DRAFT

Abilene Premium Service Test Program

Abilene QoS Planning Group *

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Abstract

The goal of this document is to describe the Abilene Premium Service (APS) and a test program open to Abilene connectors interested in obtaining wide-area QBone Premium Service (QPS) connectivity to supplement local QBone deployment and testing efforts. The intention of Abilene engineering is to evolve the Abilene Premium Service into an exemplary implementation of the QBone architecture. Deployment will be in four phases, with each phase offering an incrementally stronger service assurance converging toward the QBone Premium Service definition, as well as offering incrementally better measurement, monitoring, and setup functionality. This document describes the APS test program (including its operational aspects and a detailed description of the expected service phasing), provides an overview of the implementation of APS on Abilene's Cisco GSR routers, and defines the requirements for connectors who wish to participate in the APS test program. This document is an evolving draft and is subject to change without notice.

1 Abilene QoS

The Abilene backbone network provides high-performance best-effort nationwide connectivity to Internet2 universities and other institutions. Internally, Abilene is a pure packet-over-SONET (POS) network, providing coast-to-coast OC48 (2.4 Gbps) IP transit. Connectors attach to one of ten POPs with either POS or IP-over-ATM access circuits, running at OC3 (155 Mbps), OC12 (622 Mbps), or OC48 (2.4 Gbps) speeds. Logical connectivity at the time of writing is shown in Figure 1.

This document describes the test program for an evolving Abilene QoS service—the Abilene Premium Service (APS). APS is designed for full interoperability with the QBone Premium Service (QPS) [Dra99] and aims to provide a low-loss, low-jitter inter-connector transit service that can be concatenated with other QPS implementations to build an end-to-end

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interdomain service. In addition to receiving differentiated treatment for APS packets, APS test program participants will benefit from access to Abilene QoS measurements and (limited) technical support to assist with access-router configuration issues.

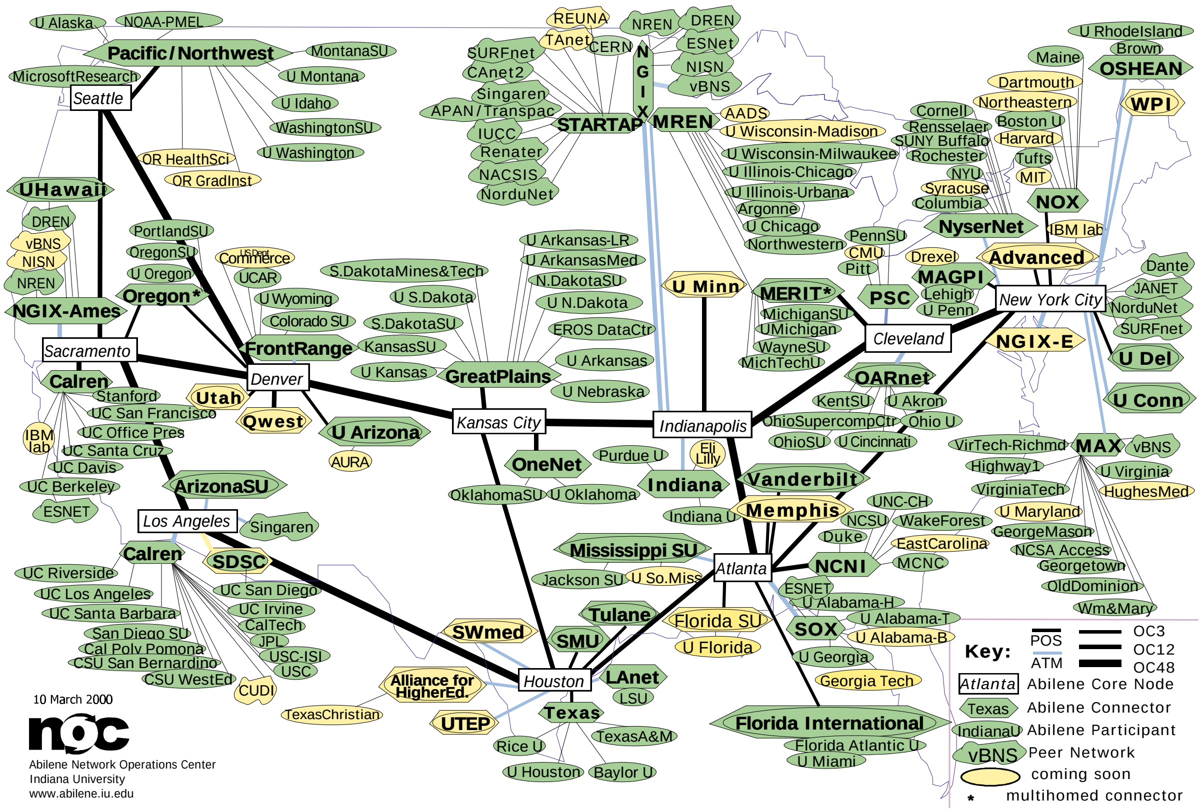

Figure 1: Abilene Logical Connectivity (February, 2000)

It should be understood that the Abilene Premium *Service* described in this document is neither a production Abilene service nor a pre-production Abilene service. APS is a "service" only in a technical sense meant to distinguish the treatment of APS packets from the treatment of non-APS packets in the Abilene network. The APS test program represents Abilene's participation in the QBone initiative; it is fully consistent with the goals, flavor, and architecture of the QBone.

Being an Abilene connector is necessary but not sufficient for participation in the APS test program. The Abilene network operations center (NOC) and Abilene QoS engineering group will determine when to admit new APS test program participants on a case by case basis based on the technical and operational constraints in place. A good-faith effort will be made to accommodate all qualified connectors who want to participate in the APS test program, but no assurances are made. Because it is our ultimate intention to evolve APS into a production Abilene service, some language in this document may be suggestive of APS as a production Abilene service. It should be understood, however, that APS is still very much in the testbed phase, evolving in its definition and realization as more is learned about the engineering of scalable and robust IP QoS services.

The remainder of this section describes the anticipated uses for APS and motivates the deployment of QoS on an uncongested backbone. Section 2 describes the ideal Abilene Premium Service model, including the measurement and monitoring data and tools that we aim to provide; this section also describes the expected and actual service phasing. Section 3 gives detailed descriptions of the implementation of APS service features on Abilene's Cisco 12008 GSR routers and the implementation of the APS measurement instrumentation and dissemination infrastructure. Finally, Section 4 describes requirements for APS test program participants and procedures for interacting with the Abilene NOC to request APS connectivity during the test program period.

1.1 Anticipated Uses

Because Abilene is a transit network, the primary clients of the APS will be connector networks. APS reservations will be negotiated only with Abilene connectors, and not with non-connector Abilene participants or Abilene secondary participants. Each APS reservation is between Abilene and an Abilene connector, and represents a commitment to deliver APS forwarding to a well-specified traffic aggregate originating from or having as its destination another Abilene connector. In this sense, strictly speaking, APS provides QoS only between the access points of participating connectors, and not end-to-end. However, the ultimate goal of APS is to fit into the end-to-end framework articulated in the QBone Architecture [Dra99] and to participate in extending a low-loss, low-jitter service to the end users of QoS-needy applications.

1.1.1 Enabling QoS-needy Applications

The QBone Premium Service, and consequently the APS, targets the needs of real-time interactive applications. Real-time applications typically support either human-to-human collaboration or human-to-machine remote control, and demand a level of interactivity that imposes stringent worst-case delay, jitter, and loss requirements on the underlying network service. These applications often demand worst-case network performance bounds that must be maintained on any time interval longer than a few tens of milliseconds. Examples of human-to-human collaboration include conferencing, VoIP, and teleimmersion. Examples of human-to-machine remote control include control of remote scientific instruments (*e.g.* microscopes, telescopes), and data-immersive environments, in which researchers interact and steer remotely-rendered models or data visualizations.

We envision that APS will play an important role in providing backbone transit for QBone traffic. Technical support will be provided to connectors to assist with configuring connector access routers and local network monitoring devices participating in the QBone measurement infrastructure. However, meaningful end-to-end QoS services for end users can only be realized if Abilene connectors and participants work to extend the QBone Premium Service implemented by APS across non-trivial pieces of their gigaPoP and campus/enterprise networks.

1.1.2 Enabling "Virtual Peerings"

Because APS assurances are applied to marked traffic aggregates between pairs of Abilene connectors, they may be used to guarantee a certain level of service between participating connectors. The Abilene Premium Service leverages the expedited forwarding (EF) per-hop behavior under standardization in the IETF [JNP99] to implement an aggregate forwarding service model that has been described as like a *"virtual leased line"*. From a forwarding perspective, the connectivity between connectors with an APS reservation in place should be as if they were connected by a leased line. However, because from a routing perspective each is still peering with Abilene, a true *"virtual peering"* would have to involve additional IP tunneling between routers participating in the overlay network.

Whether the requirement is to support a one-time wide-area demonstration of an application with specific network performance needs, or to support an ongoing virtual overlay network for computer science researchers experimenting with new network protocols or distributed systems models, we envision that APS will be a useful tool for network managers. The value of APS to network managers and end users alike is particularly great when APS may be concatenated with other QPS implementations to increase the topological extent of the QPS assurances.

1.2 Why Here? Why Now?

Because Abilene is currently very lightly loaded [1] and new fiber deployments and link technologies such as DWDM and gigabit Ethernet promise to greatly reduce the cost of bandwidth, some have argued that an overprovisioned best-effort network is a far simpler and cheaper way to achieve the end-to-end performance assurances that applications need. We believe that if Internet2 networks are going to support the emergence of new advanced applications, relying on best- effort bandwidth growth alone is a risky strategy.

There are three fundamental reasons why we are aggressively pursuing the deployment of Abilene QoS and participation in the emerging end-to-end QoS infrastructure of the QBone.

The foremost reason is that even in today's lightly loaded Internet2 networks, congestion is a problem. Today, many end-to-end performance problems arise because of congestion local to the campus stub networks, where commodity traffic is intermingled with non-commodity Internet2 traffic. Furthermore, physical infrastructure improvements to local area networks

[1] 5% interior link utilizations are typical at the time of writing

are costly and time-consuming. To assume that universities can grow out of these congestion problems is at best overly optimistic and at worst reckless. In the wide-area there are far fewer congestion points, but they do exist, particularly at peering points with international R&E networks (many of whom are connected to Abilene though costly and congested submarine circuits).

The second reason is the need to prepare for congestion if and when it occurs. The history of the growth of Internet traffic is full of examples of new applications whose rapid growth came as a complete surprise. Indeed, it is the intent of the Internet2 project to create an environment conducive to the explosive growth of new applications. The recent growth of Napster/MP3 traffic provides just such an example, though in this particular case the application in question is widely regarded as without educational merit. By not deploying QoS to protect valuable new interactive applications, Internet2 risks becoming a victim of its own success. All evidence shows that the Internet is subject to a “tragedy of the commons” market dynamic, in which use of a common resource (bandwidth) with neither rationing nor pricing feedback results in sub-optimal benefit for all users.

Finally, and perhaps most importantly, there is a need to blaze a trail for other Internet2 networks in which congestion is more of a problem and deployment of QoS more of a challenge. Abilene seeks to implement an exemplary QoS architecture that can be modeled and studied by campus and gigaPoP network architects as they seek to extend QoS services throughout their networks.

2 Abilene Premium Service (APS)

As has been mentioned, the Abilene Premium Service is defined in terms of the QBone Premium Service [Dra99], which in turn is based on the ”virtual leased line” (VLL) premium service described in [NJZ99]. The goal of this service is to combine expedited forwarding (EF) [JNP99] with strict ingress policing to provide near-zero packet loss and very low, bounded-worst-case queuing delay.

The APS service description articulated in this section and implied by the specification of the QBone Premium Service [Dra99] represents an ideal, toward which the APS service provided under the APS test program will converge. During the course of the APS test program, the actual APS performance observed by participants may differ substantially from the ideal described here. Projected and actual deviations from the service ideal are discussed in Section 2.4, which identifies four distinct phases of APS deployment.

2.1 Premium Packet Transit

The APS, consistent with the specification of the QBone Premium Service, will provide a "Premium" transit service for EF aggregates. To conforming traffic aggregates marked with the recommended EF DSCP of 46 (101110), APS will provide the low-loss-and-jitter assurances described in the QPS specification.

Initially, APS aggregates will be classified only by ingress interface and DSCP value (this is the so-called "fire hose" model of classification). Ultimately the intent is to set APS profiles at the granularity of simplex {ingress, egress} pairs (this is the so-called "virtual trunk" or "virtual wire" model).

As with the QBone Premium Service, reservations are contingent on AS path stability, but *not* on hop-by-hop path stability. Consequently, when a new APS request is admitted, the requester will be quoted a worst-case jitter bound that reflects pessimistic assumptions about interdomain routing. A jitter bound for the default interdomain route and/or a 95^{th} percentile jitter bound may also be quoted.

2.2 Always-on Measurement and Analysis Tools

No service offering would be complete without mechanisms for verification and analysis. Abilene is currently collecting SNMP statistics, and Advanced has deployed Surveyor to verify best-effort traffic metrics. The QBone will require a whole new set of metrics to accommodate verification of service [Dra99]. Abilene is planning to collect new sets of SNMP statistics for Expedited Forwarding, as they become available. Similarly, Advanced is devising extensions to the current Surveyor program for active measurement of the metrics required by the QBone Architecture.

Currently the best-effort statistics are not located at a single site for public inspection, and due to shortage of resources some of the collected statistics are not publicly available anywhere. It is clearly desirable to make all the collected statistics, both BE and EF, available at a single distribution point. The Ohio GigaPOP (OARnet) has agreed to house a server and create tools to provide a single point of distribution for all statistics collected. The data will be made available via HTTP in both text and graphic formats, as specified in the QBone Architecture document [Dra99].

2.3 Connector Support

Limited technical support to APS test participants will be available from NCNE and the Abilene NOC.

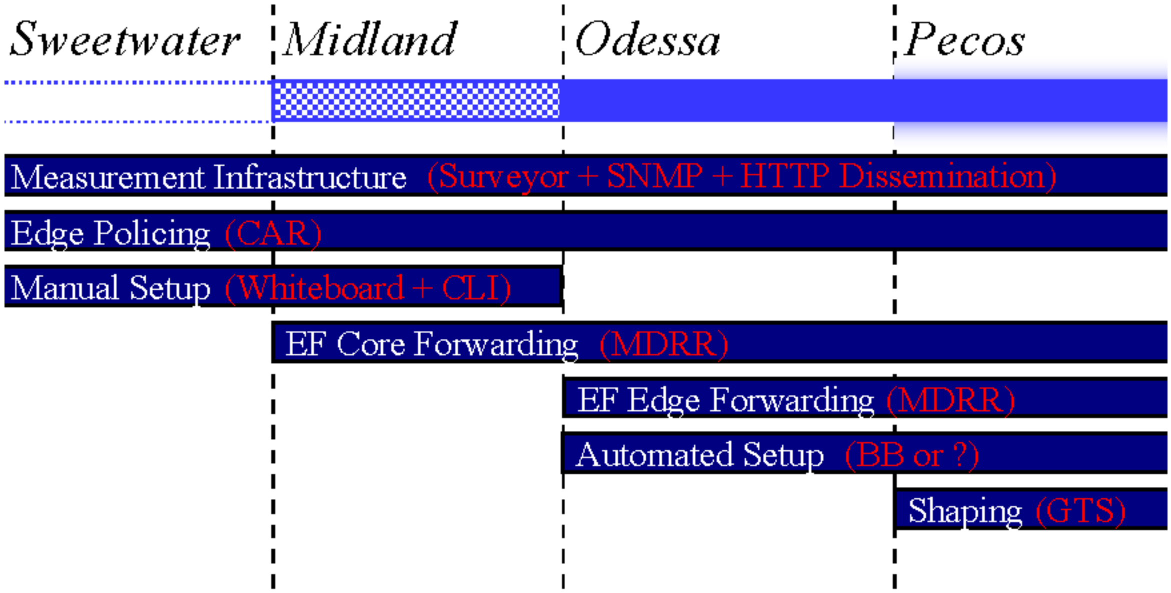

Figure 2: Expected Service Phasing

2.4 Expected Service Phasing

The Abilene Premium Service will be deployed in four distinct phases, each representing a closer approximation to the APS service ideal described above. The phase descriptions below contain important qualifications and caveats that relate each phase to the ideal APS service model. For current and past phases, what is described is the actual APS service seen by test program participants. For future phases, the expected enhancements and evolution of the service are described.

The current phase of the APS test program is: *Sweetwater*.

2.4.1 Phasing Overview

Figure 2 depicts an overview of the expected service phasing. There are four phases (*Sweetwater, Midland, Odessa, and Pecos*), which are principally defined by the presence or absence of key pieces of core and edge functionality.

2.4.2 Sweetwater

The Sweetwater phase is characterized by three pieces of functionality:

- **Edge Policing** EF-marked packets that a connector injects into Abilene are policed to an agreed-upon profile and dropped if they exceed its configuration.

- **Over-provisioning** Conforming EF-marked packets injected into Abilene receive the same high-performance best-effort service given to non-marked packets (*i.e.* DSCP=0).
- **Measurement** Best-effort and QoS measurements consistent with those recommended by the QBone Architecture are made available through a web-based interface.

This phase began in March 2000, and remains the current phase of the APS test program. Important caveats and qualifications to the APS service ideal are discussed below.

Reservation requests must specify a destination subnet address. However, multiple reservation requests are aggregated into a single APS profile, which are policed at the connector's interface according to the "fire hose" model, which is to say: without regard to destination.

Because EF-marked traffic is receiving no preferential forwarding treatment, no bounds on loss or jitter may be assumed. The loss and jitter characteristics of a conforming APS stream should be identical to the loss and jitter properties of Abilene's production best-effort service.

Under Sweetwater, the full set of measurement statistics required by the QBone architecture will not be immediately available. BE and EF interface load and loss statistics will among the first measurements made available. This will allow participants to check the behavior of the APS policer at their access interface.

2.4.3 Midland

The Midland phase extends Sweetwater's functionality in two ways:

- **Core EF Forwarding** Cisco's MDRR queuing will be configured on all interior cards to deliver EF forwarding across the Abilene core.
- **Full Edge Policing** To protect the EF queues in the core, the edge interfaces of non-participants in the APS test program will be configured to prevent (or at least detect) EF traffic being injected into the network; the interfaces of APS test program participants will continue to admit an agreed-upon profile of EF traffic.

Because EF-marked traffic is receiving preferential forwarding treatment only over interior links and not through edge interfaces, no bounds on loss or jitter may be assumed. However, the loss and jitter characteristics of a conforming APS stream should be no worse (and possibly better) than the loss and jitter properties of Abilene's production best-effort service.

During the Midland phase, it is expected that the Abilene QoS measurements infrastructure will be collecting nearly all statistics mandated by the QBone architecture.

2.4.4 Odessa

The Odessa phase extends Midlands's functionality in one way:

- **Edge EF Forwarding** Cisco's MDRR queuing will be configured on all Abilene interfaces traversed by an APS flow to provide true edge-to-edge EF forwarding.

During the Odessa phase it will be possible to reason about the worst-case jitter that will be experienced by a conforming APS flow. Reservation request responses will include explicit jitter- bound assurances.

2.4.5 Pecos

The Pecos phase rounds out APS as fully compliant with the QBone Premium Service specification. In particular, Pecos extends Odessa with:

- **Egress Shaping** As conforming APS traffic aggregates exit Abilene, they will be shaped to conform to the agreed-upon downstream profile.

Accurate traffic shaping is necessary because burstiness may be introduced into conforming APS aggregates as they are merged with other conforming aggregates in traversing Abilene. In the absence of traffic shaping, APS will differ from the desired "virtual leased line" / "virtual wire" service model, jitter bounds will have to be padded, and "cushions" will have to be added to downstream token bucket policers to maintain extremely low packet loss in the presence of jitter. If the absence of traffic shaping becomes prohibitively damaging to the measured jitter in earlier phases, earlier support for limited shaping functionality will be explored.

3 Implementation Overview

3.1 Policing: Committed Access Rate

The Sweetwater Phase states that ingress Abilene Premium Service traffic into the core will be policed in accordance with a specified SLA. The Cisco 12008 routers, into which Abilene participants connect, will use Cisco's Committed Access Rate (CAR) to limit QBone participants to their SLA specifications.

CAR provides a rate-limiting feature that allows you to allocate both bandwidth commitments and bandwidth limitations to traffic sources and destinations, while also specifying policies for handling traffic that exceeds the bandwidth allocation.

CAR is used to enforce a maximum transmit rate (rate limit) for IP traffic only. Non-IP traffic is not rate-limited. As a traffic policer, the rate-limiting feature of CAR is most commonly configured on interfaces at the edge of a network to limit traffic into or out of the network. CAR does not smooth or shape traffic and thus does no buffering and adds no delay.

The CAR rate-limiting feature uses token bucket filters to measure the traffic load and to limit sources to bandwidth allocations while accommodating the inherently bursty nature of IP traffic. For traffic that exceeds allocated bandwidth, CAR uses Extended ACLs to define policies, including bandwidth utilization thresholds under which packet priority is modified or packets are dropped.

3.2 Expedited Forwarding: MDRR

The Cisco 12008 Routers that make up the Abilene Core must have the ability to guarantee low latency passage and 0Premium Service traffic. In order to accomplish this, modified deficit round robin (MDRR) will be used.

MDRR is able to accommodate delay-sensitive traffic, such as APS, on the Cisco 12000 GSR series routers. MDRR includes a low-latency, high-priority (LLHP) queue that is treated differently from the other queues associated with service classes. This special queue is used to handle delay-sensitive traffic.You can configure MDRR for strict priority handling of the LLHP queue. If the queue contains packets, it is serviced first, until all its packets are sent. Within MDRR, IP packets are mapped to different class-of-service queues based on precedence bits. The queues are serviced in round-robin fashion except for one, the special queue used to handle APS.

DRR is a packet queueing and scheduling protocol designed to provide features similar to those provided by WFQ (such as class and flow differentiation, bandwidth allocation, and delay bounding), but for high-speed transport links operating at OC-3, OC-12, and higher speeds. MDRR extends the DRR protocol to include a high-priority queue that is treated differently from the other queues associated with service classes.

For each set of CoS queues supported, MDRR includes an LLHP queue designed to handle special traffic, such as Abilene Premium Service, in a manner that is different from the other queues associated with service classes. Except for the LLHP queue, MDRR services all queues in round-robin fashion.

These are the basic steps that define how DRR works:

1. Packets are classified based on IP precedence and inserted in the appropriate queues.
2. Active queues are serviced in round-robin order:
   (a) Deficit counter values for each queue are initialized to 0.
   (b) The configured quantum size is added to the deficit counter of the first queue. The first packet in the first queue is dequeued and the deficit counter is decremented. This process repeats until the queue is empty or the deficit counter goes negative. A full packet is serviced even if the deficit counter runs out during the processing. If there is a remaining deficit, it is added to the quantum to be used to service the queue next round.
   (c) The process described in Step b is repeated for each successive queue.

If the receive (input) interface is an engine 0 card, for example, which supports up to 16 slots depending on the type of chassis used, there are 8 queues per slot. On the transmit (output) side, there are 8 queues per interface. For each set of 8 queues, you can configure whether the LLHP queue is used in strict priority mode or alternate priority mode. Data is sorted and enqueued from the receive queue to the appropriate transmit queue. MDRR maps IP traffic to different CoS. That is, it enqueues packets based on the IP precedence value of the packet.

These are the basic steps that define how MDRR works as a modification to DRR:

1. If MDRR is configured for high priority mode and the LLHP queue contains packets, MDRR services that queue first. If MDRR is configured for fair priority mode, a queue other than the LLHP queue was last serviced, and the LLHP queue contains packets, then the LLHP queue is serviced first; if the LLHP queue is empty, then the next active CoS queue is serviced, in round-robin fashion.
2. The deficit counter for the queue is incremented for the queue to be serviced.
3. Packets from the queue are serviced until the until the queue is empty or the deficit counter goes negative. The remaining deficit, if any, is added to the quantum to be used to service the queue next round.
4. The process described in Step 3 is repeated for each successive queue.

3.3 Measurement Infrastructure Implementation

As was mentioned in section 2.2, an always-on measurement and analysis system will be made publicly available. The roadmap to implementing this service is still shaping up, but is expected to follow the requirements of the service phasing discussed in Section 2.4.

The Ohio GigaPOP will aggregate and serve Abilene QoS measurements from a central server—`tombstone.oar.net`. The Abilene QoS measurement infrastructure will rely on measurements from four different sources:

1. **Surveyors** Each Abilene PoP includes a rack-mounted Surveyor active measurement machine; currently these are connected to Abilene's GSR routers via the Ethernet service port, which is not representative of the router's actual performance because all service port traffic is handled by the route processor (RP). Abilene's Surveyors are currently being upgraded with OC3 ATM NICs, which will be connected to dedicated OC3 ATM ports on the GSRs, allowing highly accurate one-way measurements of packet loss and jitter. APS test program participants should deploy local Surveyor measurement machines and initiate active measurement peering sessions with Abilene's Surveyors.
2. **SNMP** The Abilene NOC has developed and deployed SNMP monitoring tools that collect SNMP MIB statistics from the Abilene routers at regular intervals. New MIBs to export DiffServ configuration information are under standardization and will be collected as soon as they are implemented on the GSRs.
3. **Router Command Line Interface** In the absence of a complete set of DiffServ MIB statistics, certain data may be collected through automated querying and parsing of the router CLI.
4. **Reservation System** Statistics on requested and admitted reservations will initially be kept manually, but will ultimately be exported by an "Abilene bandwidth brokering" system participating in an automated signaling protocol.

Table 1 below summarizes how we anticipate collecting the metrics required or recommended for collection under the QBone architecture [2]

Initially, measurement statistics will be available with a least a 15 minute lag. Future work will focus on designing an infrastructure for near-real-time dissemination of measurement data.

4 APS Test Program Participation Requirements

To participate in the APS test program, Abilene connectors must meet certain requirements. First, each APS test program participant must be an active participant in the QBone initiative, working to extend the QBone Premium Service through a non-trivial piece of their

[2] A minor change to the requirements of the QBone Architecture Document v1.0 [Dra99] is assumed; specifically, the beInterfaceLoss and efInterfaceLoss metrics are assumed to be 2-tuples (packets sent, packets received), rather than the 4-tuples (packets sent, packets received, bytes sent, bytes received) described in the architecture document.

Metric	Source
efPathLoss	Surveyor
bePathLoss	Surveyor
efInterfaceLoss	CLI
beInterfaceLoss	SNMP
efDV	Surveyor
beDV	Surveyor
efLoad	CLI
beLoad	SNMP
efTrace	Surveyor
beTrace	Surveyor
linkBW	NOC
efCom	Reservation System
efRes	Reservation System

Table 1: Abilene Measurement Metric Collection

local infrastructure. Second, each participant must be working in good faith to implement the QBone measurement architecture and to make all QoS configuration and performance data publicly available. Finally, APS test program participants must implement a minimum set of functionality (described below) on their Abilene access routers.

4.1 Access Router Requirements

APS connector access routers must meet certain minimum requirements in order for the APS service to function correctly. In particular, the access router must assure that egress APS traffic (to Abilene) is marked with the recommended EF code point, 46 (101110) [JNP99], and be shaped to conform to the agreed-upon APS service profile. Similarly, the access router should monitor ingress QPS traffic (coming from Abilene) to assure compliance with an agreed-upon ingress profile (dropping any out-of-profile traffic, as is recommended by the QBone Premium Service specification [Dra99]). It is strongly recommended that participants monitor the ingress policing of EF traffic on their access routers, and alert the Abilene NOC if APS traffic appears to violate the agreed-upon profile.

In practice, the variety of capabilities represented by the various deployed equipment and software versions will require some flexibility in parameter setting, at least in the short term. This may result in “successive approximations” to ideal QPS behavior. For example, if the access router cannot adequately shape at the contracted rate, the token bucket burst parameter on the Abilene side might be set artificially high (introducing a “cushion” of sorts). At the expense of raising the offered jitter bound, this would potentially allow some burstiness toward Abilene, and prevent dropping of traffic that, if properly shaped, would have been admitted. This implies that we will have to monitor the effect of such approximations, and try to determine whether they have excessive impact on the QPS offering. For this reason (and to promote the greater good of the QBone), access domains should also participate in the QBone measurement infrastructure.

4.2 Connector QoS Contact

Each connector participating in the APS test program must identify to the Abilene NOC a technical contact, who is responsible for QoS operations in the connector's domain. This individual will be informed of changes to the APS test program generally and changes particular to the QoS performance or configuration of the connector's access interface. Additionally, this individual will be responsible for responding to requests for configuring downstream (from Abilene) QPS capacity, and for resolving all other matters relating to the connector's bidirectional QoS peering with Abilene.

By default, all communication with an APS test program participant will be cc'd to the connector's primary Abilene technical contact. If the connector's primary Abilene technical contact agrees, we will communicate solely with this individual.

4.3 Initiating Reservations Requests

Requests to participate in the APS test program should be in the form of an "APS Test Program Participation Request" accompanied by one or more "APS Reservation Requests". Participation requests and reservation requests should be in the formats shown in Tables 4.3 and 4.3 respectively, and should be submitted by email to noc@abilene.iu.edu.

Upon receiving an initial participation request, the Abilene NOC will respond with either:

1. An acceptance to the APS test program, including an admissions response to the initial reservation request(s), *or*
2. An explanation of why participation in the APS test program is not possible at the current time, possibly including recommendations for overcoming technical obstacles and a suggested time to re-submit a request for participation.

Once a connector has been confirmed as an APS test program participant, they may submit additional reservation requests at a frequency to be determined by the Abilene NOC.

Note that during Sweetwater, although separate reservation requests are submitted for each subnet for which a connector desires QPS service, these requests are aggregated into a single "fire hose" style APS profile at the connector's upstream Abilene interface.

Field	**Required / Optional**
Connector	Required
Contact Name	Required
Contact Email Address	Required
Access Router Make and Model	Required
Ability to Accept Upstream Reservation Requests (yes/no)	Required
Comments	Optional

Table 2: APS Test Program Participation Request Format

Field	**Required / Optional**
Connector (source)	Required
Short Description of Reservation Purpose	Required
Desired Downstream Peak Rate (0-20Mbps)	Required
MTU (in bytes) for APS traffic (may differ from link MTU)	Required
Destination Subnet Address	Required
Desired Reservation Start Date	Required
Desired Reservation End Date	Optional
Comments	Optional

Table 3: APS Reservation Request Format

The interface for submitting reservations requests is expected to evolve, first into a web-based form, and later into an automated interface in compliance with the evolving QBone signaling architecture.

To process reservation requests, the Abilene NOC will consult with the Abilene QoS Planning Group to evaluate whether the request can be granted, and will respond to the test program participant in a timely manner.

4.4 Responding to Reservation Requests

Note that in the QBone architecture, QoS peerings are symmetric and bilateral, and reservation requests are initiated by the sender or forwarded by transit domains downstream from the sender. Consequently, participating connectors must be prepared to receive and respond to reservation admissions requests from Abilene for QPS reservations toward connectors.

Until the QBone architecture has been expanded to include experimentation with a trial signaling protocol, all reservation establishment and negotiation will be manual, and will follow protocols peculiar to each individual bilateral peering between QBone domains. Connectors participating in the APS test program should inform the Abilene NOC if they want to evolve a reservation request mechanism materially different from the email-based protocol described in Section 4.3.

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