GNA – Global Network Architecture
Web: http://gna-re.net/

global network architecture

A White Paper discussing the role of the Commons in the GNA.
Dale Finkelson
5 December 2016

Executive Summary

Sharing capacity, and allowing access to resources, has been a characteristic of the Internet from its inception – though not always an explicitly articulated feature. Describing the basis of this sharing is fundamentally important to understanding the Global Network Architecture (GNA). This paper proposes a framework for sharing the sets of resources the GNA describes, a framework that is aligned with historical views of the Internet as well as economic theory. This framework called the Commons underscores the collaborative nature of Global R&E Networking.

A generally accepted model for obtaining infrastructure, one that follows the GNA reference architecture, posits that individual components of that infrastructure will have a single or small number of owners, referred in this paper as Investors. These individual pieces of infrastructure will have capacity limits, and in some cases usage constraints. What is presented in this paper is a framework for the sharing of these resources, while acknowledging that these resources are often limited.

This framework, which recognizes that sharing of resources is fundamentally an economic issue –not a technical issue–, describes how well-known economic theories of resource management apply to the resources of the GNA. In particular how the idea of The Commons applies to network resources.

Introduction and Definition

The GNA incorporates an economic model for sharing scarce resources called the Commons. While there may well be general ideas about this model, there has not yet been a clearly articulated statement of how the model applies in the context of the Global Network Architecture. This document is intended to provide that statement, as well as recognize the historic importance of this theory to the development of the Internet.

Historically, the Commons refers to and derives from the concept of common land in medieval English Law. More recently, and more generally, it refers to cultural and natural resources that may be of finite extent but are available to all, such as air, water and other resources in the natural sphere, information in the

cultural sphere and carrying capacity in the Internet. Mayo Fuster Morrell has characterized the Digital Commons as "information and knowledge resources that are collectively created and owned or shared between or among a community and that tend to be non-exclusive, that is, be (generally freely) available to third parties. Thus, they are oriented to favor use and reuse, rather than to exchange as a commodity. Additionally, the community of people building them can intervene in the governing of their interaction processes and of their shared resources[1]".

While this concept may not have been frequently or explicitly applied to information resources, internetworking and global networking, it is a valuable framework from which to look at the systems that are being put into place to support the global delivery of information and support of science, research and education, envisioned within the GNA framework. While this paper will not spend significant time on historic discussions, it acknowledges that had early instances of the Internet, e.g. NSFnet, not adopted this sharing framework the Internet may well not have developed into the powerful resource known today. Other early proprietary and centrally managed networks did not attain the critical mass to succeed that IP networking achieved due in part to their failure to adopt the open sharing models of the early IP networks.

The Commons is defined then as the willingness of organizations to adopt a policy for sharing GNA resources within the R&E community and with non-investing 3rd parties as a means of expanding the reach of research and education.

The Commons is not capacity that is specifically allocated on a link for use by organizations and individuals that are not investors in a resource. To suggest that the Commons is specifically allocated bandwidth would be to attempt to propose an essentially technical solution on what is a non-technical policy and an economic choice.

Supporting research traffic flows

On circuits serving the R&E community for research there is frequently a need to accommodate bursting of high capacity data flows. A consequence of this need is the provisioning of circuits with far greater headroom then is normally provided in the commercial space. The theory of the Commons does not suggest that these high capacity flows should not occur or that they should not take precedence – only that as a matter of policy organizations providing these circuits should allow open access to these circuits in a manner that does not interfere with their primary purpose.

_____

1 Fuster Morell, M. (2010, p. 5). Dissertation: Governance of online creation communities: Provision of infrastructure for the building of digital commons.

Shared Value

Considering the total set of Global capacity that could operate under the GNA Reference Architecture, the Commons has the effect of adding value to any contribution of a link to the GNA. Because of the existence of the Commons, an Investor in capacity in one region of the world will have the ability to move traffic on any and all other global links. For the investor to achieve this extended reach otherwise would necessitate a substantial investment, one well beyond most organizations' ability.

One suggestion is that all Investors should allocate a fixed portion of capacity of their link to the Commons, meaning that any Investor contributing to the GNA has an obligation to make at least some percentage of the capacity available, on a fixed basis, to non-investors on that link. This is not what is meant by the Commons and does not reflect the working of this economic model.

This paper proposes that as the community gains experience with implementations following the GNA framework, use of the resources should be monitored carefully in order to understand if and how capacity is being utilized and who is utilizing it, including the use resulting from adopting the Commons model. With instrumentation it will be possible to determine if other parties, based on their actual use, should be approached as potential investors in augmented capacity on a certain link. Further, if a given link does require augmentation, the governance group for that link should have mechanisms to augment capacity when needed.

As organizations adopt the Commons as a part of their policy and thus it becomes included in the GNA architecture this may well lead to an overall greater use of the capacity on any of these circuits, but that increased utilization simply points to the value of a given link and the connections it enables. It further provides evidence and justification for the need to work to increase investment and capacity along that path.

Resources

The network resource being provided by the GNA is the ability to construct and use an end-to-end connection between two or more sites across a set of physical infrastructures for some duration in a way not possible prior to the GNA.

Considering all these factors, the network resource available as the Commons will be defined as:

The ability to use a service end-to-end through one or a series of physical infrastructures at some time for some duration without explicit use based

charges.

Users of the GNA-compliant service

These infrastructures, particularly the circuits between the exchanges, will be the result of agreements, typically bilateral in nature, between organizations that have a specific interest in contributing to a global infrastructure interconnecting exchange points in order to be able to provide services between domains.

There will be organizations, e.g. emerging R&E networks that have connections to one or more exchanges that would wish to provide their users access to other providers present at the exchange point. However these organizations may well not participate in the agreements covering the cost of those circuits or participate in other agreements defining a cooperative sharing arrangement. Such organizations may well be developing R&E Networks or NRENs who are constrained in their ability to cover the often-high cost of these big pipes.

The Commons provides a mechanism whereby investors in capacity in one part of the globe can bring added value to their investment by essentially access to resources with investors in resources in other parts of the globe. This ultimately has the effect of providing a more complete global infrastructure.

The goal of the Commons is to provide some (as yet undefined, and likely varying over time) amount of access to these resources for those groups as well as to the non-guaranteed traffic of the investors.

Advantages of resource sharing

No R&E Network is going to be able to install resources on the scale needed for science, research and education at all locations around the globe. Having the Commons as a means to share capacity on infrastructure provided in differing locations leverages the value of that investment over the entire GNA community. This leveraging and sharing is a fundamental principle and value of the GNA.

Furthermore, science, research and education are worldwide endeavors, with participants in all parts of the globe. Providing broad access to facilities for groups not able to build global access, while perhaps not a responsibility of the more resource rich R&E networks, is certainly of value to them. That combined with the value of sharing resources between Investors in differing parts of the globe (NRENs' A and B invests in one area and NRENs' C and D in another and each set allows the other to use the Commons) is a clear value add to the investment any given R&E Network makes.

Added value also derives from providing access to the entire global community

from the NRENs that are able to build a global infrastructure and from helping those emerging NRENs make the case that building and improving their connectivity is of value to their constituents as well as to the global R&E community.

By providing that access, however limited it might be, the reach of the science and education community is extended to regions that otherwise would not be readily available. Allowing this connectivity and use of resources not only allows the flow of information to those areas, it also encourages the flow of information out of those areas. And the global reach of the R&E networks is in the end only as useful as the extent of the information flow that they enable.

Annex A. GNA Resource Management: Considerations by Elinor Ostrom

The problem of resource management is an economic issue that has been known and discussed for some time. And while the context of those discussions may well have been varied, the core elements are well understood.

In 1990, Elinor Ostrom published "Governing the Commons: The Evolution of Institutions for Collective Action"[2]. Her work on the Commons earned her a Nobel Prize in Economics in 2009[3] among many other awards. While this is not the place for a detailed discussion of her work, Ostrom in that work identified eight "design principles" of stable local common pool resource management:

1   "Clearly defined boundaries (clear definition of the contents of the common pool resource and effective exclusion of external un-entitled parties);
2   Rules regarding the appropriation and provision of common resources that are adapted to local conditions;
3   Collective-choice arrangements that allow most resource appropriators to participate in the decision-making process;
4   Effective monitoring by monitors who are part of or accountable to the appropriators;
5   A scale of graduated sanctions for resource appropriators who violate community rules;
6   Mechanisms of conflict resolution that are cheap and of easy access;
7   Self-determination of the community recognized by higher-level authorities; and
8   In the case of larger common-pool resources, organization in the form of multiple layers of nested enterprises, with small local CPRs at the base level.

A look at how these rules would apply in the context of the global R&E network community will help to make clear the role the Commons could play in that framework.

The first, and perhaps most critical, aspect to be understood is that a discussion of resource use, whether it be grazing land or bandwidth, is an **economic and policy** question. It is not a technical or architectural question subject to technical solutions. It is a question about how to manage the economics of the system within which the Commons applies.

_____

2 Ostrom, Elinor (1990). *Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge University Press. ISBN 0-521-40599-8.
3 See: https://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/2009/ostrom-facts.html

1) *Clearly defined boundaries (clear definition of the contents of the common pool resource and effective exclusion of external un-entitled parties);*

Earlier in this paper a general description of the resource and intended users of the resource was presented. A fuller discussion of both the boundaries and the intended recipients will need to take place.

As an upper bound it is certainly fair to say that any use that is of regular occurrence and causes an augmentation strategy to be invoked goes beyond appropriate use of the resource enabled by participating in the Commons. Equally any organization that is clearly capable of contributing to the infrastructure but simply chooses not to could be restricted in their ability to use the resources. Decisions about contributing to the resource are economic and policy decisions; they are almost never technical decisions. As such they need to be approached from the point of view of governance, not technical committees.

The larger discussion of these limits would be centered on understanding how close to those limits is acceptable, what frequency of use is acceptable, value derived by the stakeholders customers of allowing use and the times access is granted. Further discussions on the role of transit in the Global Network Architecture will also be relevant in these discussions.

2) Rules regarding the appropriation and provision of common resources that are adapted to local conditions

The GNA is intended to be global in breadth. The conditions that apply to the use of the resources within any region may well differ from any other region. This may be due to cost, availability, general economic condition of the region or overall organization of connectivity in a region.

The expectations on the Commons, where substantial 100 Gigabit links are in use in one region, will be different from regions where there is only 1 such link or where the level of connectivity is still multiple 10Gs or smaller.

However, in line with the stated view, the general principle will be that any unutilized space is made available by adopting the model of the Commons.

3) Collective-choice arrangements that allow most resource appropriators to participate in the decision-making process;

A main feature of the GNA is its acknowledgement that one of the most significant elements of the Architecture is an understanding of governance and the need to have an inclusive attitude towards all of the real and potential stakeholders in resources contributed to the GNA.

The GNA **cannot be** a top down management structure; it is an open participatory structure with a set of lightweight and clear rules attached. As such it allows and encourages the Investors to participate in all decision processes.

4) Effective monitoring by monitors who are part of or accountable to the appropriators;

It is clear and well understood that measuring and monitoring the usage of these resources is fundamental to the successful operation of any infrastructure that is compliant with the GNA. This is true not just to be clear about the use of the resources the participation in the Commons enables but in general for the stakeholders to understand the value proposition of the investments they have made.

The value of measurement and reporting extends also to the users of the Commons enabled resources. Accurate accounting will provide them a base for understanding the value proposition for their own eventual investments in similar resources.

5) A scale of graduated sanctions for resource appropriators who violate community rules;

Again this is a topic that will require more attention from the stakeholders and may vary from place to place. The simple answer is that the sanctions would range from an expectation to contribute to the financial commitments of the resource to some degree that is appropriate the use being made all the way to an exclusion from use of the resource when there is a clear intent to continue excessive use without making any contribution.

Being able to apply these or any sanctions will depend critically on having accurate and current information about activity within the commons. The intent is not to punish for past behavior but to modify future behavior based on information about past behavior.

6) Mechanisms of conflict resolution that are cheap and of easy access;

Because of the nature of access to these resources, typically via an exchange point and either a BGP peering or some automated circuit setup mechanism, resolution of potential conflicts, at a technical level, are straightforward to address.

At the management level, resolution would be through a discussion process between the users of the resources and the stakeholders of the resources that are being used. The exact nature of these discussions will be determined by the stakeholder community.

7) Self-determination of the community recognized by higher-level authorities;

The structure of the GNA must be able to thrive in a self-governing environment. The contributions of an organization will be accepted as resources for the GNA only if those resources conform to the requirements and expectations of the reference architecture. Should a governmental organization or other authority wish to bring resources to the global infrastructure those resources may well not be acceptable if there are restrictions placed on their use.

A defining characteristic of GNA resources is that they are open access facilities. Any organization or authority attempting to participate in this activity but wanting to impose AUPs or other use restrictions on paths may not be acceptable as a part of the GNA, depending on the nature and scope of those restrictions. While it would be preferred to see no additional restrictions on GNA pipes, this may not be a reality today and we have to be mindful of this. A thorough discussion on what could be feasible should be undertaken.

Through this means self-determination will be preserved.

8) And In the case of larger common-pool resources, organization in the form of multiple layers of nested enterprises, with small local CPRs at the base level.

The entire structure of the GNA is one of layered or nested resources. There are completely local facilities, regional facilities, exchanges and global facilities. Most of the attention has been placed on the global facilities. This is because the concept of the Commons really only comes into play where there is the potential for transit. Most local or regional facilities only connect their members or participants. In this case all traffic will have one of those participants as an end point.

This differs from the global infrastructure where a small number of willing and able organizations will be collectively installing large and expensive infrastructure capable of transit, some portion of which they are willing to make available to the less able, though perhaps no less willing.

Note that this does require development of a thorough understanding of "transit" in global networks.

Annex B. Avoiding the Tragedy of the Commons

Historically the difficulty with designating a resource as a "*common unregulated area*" has been the conflict between the view an individual would take towards using that resource and the needs of the group for a shared resource. This is best stated by analogy, and here I quote from "The Tragedy of the Commons" by Garret Hardin written in December 1968[4]:

_____

4 See: http://science.sciencemag.org/content/162/3859/1243.full

"The tragedy of the commons develops in this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy."

And:

"Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another; and another... But this is the conclusion reached by each and every rational herdsman sharing a commons. ***Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit--in a world that is limited."***

In the context of the Commons as described in this whitepaper any given producer, i.e. user, of the available bandwidth, derives additional benefit (e.g. faster access to data then someone else) from continuing to use the available capacity to the maximum they are able until overall the usage is driven to the point where effective use of the capacity is no longer possible by anyone. Loss of effective use might for instance mean that congestion has created a situation where any given flow is subject to sufficient dropped packets to render the effective throughput a mere fraction of what it should be within the resource.

At its core this is a situation where there is a finite resource and an essentially infinite demand. In such a case the optimal use of the resource cannot be 100%. Use of the resource at 100% effectively closes the door to the resource being available to other users. For it to remain useful as a path to creative innovation it must be available to new and unknown uses, and at 100% utilization that would never be true.

By effectively adhering to the principles that Dr. Ostrom has developed for understanding and managing the Commons it is possible, and likely, that this "Tragedy" can be avoided. Clear boundaries, effective measurement along with collective management and mechanisms to deal with abuse will allow the Commons to remain an effective and essential part of the emerging Global Research and Education environment.

To once again reflect Dr. Ostrom:

A resource arrangement that works in practice can work in theory.[5]

5 Fennell, Lee Anne (Mar 2011). "Ostrom's Law: Property rights in the commons". *International Journal of the Commons* **5** (1): 9–27. ISSN 1875-0281. Retrieved 16 February 2015.