Network Condition Adaptive Real-time Streaming of an Intelligent Ubiquitous Middleware for U-city

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Abstract

In U-city(Ubiquitous City) environment, many types of real-time video data can be implemented in varied cases. For instance, the mobile user device can be in difficult environment to communication. When real-time streaming, it is necessary to ensure stable streaming and minimizing data loss rate. Unbreakable real-time video streaming is need to escape these environment or save distressed people. It needs that network adaptive real-time streaming to ensure real time streaming. In most case real-time streaming is more sensitive to delay between each frame, rather than quality of one frame. It can ensure real-time video streaming and scalability of transmission by control variable quantization parameter. In this paper, we describe and suggest continuity real-time streaming technique that adaptive to network condition for U-city environment. And it can support varied user device in intelligent ubiquitous middleware Smart UM. And it also can ensure continuity of real-time video streaming. The adaptive streaming system can also applied to varied many other systems.

1. Introduction

The U-City(Ubiquitous City) that our society aimed, needs new technique of acquisition varied video data and managing efficiently for real-time streaming. In media data, especially video data is very large and complexity. Moreover it requires a lot of technical support. In the U-city, there will be need efficient techniques of processing video data. And also need efficient transmission technique of real-time video streaming in many situations of our life. These situations may be a calamity of human structures or natural disaster or many other accident of human life. In order to adapt for varied situations we need integrated management system about real-time video data for adaptive streaming.

In most case real-time streaming is more sensitive to delay between each frame, rather than quality of one frame. At real-time streaming delay can cause very critical problem. And it is necessary to ensure stable streaming and minimizing data loss rate. Furthermore, It is necessary that supporting stable network bandwidth for stable real-time video data streaming in wired and wireless network environment. Varied network in U-city is change dynamic due to many reasons.

For example, suppose that user device place in not good situation to communicate with others because there may be poor environment. This may be user device placed in elevator or some kind of location which does not affect communication signal. And it may be a situation to secure distressed people with a camera attached mobile equipment of rescue party. Rescue party's mobile camera equipments send and receive video data. And secure distressed people successful by using these real-time media data streaming.

Since user device placed in any situation, it is necessary and big issue that minimizing data loss. And less-break off relay streaming data is also important in this situation that need real-time video streaming. To possible less breakable and low delay real-time streaming, it needs adaptive real-time streaming by network condition. We can ensure real-time video streaming and scalability of transmission by control variable quantization parameter. And it can also minimize delay of real-time streaming.

In This paper, we suggest an architecture and implementation of adaptive real-time video streaming system that compatible with the intelligent ubiquitous middleware by using H.263 codec. It can support varied user device in intelligent ubiquitous middleware Smart UM[1]. And also we are insistence that adaptive real-time video streaming system can ensure scalability in many network environment. We focused on guarantee of software QoS and take a side view of software.

The outline of the paper is organized as follows, In section 2, we introduce the design of the intelligent ubiquitous middleware which is composed of the four layers. And section 3 describes the quality of scalability in video systems. The architecture of the network condition adaptive real-time streaming is discussed in section 4. Section 5 shows implementation. And section 6 analysis the benefit and availability of our system. Finally, section 7 gives conclusions and explains future works.

2. Intelligent Ubiquitous middleware

Ubiquitous computing plays as a fundamental technology for U-city which provides various integrated services for intelligent city. In u-cities, critical decisions should be made in a timely manner by the efficient cooperation among single individuals or groups or by the real time computation of data relevant to the decision. A key piece to realize U-city is middleware. However, still, we cannot find any ubiquitous middleware which properly and efficiently supports the coordination and real time computation to meet the critical situation in a flexible and timely manner. Thus we developed an intelligent ubiquitous middleware as figure 1.

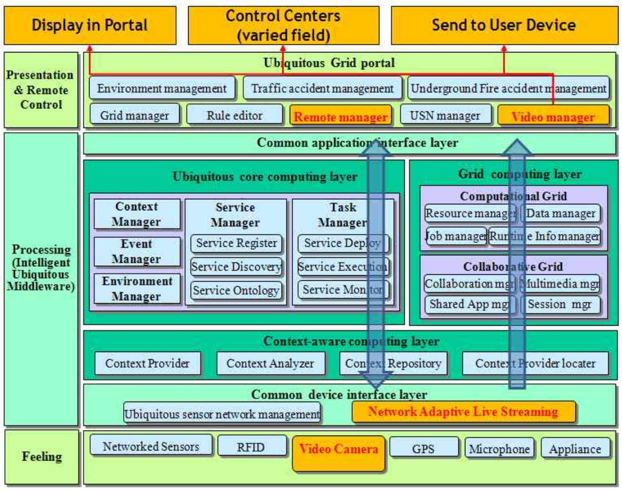

Fig. 1 Intelligence ubiquitous middleware : SmartUM

SmartUM[1] has four layers which support the unified intelligent ubiquitous computing : Common Application Interface Layer, Ubiquitous Core Computing Layer, Context-Aware Computing Layer and Common Device Interface Layer. It has multi-layered architecture which provides modularity and expansibility, reduces complexity and increases reusability of each component.

SmartUM, uses ontology-based techniques which provides context-aware information. It's key feature lies in its ability to define the context based on concept of specific domain ontology, interpret and aggregate the data through sensor network after context extraction and reason about various contexts. Through the reasoning process, high-level contexts can be derived from low-level ones. Context-aware computing layer is responsible for the management of context-aware information based on ontology technologies.

Ubiquitous Core Computing Layer performs intelligent services such as automatic service discovery, automatic service deployment and automatic service execution based on inferred contexts offered by Context-aware Computing Layer in order to provide an automatic computing environment and make applications or services used everywhere in a timely and cooperative way. It converges information from a variety of different devices and environments in order to provide predefined services in each application.

SmartUM gives a user-transparent infrastructure that generates and provides intelligent services, which are invisible to users, to various U-city applications. SmartUM can directly be connected to a ubiquitous portal which is easy-to-use, yet convenient user interfaces. Thus, it can be used in various kind of U-city applications and shorten the period and expense to develop the U-city applications.

SmartUM provides common device interface to feeling devices such as sensors, microphone and video cameras. We need a special streaming technology to process the multimedia data acquired by a number of camera array installed in multiple locations throughout the U-city. We have to solve the technical difficulties associated with the large scale multimedia data streaming in order to process them. This paper shows our solutions to overcome the technical difficulties at the middleware level.

Our solution focuses on improving the traditional media streaming system by streaming high capacity scalable real-time media and developing it into practical applications

3. Quality of scalability

One of the scalable codec H.264 SVC(Scalable Video Coding) is well known. This standard has been developed as network friendly. H.264 SVC encode video data by hierarchical layered coding. It derive multiple encoded video data which has different quality and peculiarity from one video source. So it can provide varied quality and size of video data. And it also provide a variety of multiple grade video properly due to requests of user. Scalability of video stream can offered by different method beyond H.264 SVC.

Examples of this method is CGS, MGS, FGS[2-7]. CGS(Coarse-Grain Scalability), in similarity to spatial scalability, uses different dependency layers with refinements. FGS(Fine-Grain Scalability) uses an advanced form of bitplane coding for encoding successive refinements of transform coefficients. MGS tackles a number of problems that are encountered for CGS, such as the limited number of rate points, and the lack of flexibility for bitstream adaptation. Generally in quality of scalability, bit stream compose base layer and enhancement layer. Base layer contain information of basic encoding data and basic data for minium quality. Enhancement layer contain additional information to improve video quality of base layer.

Nevertheless, H.264 SVC is required excessive hardware performance because it takes large amount of encoding operation. For this reason, H.264 SVC is irrelevant for real-time video streaming. Therefore, we show uncommon and efficient technique to using H.263 for real-time streaming.

4. System architecture

Network adaptive real-time video streaming system is possible that support varied condition of network by using quality scalability at the real-time streaming. The H.263 video data encoding step is like figure 2.

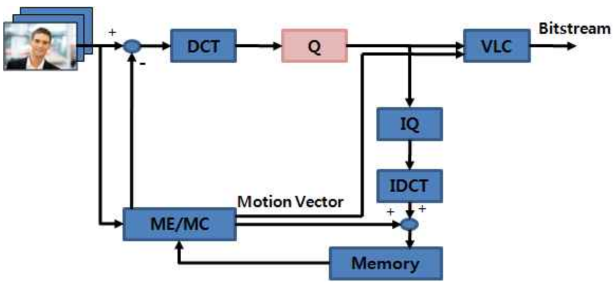

Fig. 2 Video encoding step

The quantization step Q is executed after DCT(Discrete Cosine Transform) step to remove high-frequency components that is less sensitive to human eyes. The quantization step performs a big role of compression to reduce data size and also involve quality. Therefore, it can offer a variety of video quality and capacity by changing the quantization parameter(QP) value according to pre-set network channel in several state. A compare of relationship among QP and quality and data size is shown at figure 3.

QP	Compression Rate	Data Size	Quality	Network Bandwidth
8	Low	Big	High	Good
10	↕	↕	↕	↕
12				
16	High	Small	Low	Bad

Fig. 3 Relationship among QP and quality and data size

It can control video data rate and size by changing QP value. And it can adapt varied network condition. Because We focus on continuous real-time streaming. Rate control cannot ensure continuation of real-time streaming depending on the status of network bandwidth. Even quality is reduced, Adaptive real-time video streaming system can ensure quality scalability and non-break off streaming. This technique is needed in order to support many of system that require real-time video.

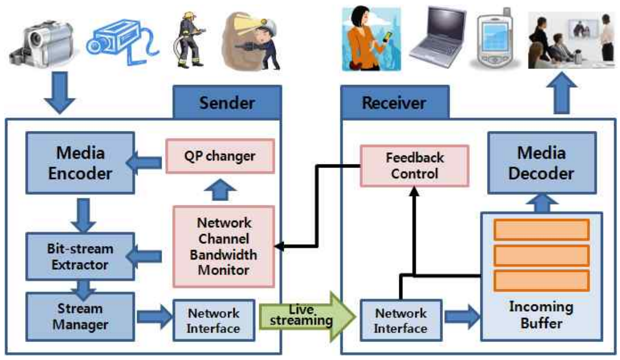

Fig. 4 System architecture

The system architecture is shown at figure 4. Sender does encoding video data by using own camera unit and transmit encoded data. And Network channel bandwidth monitor observe network channel condition continuously in the Smart ubiquitous middleware. This module grasps available bandwidth and communicates with QP changer module to control encoding rate of encoder by pre-determined QP value. And feedback control may help to grasp network channel condition. All of these components are compatible with intelligent ubiquitous middleware.

5. Implementation

We implement the network condition adaptive real-time video streaming system that compatible with intelligent ubiquitous middleware for U-city.

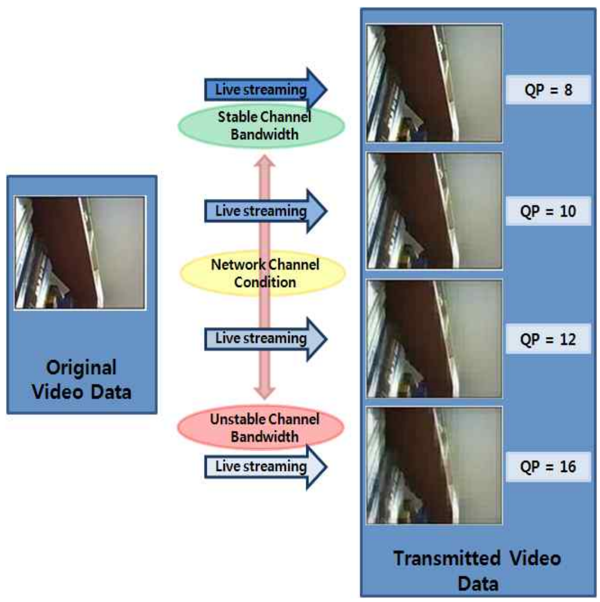

Fig. 5 Implementation of the network adaptive real-time video streaming system

Figure 5 shows an implementation of the network condition adaptive real-time video streaming system. Transmitted picture is a QCIF(176x144) size streaming data. This system has designed behavior at WLAN. In the near future, we have development plans about this system to support a variety of network interface channel. In the picture left side is original video data. It may be a sender device. The default QP is set to 8 at H.263 codec. If there are no excessive traffic at the network which contains the user device or if this network can provide quite stable bandwidth, then transmit the original data to receiver without change QP.

But if the network channel condition getting worse, then change the QP. This make discrimination of transport possible with variable encoding rate. Right side of figure 4 means transmitted data of receiver. We implement several grade QP value. Each QP value represents each transmission modes depending on the state of network. The QP value can be changed by purpose and network condition. It has different quality between QP value 8 and QP value 16. QP value 16 has more blocking condition in the picture because of higher encoding rate. But it has less data size than other one.

By default, the quantization process is loss compression step. Therefore, higher compression rate means low quality of video data. And low quality of video data has small data size. In addition, small data size needs a few network bandwidth to transmit video data. In other words if there are bad condition network and it provide only a few bandwidth, then the sender that video acquisition module improve QP value to increasing encoding rate.

And the transmission of real-time video data is maintained continuously without break off streaming. The data size of real-time video streaming is different according to what kind of current video data.

6. Analysis

In this section we discuss and analysis between Peak Signal to Noise Ratio(PSNR) and Bandwidth Requirement by changing quantization parameter(QP).

Description	Average PSNR(dB)	Bitrate(Kbit/s)	Compression Ratio
Miss America(QCIF), 30fps	-	9124	1:1
10fps, 20Kbps	38.51	22.81	133:1
10fps, 50Kbps	41.75	56.70	54:1
10fps, 100Kbps	43.98	112.09	27:1
10fps, 500Kbps	48.38	505.61	6:1
Description	**Average PSNR(dB)**	**Bitrate (Kbit/s)**	**Compression Ratio**
Carphone(QCIF), 30fps	–	9124	1:1
10fps, 20Kbps	29.79	21.83	139:1
10fps, 50Kbps	32.82	52.76	58:1
10fps, 100Kbps	36.0	105.47	29:1
10fps, 200Kbps	44.5	522.4	6:1

Fig. 6 Correlation between video quality and bit rate

Figure 6 shows correlation between video quality, bit rate and encoding rate. These examples are Miss-america and Carphone which is QCIF size video data. As shown in figure 3, when the network bandwidth is poor then the compression ratio set high and this video provide low PSNR. Conversely, when the network bandwidth quite good, the compression ratio is low and PSNR is more high.

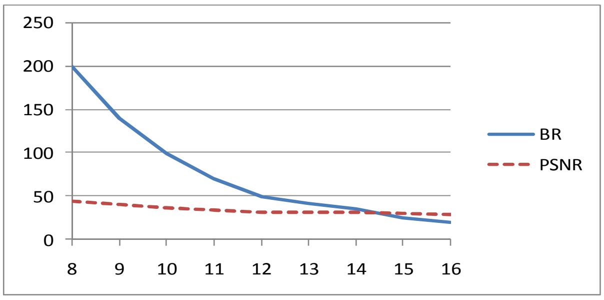

Fig. 7 Relation between PSNR and bandwidth requirement

Figure 7 shows the relation between PSNR and bandwidth requirement. BR means bandwidth requirement. It is dramatically reduce of bandwidth requirement that is depending on the value of increases QP. It means that compression ratio increase and also compressed data is much smaller than normal data that compressed by default QP as 8.

Nevertheless, It can be found that reduction of PSNR is not rapidly than reduction of BR. Reduce rate of PSNR is much more gradually. As a result, It is increasing block-phenomenon but it is not difficult to recognize object in screen. The significance of this graph is that it is acceptable loss of video quality by increasing of compression ratio for reduce frame delay. The point is that delay of between frames is more sensitive than quality of each frame at real-time streaming. Therefore, It can be guaranteed Low-delay streaming regardless a little loss of video quality at which network bandwidth is poor. This low-delay real-time streaming can be applied to emergency rescue system such as inform the emergency escape path to user device that we mentioned before.

7. Conclusion and future work

When real-time video streaming, it is necessary to ensure stable streaming and minimizing data loss rate. In the U-city environment, there are varied network device and condition. Therefore, we need integrated management system of real-time video data for adaptive streaming to support various user devices. The SmartUM with network adaptive real-time streaming can be a solution of integrated management system for U-city.

In this paper, we suggest network condition adaptive real-time video streaming system that compatible with intelligent ubiquitous middleware for U-city. We are implement the system and measure that the correlation between video quality and require bandwidth. Our proposed model can save system and network resources through studies on scalable video coding techniques.

The increasing of compression rate ensures less requirement of bandwidth. It means that low delay real-time streaming is possible at poor network environment with low bandwidth. And the reduce rate of PSNR is much more gradually and reasonable. It guarantees QoS of video data and scalability as a side view of software by control quantization parameter. And it also ensures continuity of real-time video streaming. The adaptive streaming system can also applied to varied many other systems.

We believe that our model provides the optimal video transmission technique for the next generation network convergence environment in which mobile devices have multiple network interfaces. And it can be also applied many other systems.

As a future work, it is necessary to study of reduce hardware limitation of H.264 SVC for advance real-time video streaming to grantee more multifarious scalability. And it can support better quality video streaming and it can also apply multi-path streaming to improve error resilience by using SVC.

8. Acknowledgment

This study was supported by the Seoul Research and Business Development Program(10516), Seoul, Korea.

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