Content-aware and Network-adaptive Video Streaming of a Ubiquitous Middleware

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Abstract — **In this paper, we explain the context-aware and network-adaptive video streaming model in our intelligent ubiquitous middleware, SmartUM. We introduce a new method for controlling admissions of clients, extracting bit-streams, and allocating appropriate channels. The proposed method can save system and network resources through studies on scalable video coding techniques. Moreover, the outcomes of this research can be applied to the broadcasting server engine optimized to the 4th generation mobile devices. The component of multiple based scalable video streaming provides the optimal video transmission technique for the next generation network convergence environment in which mobile devices have multiple network interfaces.**

Keywords — **Ubiquitous Middleware, Video Streaming, Context Aware, Network-adaptive..**

1. Introduction

SmartUM is an intelligent ubiquitous middleware, which provides a data acquisition interface to sensors and ubiquitous sensor networks and inference engine service that can process the collected data to make context-ware, that is, intelligent decision, therefore, optimal operations can be invoked and proper information is generated as shown in figure 1.

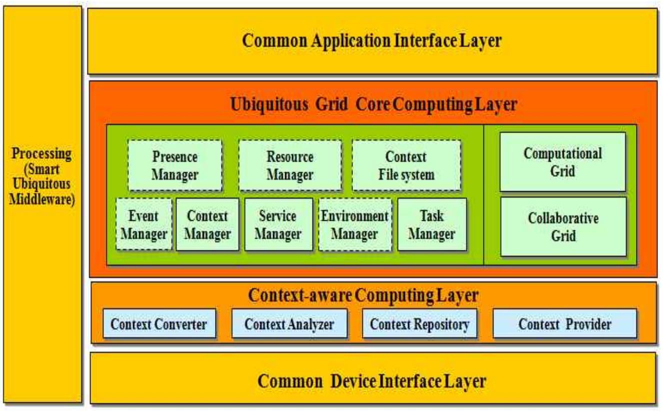

Figure 1.

Common Device Interface Layer contains the component of multiple based scalable video streaming to support stable network bandwidth for real-time video data streaming. This paper explains the component in detail. The component includes the optimal video transmission technique for the next generation network convergence environment in which mobile devices have multiple network interfaces. It uses content-aware and network adaptive video streaming technology over multiple network interfaces. We also show an application to the system which guides evacuation route to prevent the disaster in underground infrastructure. The method proposed by this paper has following merits.

First, it can support admission control for various user sessions. Second, it can support various capability of user's mobile device by using H.264 SVC(Scalable Video Codec) technology. Third, it can support content-aware UEP for streaming video streams over multi-channel network. Figure 2 shows the system architecture of the component.

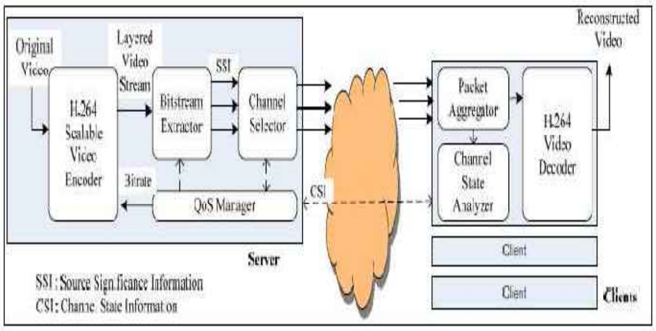

Figure 2.

2. The Overview of SmartUM

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. In this section, we give brief explanation of our ubiquitous middleware.

SmartUM 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.

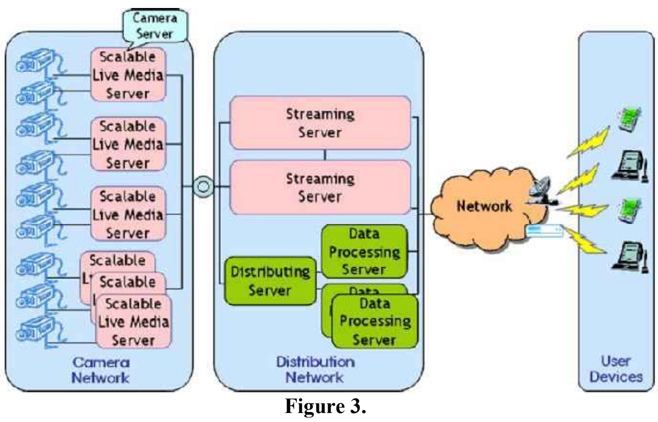

Figure 3.

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

Figure 3 and figure 4 show conceptual overview our solution called SLiM(Scalable Live Media) system. The SLiM server manages and controls a large of cameras and encodes the multimedia data acquired by cameras. The steaming server streams the encoded multimedia contents according to the QoS. Moreover the distributing server transfers the media to the corresponding server according to the registered information.

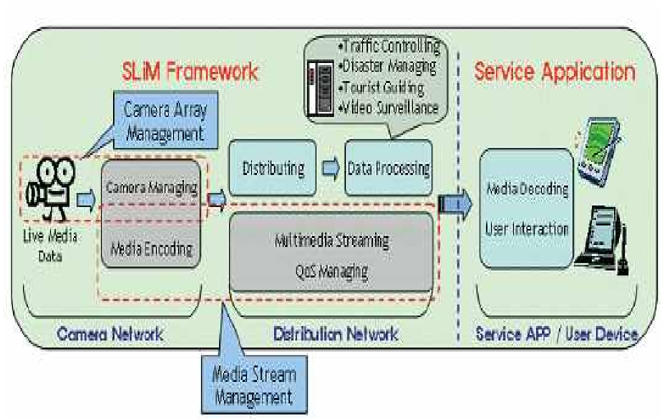

Figure 4.

3. Video Encoding and Streaming over Multi-channel

We use the technique of ITUT H.264 scalable extension for encoding video source data. Therefore the video encoder makes scalable video, and the server streams it to the client for supporting device capability by assisting the QoS manager.

3.1. Video Encoder : H.264 Scalable Extension

It is not easy for a system to simultaneously support the multiple user devices. One of the problems is that the capability of user''s devices is quite diverse. So, conventional multimedia streaming system has been constantly improved to solve these problems through several ways. The easiest way is to do only multimedia service of format fixed to the client application.

However, this way is not suitable to the current environment due to various mobile devices. The next approach is using the transcoding technique. However, it is also hard to support diverse devices in real time because the complexity and storage of transcoding is too high. Therefore real-time transcoding is not yet suitable to this large-scale system.

One way to overcome this problem is to use scalable encoding techniques. It has a merit of supporting multiple devices with a single source, so that it can handle diverse user devices and also support real-time streaming without transcoding. As a result, the system uses H.264 scalable extension techniques. Since it is possible for this technology to support spatial, temporal, and SNR scalability simultaneously, it can support the diverse screen size and resolution and also diverse network bandwidth. Further, because the ratio of compression with respect to quality of picture is excellent, it is possible to reduce the bandwidth of the entire system[1,2,3]. This study used the reference code (JSVM) via a CVS server. H.264 scalable extension can support diverse user devices.

This is processed at the scalable encoder module and the QoS manager module in our system. First, the video encoder of the server makes the layered encoding data by using the H.264 scalable encoder. In this way, the system can provide differentiated services according to the capability of the devices.

3.2. Video Streaming Process

Figure 2 shows new video streaming system architecture for content-aware streaming to various user devices. As shown in this figure, the target bitrate information delivered to the video encoder is used as the category information for determining the level of scalable encoding. For example, if all sessions can be served by the base layer encoding, the media encoder does not encode the enhancement layer. In this way, the selective scalable encoding method saves the resources of the complete system. The video encoder of the server gets the target bitrate information as the encoding option from the QoS manager. The video streaming processes are as follows:

1) User device requests streaming service to the server.

2) QoS manager of the server performs admission control by using channel state information(CSI) from channel state analyzer of the client. In this case, we assume channel state analyzer knows its own network interfaces and bandwidth.

In most cases, bandwidth of WCDMA, HSDPA, and Bluetooth is not changed quickly in application layer for its internal channel allocating mechanism.

3) Bitstream extractor extracts bitstream according to the allocated BW and information of multichannel network condition.

4) Channel selector selects an appropriate network hannel for each packet and transmits them to the client with multiple network interfaces.

3.3. QoS Manager : Admission Control

To provide the service differentiation as the priority of session of user and the characteristics of the user device, there must be a component to control requests of user sessions. The components of the system have 1:N relations: the relationship between the streaming server and user''s device is 1:N. This section explains the QoS management between components with 1:N relation. QoS managing of the network bandwidth can be performed by interaction of the internal information between the server and user devices. In this study, the priority-based admission control model is designed and implemented for managing the network BW. Priority-based admission control model controls admission through allocating the network bandwidth according to bandwidth requests of user applications. This model for allocating bandwidth is explained as follows: The user application which requests the data from the streaming server notices the maximum and minimum bandwidth that would be served. At this time, the session of the user device has priority, and this information can be set up by the policy of the QoS manager.

In such way, the QoS manager allocates the bandwidth to each session of the client by using the upper bound bandwidth, lower bound bandwidth, and priority information. A point of difference with other models is using the information of ''upper/lower bound bandwidth'' for allocating the bandwidth. This has the advantage that it can use capability information of various mobile devices and quality of service information from user applications.

For instance, the upper-bound information is determined as capability limitation of user device having low performance and lower-bound information is determined for guaranteeing the least service quality to the user application. Firstly, this model calculates the sum of least bandwidth of each session. If this value is exceeds, the maximum available bandwidth is analyzed by the network analyzer, and it cannot allocate the resource to each session. If the sum of maximum bandwidth requested from each session comes less than the maximum available bandwidth, as much as the maximum bandwidth is allowed to be allocated into each session. This model must solve the problem in every case except the two examples mentioned above. When the least of bandwidth is allocated into each channel, there remains available bandwidth. Then, the remained bandwidth is allocated in turn according to the priority order of each session.

If the bandwidth allocated this way is greater than the sum of the requested maximum bandwidth of the application, only the requested maximum bandwidth is allocated. The session allocated in this way is deleted from the list, and this model keeps on running repeatedly until the list is empty.

3.4. Channel-adaptive Video Stream Extraction for Multichannel Streaming

After admission control, server extracts an appropriate video layer from scalable video content and transmits it to the client. This section addresses this mechanism in detail. The bitstream extracting algorithm proposed in this study, which considers the characteristics of video stream and channel condition consists of two steps. The first is layer selection stage that determines from which layer of the SVC-encoded bitstream to extract. The second is channel selection stage which determines how to divide and allocate the packets to appropriate channels. Figure 5 shows the proposed bitstream-layer selection diagram, and the algorithm for the method is addressed below.

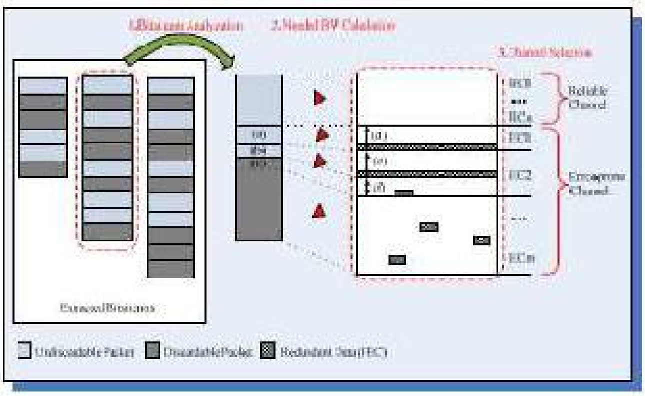

Figure 5.

4. Deploying the Implemented System to a U-City Application

The new mechanism proposed in this paper is partially implemented and deployed to a U-City application. This system can transmit evacuation route to users by using available network channels even though some of them are malfunctioned in a disaster condition. The snapshots of implemented system are as figure 6 and the demonstration video clip of it is referenced in this paper.

Figure 6.

5. Conclusion

This paper addresses a new model to control admission of clients, extract bit-streams, and allocate appropriate channels. Our proposed model can save system and network resources through studies on scalable video coding techniques. Moreover, the outcomes of the research can be applied to the broadcasting server engine optimized to the 4th generation mobile devices. 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. We are currently enhancing the explained model to do context-aware and network adaptive video streaming more smoothly and efficiently.

Acknowledgement

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