DOCSIS 1.1 – WHERE GAMING AND QUALITY OF SERVICE (QOS) INTERSECT

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Abstract

Broadband on-line gaming is poised to be a key usage demand for residential high-speed data customers. With the recent releases of hugely multiplayer games such as Ultima Online and the availability of network enabled gaming consoles such as the Microsoft Xbox and Playstation 2, there are increasing opportunities for MSOs to cater to (and profit from) the demands of the broadband gamer.

VIDEO GAMING IS NOT A GAMBLE

Given the public launch of broadband-enabled gaming consoles in the last year, such as the Microsoft Xbox and Sony Playstation 2 consoles, considerable interest in cable modem service has been generated within the gaming community.

By January 7th, 2003, Microsoft announced that more than 250,000 subscribers had signed up for the Xbox Live service that was launched on November 15th, 2002 – this is twice as much as initial sales projections [1]. With 21.5 million Sony Playstation 2 consoles shipped to North America as of January 9th, 2003 [2], one can expect that quite a few owners will opt to purchase network adapters allowing for on-line game-play over a cable modem. To a lesser extent there is still demand for network access from Nintendo GameCube customers and the customers with the more aged Sega Dreamcast.

As the console gaming industry is a multi-billion dollar industry within North America [3], where are the opportunities for Multiple Service Operators (MSOs) to provide gaming services that provide added value to their customers and subsequently results in new revenue streams?

The most obvious possibility is to simply use gaming to attract new high-speed data customers to cable modem service. Every Xbox console is manufactured with an Ethernet port that is the sole interface for networked-based games. Xbox Live games are typically written for network play with the assumption that the bandwidth available will be less than 64Kbps upstream and downstream. It is relatively easy to provide a DOCSIS configuration file for a cable modem that limits its bandwidth consumption to 64Kbps. Likewise, the physical location of the Xbox relative to the physical location of a cable modem within the home is not a real problem given the availability of wireless Ethernet bridges and wireless-equipped cable modems. This opens up our potential pool of customers beyond households containing PCs.

The question is: Can MSOs offer this product without cannibalizing its existing high-speed data customer base? One stumbling block is that while it is easy to limit a cable modem service to 64Kbps, it is far more difficult to limit a service to only support console gaming. While the IANA list of well-known port numbers describes both TCP and UDP ports 3074 as being the "Xbox port"[4], our observations have shown that Xbox Live games use a wide variety of ports, of which 3074 is merely the most used. This greatly limits an MSO's ability to create filters on a cable modem to allow Xbox traffic yet disable the customer's ability to attach his PC to a "gaming cable modem" to surf the web or run peer-to-peer applications. Likewise, attempts to filter traffic based upon the MAC address of the console are fruitless given the end-user's ability to change the Xbox's MAC address at will. Similar behavior is seen from Sony Playstation 2s.

On a practical operations note, typically ISPs like to sign up customers with the minimum of paperwork. Customers are usually instructed to accept the ISP's "Terms and Conditions" electronically on a web page. This proves to be challenging for a new gaming-only customer to complete using only a gaming console.

It is worth pursuing the concept of attracting new customers from households which either only contains gaming consoles or which contain both consoles and PCs but have not yet opted for cable modem service, at a service tier whose bandwidth is less than the typical residential high-speed data tier. The MSO's market trials are still in their infancy, and there is not yet enough statistical data to determine whether offering lower-priced gaming tiers will cannibalize higher-priced PC-centric tiers, but anecdotal observations have so far indicated that downgrading very seldom occurs.

Co-Location Opportunities

Game publication is a multi-billion dollar revenue generator for large game publishers such as Electronic Arts [5], and as a result, these publishers spend a great deal of time and money to ensure that the servers on which the games are hosted are highly available, scalable to the number of customers playing, and well located within the network to provide low-latency gameplay. The Xbox gaming servers seem to provide a consistent "feel" to the gameplay as the servers for each title are managed by Microsoft. The game servers for PS2 games are not maintained by Sony, but are maintained by the individual publishers. Regardless of the model for server maintenance, the argument can be made that co-locating the gaming servers within an MSO's network can be a win-win situation for the publishers and the MSO. The MSO's customers experience even lower network latency which should make the customer and the publishers happy and the MSO benefits by keeping more gaming traffic on their network and off of the backbone.

Quality of Service Opportunities

What value-add could an MSO possibly bring to a gaming experience for which a gamer might actually pay? After all, console gaming over a cable modem works well today. One differentiator for MSOs is the ability to offer quality of service (QoS) guarantees. While console gaming works well today in a purely best effort data environment, MSOs will soon be offering many new services which will constrain how much bandwidth is available for best effort services. A perfect example is the offering of Voice-over-IP (VoIP) in a DOCSIS 1.1-enabled network. Assuming that the VoIP traffic is being transmitted using the DOCSIS Unsolicited Grant Service (UGS) traffic flows on the same upstream and downstream channels as the traditional Best Effort services, then for each phone call being made through a CMTS, there is obviously less bandwidth available for gaming.

In a bandwidth constrained environment, would gamers pay to possess a guaranteed amount of bandwidth and guaranteed latency dedicated to console traffic? Probably. One can argue that as new services are rolled out, MSOs will also be rolling out more efficient equipment (higher modulation profiles, DOCSIS 2.0, etc) that will offset any bandwidth constraints created by new services. The counter-argument is that this is unlikely given customers' penchant for consuming all bandwidth available to them, and even were it true, gamers may still be willing to pay a small fee just to achieve guaranteed low latency for their consoles. Gamers are constantly looking for an edge over their on-line opponents and are convinced that low latency gives them that edge.

QoS – Background

The DOCSIS 1.1 specifications created a foundation upon which products with quality of service requirements such as latency and bandwidth can be built. There are essentially two mechanisms for defining quality of service, "provisioned QoS" (pQoS) or "dynamic QoS" (dQoS). The parameters dictating the pQoS settings are pre-defined in the DOCSIS configuration file that the cable modem receives at the time that it boots. The DOCSIS configuration file would typically define a classifier that determines which packets are affected by the defined quality of service rules. The packets that meet the classifier's parameters make up a unidirectional stream of packets known as a "service flow". For example, since the majority of Xbox gaming traffic is transmitted to and from port 3047, a classifier can be defined which places all UDP or TCP packets transmitted to, or received on, port 3047 onto a particular service flow. That service flow has QoS parameters associated with it, such as a scheduling type (e.g. real time polling vs. best effort) and latency requirements (e.g. sub 150ms). All other traffic could default to a standard best effort service flow which would have a lower transmission scheduler priority.

Obviously, the DOCSIS 1.1 specifications only handle reserving and allocating bandwidth within the DOCSIS domain, specifically between cable modems (CMs) and the cable modem termination server (CMTS). End to end QoS can be setup with a combination of DOCSIS 1.1 and DiffServ or MPLS.

Dynamic QoS is typically used today in PacketCable-based voice over IP (VoIP) deployments. In this case bandwidth is reserved for voice calls "on the fly" between the cable modem and the CMTS only when a message is generated that indicates that a customer's phone has gone off-hook. An extension to the voice-centric PacketCable specifications is a promising possibility for future gaming services. The primary functions defined by the PacketCable VoIP specifications are QoS authorization and admission control, generation and capture of billing information, and security. These are all functions desirable in a QoS-aware gaming environment. CableLabs has been working on an extension of these specifications, known as PacketCable Multimedia [6], which expands the residential voice-centric specifications to be a general purpose platform for delivering many IP-based multimedia services that depend upon QoS. Note that while the PacketCable Multimedia framework is based upon the VoIP PacketCable specifications, the implementation of a VoIP PacketCable service is not a pre-requisite for PacketCable Multimedia-based gaming as gaming has no requirements for voice specific items such as wiretapping, PSTN interconnects, etc.

PacketCable Multimedia Architecture for Gaming

The easiest way to describe the PacketCable Multimedia Architecture is to provide a diagram of the architecture and discuss the functionality and interaction of each of the components as it related to providing QoS for gaming applications.

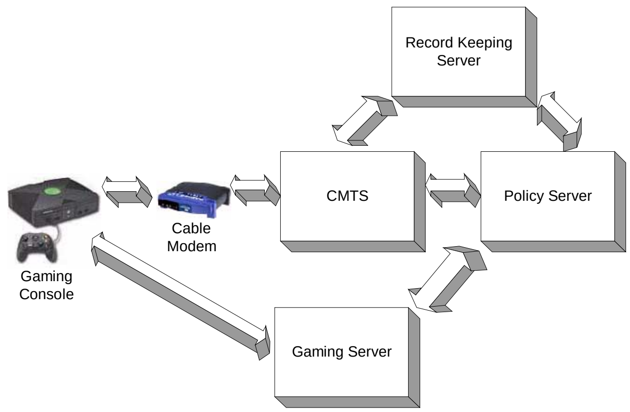

Figure 1 - PacketCable Multimedia Architecture for Gaming

Our assumption is that the gaming console has no concept of its QoS requirements nor of the PacketCable signaling like that available to a VoIP MTA (multimedia terminal adapter) to signal its desire for QoS reservations. Instead, a gaming console simply communicates with the gaming server as it does today. (e.g. Xbox's MechAssault game causes the Xbox to communicate with Xbox Live servers to set up a gaming session between players).

The CMTS is the gatekeeper (referred to as a Policy Enforcement Point or PEP) which determines whether the resources are available to reserve bandwidth between the cable modem and itself. Thus, the gaming server must communicate the console's bandwidth needs to the CMTS. It does so through an intermediary known as the Policy Server. As there could be many different applications all of which are contending for limited bandwidth resources, the Policy Server determines the relative priority of each request (based upon business rules) to determine which requests for QoS should actually be given to the CMTS. The Policy Server is also referred to as the Policy Decision Point (or "PDP").

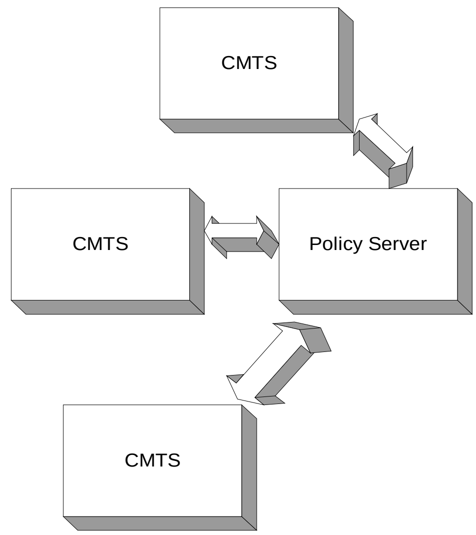

Figure 2 – A single policy server can serve multiple CMTSs.

Once instructed by the Policy Server of the gaming console's QoS requirements, the CMTS creates service flows for an individual cable modem's gaming traffic with the appropriate QoS characteristics. As an option, the PacketCable Multimedia architecture also takes into account the desire to track the actual usage of the QoS-based service flows for billing purposes. These billing records are gathered and maintained on the Record Keeping Server.

The gaming server and the policy server are expected to reside within the MSO network and are considered trusted devices. The gaming server must also take on the responsibility of authenticating the gaming console and assuring that the consoles are authorized to request gaming services.

Messaging Protocols

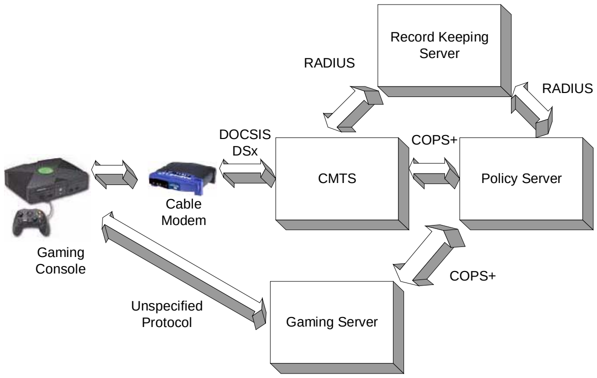

Figure 3 – Messaging Protocols

Obviously, there is also a messaging flow between the CMTS, Policy Server, Gaming Server, and gaming console which indicates the success or failure of the QoS provisioning. The messaging between the gaming console and the gaming server is outside of the PacketCable specifications. The messaging from the gaming server to the Policy Server and from the Policy Server to the CMTS is IETF's COPS based. Any event messaging sent from the Policy Server or CMTS to the optional Record Keeping Server is RADIUS based, and the CMTS/cable modem exchanges to establish QoS-based service flows is based on DOCSIS DSx messaging.

This has been a greatly simplified explanation of QoS allocation. Upstream and downstream service flows are handled by the CMTS in different manners. Upstream transmissions are made on a contentious, shared-access medium, where downstream traffic is handled by the CMTS as if it were a traditional IP router. The specifics of the QoS parameters that are associated with upstream and downstream service flows (these parameters are different) and the service flow scheduling types can be found in the VoIP-centric PacketCable 1.0 specifications. [7]

You will notice that there are a few things missing which simply fall outside of the PacketCable Multimedia domain, namely end-to-end network QoS setup including Policy Server to Policy Server communications. One can imagine that gamers desire low network latency on each network segment over which their gaming traffic travels. This can conceptually be handled by DiffServ or MPLS – most MSOs would argue that their network backbones are over-engineered and that the DOCSIS component is where the bandwidth is the most valuable resource.

Most relevant gaming servers have the ability to match gamers based upon their historical levels of quality of play (that is to say, based upon how good the player is at performing the game), and also based upon the latency of the gamer's network connections. Obviously, one goal of the PacketCable Multimedia framework can be to lower the latency of an individual gamer's network connection to the CMTS. The game servers would need to report the gamer's potential latency when matching up gamers rather than their pre-service-flow-setup latency. This could require some additional communication between the gaming server and the policy server and potentially inter-policy server or inter-gaming server communications.

The gaming consoles described above are referred to in the PacketCable Multimedia Architecture Framework as "legacy" clients as these consoles are unaware of the QoS capabilities and signaling necessary for the QoS negotiations within the framework.

A second type of client can have some PacketCable awareness built-in – when a network-based game is started, the client can request QoS. The console can now signal to the CMTS to add, change or delete bandwidth reservations, but the CMTS will only accept the reservations if the gaming server and policy server have authorized the console's reservation. This is very similar to the behavior of a VoIP MTA. This concept of building PacketCable awareness into a console or console game will probably not receive much enthusiasm for implementation by the game developers unless there is a considerable client base that could make use of it. For that reason, we anticipate that support for legacy clients must be well implemented first.

The third type of client is one which is totally PacketCable aware and does not depend upon a gaming server to setup its QoS. Instead the console is capable of transmitting its own bandwidth QoS requests to the CMTS along with authorization credentials. The CMTS passes the request onto the Policy Server which authenticates and authorizes the consoles request. The request message is then sent back to the CMTS which will then setup the appropriate service flows for that console.

The details of the PacketCable Multimedia signaling message structures, service flow scheduling types, service flow management, etc are outside of the scope of this document, but should be publicly available in the CableLab's PacketCable Multimedia Technical Report and Specifications by the time of the publication of this document.

Summary

Console gamers are able to use cable modem connections today with good results. As MSOs deploy new services that consume more of the limited bandwidth available between the cable modems and cable modem termination servers, the gamers' user experience could become less attractive. One method to enhance the user experience is to implement a PacketCable Multimedia Architecture that would enable QoS guarantees for gaming consoles without modification to those console or console games. This architecture would require enhancements to the gaming servers to make the server applications capable of interacting with the Policy Servers.

We have seen that there are a lot of customers playing games on our broadband networks, research shows that they are willing to spend vast quantities of money to do so, and they have voted with their wallets to use today's low-latency, high speed connections - it is up to the MSOs to cement the relationship by providing a service which is unobtainable from other providers.

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