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Quality of Service and Differentiated Service in Cellular Networks

[1]Mohammod Shamim Hossain and [2]M. Anwar Hossain
[1]School of Science and Technology, Bangladesh Open University, Board Bazar, Gazipur 1705, Bangladesh
[2]ITsoft International, Dhaka 1230, Bangladesh

Abstract: The recent QoS model of the Differentiated Services (DiffServ) approach including premium service, assured service and best effort service in intended for usage in wire line networks and Internet. However, cellular networks are popular and becoming more popular within the years to come. So there is a need for surveying the recent research work on QoS model for DiffServ in cellular networks. One of the QoS aware crucial problems is handover problem. Another problem of cellular network includes low channel capacity i.e. low bandwidth and classification of packets within a flow.

Key words: QoS, DiffServ, cellular networks, voice over IP

INTRODUCTION

In today's information age, telecommunication technology has the ability to access everything, everywhere, all the time. The cellular networks fulfills this dream by aggregating of all kind of traffic such as voice, multimedia data transfer etc. in the same transport technology.

Due to the unprecedented demand of multiple services such as voice, data and other multimedia applications over cellular networks, there is a need to provide Quality of Service (QoS) in cellular networks. If QoS is not administered at the cellular network, a cellular or mobile data communication system cannot protect itself when too many undifferentiated users try and access the cellular network for data services. For example, if scores of teenagers are downloading heavy bandwidth applications (MP3 files) simultaneously, system may 'crash' disrupting service for millions of enterprise users and power consumers.

Compared to their wired counterpart, wire-less/mobile networks must deal with several problems which make it very difficult to provide Quality of Service (QoS): (1) resources (e.g., bandwidth) in wireless networks are scarcer than in wired networks; (2) wireless channels are prone to location-dependent, bursty and time-varying errors; (3) users tend to move around during a communication session causing hand-over between cells.

QoS, is a collective measure of the level of service delivered to the customers by service providers, characterized by basic performance criteria such as throughput, delay or jitter, loss and reliability. ISO standard defines QoS as a concept for specifying how good the offered networking services are. In another words, QoS defines nonfunctional characteristics of a system, affecting the perceived quality of result[1]. QoS parameters related to technology are throughput, delay, jitter, loss and reliability; QoS parameter related to static management are specification, negotiation, admission control and resource reservation.

DiffServ, QoS model endorsed by IETF, is architecture for implementing scalable service differentiation in the Internet. Service defines some significant characteristics (throughput, delay, jitter, loss or relative priority of accessing to network resource) of packet transmission in one direction across a set of one or more paths within a network. Service differentiation is desired to accommodate heterogeneous application requirements and user expectations and to permit differentiated pricing of internet service[2].

CELLULAR SYSTEM ARCHITECTURE

Increases in demand and poor quality of existing service led mobile service providers to research ways to improve the quality of service and to support more users in their systems. Because the amount of frequency spectrum available for cellular use was limited, efficient use of the required frequencies was needed for cellular coverage. Each cellular coverage region is planned according to an engineering plan that includes cells, clusters, frequency reuse and handover. The cellular networks (Fig. 1) consist of the following four major components that work together to provide cell service to the subscriber:

Corresponding Author: Mohammod Shamim Hossain, School of Science and Technology, Bangladesh Open University, Board Bazar, Gazipur 1705, Bangladesh

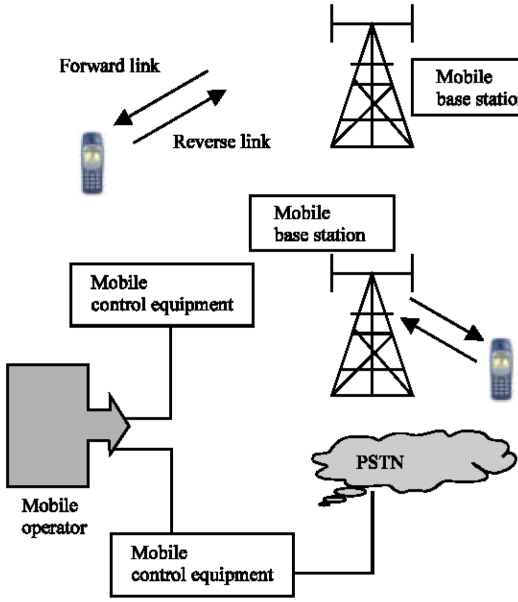

Fig. 1: Cellular system component

- Public Switched Telephone Network (PSTN)
- Mobile Telephone Switching Office
- Cell Site with antenna System
- Mobile Subscriber Unit or Mobile Terminal (MSU/MT)

In cellular networks[3], a service coverage area is divided into smaller hexagonal areas referred to as cells. Each cell is served by a base station. The base station is fixed. It is able to communicate with mobile stations such as cellular telephones using its radio transceiver. The base station is connected to the Mobile Switching Center (MSC), which is in turn connected to the Public Switched Telephone Network (PSTN). The MSC controls calls, tracks billing information and located cellular/Mobile subscribers.

There are two types of link in the cellular system: Forward link that are used to carry traffic from the base station to mobile station, Forward link are used to carry traffic from mobile to the base station.

The frequency spectrum allocated to wireless communications is very limited, so the cellular concept was introduced. The concept of frequency reuse is based on assigning to each cell a group of radio channels used within a small geographic area. Cells are assigned a group of channels that is completely different from neighboring cells to avoid radio interference. The same channels can reuse by two cells that are far apart such that their frequencies do not interfere. By reducing the size of cells the cellular network is able to increase its capacity and therefore to serve more subscriber.

One of the key issues of cellular system is Handover, which occurs when mobile subscriber travels from one cell to another during a call. As adjacent areas do not use the same radio channels, a call must either be dropped or transferred from one radio channel to another when a user crosses the line between two adjacent cells. Because dropping the call is unacceptable, the process of handover is created. Handover occurs when the cellular telephone network automatically transfers call from one channel to another channel as mobile crosses adjacent cells.

AN OVERVIEW OF DiffServ IN CELLULAR NETWORKS

Differentiated Service Model (DiffServ) is currently a popular research topic as a low-cost method to bring QoS to today's Internet and cellular Networks. A very little research regarding QoS and DiffServ have been done on cellular networks but intensive research efforts have been done on wired networks. However, at the end of 20th century, some research efforts have done on wireless. For example, Sadeghi and Knightly[4] discussed about the architecture and algorithms for scalable mobile QoS[5] implemented a DiffServ router on linux platform, Borg *et al.*[6] talked about multifield packet classification, Yeom and Reddy[7] studied packet marking issue in DiffServ,

Mahadevan and Sivalingnam[8] described the design and implementation of an enhanced Differentiated Service (DiffServ) architectural framework for providing QoS in wireless networks. QoS for wireless or cellular networks is also described by Mahadevan and Sivalingam, Pekrins[9-10].

Differentiating service in a network is achieved using different Quality of Service. (QoS). There are two kinds of Differentiating service in a network, integrated Service (Intserv) and Differentiated Service (DiffServ)[2]. IntServ is used to reserve resource between a sender and a receiver for each session using signalling. DiffServ is used to classify traffic into different classes where each class will get some QoS. Two important (QoS) measures for current cellular networks are the fraction of new and handover calls that are blocked due to unavailability of channels (radio and/or computing resources)[11]. The usage of IP as transport technology solves some of the internetworking problems between different technologies but at the same time, IP quality of service mechanism are not fully adapted to the reality of QoS aware mobility between different technologies. This causes strong problems in terms of network performance, QoS provisioning, AAAC (Authentication, Authorization, Accounting and Charging) and Mobility.

Table 1: Differentiated Service field (DS field)

0	1	2	3	4	5	6	7
Differentiated Service Code Point (DSCP)							

DiffServ is architecture for implementing scalable service differentiation in the Internet[2]. It adopts a purely datagram architecture which defines simple forwarding mechanisms for interior network routers, pushing most of the complexity onto the network edges. The DiffServ architecture proposes a new format and use of the IP header for packet classification, called the DS (Differentiated Services) field[12]. In IPv4, it defines the layout of ToS (Type of Service) octet; In IPv6, the Traffic Class octet. The IP header is divided into the 6-bit Differentiated Services Code Point (DSCP) and a 2-bit unused field (Table 1). A base set of packet forwarding treatments (per-hop behaviuor, or PHB) is also defined[13]. Traffic flows are aggregated into a few classes handled by routers according to a set of PHBs. The DiffServ architecture is composed of a number of functional elements, namely packet classifiers, traffic conditioners and Per-Hop forwarding Behaviors (PHB)[2]. By marking the DS field of packets differently and handling packets based on their DS field several differentiated service classes can be provided, i.e., premium service, assured service and best-effort service[14].

The DiffServ architecture has been designed to implement the service differentiation in the Internet, but only a few proposals[15-17] address the issue of providing service differentiation in cellular networks. All these contributions consider only two fundamental types of traffic (i.e., voice and data) and the higher priority is simply given to voice calls over data. In 3G mobile communication systems, e.g., UMTS, high-rate data services will be supported. Data transmission will no longer be the supplementary service. Therefore, it is necessary to set up appropriate service classes for supporting heterogeneous services beyond the fundamental voice and data classes and implement service differentiation in cellular networks to support multiple traffic types. Corresponding to the DiffServ architecture, service classes in cellular networks can be mapped as follows:

Premium service: for real-time highly delay-sensitive connections such as voice and low-rate video.

Assured service: for non-real-time delay-sensitive connection-oriented connections with limited delay bounds such as FTP and WWW browsing.

Best-effort service: for delay-tolerant message-oriented connections such as paging and electronic mail.

QOS IN CELLULAR ENVIRONMENTS

Now a days cellular networks are becoming to target IP (eg. VoIP) applications in their service offerings. The 3G cellular networks intend to extend this strategy to a higher degree, transforming the voice service in an IP service as well. So IP is using to transport all type of data between nodes in the core networks. The IP protocol was not originally designed to provide different grades of QoS. Nevertheless an IP approach to e2e QoS is required to be able to build an all IP world without relying on any layer 2 specific QoS mechanism.

During proceeding VoIP call, Mobile terminal periodically move between technologies (vertical handover) and between cells of the same technology (horizontal handover). This causes serious problems: these VoIP calls require the reservation of certain network resources, the assurance of certain QoS parameters and often the confirmation of administrative information. So handovers have to be done in a short period, without disturbance in the established communications. Issues as QoS assurances in mobile environments can be structured in five layers[18] of complexity: I) physical; ii) cell; iii) network, iv) management and v) administration.

- The physical layer problems are associated with the fundamental connection capabilities. If any of the transmission links (wired, wireless) places any limits to QoS (e.g. delay assurances), then this will impact the overall end to end (e2e) service.
- The cell problems are motivated by the flow handover across neighbouring cells. QoS parameters have to be satisfied at the time of handover between similar cells.
- The network problems are due to changes in the IP network of attachment. This can be described as the classical mobile IP problem, increased with QoS constraints and strong timing limitations for the handover phase.
- Management problems are concerned with network management, core network configuration in order to assure the required QoS levels.
- Administration is here used in the context of accounting, logging and charging users and ISPs for resource usage.

The issue of handover illustrates the network changes in heterogeneous mobile environments. An analysis on the issues of QoS provision in a mobility environment has to consider these multiple Context Switches (CS)[18], which are as follows:

- CS I: Mobile terminal changing wireless cells: A MT crosses the border between two wireless cells (either UMTS or WLAN). There is no AAAC traffic.

- CS II: Mobile terminal changing IP Autonomous Domain (AD): A MT becomes connected to a different AD. This will require AAAC traffic.
- CS III: Mobile terminal changing wireless provider: A MT switches wireless provider. This will require AAAC traffic.
- CS IV: Mobile terminal changing transport technology (either wireless or wired): A MT switches from wired to wireless connections or between different wireless technologies. This may, or may not, require AAAC traffic. When QoS issues are considered in these CS, the handover problem becomes much more complex.

Problems and possible solution: Marques *et al.*[18] discussed some network topologies to help solving or minimizing the QoS problems that may occur at the cell and network layers. The mobility support of IPv6 is better than the IPv4 support. The layer 3 handovers are currently a problem in terms of the time they take to be done. The followings are some problems concerning handover and some possible solutions discussed by Marques *et al.*[18].

Wireless-wireless (same technology) handover: There exist layer 2 handover in first and second generation networks but in 3rd Generation Networks there exist layer 3 handover as well, which causes the overall delay of layer 2 plus layer 3 handovers delay.

To minimize the overall delay, both layer 2 and layer 3 handover should be decoupled. To fulfill these objectives, the following two conditions must be satisfied:

- Every layer 3 router must serve several radio cells
- Every layer 2-border radio cell must be served by more than one layer 3 router

Wireless-wireless (different technologies) handover: In this case one cannot guarantee that there will be an overlap of both technologies coverage to allow the handover. The decision on the handover must be taken in a cost basis, that is, every time the cost is lower, the handover should be made and the opposite should only occur if:

- The user explicitly asks for it;
- The user has a premium service and the mobile is configured to change to the most powerful technology.

Wired-wireless handover: If a MT is connected to a fixed technology (such as Ethernet) and the cable is suddenly unplugged, all the connections will be dropped, unless some measures are taken. Two different situations may occur:

Table 2: Targeted network services[19]

Service ----------------- Name	Class	Relative priority	Service parameters	Typical usage description
SIG	AF41	2a	Unspecified Signaling	(Network usage)
S1	EF	1	Peak BW: 32 Kbit/s	Real time services
S2	AF21	2b	CIR:256 kbits/s	Priority (urgent) data transfer
S3	AF1	2c	Three drop precedence (Kbs) AF11-64 AF12-128 AF13-256	Olympic service (better than BE: streaming, ftp etc.)
S4	BE	3	Peak bit rate: 32 kbit sec^{-1}	Best effort
S5	BE	3	Peak bit rate: 64 kbit sec^{-1}	Best effort
S6	BE	3	Peak bit rate: 256 kbit sec^{-1}	Best effort
S7	BE	Special Service Requesting AAAC contact for DSCP		

- The wireless network resources are free of charge for instance, a wireless LAN belonging to the same company;
- The wireless network resources are to be paid for instance, changing to an UMTS network.

As it is known the main purpose of DiffServ model is to provision end to end QoS guarantees by using service differentiation in cellular network. Maarquesta[19] represent end to end QoS architecture for DiffServ model. The offered network service parameters i.e. DiffServ network parameters of the said architecture is given in Table 2, where the network services will be one of three basic DiffServ[20] types: EF-expedited forwarding, AF-assured forwarding and BE-best effort.

CONCLUSIONS

As far it is known, there has been very few works addressing the problem of providing QoS and Differentiated Service in cellular networks. Recently some researches have been going on in Europe (Mobidick) and North America (Bell Lab) on QoS service in Cellular and wireless networks. I hope the discussion of the said topic in this study will give some idea. The key problems surrounding the architecture mentioned are concerned with efficient handover solutions across different cells. This article briefly described some of the handover problems and possible proposed solutions. There is a need for more study and research on this topic.

REFERENCES

1. Chamlers, D. and M. Solman, 1998. Survey of QoS of service in mobile computing environments. IEEE Comm. Survey, 2: 4-5.

2. Blake, S., D. Black, E. Davies, Z. Wang and W. Weiss, 1998. An architecture for differentiated services. IETF draft, RFC 2475, pp: 1-10
3. Stojmenovic, (Ed.), 2002. Handbook of Wireless Networks and Mobile Computing, John Wiley and Sons, pp: 27-28.
4. Sadeghi, B. and E.W., Knightly, 2000. Architecture and algorithms for scalable mobile QoS, http://cmc.rice.edu/research/theses/SAD2000APR4ARCHITECTU.pdf
5. Blessand, R. and K. Wehrle, 1999. Evaluation of differentiated services using an implementation under Linux. Proc. IWQoS'99, London, pp: 15-20.
6. Borg, N., E. Svanberg and O. Schelen, 1999. Efficient multifield packet classification for QoS purposes. Proc. IWQoS'99, 1999, London.
7. Yeom, I. and A.L.N. Reddy, 1999. Impact of marking strategy on aggregated flows in a differentiated services network. Proc. IWQoS'99, 1999, London, pp: 156-158.
8. Mahadevan, I. and K.M. Sivalingam, 2001. Architecture and experimental framework for supporting QoS in wireless networks using differentiated services. ACM J. Mobile Networks and Applications, 6 : 385-395.
9. Mahadevan, I. and K.M. Sivalingam, 1998. Architecture for QoS guarantees and routing in wireless/mobile networks. Proc. ACM Intl. Workshop Wireless Mobile Multimedia. Dallas, pp: 11-20.
10. Perkins, C., 2002. IP Mobility Support. RFC 2002, pp: 1-17.
11. Ramjee, R., R. Nagarajan and D. Towsley, 1995. On optimal call admission control in cellular networks. University of Massachusetts Technical Report UM-CS-1995-064, pp: 1-27.
12. Nicholas, K. *et al.*, 1998. Definition of Differentiated Services Field (DS Field) in the Ipv4 and Ipv6 Headers, IETF draft, RFC 2474, pp: 3-5.
13. Bernet, Y. *et al.*, 1998. A Framework for Differentiated Services. IETF Draft, pp: 1-32.
14. Xiao, X. and L.M. Ni, 1999. Internet QoS: A big picture. IEEE Network, 12: 8-18.
15. Um, H.Y., S.Y. Lim and J.W. Ahn, 1998. Access control schemes of integrated voice/data traffic in cdma cellular system. Proc. ICUPC'98, Florence, Italy, pp: 307-310.
16. Liu T.K. and J.A. Silvester, 1998. Joint admission congestion control for wireless CDMA system supporting integrated services. IEEE J. Select. Areas Commun., 16: 845-857.
17. Sadeghi, B. and E.W. Knightly, 2000. Architecture and algorithms for scalable mobile QoS, http://cmc.rice.edu/research/theses/SAD2000APR4ARCHITECTU.pdf
18. Marques, V., R.L. Aguir, F. Fontes, J. Janhert and H. Eissiedler, 2001. Enabling IP QoS in mobile environments. IST mobile communications summit 2001. Barcelona, Spain, September 9-12, 2001, pp: 300-305.
19. Marques, V., R.L. Aguir, N. Chaher, A. Cuevas and J.I. Moreno, 2003. A simple QoS service provision framework for beyond 3rd generation scenarios. 10th International Conference on Telecommunications ICT'2003, Papeete, French Polynesia, February 23-28, pp: 1-7.
20. Semeria C. and J.W. Stewart, 2001. Supporting differentiated service classes in large IP networks. White Paper, Juniper Networks, December 01, http://www.Juniper.net