QoS of streaming video traffic over UMTS networks

Amitabh Mishra and John Korah
Bradley Department of Electrical & Computer Engineering
Virginia Polytechnic & State University
Blacksburg, VA 24061

ABSTRACT

There are four different levels of QoS traffic classes stipulated in UMTS specifications [1], which UMTS network need to support. These traffic classes are: Conversational, Streaming, Interactive, and Background. The main distinguishing factor between these classes is how delay sensitive the traffic is. Video stream class of traffic for a broadband wireless network has lot of challenges to overcome; principal among them is the preservation of time delay variation between information entities within a flow. In this paper we model video stream traffic over an UMTS network and examine end-to-end delay variation. Using the results we discuss the architectural implications of radio access network (UTRAN), core network, and the video server on the overall delay. In addition we also analyze the performance impacts of the underlying transport and network layer protocols.

Keywords: UMTS, QoS, video, Wireless Network, Third Generation, Model

1. INTRODUCTION

UMTS [2] will provide a seamless communication among subscribers, which is independent of the location, the type of terminal, the means of transmission (wired or wireless), and the choice of technology. UMTS is currently under development around the globe and will see a limited functional deployment by the middle or the end of 2002 [2]. When fully developed and deployed, UMTS is projecting to provide:

- Service differentiation between service offerings of various serving networks and home environments
- A range of services currently provided by the wired networks
- Services via hand held, portable, vehicle mounted, movable and fixed terminals
- Audio, Video and Data Services
- Support for Global Roaming

UMTS specifications have proposed to support four different traffic classes with the key differentiator among the classes being the sensitivity to tolerate delay. For example, the conversational class is primarily meant for the real-time traffic such as voice, which is delay intolerant. The streaming class, on the other hand, is also meant for the real time traffic such as audio and video. While this class can tolerate a higher overall delay than conversational class, its very sensitive to jitter. Network applications such as web browsing, database accesses etc. belong to the interactive class of applications. For interactive class of applications, the important performance parameter is the round trip delay for a request response pattern. The background class primarily handles the delay tolerant applications such as E-mails, file transfers etc.

There is significant research activity at the present time in the area of transporting MPEG-4 video over the Internet [3], [4], [5], and it is beginning to get some attention in the wireless research as well [6], [7], [8]. In reference [8] authors focus on streaming video transmission over the EGPRS networks. In this paper our focus is on transmitting MPEG-4 data streams over UMTS networks. This is for the first time this topic is being studied, as there are no papers dealing with this issue for UMTS networks in the literature as of this writing to the best of our knowledge.

In this paper we model video stream traffic over an UMTS network and examine end-to-end delay variation. Using the results we discuss the architectural implications of radio access network (UTRAN), core network, and the video server on the overall delay. In addition we also analyze the performance impacts of underlying transport and network layer protocols.

Quality of Service over Next-Generation Data Networks, Mohammed Atiquzzaman, Mahbub Hassan, Editors, Proceedings of SPIE Vol. 4524 (2001) © 2001 SPIE · 0277-786X/01/$15.00

The remainder of this paper is organized as follows: Section II presents in brief the UMTS network architecture and its major components. In Section III we present basic assumptions used in the model with regard to the network configuration and the protocols. The details of the performance model and the important results will be presented during the conference.

2. UMTS ARCHITECTURE AND REFERENCE MODEL

2.1 UMTS Architecture

Figure 1 shows a high level view of UMTS network architecture consisting of six main components and the major interfaces. These six components are UTRAN (UMTS Terrestrial Radio Access Network), Core Network, SS7 network; Circuit switched network, and the external packet data network. Major interfaces between the entities are also given. The Core network comprises of a circuit switched (CS) domain for providing voice and the circuit switched data services and of a Packet Switched (PS) domain for providing packet based services. Figure 2 depicts a logical architecture of UMTS by showing the CS domain on the left and the PS domain on the right. The radio access network for both the domains is UTRAN, which is composed of a set of Radio Network Subsystems (RNS). The RNS are in turn composed of two main logical elements: Node B and Radio Network Controller (RNC). RNS is responsible for the resources and the transmission/reception in a set of cells where a set of cell (sector) is one coverage area served by a broadcast channel.

RNC is responsible for the use and allocation of all the radio resources of the RNS to which it belongs. A RNC can be logically split into two entities: the first entity controls the base stations (Base Station Controller) and the second entity, is responsible for traffic processing. The base station controller is mainly in charge of the allocation and usage of all radio resources with the aim of hiding the details from the core network. The traffic-processing unit mainly handles the user voice and packet data traffic, performing the actions on the user data streams that are necessary to access the radio bearers.

Node B is mainly responsible for radio transmission and reception in one or more cells to/from the user equipment (UE).

The UMTS Iu interface is open logical interface that interconnects one UTRAN to the core network. Iu interface is described in detail in [9].

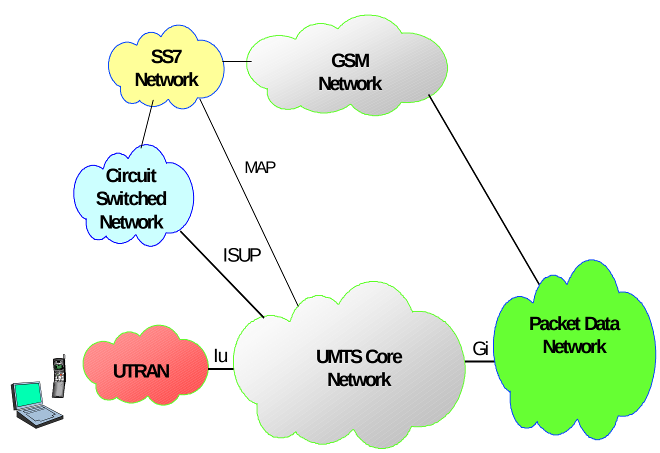

Figure 1 – UMTS Architecture

In the following we briefly describe the functions of some of the nodes in the circuit and packet domains. For details please see [10, 11, 12].

2.1.1 Circuit Switched Domain

3G-MSC is the main core network element for providing circuit switched services. The 3G-MSC provides the necessary control and the corresponding signaling interfaces e.g. SS7, MAP, and ISDN. 3G-MSC may also provide gateway functionality for inter-connecting to external networks like PSTN, ISDN. The key functionality provided by the MSC includes: Mobility Management, Call Management, Supplementary Services - such as call forwarding, Circuit switched data services, Support of SS7, MAP and RANAP interfaces to complete originating or terminating calls in the network in interaction with other entities of a mobile network, e.g. HLR, Short Message Services, and *VLR* (Visitor Location Register).

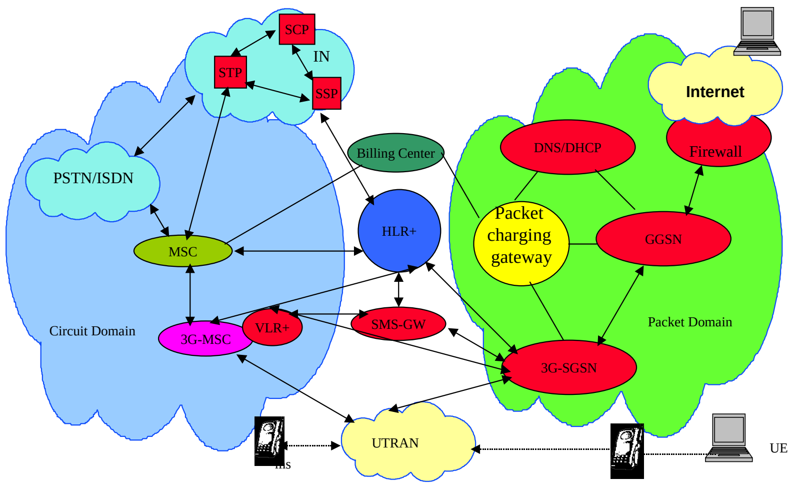

Figure 2 - UMTS Logical Architecture of UMTS Core Network

2.1.2 Packet Switched Domain

The important network nodes that form the packet domain are:

3G-SGSN: The 3G-SGSN is the main core network element for packet services. It provides the necessary control functionality both towards the UE, and the GGSN. It also provides the appropriate signaling, and data interfaces. These include connection to an IP based network towards the GGSN, SS7 towards the HLR and TCP/IP or SS7 towards the UTRAN.

Functionalities provided by the 3G-SGSN include: Session Management; Support for Iu, Gn, MAP interfaces*;* Short Message Services, Mobility Management, Subscriber database functionality, and Charging.

GGSN: provides inter-working with the external packet-switched network and is connected with the SGSN via an IP based network. The GGSN may optionally support an SS7 interface towards the HLR, which is used in order to handle mobile terminated packet sessions.

Functionality provided by the 3G-GGSN includes: Maintain information on mobile location at SGSN level, Act as a Gateway between UMTS Packet Network and external data networks (e.g. IP, X.25*)*, Provide Gateway specific access methods to Intranets (e.g. PPP termination), Provide user data screening / security, Support *c*harging for the external data network usage by the user.

Firewall: This entity is used to protect the operator’s backbone data network from attack from external packet data networks.

DNS / DHCP: The DNS server is used, as in any IP network, to translate host names into IP addresses. A DHCP (Dynamic Host Configuration Protocol) server is used to manage the allocation of IP configuration information by automatically assigning IP addresses to systems configured to use DHCP. Additionally, the GGSN may have to allocate a dynamic address to the UE upon PDP context activation.

Packet Charging Gateway provides a mechanism to transfer charging information from the SGSN and GGSN nodes to the network operator's chosen Billing Center.

Billing Center collects CDRs (Call Detail Record) and produces customer-billing information.

SMS-GMSC supports short message service via a Gateway MSC (GMSC) for packet and circuit mode messages.

3. PERFORMANCE MODEL & RESULTS

An end-to-end simulation model of the streaming video application consists of a video server connected to the Internet via a router. The UMTS core network consisting of a SGSN and a GGSN is interfacing with the Internet using the Gi interface on one end and the Radio Access Network (RAN) consisting of a RNC and a Node B on the other through the Iu-ps interface. RAN interfaces to the UE via Uu interface. The UE is assumed to be a Laptop. The simulation model has been developed under the following assumptions:

1. The video is transmitted using MPEG-4 format
2. The external packet network implements Diffserv QoS mechanisms
3. The signaling required for the connection establishment and the packet data protocol (PDP) context activation is not modeled. It is assumed that the connection is already established and the network has already granted the requested bandwidth by the UE end-to-end.
4. UE is assumed to be stationery
5. The video is transported over RTP/UDP/IP stack and the control information over the TCP/IP stack
6. The end-systems are H.323 compliant

Some of the results provided by the simulation model developed using OPNET [12] are:

1. End-to-end delay
2. Jitter
3. Overhead of protocols
4. Throughput

4. CONCLUSIONS

The performance results computed by the simulation model of a streaming video application over the UMTS network are currently being analyzed, and these will be presented during the conference.

7. REFERENCES

1. UMTS QoS Concept, 23.07, version 0.4.0, 1999, http://www.etsi.org
2. 3GPP web site: http://www.3gpp.org
3. D. Wu, et al, "On end-to-end architectures for transporting MPEG-4 video over the Internet", IEEE Trans. on Circuits & Systems for Video Technology, Vol. 10, No. 6, Sep. 2000, pp. 923-941
4. D. Wu, et al, "Optimal mode selection in Internet video communication: An end-to-end approach", IEEE ICC 2000, pp. 264-271
5. A. Lombardo, "Traffic Specification for MPEG video transmission over the Internet", IEEE ICC 2000, pp. 853-857
6. D. Shen; Chuanyi Ji "Admission control of multimedia traffic for third generation CDMA network" IEEE INFOCOM 2000, pp. 1077-1086
7. F.K.L Lee, et al, "Providing deterministic quality of service guarantees in multimedia wireless networks" IEEE Vehicular Technology Conference, VTC 2000-Spring, 51st, Volume: 1, pp. 460 -- 464
8. K. Chawea et al, "Transmission of streaming video over an EGPRS wireless network " IEEE Multimedia and Expo, ICME 2000, Volume 1, pp. 275 –278
9. 3GPP TS 25.410: UTRAN Iu Interface: General Aspects and Principles; V0.2.1
10. ETSI, Digital Cellular Telecommunications Systems (Phase 2+) Service Description, GSM 03.60,v6.4.0, 1997

11. J. Soininen, “GPRS and UMTS Release 2000 All-IP option”, Mobile Computing and Communications Review, Vol. 4, Number 3, July 2000, pp. 30-37
12. OPNET- Modeler, Version 7, MIL3, Inc., 2001