A Context-Aware Streaming Agent Method for Optimal Seamless Service in a Vertical Handover Environment

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Abstract. We propose a novel context-aware streaming agent to achieve optimal high quality seamless streaming service in heterogeneous wireless networks and mobile terminals and to utilize high WLAN bandwidth in mobile phones. The major difference between our proposed method and existing methods is the use of mobile terminal oriented context-aware streaming adaptation. We outline a streaming network architecture among the streaming server, gateway, and mobile terminal, an extended RTSP protocol and a streaming quality level selection algorithm in the mobile terminal. We consider vertical handover between HSDPA and 802.11g/n and take advantage of H.264 Scalable Video Coding (SVC). Our new method makes optimal seamless streaming service possible for various network situations, terminal capabilities, and user preferences. Streaming agents first determine adequate quality level based on user preference, terminal constraints, dynamic network conditions and battery status. Then a gateway requests an adequate SVC layer to be sent to the server based on the agent's requested quality level. Agent and gateway communicate using an extended RTSP protocol which enables content quality modification during streaming. Our novel streaming agent method improves user satisfaction. By selecting an "optimal network condition" policy, we can improve content and maximize the potential of the 3.28 SVC layer. By minimizing power consumption, we can reduce power consumption by 13% by processing a different SVC layer.

Keywords: Streaming agent, Seamless streaming service, Heterogeneous wireless networks, Mobile phones.

1 Introduction

Recently produced mobile terminal equipped 3G and WLAN modules simultaneously and LCD more then WVGA size and codec which decoding capability

* This research was supported by the MKE(The Ministry of Knowledge Economy), Korea, under the ITRC(Information Technology Research Center) support program supervised by the NIPA(National IT Industry Promotion Agency) (NIPA-2010-(C1090-1021-0009)).

T.-h. Kim et al. (Eds.): FGIT 2010, LNCS 6485, pp. 719–726, 2010.

more then H.264 Main Profile. Some products can encode HD 720p. We focused on improving streaming service in enhanced wireless networks and mobile terminals. This paper describes a novel context-aware streaming agent that uses a streaming network, extended RTSP protocol, and a streaming agent in its mobile terminal. We utilize QoS and mobility for vertical handover and H.264 SVC.

2 Related Studies

This paper considers vertical handovers, end-to-end QoS[4], H.264 SVC codec[5], multimedia protocols (RTSP, RTP, and SDP), streaming servers, gateways, agents and, terminal capability. Adaptive streaming, and streaming using H.264 SVC, are areas of active research. MPEG-21 DIA and JVT's H.264 SVC are already standardized, and release 6 of the 3rd Generation Partnership Project (3GPP) added adaptive streaming in PPS (Packet-Switched Streaming). Streaming adaptation in MPEG-21 DIA [6], 3GPP PSS and H.264 SVC are based on client feedback. With these approaches, quality is initially fixed and it is impossible to dynamically change content quality factors such as frame rate and resolution. 3GPP PSS adaptation techniques [2] employ bit-stream thinning and switching, meaning that only frame rate change is possible. In this paper, we create an agent in a mobile terminal that can adapt content quality and select access networks for maximum user satisfaction.

3 Context-Aware Streaming Agent

This paper references established standards and on-going standardization efforts. We exclude detailed discussion of QoS and mobility in vertical handovers and quality evaluations of the proposed method. We focus on streaming agents, network entity, protocol and use-case.

3.1 Streaming Network

We propose a streaming network using H.264 SVC. Fig 1 depicts the streaming server, streaming gateway, and mobile terminal.

streaming server has H.264 SVC encoded contents. Each dataset is input in two files. One is encoded with a scalable baseline profile for mobile environments, and the other is encoded with a scalable high profile for high quality content. Each encoded H.264 SVC file has three layers. The Base Layer is for horizontal/vertical handover in poor transmission conditions. Enhanced Layer 1 is used under most conditions. Enhanced Layer 2 is used under particularly good transmission conditions. The scalable baseline profile uses only temporal scalability in a mobile environment. It requires more decoding power and is easy to adapt in mobile environments. The scalable high profile uses spatial scalability in this context. Additional temporal/SNR scalability can be used. The two profiles have a total of six quality levels [Table 1].

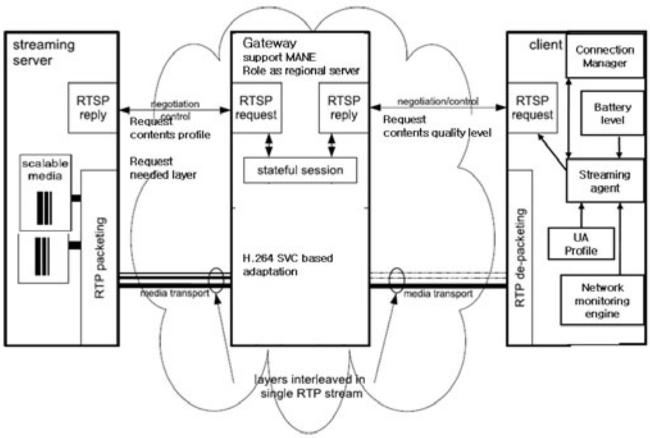

Fig. 1. Streaming network model

Table 1. Sample content format stored in the streaming server

Content Profile	Scalable Baseline Profile			Scalable High Profile		
Layer	BL	EL1	EL2	BL	EL1	EL2
Resolution	240p	240p	240p	480p	720p	1080p
Frame /second	10	20	30	30	30	30
Bitrates (bps)	180 - 250K	250 - 512K	512 - 800K	1 - 1.5M	2 - 3M	4 - 6M
Quality level	0	1	2	3	4	5

Content type does not depend on whether HSDPA or WLAN accesses the network. The mobile terminal's role is to select an appropriate quality level, while the server's and gateway's role is to send contents or layer to the mobile terminal. The server can send only enough layers of content to avoid IP backbone network traffic congestion for the uni-cast stream, and sends a whole stream of appropriate profile contents to the gateway for multi-cast and broadcast streams to support heterogeneous networks and devices. The streaming gateway [1] is located between the access core network and the IP backbone network. The access core network manages 3G and WLAN access networks simultaneously. It also should support Media Aware Network Elements (MANE) and truncate the SVC stream, which is received from the server, up to the needed layer depending on the access network's bandwidth and mobile terminal's request. The gateway should also support the assembly of multiple RTP streams from the server to a single RTP stream for the terminal because wireless environments have bandwidth constraints. Only needed layers are assembled and sent to the terminal.

A streaming agent sends the terminal's UA Profile and selected quality level to the gateway at first negotiation. The gateway requests and negotiates with the server depending on the terminal's request. During the horizontal/vertical handover, signal quality and battery status change, and the agent determines the best quality level based on user policy and terminal constraints, then sends the selected quality level to the gateway. When the terminal moves from 3G to WLAN, signal quality is improved, and the agent requests increased content quality. When the battery level is low, the agent requests a decreased content quality level for more battery time. Changing the quality level is limited by user policy, codec and LCD constraints.

3.2 Extended RTSP Protocol

To support the terminal agent, the RTSP protocol between the terminal and gateway and between the gateway and server must be changed. Extending the RTSP based on 3GPP PSS [3] is for dynamic contents quality change to support agent's request. The extended RTSP protocol is applied to the terminal and gateway. This paper describes an extended RTSP protocol between the terminal and gateway but can also be applied between the gateway and server.

The existing RTSP is modified in the DESCRIBE command and the response to the support agent request in the first negotiation.

1) c→s DESCRIBE : Send UA Profile to gateway with additional terminal information and selected contents.
2) s→c Reply of DESCRIBE : Gateway sends SDP to terminal. SDP contains gateway (or server) supported content quality level. In this method, the gateway can decrease the quality level by monitoring the network.

Next, RTSP is extended to support the dynamic content quality level issued by the terminal when adding the QoS_CHANGE command. Gateway and terminal can be issued at anytime during the streaming.

1) c→s / s→c QoS_CHANGE : Terminal requests a new content quality level to reflect the wireless access network's signal status and battery status.
2) s→c / c→s Reply of QoS_CHANGE : Gateway can accept by sending "OK" or sending supportable contents to the server or gateway.

3.3 Context-Aware Streaming Agent

The streaming agent selects the optimal quality level based on the constraints of the twork and terminal. [Table 2] lists constraints. The agent has information about user preference and terminal constraints. Information on network status and battery level is available from the connection manager and the power manager. The agent is able to change the streaming content's quality level dynamically during streaming service. Figure 2 shows how to select quality level.

Table 2. Constraint items of streaming service

Terminal Constraints and User Policy (Fixed Constraints)	Constraint of Air Conditions and Battery (Dynamic Constraints)
User policy for vertical handover	Vertical handover case
Maximum supported H.264 SVC codec	Horizontal handover case
LCD resolution	Good signal quality
User policy for battery and network throughput	High signal quality
	Battery status

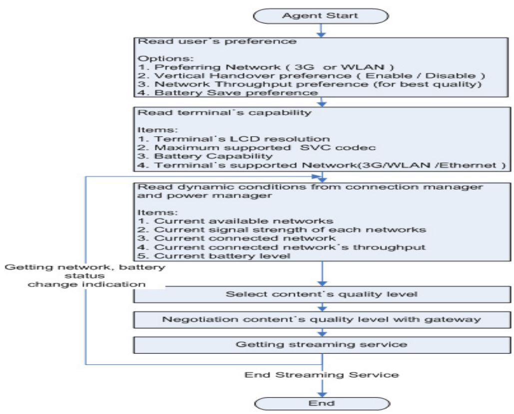

Fig. 2. Quality level selection process

The streaming agent selects quality level based on user preference. There are four options.

1) Preferred Network
   Select a user's preferred network. The selection of the initial network connection for streaming service is related to network cost.
2) Vertical Handover Preference
   By enabling this option, a user can obtain quality service from various networks during vertical handover.
3) Network Throughput Preference
   User obtains maximum quality with maximum throughput. Battery consumption will increase.
4) Battery Save Preference
   Power is saved at the cost of quality.

4 Experimental Results and Discussion

In this experiment, we obtained data by testing Palma-CE1-Conditions using SVC reference software [7]. This software extracts the SVC layer using bitrates at various levels of video resolution and frame rate. We identified seven layers as listed in Table 3 by layer number, video resolution and frame rates. CIF 15fps and 4CIF 30fps have bitrates with different SNR scalability to compensate for bitrate gaps between layers. Layer 0 is QCIF 15fps at a maximum of 128Kbps. 128Kbps is guaranteed in most 3G services by APN for streaming service QoS. From layer 0 to layer 3, we assume that each layer is a layer of the SVC file encoded with a Scalable Base Profile. From layer 4 to layer 6, we assume that each is a layer of the SVC file encoded with a Scalable High Profile. Layer 0 and layer 4 are the base layers of each SVC file and are compatible with H.264 AVC. Table 3 also shows the content quality ratio and decoding power consumption ratio. These two factors are assumed to measure content quality and decode power consumption. They are relative values compared with layer 6 (4CIF, 60fps, 2018Kbps). Table 4 lists testing terminals. Fig 3 shows available bandwidth variation in the test case. At the 50 minute point, the line is split into two lines. The upper line is for WLAN after vertical handover. The lower line is for 3G without vertical handover to WLAN.

Table 3. Conditions for each layer

Layer (Quality Level)	Resolution	Frame Rate (fps)	Bitrates (Kbps)	Contents Quality Ratio	Decoding Power Consumption Ratio
0	QCIF	15	128	10%	10%
1	CIF	15	256	20%	20%
2	CIF	15	384	30%	30%
3	CIF	30	512	50%	50%
4	4CIF	30	1024	70%	70%
5	4CIF	30	1536	80%	80%
6	4CIF	60	2018	100%	100%

Table 4. Test terminals

Layer (Quality Level)	Resol-ution	Frame Rate (fps)	Bitrates (Kbps)	Contents Quality Ratio	Decoding Power Consumption Ratio
A0	CIF	CIF30	X	-	X
B0	4CIF	4CIF60	X	-	X
C0	4CIF	4CIF60	X	-	X
A1	CIF	CIF30	O	Network	O
B1	4CIF	4CIF60	O	Network	O
A2	CIF	CIF30	O	Battery	O
B2	4CIF	4CIF60	O	Battery	O

By using a PC simulation program that implements streaming agent methods, we obtain the selected quality level. Table 4 and Table 5 show test results.

In Table 5, A0, A1, A2 can obtain CIF 30fps content. The streaming agent with A1 and A2 installed obtained 2.51 more layers than an agent with only A0 installed. B0 and B1 provide enough terminal capability to obtain 4CIF 60fps

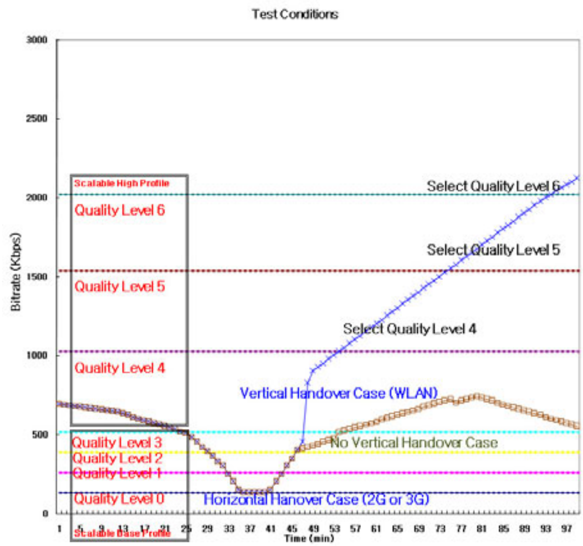

Fig. 3. Test scenario: variation of available bandwidth

Table 5. Test Result I

Section	1	2	3	4	5	6	7	8	9	10
Time (min)	1-25	26-33	31-44	34-44	45	46-48	49-54	55-75	76-94	95-100
Duration	25	5	3	11	1	3	6	21	19	6
3G only case	3	2	1	0	1	2	2	3	3	3
3G/ WLAN handover case	3	2	1	0	1	2	3	4	5	6
Selected Contents Layer										
A0	0	0	0	0	0	0	0	0	0	0
B0	0	0	0	0	0	0	0	0	0	0
C0	3	0	0	0	0	0	3	3	3	3
A1	3	2	1	0	1	2	3	3	3	3
B1	3	2	1	0	1	2	3	4	5	6
A2	3	2	1	0	1	2	3	3	3	3
B2	3	2	1	0	1	2	3	3	4	4

Table 6. Test Result II

	LCD Resolution	Supported Codec	Agent installed	Agent's policy	Vertical Handover Support
A0	CIF	CIF30	X	-	X
B0	4CIF	4CIF60	X	-	X
C0	4CIF	4CIF60	X	-	X
A1	CIF	CIF30	O	Network	O
B1	4CIF	4CIF60	O	Network	O
A2	CIF	CIF30	O	Battery	O
B2	4CIF	4CIF60	O	Battery	O

contents. B0 does not support vertical handover, and is not an installed agent. B0 only receives the contents of layer 0, which is streamed as H.264 AVC in the 3G network. B1 fully utilizes the available network bandwidth by moving to the WLAN network and receives a 3.28 average SVC layer. B1 and B1 have an agent, but B1's agent policy is "Network Throughput Preference," and B2's agent policy is "Battery Save Preference." Therefore, B1 receives 0.77 average SVC layer more than B2. But B2 saves 13% more battery power then B1. These results show that by using a streaming agent method, users receive higher quality streaming in a vertical handover environment. Power consumption can also be reduced.

5 Conclusions

This paper proposes a context-aware streaming agent to produce seamless streaming service with optimal quality based on network and terminal capability. Experimental results show the streaming agent improves user satisfaction. By selecting "optimal network conditions", we maximize the 3.28 SVC layer. By selecting "optimal battery condition" policy, we reduce power consumption by 13%. In future work, implementation of a real streaming server, gateway and terminal with the proposed method will be completed along with content quality evaluation, objective measurement of user satisfaction and network performance testing.

References

1. Kuschnig, R., Kofler, I., Ransburg, M., Hellwagner, H.: Design options and comparison of in-network H.264/SVC adaptation. Journal of Visual Communication and Image Representation 19(8), 529–542 (2008)
2. Schierl, T., Wiegand, T., Kampmann, M.: 3GPP Compliant Adaptive Wireless Video Streaming Using H.264/AVC. In: Proc. IEEE International Conference on Image Processing, September 2005, pp. 696–699 (2005)
3. Frojdh, P., Horn, U., Kampmann, M., Nohlgren, A., Westerlund, M.: Adaptive Streaming within the 3GPP Packet-Switched Streaming Service. IEEE Network 20(2), 34–40 (2006)
4. Wu, D., et al.: Streaming Video over the Internet: Approaches and Directions. IEEE Trans. Circuits Sys. Video Tech. 11(3), 282–300 (2001)
5. Horn, U., et al.: Robust Internet Video Transmission Based on Scalable Coding and Unequal Error Protection. Image Commun., Special Issue on Real-time Video over the Internet 15(1), 77–94 (1999)
6. ISO/IEC 21000-7:2004, Information Technology - Multimedia Framework (MPEG-21) - Part 7: Digital Item Adaptation (2004)
7. Reichel, J., Schwarz, H., Wien, M.: Joint Scalable Video Model. JSVM-6. ISO/IEC JTC 1/SC 29/WG 11 (April 2006)