialize a result set (rs) = φ
//Read the inputs of configuration set p[n]
    2. Compute p[n] for all l<=b
    3. Procedure B&B(b)
begin
   X: node pointer;
   X:= new(node); // this is the root node which is the dummy start node
   H: heap;             // A heap for all the live nodes. It's a max-heap (i,e)
network with            maximum capacity Ci.

  while (true) do
    if (X is a final leaf) then X is an optimal solution. print out the path from X to the
root;
      return rs;
    endif
    Expand(X);
    if (H is empty) then
          report that there is no solution;
          return ;
    endif
  endwhile
end

Procedure Expand(X)
begin
 - Generate all the children of X;
 - Compute the approximate cost value CC of each child;
 - Insert each child into the heap H;
end
```

Computation Complexity: Given 'n' items, the overall complexity of BBMVHO is O(log n) .

Proof: In the worst case, the branch and bound algorithm will generate all intermediate stages and all leaves. Therefore, the tree will be complete and will have 2n-1 – 1 nodes, i.e. will have an exponential complexity. However, it is still better than the brute force algorithm because on average it will not generate all possible nodes (solutions). The required memory depends on the length level of the tree.

7. VERTICAL HANDOVER

This paper focuses on multimedia streaming over heterogeneous network which consists of Wi-Fi and WIMAX technologies .It support the continuous provisioning of multimedia flows i.e., service continuity during handoffs when a wireless device disconnects from one network and re-connects to a new one . In particular vertical handoff situations that occur when mobile devices dynamically change not only their access points but also the wireless access technology/infrastructure they are using, e.g., from Wi-Fi to WiMAX possibly requiring dynamic content adaptation.

In order to facilitate streaming as smooth as possible while the user roams through different networks, Scalable Video Coding (SVC) is used. Use of SVC enable video streaming with packet losses as high as 20%.Traditional video streaming using AVC can tolerate 2 to 3% of packet loss .This difference is very significant because due to handover latency packet loss may occur, SVC provides better QOE to user even in the presence of packet loss. The QOE of user is examined by computing PSNR value.

7.1 Simulation Framework

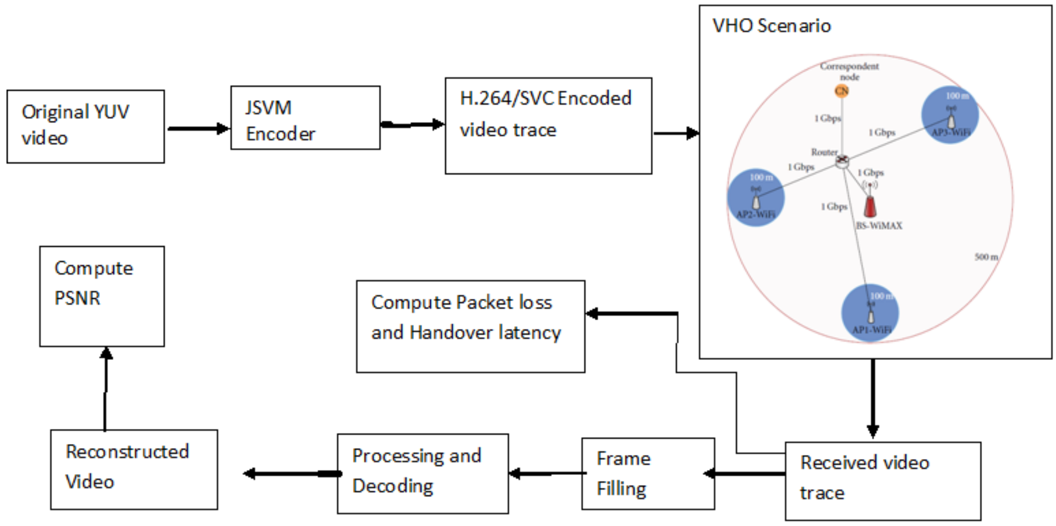

Fig. 3 SSVHO Architecture

In Fig. 3 SSVHO (Scalable Video Coding Streaming Vertical Handover)architecture, the JSVM encoder encodes the raw video file into SVC bit streams .The bit-stream extractor can be used to extract sub-streams of an SVC stream .The sub-streams represent streams with a reduced spatial and/or temporal resolution and/or a reduced bit-rate. Nomadic user in heterogeneous network stream the video trace file ,if required vertical handover can be performed to improve the QOE during streaming process .To examine the QOE of user PSNR can be computed .In order to compute the PSNR value ,the same number of frames with the original raw video is needed. Therefore, frame filler is used.

7.1.1 VHO scenario

Handover happens when the mobile device is in movement and detects that it is losing coverage, so it needs to "jump" to another network. When the Handover is within the same technology, for example, between Wi-Fi cells, it is called a horizontal Handover. If it is executed between different technologies, for example, WiMAX to Wi-Fi, then it is called vertical Handover.

VHO scenario (Pseudo code)

1) MIHF:
IF(message_ type==”GET _STATUS request”)
Do
//Search for available interfaces in MIH information service and respond to MIH user with the best candidate network selected using MMKP.

2) Agent:
//send RS (Router Solicitation) message to Agent of connected interface (WiMAX) .Upon receiving the RA(Router Advertisement) configure the layer 3 details.

3) CN (Correspondent node) starts to send SVC (video trace file) traffic to the MN. Traffic is received through WiMAX interface.

4) Whenever MN encounters a better network during its mobility, it is connected to that interface (vertical handover) and using RS/RA, layer 3 details can be reconfigured to new interface (Wi-Fi)

5) CN redirects the CBR traffic to new interface.

6) When there is no Wi-Fi coverage, the MIH user now switch to WiMAX network as this connection is available and SVC traffic (video trace file) can be redirected via WiMAX with the help of CN.

8. PERFORMANCE EVALUATION AND DISCUSSION

Fig.4 showing SVC's resilience to packet loss illustrates that as the signal degrades and packet loss increases, the video quality or peak signal to noise ratio (PSNR) does not significantly fall, in comparison to the regular H.264 transmission.

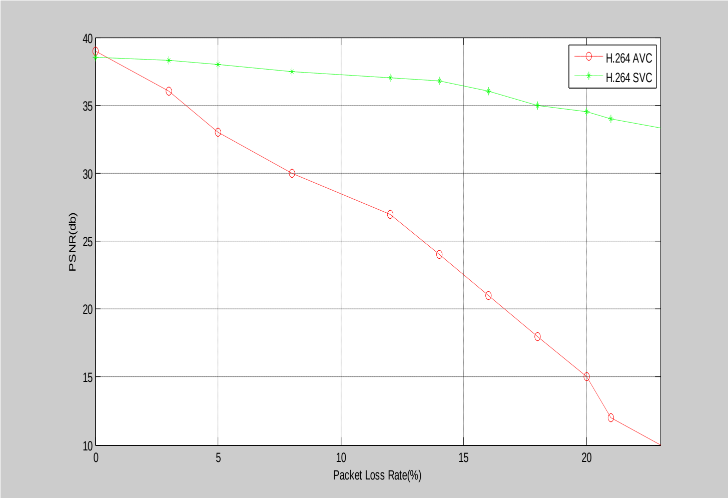

Fig. 4 Graph showing SVC's resilience to packet loss

9. CONCLUSION & FUTURE WORK

Though there are numerous research efforts in adapting streaming media according to the network characteristics and end-user equipment, seamless transfer of the on-going session as the client wanders through heterogeneous networks is a challenging process .The video was encoded using Scalable Video Coding (SVC) and streamed through heterogeneous networks (Wi-Fi and WiMAX) whose performance is evaluated using metric like PSNR and proved to be better than the AVC standard.In this paper we proposed a mechanism for radio access network selection based on Multidimensional Multiple choice knapsack problem (MMKP).We also devised our own heuristic to solve the network selection problem during vertical handover. We proved that the runtime complexity of our heuristic is O(log n).

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