Architecture Design of Video Transmission between UMTS and WSN

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Abstract

The wireless sensor networks (WSN) provide bridges between the virtual world of information technology and the real physical world. The unification of this variety of streams under the same umbrella standard has significance for the design of the supporting architecture that transmits the multimedia streams between video sensor and 3G networks (UMTS).

This paper contributes to the effort by introducing a new architecture for video transmission from a sensor to the UMTS terminal at a low cost and power for the purpose that the video sensors can be within the reach of UMTS for best utilization of UMTS coverage. The integration of the mobile network infrastructure and sensor ad hoc networks can reduce the cost of building new infrastructure and enable the large scale deployment of sensor networks.

Keywords

UMTS, WSN, Circuit Switch, Packet Switch, 3G-324M, Video Transmission

Technical Areas

[**Ubi-media Infrastructure**]: 3G and Advanced Communication Techniques, Cross-Network Communication Techniques

1. Introduction

Recent technological advances give us a prospect that a huge amount of low-power inexpensive video sensor devices could easily communicate with other networks like UMTS network and WiMAX networks, merging them together in a hybrid network to bring the sensor video streaming to the terminal anywhere. With the rapid development of third generation telephony (Video Telephony), it is possible that different network domains i.e. circuit switch networks (CSN) and packet switch networks (PSN), could interconnect with each other to achieve pervasive video communication The UMTS network, foreseen to be the enabling technology for multimedia services with up to 64kbps for circuit switch network and 2 Mbps for packet switch network, makes it feasible for visual communication over the wireless link. Compared with the UMTS infrastructure network, the sensor network builds up a self-organizing ad hoc network to forward data packets to the sink nodes using multi-hop connections. Researchers at Berkeley developed embedded wireless sensor networking devices called motes, which were made publicly available commercially, along with TinyOS, an associated embedded operating system that facilitates the use of these devices. To date, wireless multimedia study has focused on robust video transmission over general PS wireless channels. Fig. 1 shows an easily programmable, fully functional, relatively inexpensive platform for experimentation, and real deployment has played a significant role in the ongoing wireless sensor networks revolution. There is, however, a scarcity of work performed on delivering data from sensor wireless PSN or system to other CSN. The key issue for data delivery over 3G network, which consists of several layers, is that it is not obvious how to achieve end-to-end optimality for data delivery although a single-layer performance can reach

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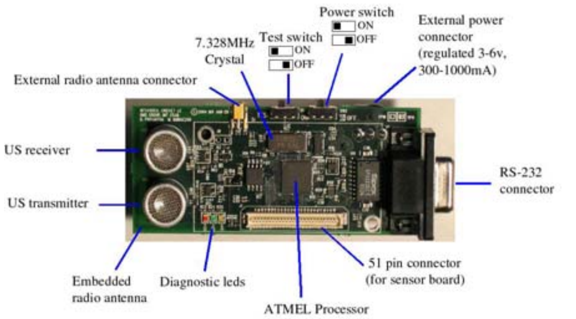

Figure 1. Sensor hardware components and layout

optimum. M.Y.Aal Salem did some work [14] about the interoperability framework for Sensor and UMTS networks; however this work is based on the UMTS packet switch network, the video could not send to the mobile user directly. It's well known, that the UMTS circuit switch video system is QOS guaranteed system. Target to solve such problem; we designed and implemented a prototype system, providing a novel architecture to communicate between the WSN and UMTS to move video from a sensor to a 3G handset user at low cost and power. Our previous work mainly focused on the videoconferencing for 3G wireless network [1] and 3G-324M protocol implementation [2-6].

The paper is organized as follows: Sec. 2 provides details on implementation of 3G-324M. Sec. 3 describes the new interoperability architecture for sensor and the UMTS and presents the interoperability framework for the sensor and UMTS networks. Conclusion and future work are given in Sec. 5.

2. Implementation of UMTS framework

Communication between sensor nodes to build a cluster network can be achieved in a variety of ways. The efficiency of the network depends on sink location, which directly affects the lifetime of the sensor network. However, the sensors within a cluster communicate with the sink node that is allocated to them via short-range wireless communication links.

The interoperability framework for sensor and UMTS network approach, which will be explained later in this paper, moves data from the gateway to the user at a lower cost and power by using the Universal Mobile Telecommunication System, which is standard for the Third Generation Mobile System (3G). The integration of the mobile network infrastructure and sensor networks will reduce the cost of building new infrastructure and enable the large-scale deployment of sensor networks. In a wireless environment, where bandwidth usage is significant, short address length and simplicity of user entry on limited keypads are the distinguishing features between various systems.

2.1. UMTS Circuit-Switched Mobile Video

3G-324M [11, 12] is an umbrella standard that enables real-time multimedia services over circuit-switched wireless networks. It includes protocol elements for multiplexing and demultiplexing of speech, video, user, and control data (H.223)[7] in a single 64Kb/s circuit, call control (H.245)[8] video (H.263 and MPEG-4) and audio codecs (AMR-NB[13] and G.723.1[9]). A block diagram of 3G-324M and the relevant 3GPP specifications is presented in Fig. 2. Note that the 3GPP call setup requirements are spread in several documents. 3G-324M is derived from H.324, which is a standard made by ITU-T for low bit rate multimedia communication, while H.245 and H.223 are two main parts under H.324 and have given specific descriptions about the procedures of message transformation and data transmission multiplexing. H.324 and its annex C are referred to as H.324M for mobile terminals.

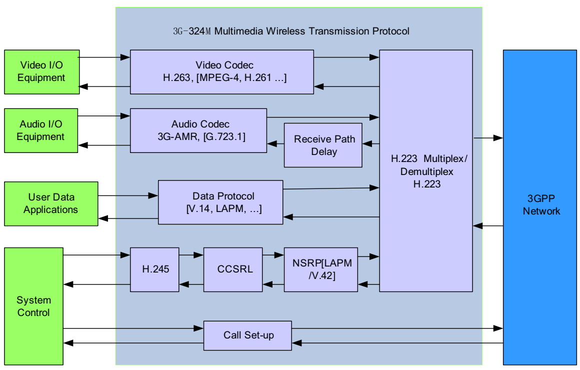

Figure 2. 3G-324M structure

2.2. Summary of the H.324

H.324 describes terminals for low bit-rate multimedia communication, utilizing V.34 modems operating over the General Switched Telephone Network (GSTN). H.324 terminals may carry real-time voice, data, and video, or any combination, including videotelephony. H.324 terminals may be integrated into personal computers or implemented in stand-alone devices such as videotelephones. Support for each media type (voice, data, and video) is optional, but if supported, the ability to use a specified common mode of operation is required, so that all terminals supporting that media type can interwork. H.324 allows more than one channel of each type to be in use. Other ITU-T Recommendations in the H.324-Series include the H.223 multiplex, H.245 control, H.263 video codec[10], and G.723.1 audio codec. H.324 makes use of the logical channel signaling procedures of ITU-T Rec. H.245, in which the content of each logical channel is described when the channel is opened. Procedures are provided for expression of receiver and transmitter capabilities, so transmissions are limited to what receivers can decode, and so that receivers may request a particular desired mode from transmitters. H.324 terminals may be used in multipoint configurations through MCUs, and may interwork with H.320 terminals on the ISDN, as well as with terminals on wireless networks.

2.3. Functional Elements Covered by 3G324M

The Video codec (H.263 or H.261) carries out redundancy reduction coding and decoding for video streams. The Audio codec (G.723.1) encodes the audio signal from the microphone for transmission, and decodes the audio code which is output to the speaker. Optional delay in the receiving audio path compensates for the video delay, so as to maintain audio and video synchronization. The Data protocols support data applications such as electronic whiteboards, still image transfer, file exchange, database access, audio graphics conferencing, remote device control, network protocols, etc. Other applications and protocols may also be used via H.245 negotiation. The Control protocol (H.245) provides end-to-end signaling for proper operation of the H.324 terminal, and signals all other end-to-end system functions including reversion to analogue speech-only telephony mode. It provides for capability exchange, signaling of commands and indications, and messages to open and fully describe the content of logical channels. The Multiplex protocol (H.223) multiplexes transmitted video, audio, data and control streams into a single bit stream, and demultiplexes a received bit stream into various multimedia streams. In addition, it performs logical framing, sequence numbering, error detection, and error correction by means of retransmission, as appropriate to each media type. The Modem (V.34) converts the H.223 synchronous multiplexed bit stream into an analogue signal that can be transmitted over the GSTN, and converts the received analogue signal into a synchronous bit stream that is sent to the Multiplex/Demultiplex protocol unit.

2.4. Multimedia Data Streams of 3G324M

At the low level of mobile terminals, multimedia data streams are classified as video streams, audio streams, data streams and control streams:

Video streams are continuous traffic carrying moving color pictures. When used, the bit rate available for video streams may vary according to the needs of the audio and data channels.

Audio streams are real-time, but may optionally be delayed in the receiver processing path to maintain synchronization with the video streams. In order to reduce the average bit rate of audio streams, voice activation may be provided.

Data streams may represent still pictures, facsimile, documents, computer files, computer application data, undefined user data, and other data streams.

3. Interoperability and Gateway Design between WSN and UMTS Networks

Here we propose an approach that will allow the different network standards to communicate with each other. The scope of this work is to develop a framework that will allow the integration of sensor networks into the fabric of other wireless networks. The framework has been divided into two parts: the UMTS portion and the gateway. The UMTS networks enable direct access of the sensor network, where the user can request data anywhere and anytime.

3.1. Video WSN and UMTS Gateway architecture

The proposed architecture of a wireless sensor network gateway is shown in Fig. 3. It is a flexible architecture that supports a range of communication technologies, so that no or minimum modification is required for sensors and user applications. The architecture consists of four layers which are Physical Layer, Communication Layer, Middleware Layer and Application Layer respectively. Physical layer provides the physical connection to UMTS network via a UMTS modem, to the sink node of a sensor network through a wired link. Network Interfaces is the communication layer. Two different communication technologies are supported by the gateway: the wide range UMTS communication interface and the short-range sensor network communication interface. In this situation, gateway is responsible for bring video data from sensor network to UMTS CS network and, in the reverse way, bridging control data from CS network (indeed from a mobile phone in UMTS network) to sensor network. Sensor network middleware represents the central component of the gateway architecture. This is the layer that divides communication between the sensors and the users, encapsulates the internal organization of the sensor network and provides API function to the users. The user application layer employs the API functions that are provided by the sensor network middleware. Depending on the application scenario, short-range wireless communication links and the wide-area network are used for communication between users and gateways.

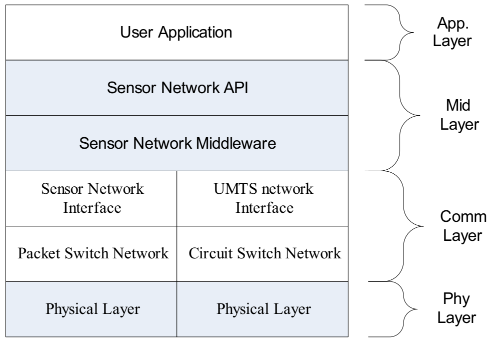

Figure 3. WSN and UMTS Gateway architecture

We have just introduced our novel WSN and UMTS gateway architecture that provides an easy accessibility for system developers. We would also like to discuss the interoperability between WSN and UMTS Network Model that interconnects the ad hoc WSN and infrastructure UMTS network by the gateway. The aim of the proposed solution is to receive data on demand or at any time and anywhere throughout the country, or to share these data with other organizations worldwide by using Internet or UMTS technologies.

This solution allows our framework to implement the video transmission to an infrastructure network from a sensor network using the gateway, which was chosen for its features. This solution allows the gateway to send the video data, which can easily be received by any mobile phone in any location. The H.324M is used to transport the messages from the gateway to the mobile. It is responsible for the general requirements, architecture and functionality. The Internetworking Function (IWF) acts at a role of protocol design between CSN and PSN. The process for sending a video from the sensor to the mobile client (data receiver) as follows:

- Each gateway registers itself as a mobile unit in the Home Location Register (HLR) on the UMTS network. The gateway address is based on the Mobile Station ISDN Number (MSISDN) that is operated by the device. In many paging systems, users are assigned PINS that are used to authorize a caller to deposit a message. This addressing problem can be solved by adding this number to the gateway memory, or changing the gateway design to allow the USIM card to cooperate with it. After this, the gateway is ready for the next step.

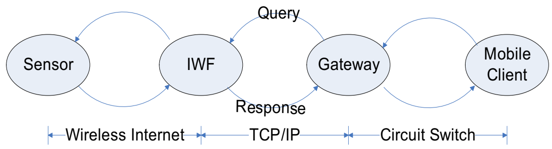

Figure 4. Interoperability between WSN and UMTS Network Model

- Video sensors gather the video data and transmit it to the gateway
- Gateway receives the video from the sensor.
- Gateway transcodes the video to H.263
- Gateway forward the video to mobile client by H.324m

3.2. Design of the Gateway of UMTS and WSN

The wire and wireless sensor network has a role of gathering the sensor status data. The gateway does not only offer sensor status information to remote users but also receives sensor control messages from the external network.

Fig.5 show the structure of the UMTS and Sensor Network Communication system proposed in this report. The system consists of the IWF, control server and the web based client, which is connected to gateway through the packet switch network. Beside, the gateway is connected to circuit switch network via UMTS mobile communication network. The IWF has a role of collecting data from sensor network and converting network protocol to connect the sensor network to the external network.

Fig. 6 shows the system platform for the sensor and UMTS gateway proposed in this paper. The implemented system consists of a gateway, a

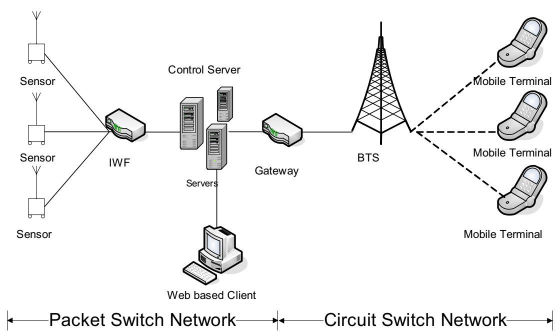

Figure 5. UMTS and WSN Communication System Structure

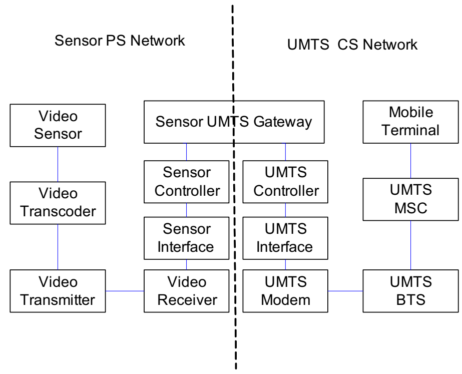

Figure 6. WSN and UMTS inter-working system platform

video sensor and a mobile terminal. The video sensor is simulated by a laptop with web cam and a sensor node. The gateway is implemented with embedded system Tony OS. The hard ware consist a laptop PC, a sensor sink and a UMTS modem.

Fig. 7 shows the implemented gateway, video sensor and mobile terminal, which are configured to transmit video from sensor node to UMTS mobile terminal. The sensor node collects the real time video data and transmits it to gateway though TCP protocol. The gateway transcodes the video and forwards the data to mobile terminal through the H.324 protocol.

4. Conclusion

UMTS users could conveniently and quickly access sensor network. In this paper, we have proposed the architecture for video transmission from WSN to UMTS networks which allow an ad hoc PSN communicates with a CSN. However few researchers consider integration of the mobile network infrastructure a sensor networks. This

Figure 7. Gateway, video sensor and mobile terminal

paper presented our new approach, using the characteristics of sensor networks and mobile network infrastructure to deliver sensor network signals. Future more, we build up the platform and implement the video gateway. The advantages are that communicating between these two systems dynamically and intelligently can reduce the cost and increase the lifetime of sensor networks. It was also shown that this approach is suitable for all organizations, and for gathering data on demand. The feasibility and viability of the proposed method has been proven through initial experimental work.

5. Acknowledgements

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