On being a U.S. UCAN connector: An R&E perspective

Draft: March 22, 2011

Introduction

This paper is intended to provide input for a connector agreement for U.S. UCAN that would recognize the unique attributes of traditional R&E networks and provide a common set of requirements and standards for other organizations that want to serve Community Anchor Institutions (CAIs) and connect to U.S. UCAN. It is presented as a draft from a small group formed under the auspices of the Internet2 NTAC. Although the group has solicited feedback from the full NTAC, the document is still a draft, and has not yet been endorsed by the NTAC.

The following section provides a summary of the key issues derived from earlier drafts and subsequent discussions with NTAC members. Also appended are three documents from three distinct sub-groups that formed the basis for an early draft, each of which has been revised to reflect feedback from NTAC members to date.

Summary

Participation in the community

First and foremost, it is important to recognize that the connector agreement in question is an agreement between members of a community, as opposed to a commercial fee for service arrangement. The cooperation, flexibility, transparency and cost-effectiveness that has made R&E networking successful derive primarily from the community model. Accordingly, new connectors should be prepared to join the community and participate fully in the governance process.

Independence of connectors

At the same time, the community consists of a diverse set of entities whose organizational structures and charters vary widely. The U.S. UCAN framework should foster the cooperation necessary for delivering reliable end-to-end services while at the same time providing the flexibility to allow connectors to function as independent businesses without hindrance.

Breadth of CAI community served

As some connectors expand the constituencies they serve, it is important to keep in mind that not all connectors will serve all CAIs in their geography. The connector agreement should reflect the fact that new and existing connectors may choose to serve some or all CAI groups, but that where connectors currently exist they have right of first refusal for those groups they choose to serve.

Service Options

A service matrix should be developed that lists the super-set of services currently available from the various members of the community, as well as those under development. This will aid in the development and provisioning of end-to-end services that include multiple organizations, and serve as a guide to new connectors. One important note is that connectors are not required to provide all services described in the matrix.

Operational cooperation

Prospective connectors should agree to some level of operational cooperation that is flexible enough to include a diverse set of connector needs and circumstances. The overall goal should be to establish low-friction relationships between Network Operations Centers (NOCs) that allow for proactive identification and correction of performance issues and outages in the timeliest possible manner.

Well defined NOC-NOC processes should be created, but they need to be kept flexible enough so that connectors can organize their business in the way that makes sense for them. One example that illustrates this type of business flexibility is the issue of NOC responsiveness. Rather than specify that a connector must have a 24/7 NOC, a target should be about an agreed upon level of service (such as response to a level *X* incident in *Y* minutes, etc.). This allows a connector to meet the service target without constraining the method used.

Service Levels

In order to ensure quality end-to-end services, some measurable performance criteria need to be met by each connector in order to meet a set of overall system performance goals. These criteria should be expressed in terms of targets. With a reasonably common set of performance measurement tools, good NOC-NOC communication, and engagement in a governance system that sets the targets, the community can provide a high-quality end-to-end service and avoid punitive Service Level Agreements that might be appropriate in a commercial fee for service environment.

Performance Criteria and Measurement

There are certain network performance criteria that are characteristic of R&E networks: low latency, low jitter, low packet loss, high headroom, etc. Bi-lateral targets for these (and others, as needed) should be specified for both connectors and the backbone.

In order to verify compliance with the service targets described above, connectors should provide a transparent view into the performance of their networks. Connectors should also provide well-managed test points at a suitable number of locations in their network to allow partner NOCs to run diagnostics and troubleshoot performance issues. The R&E community has invested in developing open-source tools that meet some or all of these criteria, and these tools should be exploited where possible.

UCAN Services Requirements Strawman:

General understanding of CAI network architecture:

CAI(s) <--> CAI Border <--> Last mile provider (Local) <--> REN or ARN (Regional) <--> US UCAN (National) <--> REN or ARN (Regional) <--> Last mile provider (Local) <--> CAI Border <--> CAI(s)

First we should define the UCAN CAIs to determine what services each may require. A prospective UCAN connector may opt-in as a provider to some if not all of the sectors noted below:

- PS: Public Safety
- Health: Healthcare Institutions
- Library: Public Libraries
- K12: Schools up to grade 12
- Comm: Community Colleges
- Research: Research Institutions, Research Parks

Connector	**Standard Requirements**	**Other CAI Elected Requirements**
PS **	Standard L3 Cloud or Multipoint L2 or L3VPN	IPv6, Encryption (edge), Voice, Multicast, Redundancy, Rapid Provisioning and Reconfig, SLU
Healthcare **	Standard L3 Cloud and/or L3VPN	IPv6, Voice, Multicast, Redundancy, Rapid Provisioning and Reconfig, REN access, SLU
K12 **	Standard L3, L3VPN + REN access	IPv6, Content Filtering, SLU
Library **	Standard L3, L3VPN + REN access	IPv6, Mixed Content Filtering, SLU
Comm **	Standard L3 + REN Access	IPv6, Multicast, Additional L2 circuits, High Bandwidth possible, Large amount of backbone headroom, SLU
Higher Education & Research **	Standard L3 + REN Access	IPv6, Multicast/Multicastv6, High Bandwidth, On demand HS circuits, Dedicated Waves, Large amount of backbone headroom, SLU

** Traditional RON or Internet2 CAI

SLA or SLU?

- Most RONs do not offer an SLA to its membership and in most instances this will not change as U.S.UCAN is rolled out. The middle ground is that most RONs or ARNs will define a service level understanding (SLU) based upon input from its membership.

- We should ask any prospective new connector to join the community and participate in governance. The emphasis should be on the fact that this is not a strict fee for service arrangement, but a cooperative community. In addition, the CAIs that use the connector to aggregate should also be part of the community, and participate in governance. Governance means participating in resource allocation, etc, not just sitting on working groups.

- Members of the community should agree to some level of operational cooperation that is flexible enough to include a diverse set of connector needs and circumstances. The overall goal should be to be to establish NOC-NOC communication that proactively finds and fixes performance issues and outages in the timeliest possible manner. Well-defined processes will help, but they need to be kept flexible.

- If we decide that some measurable performance criteria needs to be met be each participant in order to meet a set of overall system performance goals, then we need to express it in terms of targets. With a reasonably common set of performance measurement tools, good NOC-NOC communication, and engagement in a governance system that sets the targets, we can avoid punitive SLAs and provide a high quality end-to-end service.

Possible National NOC to R&E NOC mechanisms to measure performance:

- Looking-glass (L3 only), Router Proxy (L3 only), Utilization Graphs, Documentation(to be defined), Network Monitoring Status, Real-time data (netflow, snmp traps, L3 only).
- Active Monitoring tools at each layer of the CAI network architecture using an agreed upon standard. NOCs support the end-to-end testing of network issues.

General discussion

- Some RONs treat Higher Ed networking separate from networking in support of Research which can often involve non-standard, non-production, or even alpha level equipment. At least one RON operates a separate research network from the rest of the CAI community they serve.

- Content Filtering is not a backbone service. Content Filtering is and should be based upon local community standards and needs to be managed at that level.

- When L3VPNs are involved, the regional carrier would terminate L2 circuits from the local carrier into an L3VPN cloud. These L3VPN clouds would peer with the national top level cloud via BGP.

- The national carrier would be responsible for most connectivity between clouds. That interconnection may also be provided at the regional level if the CAIs in that region request it or the regional provider sees value in it and the CAIs in that region accept. (We received suggestion that this item be deleted)

- In most cases the local carrier would provide layer 2 services and the regional would provide any layer 3 services.

- The local access carriers should be able to meet all of the SLU defined by the community.

- The "regional carrier" or "local access carrier" in any one area may be one or more entity, however, the "designated" regional for a given CAI category must present a single point of contact, monitoring, and visibility to the national carrier and a cohesive set of services to the CAIs.

- In a time of national, state or local emergency, "Rapid Provision and Reconfiguration" may be necessary to provide Public Safety and Healthcare with additional bandwidth resources to deal with urgent issues. This would include: Provisioning of additional bandwidth across the regional backbone, Reconfiguration of Qos to perfer Healthcare and PS traffic over all other, Maintaining additional backbone headroom for use by Health and Public Safety, Allowing "bursting" of layer 2 traffic from the local area to the regional provider(s).

- Due to the "bimodal" use of a typical backbone used for Research and Education, Community College and Research categories must be supplied with ample backbone headroom and the ability to burst at possibly "less than best effort" for major research projects and collaboration. When an R&E backbone approaches X% utilization at Y% interval, additional backbone capacity must be added.

- Certain CAIs should be provided access to the regional REN (Research and Educational Network) as part of this project. Direct REN access encourages collaboration among Educational and Research (including Health) institutions of different sizes and focus.

- When edge services are required, such as end to end encryption with the Healthcare and Public Safety areas, Either the CAIs themselves, or the Regional may provide those services, but they must be coordinated at a national level to ensure interoperability.

- The regional provider may use any combination of local ISPs, existing “REN/ARN Branded” ISP, “US-UCAN Branded” ISP, Commodity Peering, TransitRail/CPS Peering so long as it provides a robust and redundant service. The regional may simply pass on US-UCAN or Local ISPs to the CAI as a layer 2 circuit rather than route this themselves, as long as the CAI is able to handle this. When required, content filtering may be provided by the CAI.

- The existing REN in a region should be given the "first right of refusal" to become the regional in all CAI categories. The participation of the REN may be as much as end to end service in the Regional and Local areas, or as little as Layer 2 transport between "sub-regional" carriers and the National level.

Big **Questions**

- Support model
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- Who supports what?
- How much "help" do the individual CAIs need
- Who controls the CAI edge (may vary depending on CAI category)

Date: 3/14/11

Analysis of "Expanding the Community"

In reviewing the U.S. UCAN document "Expanding the Community," the authors presented a number of issues and challenges that the R&E Community will need to deal with. Most of these have day-to-day operational implications that need to be explored. Due to the diverseness of the R&E Community, and it's varying levels of support operations, U.S. UCAN presents some issues that will be hard to address across the board. Although there are a number of existing institutions that have significant influence on the R&E community (Internet2, the Quilt, StateNets, the GlobalNOC, etc), none of them are in a position to impose changes on RON's and other institutions.

Below are issues that have been identified in the document, quoting it directly, and then providing comments on the issue.

Issue #1- Ensuring Quality Service: To the extent that Community Anchor Institution (CAI) requirements dictate consistent end-to-end service quality across one or more regional networks and U.S. UCAN, the community will need to work together closely to agree on reasonable standards for implementing and managing such services.

The R&E community has numerous independent operators who will need to work together so that they can interoperate into a (seemingly) seamless operation. Each of the regional networks has their own best practices and US UCAN provides the community opportunities for innovation to share and establish standards for managing such services.

Issue #2 – Flexible Customization vs. Exception Management: As new constituents are added, and the relationships between participants in the U.S. UCAN community become more complex (e.g. arrangements other than the traditional national-regional-campus hierarchy), the challenge will be to maintain service flexibility and allow for customization where needed.

There will be challenges managing all of the exceptions, the service flexibility mentioned above needs to be consistent across all of U.S. UCAN. R&E networks strength is based on the principle of flexibility, The differences between the R&E networks is what makes them unique and what provides local and regional value. Again this will be an opportunity for the community work together to find ways to address the operational support challenges yet continue to provide the flexibility that sets us apart from commercial carriers.

Issue #3 – Expansion of Footprint: In most cases, the addition of a large number of new users (CAI's) connecting to a significantly expanded footprint will cause the regional to rethink their architecture. The extent to which existing architectures need to change is not yet clear, since there are still many unknowns regarding the size and scope of the new CAI population.

The R&E community has always been able to adapt to changing requirements of their users, this experience and knowledge will serve them well as the expansions are architected.

The management and navigation of these individual build-outs will provide even greater operational support challenges and require the R&E community to cooperate to address these challenges.

Issue #4 – Different Methods of Transport: Over the last several years, as regional and national R&E networks began to construct facilities based backbones, it became possible for them to offer transport-layer connectivity to their communities. These services may include DWDM lambdas, multiplexed Ethernet over SONET circuits, or Ethernet VLANs… It is important that U.S. UCAN and the regional networks consider the implications of providing such services to a broader community.

Another example of the need for greater R&E community cooperation and joint effort.

Issue #5 – Advanced Services: There could be a reaction against the deployment of advanced services, given that there is always a tension between the network's ability to support them and its operational complexity. With every additional service layered on top of the basic IP network, there is a larger potential set of bugs, with the prospect of affecting both basic and advanced services; a greater chance that otherwise benign changes to the network will break the advanced service and necessitate additional, potentially disruptive maintenance; and an increased risk of simple mistakes, given the intricacy of the network's configuration. All of these issues reduce network stability.

Significant deployment of non-uniform advanced services could become an operational support nightmare. The regional networks will need to be the "buffer" and provide the glue to make this work.

Issue #6 – Operations Support: An often overlooked aspect of this expansion of user base and services offered is the change in the support model that each regional will need to consider. An increase in the number of served endpoints, many with less sophisticated local support, may require a higher level of centralized support or a transition to a well-coordinated distributed support model.

[As well as...]

Many regional networks depend on a limited number of technical staff working normal business hours, with on-call or outsourced call center services for after-hours support. Despite the significant increase in operational costs, manned 24/7 help desk and network operations centers will likely be required to support mission critical, high-reliability services for health care, public safety, and other entities that deal with life and death situations. Reliance on the network outside of business hours will constrain the planning of maintenance work and upgrades, and require that service parts and technicians be available on short notice.

If these things are not attended to on a day-to-day basis, U.S. UCAN operations will grow exceedingly chaotic and problematic. This could lead to a breakdown in operational service. Building a 24x7 NOC is very expensive. Outsourcing the responsibility to another organization can also be quite expensive and challenging. Without proper attention, this will become a very big issue. The overall goal should be to be to establish NOC-NOC communication that proactively finds and fixes performance issues and outages in the timeliest possible manner. Well-defined processes will help, but they need to be kept flexible. The expanding community base may provide opportunities for the additional resources necessary for the appropriate level of service.

Issue #7 - Customized Support: Customization capability will be attractive to individual communities within the new classes of anchor institutions, each with their own needs, and each accustomed to different services and network types. At the same time the growth of participation will make customization more difficult, and the need to maintain the other characteristics of the R&E environment while increasing the depth of support, adding resiliency and controlling costs will tend to push R&E operators more in the direction of commercial ISPs and away from extensively customized offerings.

This is a classic debate, not easily won since both sides have very important and necessary aspects to them.

Issue #8 – Resiliency: Health care and public safety customers may require SLAs from the regional networks.

This would change the landscape of R&E networking considerably, and also could set a precedent for the future. This will depend upon their level of engagement with the R&E network.

Issue #9 – Business model: Existing business models of both the regional networks and U.S. UCAN will be stressed by the mix of new constituents and the commitments (and restrictions) imposed by NTIA-funded infrastructure. These organizations will be challenged to either stay true to their existing charter, modify it considerably (in conjunction with an expanded set of constituents with a vested interest), or consider forming separate entities (potentially for-profit) to deal with the new reality.

Despite the inevitability and necessity to make these changes, this has the potential to be very disruptive to these institutions and U.S. UCAN as a whole. How can we assist in this effort?

Connector Policy Requirements

Draft 1.2 3/22/11

- Connector and Internet2 will coordinate to make available detailed information concerning the performance of an end-to-end path that transits connectors' infrastructure to network operations personnel acting on the behalf of the end-to-end path user. This information shall include details such as interfaces statistics, error rates, capacity, [optionally the type, model, and software of each device], etc., so long as the disclosing of this information does not create a reasonable security or operations risk.
- Connectors shall install, maintain, and make generally available a public-facing router proxy.
- Connector is responsible for accepting requests for assistance from their downstream CAIs, and are responsible for contacting the upstream US UCAN NOC as appropriate. Connector shall adhere to community-defined best practices for coordinating the resolution of network impairments of the end-to-end path with the CAI, US UCAN NOC, and other networks as required.
- Connector and Internet2 shall use community-specifiiced open source tools to provide end-to-end performance information (i.e., the suite of tools within the PerfSONAR framework). In addition, they shall provide well-maintained test probes on their infrastructure that allow the US UCAN NOC to use them for troubleshooting and active monitoring.
- Connector and Internet2 shall maintain sufficient performance capability along paths that support CAI end systems consistent with the requirements of advanced applications. Currently this translates to increased inspection of links that regularly average 20% utilization for periods of hours a day, and mitigation (i.e., upgrade in link capacity, traffic engineering, etc.) of links that exceed 30% for hours a day. This requirement is intended to preserve one of the fundamental performance characteristics of community anchor networks.
- The US UCAN Managed Service is a best effort service that provides equal treatment of all traffic presented to the US UCAN backbone. For CAIs that require priority or guaranteed service, US UCAN private network or dedicated circuit service options should be explored.
- The US UCAN Managed Service provides direct access to some sites on the public Internet via the US UCAN Peering Service (aka TR-CPS). Connectors that wish to provide a blended service to its customers that includes access to the entire public Internet should work with commercial Internet Service Providers to fill in the connectivity gaps.
- Connector and Internet2 shall seek to minimize the end-to-end latency and jitter across its network to provide CAIs with a solid foundation for supporting real-time applications. Acceptable end-to-end values for these two parameters are 125 ms of one way network

latency and 10 ms of peak-to-peak jitter[1].

- Connector and Internet2 shall seek to minimize packet loss across its infrastructure. An acceptable value for packet loss over is 8.5x10^-8%[2].
- Connector and Internet2 shall support native IPv6 service
- Existing R&E connectors for which supporting all of these requirements would be an unreasonable burden shall display on their public web pages a description of what is not supported.
- Connector and Internet2 shall support jumbo frames[3]

[1]Based on Cisco Telepresence design criteria: http://www.cisco.com/en/US/docs/solutions/Enterprise/Video/telepresenceaag.html
and comment from Joe St Sauver

[2]http://sd.wareonearth.com/~phil/issues.html

[3]Existing Internet2 policy: http://globalnoc.iu.edu/i2network/maps--documentation/policy-statements.html