BITAG
Broadband Internet Technical Advisory Group

1550 Larimer Street, Suite 168
Denver, CO. 80202

Contact: Kaleb A. Sieh, Deputy Director, ksieh@bitag.org

# BITAG Publishes Report: Interconnection and Traffic Exchange on the Internet

Denver, CO (December 1, 2014): Today, the Broadband Internet Technical Advisory Group ("BITAG") announced the publication of its technical report on the subject of Interconnection and Traffic Exchange on the Internet. The executive summary of the report is attached here, and the full report itself can be found at: http://www.bitag.org/documents/Interconnection-and-Traffic-Exchange-on-the-Internet.pdf.

The Internet is a complex "network of networks" where individual networks are linked together to form a global network. In order for end users connected to one network to access data and services connected to another network, these networks must "interconnect" with each other, either by directly connecting with each other or by indirectly connecting through intermediate networks. Internet network interconnection, often referred to as "peering" or "transit," is an increasingly important topic as the Internet ecosystem continues to evolve.

The term "interconnection" refers to the various means by which network providers attach to and move traffic between one another, and is a collection of business practices and technical mechanisms that allow individually managed networks to connect together for this purpose. There is no central authority that manages Internet interconnection – the overall system arises because of the many bilateral and multilateral decisions that various actors make to interconnect.

Interconnection in the United States has evolved significantly since the early days of the Internet. Peering connections, where two networks interconnect without the use of intermediate networks, are increasingly the primary interconnection paths between networks, supplanting the model of hierarchical interconnection via a small group of long-distance network providers. In most cases, two parties seeking to interconnect are able to come to terms. In some cases after an agreement is reached, however, traffic volumes or other factors may change, which in rare cases have led to "de-peering" events. More commonly, such changes lead to a renegotiation of the manner or type of interconnection agreement between the two parties. Although peering disputes over traffic imbalances, and other reasons, are not new, peering disputes in the U.S. have been increasingly publicized in recent years.

With this report, BITAG's Technical Working Group (TWG) aims to provide a technical reference on the subject of Internet interconnection, and presents a detailed review on how networks connect, the development and changes in connection models, motivations for connection, how networks manage traffic between each other and some of the challenges that arise as networks evolve.

Joseph Lorenzo Hall, Chief Technologist at the Center for Democracy & Technology, and Jason Weil, Principal Engineer at Time Warner Cable, were the lead editors of the report. Douglas Sicker, Executive Director of BITAG, Chair of BITAG's Technical Working Group, Department Head of Engineering and Public Policy and a professor of Computer Science at Carnegie Mellon University, chaired the review.

**About BITAG.** BITAG is a non-profit, multi-stakeholder organization focused on bringing together engineers and technologists in a Technical Working Group (TWG) to develop consensus on broadband network management practices and other related technical issues that can affect users' Internet experience, including the impact to and from applications, content and devices that utilize the Internet.

**Questions or Comments?** BITAG welcomes any questions, comments or suggestions. Please contact our Executive Director, Douglas Sicker, at dsicker@bitag.org or our Deputy Director, Kaleb Sieh, at ksieh@bitag.org.

**– ATTACHMENT –**

**Executive Summary of BITAG Report on Interconnection and Traffic Exchange on the Internet**

The full report is available at:
http://www.bitag.org/documents/Interconnection-and-Traffic-Exchange-on-the-Internet.pdf

The term "interconnection" refers to the various means by which network providers attach to and move traffic between one another, and is a collection of business practices and technical mechanisms that allow individually managed networks to connect together for this purpose. There is no central authority that manages Internet interconnection – the overall system arises because of the many bilateral and multilateral decisions that various actors make to interconnect. In contrast to the telephone system, where interconnection is performed in a highly regulated environment, interconnection in the Internet (in most parts of the world) remains a private-sector matter.

The topic of Internet interconnection is receiving increased attention as the Internet ecosystem continues to evolve. Networks of all types interconnect among one another, including those of Internet access providers, content providers, academic institutions, and commercial enterprises. Internet connectivity is achieved by passing pieces of data, called packets, from a connected device through networking equipment, known as routers, operated by one or more network providers until those packets are delivered to the desired destination. The mechanisms that implement interconnection thus serve both technical and business purposes, and discussion concerning the technology of interconnection must, of necessity, refer to business issues to some extent – as many of the mechanisms can only be understood in that context.

Network interconnection in the United States has evolved significantly since the early days of the Internet, and today is a complex amalgam of models incorporating new connectivity options, delivery options, traffic management requirements and business practices. It is important to note the difference between the two dominant forms of interconnection, which are: (1) *transit* – where access to every publicly reachable destination on the Internet is provided for a fee; and (2) *peering* – where customer traffic is exchanged between two networks and the access provided is only to each other's network and customers. Further, when two networks peer there can also be both "settlement free" (without requiring payment) and paid arrangements.

Network operators are motivated to peer for a variety of reasons that may include both business and technical motivations. Each network operator stipulates the technical and operational criteria used to evaluate what networks they will interconnect with, and many of these requirements are made publicly available online. Connecting networks does not come without costs, and a decision to interconnect requires careful consideration of the benefits compared to the costs incurred to connect at each location.

The two common options for interconnection are either through a private bilateral arrangement between two networks using a dedicated physical connection (called a "direct interconnection"), or a multilateral arrangement where all networks connect into a public Internet Exchange switch. An Internet Exchange is a service that uses a switch infrastructure (sometimes referred to as a switch fabric or peering exchange) to provide connectivity between multiple networks. Interconnection methods are constantly evolving, and one of the more important developments in interconnection is the use of content delivery networks (CDNs). CDNs provide a more efficient means of distributing content by placing content and applications on servers distributed closer to, and sometimes within, the destination network – essentially bringing data (e.g., popular content) closer to the requestor instead of delivering the data across the entire Internet. The introduction of CDNs and IXs has contributed to the "flattening" of the historic hierarchical model of Internet interconnection.

Internet traffic has grown rapidly since the Internet's inception, and this has often been driven by the growth of popular applications. Managing the exchange of Internet traffic between networks is accomplished primarily through the use of an inter-network routing protocol called the Boarder Gateway Protocol (BGP). BGP offers network administrators the ability to implement routing policy, or in other words how traffic flows through a network. BGP's design offers limited support for inbound (traffic destined into one's network) traffic control.

Peering connections are increasingly the primary interconnection paths between networks, supplanting the model of hierarchical interconnection via a small group of long-distance network providers. In most cases, two parties seeking to interconnect are able to come to terms. In some cases after an agreement is reached, however, traffic volumes or other factors may change, which in rare cases may lead to "de-peering" events if the changes are significant enough. More commonly, such changes lead to a renegotiation of the manner or type of interconnection agreement between the two parties. Although peering disputes over traffic imbalances, and other reasons, are not new, peering disputes in the U.S. have been increasingly publicized in recent years.

In some cases traffic can flow contrary to the intentions of network operators, either in error or due to malicious activity. There are a number of important security considerations when connecting two networks. There are numerous types of attacks, as well as various motivations that may drive attackers. There are also a number of potential mitigations, as well as efforts to make routing more secure through new routing protocol extensions, notably RPKI and BGPSec.

This report provides a reference on the subject of Internet interconnection, and presents a detailed review on how networks connect, the development and changes in connection models, motivations for connection, how networks manage traffic between each other and some of the challenges that arise as networks evolve.