

Quality of Service on Wireless ATM

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Abstract

The Quality of Service (QoS) within the dynamically changing nature of wireless networks, experiences many issues, specifically in providing high and maintainable levels of QoS for high demand multimedia applications. This paper explores the current technologies and solutions developed to overcome these issues and looks particularly at *Mobiware* - a middleware solution currently being researched at the Centre of Telecommunications Research, Columbia University, New York. This paper presents a proposed extension to *Mobiware* that could provide a solution to enhance QoS in dynamic wireless networks for high demand multimedia content.

Keywords:

Quality of Service, QoS, Wireless Networks, Middleware, Mobile Communications, adaptive algorithms, Active transport

1. Introduction

Quality of Service (QoS) has been defined as “*The collective effect of service performance which determines the degree of satisfaction of a user of the service*” (Sitaraman, n.d). QoS is simply a mechanism for provisioning guaranteed bandwidth over a computer network for high demand content. For example, a simple home network may consist of an upstairs PC, and a downstairs living room TV, wirelessly connected to each other. The user may want to watch a digitally stored movie, located on the PC, on the downstairs TV without copying and storing the movie locally. First, the data must be streamed from the PC to the TV. Current streaming technologies (e.g. Windows Media 9 and RealVideo 9, introduced in 2002) permit near-DVD quality streaming at a rate of 500Kbps. This paper focuses on a lower resolution form of video, approx. 320x240 with a frame rate of 20fps (frames per second) (A Review of Video Streaming over the Internet n.d.). At this resolution and frame rate, video requires around 350Kbps to stream (Windows Media Encoded).

At these speeds, an IEEE 802.11b network (11Mbps) could sustain 31 simultaneous streams in optimal conditions, providing all streams were running a constant rate of 350Kbps. This does not include any network overhead, or any extrinsic factor affecting the quality of the network connection. The aim of QoS in this situation is to ensure each stream receives as close to 350Kbps as possible, and to insure a seamless change of bandwidth allocation to the user when necessary. The goal is to provide a dynamically changing wireless network (that is, a wireless network with devices leaving and entering the network on an ad hoc basis), with the ability to sustain every connected device running streamed multimedia applications with the required bandwidth and network conditions for, satisfactory use. The principle scenario would permit the complexity of multiple devices to simultaneously stream media.

2. Current Technologies

2.1 ATM Networks

ATM (Asynchronous Transfer Mode) networks are combination of two commonly used network architectures, combining a packet switching network with a circuit-switching network employed for telecommunications. Table 1 are some core differences between the Internet, Telco and ATM network architectures:

ATM	TELCO
Asynchronous	Synchronous
Packet switching	Circuit switching
Variable rate	Networks rates are multiples of 8Kbps
Connection-orientated network allowing the user to dynamically select resources	High speed networks have to be manually instigated
PNNI (private network-to-network interface) is a dynamic link state routing protocol	

Table 1. Differences between ATM and Telco network architectures

Although ATM networks have clear advantages, they have not been widely deployed in enterprise networks, aside for use in backbone technology (VBrick Systems, n,d). ATM is used for large-scale carrier networks for its excellent ability to deliver QoS and high bandwidth. Classes of QoS support provided by ATM are:

CBR (constant bit rate): Provides the emulation of circuit switching. This class of QoS is sensitive to delay. E.g. video conferencing and telecommunication traffic.

VBR-NRT(variable bit rate, non real time): transmits of traffic at a variable rate over time, but dependant on available user information. E.g. multimedia email.

VBR-RT (variable bit rate, real time): designed for delay sensitive applications. E.g. Voice with SAD (speech activity detection) and compressed interactive video.

ABR (available bit rate): rate based flow control. Does not require guaranteed or minimized cell delay or cell loss ratios. Dependant on network congestion, the data source is required to control the transmission rate. E.g. include file transfer and email.

UBR (unspecified bit rate): used if the above 4 are not. UBR is most widely used for TCP/IP.

ATM's cell structure is comprised of 53 bytes, of which 48 bytes are reserved for its payload. The cell incorporates a field for denoting the class of support that is currently in use (listed above). It is interesting to note (while discussing multimedia applications) that the development of the MPEG-2 standard was guided by the ATM architecture. MPEG-2 streaming is delivered in 188 byte sections, which precisely fit within the AAL5 layer of ATM. This development allows MPEG-2 streaming (up to DVD quality video) to take full advantage of the QoS provisions of ATM.

2.2 Wireless ATM (WATM)

Fundamentally the integration of ATM wired networks, into the wireless platform to encompass the end-to-end wired ATM advantages (namely QoS) in wireless technology. WATM is still in development with no agreed/fixed standards. Wireless ATM architecture comprises of a collection of base stations interconnected using wired ATM technology to provide maintainable end-to-end communications, utilizing wireless technology.

2.3 Quality of Service

To fully assess how to achieve QoS in a wireless environment, we first need to assess what it is, and what it involves. QoS provides the systems designed to provide guaranteed QoS. Its aim is to provide the end user, guaranteed bandwidth and service. QoS is applicable for high demand applications such as video and audio streaming. These applications require a minimal level of service to function, and seamless transition between levels of service. There are four main aspects of QoS to consider and be aware of:

Reliability: QoS aims to provide reliable and error free data with methods of CRC (error checking). With regard to services such as video or audio streaming, CRC/error checking can be an unnecessary and high cost overhead. Such applications can run adequately with an acceptable degree of data loss. For example, 1 dropped packet during a video stream may only mean one dropped pixel for one frame. During file transfer, error checking is vital – 1 dropped packet during the sending of a file could be the difference between a usable, successfully transferred file, and corrupt, useless data.

Delay: delay in network transmission is inevitable, and depending on the distance data must travel to reach the end user, will dramatically vary. Greater distance will usually involve data passing through more devices such as routers. Each device will add its own overhead to the transmission increasing the delay of reaching the end user. With regards to multimedia streaming applications, delay greatly affects the end users experience. As streaming means live data transfer, any stop or delay through a media stream will halt that stream. For example, additional delay in a video stream would pause and skip the video. To avoid this, devices and end applications use buffers to store a ‘build-up’ of data. The buffer receives the stream, and the application plays from the buffer. If delay occurs on the network, the video can still play from the cached buffer. When the delay subsides, the buffer can replenish. It is these buffers that form a major part to the Proposed *Mobiware* additions and enhancements.

Jitter: essentially, the arrival of incoming packets at irregular time intervals. Jitter causes delay. Buffering (as afore mentioned) is a method of ‘smoothing’ this delay and creating a seamless stream for the end user who is kept unaware of fluctuating network conditions. However, buffering has its own costs, namely additional delay. As buffers hold a cache of the incoming transmission, delay is added at the start of the transmission while the buffer is populated with data. Personally, I believe the initial delay in buffering is more than acceptable if the video or audio stream is later run flawlessly.

Bandwidth: is the quantity of packets transmitted per second. High demand applications such as audio and video demand high bandwidth. QoS services attempts to manage bandwidth utilisation to provide maintainable QoS.

2.4 RSVP

RSVP is a technology used today with IP based networks. A host would use RSVP to request specific QoS from the networks it is using. RSVP carries the request through every node in the network used to carry the required data stream. Each node is requested to provide the required resources for the QoS. RSVP runs on IP networks, both IPv4 and IPv6 and thus falls outside the scope of this paper. It is however a relevant QoS protocol used widely today.

3. Enhancing QoS for Wireless

One possible solution is to combine ATM QoS advantages with wireless adaptability to address the complexity of the problem, *Mobiware*, currently being researched at the Centre of Telecommunications Research, Columbia University, New York, attempts to do this.

3.1 Mobware

Mobware, is based on the latest distributed system technology and claims to be a highly programmable middleware platform designed to run between the radio link layer and application layer of future next-generation wireless systems, such as base stations and WATM switches. Built on distributed systems and Java technology, it uses adaptive algorithms to transport scaleable transmission flows.

A very interesting aspect of *Mobware* is its application specific ‘flow adaptation policy’. This policy in its basic form characterises each transmission stream (flow) of data and recognises its acceptable minimal level of QoS. Using this information, *Mobware* is capable of scaling each stream to match available bandwidth while attempting to ensure each transmission stream at least maintains these acceptable QoS levels. A further claim of *Mobware* is provision of QoS support that allows multimedia applications to operate transparently during handoff and through heavy QoS requirement fluctuations. *Figure 1* shows the architecture makeup of *Mobware* (Campell, A. T., (n.d).

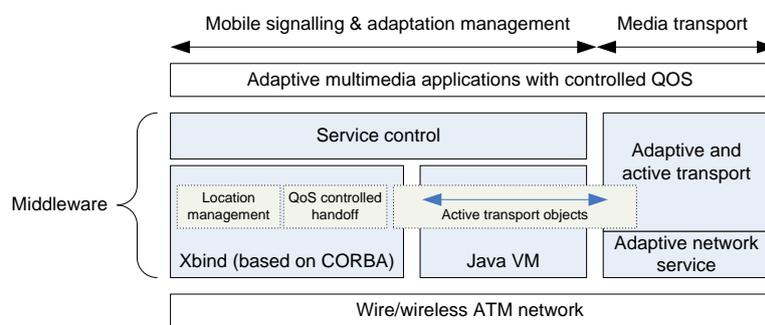


Figure 1. Mobware Architecture, (Campell, A. T., (n.d))

Mobware has set out to improve on multi-rate multimedia connections. These are difficult to achieve with current widely deployed technology, namely the Internet. And, with the rapid continual expansion of the Internet, and the increasing demand for this type of usage, solutions must be found. Multi-rate connections also require management to ensure a seamless change in transmission quality to the end user. *Mobware* achieved this through end-to-end QoS control using two methods: resource binding between devices and *Mobware*'s adaptive algorithms as illustrated in figure 1, (Campell, A. T., (n.d):

QoS controlled handoff: providing signalling of handoff events, used to represent flows, aggregation of these flows to/from devices and re-routing negotiation.

Adaptive network service: provisions QoS guarantees based on available resources.

Adaptive and active transport: supports multilayer transmission flows via *Mobware*'s API.

4. Intelligent Adaptive Buffer Control an Extension to Mobware

This paper has discussed QoS, and the methods for providing the levels requested. *Mobware* has begun to address this in wireless networks. QoS has limits and can only be provided when the available bandwidth exists, or, can be manipulated by QoS methods. However, can QoS be maintained in highly saturated networks with additional requests? A proposed solution for maintaining QoS in highly saturated networks, whilst still maintaining the levels of QoS for current users, but also providing the service for additional requests at the cost of initial delay is investigated below.

Figure 2 illustrates the above scenario in action, demonstrating the activities of iABC. Two users U_1 and U_2 are maintaining a connection for Mpeg2 video, streaming at 350kbps, without using any active buffering. A total bandwidth of 800kps is available, leaving 100kbps of bandwidth currently unused (B_a). This is determined (see equation 1) by subtracting the total bandwidth (B_T) available from the number of current users (n) multiplied by their bandwidth requirement (B_r)

$$B_a = B_T - nB_r \quad (1)$$

A third user (U_i) requests to join the network, it is predicted that the request is 1 minute of streamed video requiring a bandwidth of 350kbps. It is also predicted that users U_1 and U_2 will demand their current level of bandwidth for a prolonged period of time, resulting in the user (U_i) request normally being rejected, which is unacceptable.

iABC proposes to dynamically buffer the requirements of the current users while maintaining the QoS, enabling the request of user (U_i) to be fulfilled. This is accomplished by utilizing the predicted requirements of user (U_i). Therefore determining users U_1 and U_2 buffer (B_f) requirements, B_f is calculated by multiply the predicted transmission time requested by the available bandwidth shared between the number of existing users as shown in equation (2).

$$B_f = T_p * \frac{B_a}{n} \quad (2)$$

This is also equivalent to the delay incurred before any bandwidth is available to fulfil U_i request. In this scenario it is known that U_i requires 1 minute at 350Kbps. Therefore if U_i could utilize the total bandwidth 26.25 seconds will be needed to completely buffer the requested video download.

$$T_b = \frac{Bf_i}{B_t} = \frac{Bf}{B_r} \quad (3)$$

The iABC instructs both users U_1 and U_2 to fill their respective buffers to hold the required data freeing up bandwidth for user U_i to initiate its request. Both users U_1 and U_2 share the remaining bandwidth to populate their buffers, the amount of data required in these buffer's is determined by the time taken to populate user U_i buffer as illustrated in equation (3). In this case given the available bandwidth per user is 50kbps, therefore in this scenario it would take 183.75 seconds to fill users U_1 and U_2 buffers. On completion the total bandwidth is release to user U_i to fulfil its request, therefore 21000kbps of data is buffered to provide a minute of video. Simultaneously the buffers of users U_1 and U_2 are being emptied, at the point when user U_i request is completely downloaded, users U_1 and U_2 buffers will be completely empty, at which point they will reclaim their original bandwidth requirement form user U_i , who now can access its data from the buffer.

iABC provides an interesting proposition to provide all parties with their respective requests, while maintaining a high and maintainable QoS for all. It did however, come at a cost in terms of delay to the required service request. It is a high cost, but opposed to outright refusal of service could possibly be viable.

$$T_p = \frac{nT_s B_r^2}{B_T (B_T - nB_r)} \quad (4)$$

Combining all the variables into a single equation (see equation 4) further analysis can be carried out into the impact of varying demands on the bandwidth. As illustrated in figure 3 the longer the transmission period (T_p) the greater the delay is before the request is fulfilled.

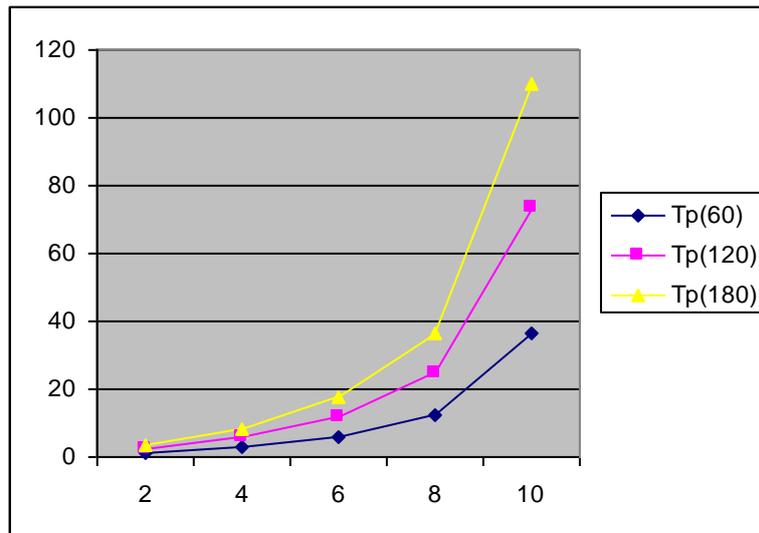


Figure 3. Effects of Transmission Periods on Delay

There are two main drawbacks that are apparent. (1) Large lead-time for user U_i , before requested resource becomes available and, (2) iABC requires high-level integration with the end application to request and instruct buffer changes.

5. Conclusions

Today's common, wired network has achieved QoS, although limited by available bandwidth. Development is ongoing, and ATM networks are still immature other than backbone technologies. With the introduction of wireless networks, a new domain has opened with new challenges for achieving true QoS. ATM is merging with wireless to form WATM, but this is also underdeveloped, with any form of standard yet to be achieved.

Mobiware is a software solution to QoS in wireless networks, attempting to resolve the problems and complexities it introduces. From current research, it appears to be making steady inroads. However much work is still needed. The proposed solution iABC demonstrates a viable solution, as illustrated in the example, where, two data streams tied the wireless network for a long period of time. In this circumstance, a 3 minute wait provided the requested resource as fast as possible in the given conditions. However, in different scenarios, if iABC incorporated further intelligent time slicing of the bandwidth between the devices the current delay would be improved. With the introduction of 54g wireless, and now 108Mbps, many more applications can be supported. Despite all solutions, QoS methods, additional bandwidth etc, we are trying to make a resource that is finite appear infinite. Ultimately,

bandwidth can only support a certain number of devices at a certain level of quality. When that limit is reached, additional requests will simply have to wait for freed resources.

Networks, like every other aspects of IT are continually and rapidly evolving. The Internet is starting to outgrow its roots, and unless new technologies like those covered in this paper can be refined and implemented on a mass and commercially viable basis, the Internet will eventually cease to function in any usable state, and will certainly be unable to cope with the future of high demand real-time content.

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