Quantum Communication

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Abstract

Intrepid Net Computing has discovered a quantum communication link from Arlington, VA to the Texas Advanced Computing Center in Austin, TX. This communication link provides instantaneous data transmission from VA to TX. Furthermore, this communication link provides quantum encryption, preventing the data from being read in transit.

Using the `buttressIT`™ network audit methodology, Intrepid Net Computing has evaluated the network topology around Washington, D.C. We mapped some critical and efficient network links from Washington, D.C. to other parts of the U.S. Our most significant finding was a very low latency link between VA and TX.

1 Introduction

They physical infrastructure of the Internet is unknown, in its entirety. There is no single organization that has the map of the entire Internet. Even restricting our attention to one country, namely the United States, there is no organization that has a map of the Internet in the United States. Dozens of organizations create and maintain portions of the Internet infrastructure. They do so with little communication between organizations, except at the places where their infrastructure physically meet.

The meeting places of multiple network infrastructures, (i.e., the places where the wires of multiple telecom companies meet) are called Internet exchange points. At these exchange points, routers direct traffic from one network to another as appropriate to the destination of each data packet. The networks of telecoms, military, national laboratory, and academia all meet at these Internet exchange points. For example the StarLight Internet exchange near Chicago is critical infrastructure for academia, national laboratories, and the telecom industry.

The backbone of the Internet is based on the old ARPA network. Today that network is sometimes called the TeraGrid. In the early 2000s the TeraGrid used high-capacity communication lines to connect computing resources across the United States. This allowed researchers on the East Coast to access high performance computing resources in California and in Texas. Today, as the world's fastest parallel computer is installed at Oak Ridge National Laboratory, this network will allow researchers in California, at Lawrence Livermore National Laboratory a previous site of a world leading parallel computer, to collaborate closely with their colleagues at Oak Ridge.

There is no single organization that has a map of the entire Internet in the United States. Not even the U.S. government can obtain such a map. The map, or topology, of the Internet is unknowable. The Internet is dynamic. Due to the ease of using DHCP and wireless connections, the topology of the Internet is constantly changing.

A map of the "backbone" of the Internet is available. The backbone refers to the most stable, high-capacity communication links in the United States. The U.S. government does have access to a map of the backbone of the Internet.

Intrepid Net Computing can create a map of the backbone of the Internet from first principles. We have begun mapping portions of the backbone. In particular, we discovered a high-capacity, near-instantaneous link between Arlington, VA and Austin, TX. This link appears to be a quantum communication link.

This document constitutes the first publicly available evidence that the United States has implemented quantum communications in a physical network. The Chinese also have a quantum communication link. The Wall Street Journal published a piece dated June 15, 2017 documenting a Chinese satellite that uses quantum communications. It is unclear whether the first implementation of quantum communication in networking was in the U.S., China, or some other place, because these projects are shrouded in secrecy.

In 2008, quantum communication was demonstrated in Switzerland over 18 kilometers by Salart, D., Baas, A., Branciard, C., Gisin, N., and Zbinden H. in Nature, 454, 86-564 (2008). These were entangled photons that were used.

Source	Destination	Latency (ms)	Distance (mi)
Arlington	Austin	7.808	1520
Arlington	Washington D.C.	8.409	4.7
Arlington	Boston	14.269	444
Arlington	Bozeman	19.917	2098
Arlington	Atlanta	24.385	640
Arlington	Champaign	32.078	698
Arlington	Oak Ridge	36.225	506
Arlington	San Antonio	36.360	1599
Arlington	New York City	36.610	231
Arlington	Denver	49.02	1661
Arlington	Salt Lake City	64.65	2084
Arlington	San Diego	74.229	2629

Table 1: Latency data collected on July 29, 2016.

2 Evidence

From Arlington, VA, we collected network latency information to destinations around the United States. The latency is a round-trip latency. The distance quoted is the driving distance in miles. Table 1 gives the latency and distance data.

This data was obtained legally from public data sources using scientific methodologies. This latency data was collected on a publicly available network with publicly available data. Our methodology is called `buttressIT`^{TM} audit. The distance data was taken from Google maps, another public data source.

The distance and latency are correlated, as in Figure 1. The best fit linear model (dashed line in Figure 1) has a correlation coefficient of 0.8948878. Intuitively, the correlation arises because the network topology must span the physical distance. For example, a data packet that is routed from Arlington to Atlanta must travel a similar distance as a car would travel. The latency is the amount of time it takes the data packet to travel along a given route.

We can see from Figure 1 that there are two outliers: Austin and Bozeman. These two data points, when included in the data set produce the regression given by the solid line. Indeed, these two data points have large negative residuals (-30.920502 and -27.327734) which are substantially larger residuals than the next largest (San Diego, 19.160530). These residuals indicate that both data points, Austin and Bozeman, are outlying. Error, or variance, in the measurement of latency is not a sufficient explanation for these two outliers.

Intuitively, the only conceivable way that a data packet from Arlington, VA can reach the Texas Advanced Computing Center in Austin, TX faster than a data packet can reach Washington, D.C. is by use of instantaneous quantum communications. An astute reader would immediately ask about the noise involved in measuring the latency. While noise might easily obscure the evidence of a link, noise cannot explain the simple fact that the lowest latency measurement in our data set was observed on the route between Arlington and Austin.

Similarly, the latency to Bozeman, MT from Arlington, VA is much faster than expected from the distance on the map. Still, the latency to Bozeman, MT is slower than the latency to Austin, TX. This suggests that there may be a second quantum communication link on the route to Bozeman, but not directly there. This second conclusion is more uncertain. The latency is slow enough to indicate that a significant portion of the route was over traditional wires.

This study was performed in a fashion that is repeatable. However, if public access to these routes is denied, it would be impossible to repeat the experiment.

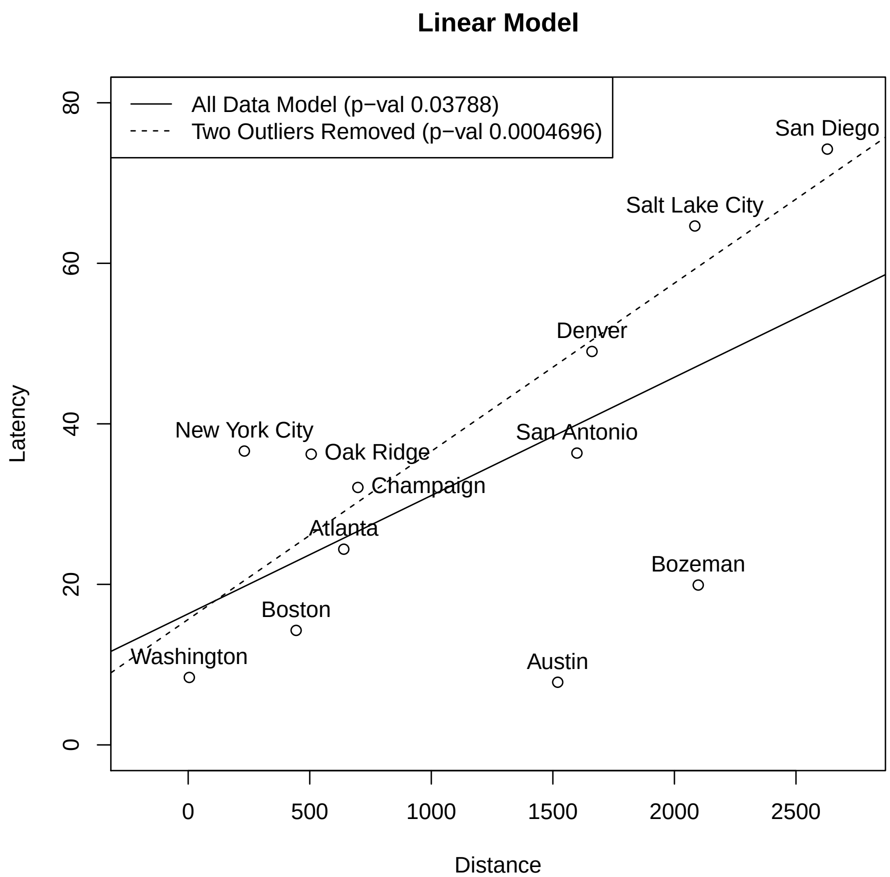

Figure 1: The input variable is distance and the response variable is latency. This plot shows the regression lines for two linear models. The solid line is the linear regression fit to the whole data set (p-value 0.03788). The dashed line is the linear regression fit to the data set with the two outliers (Austin and Bozeman) removed (p-value 0.0004696).

3 Conclusions

While the map, or topology, of the Internet is unknown and dynamic, certain stable links in the network can be discovered. Intrepid Net Computing uses special algorithms to reveal portions of the topology of the Internet. This manuscript details data on one particular communication link in the public Internet, as of July 2016.

The data in this manuscript strongly supports the conclusion that the U.S. government is operating a quantum communication link between Arlington, VA and Austin, TX that was available to the public Internet in July 2016. The data was latency information collected in Arlington during that time. Indeed the lowest latency in the data set was observed on the route between Arlington and Austin. The second lowest latency observed was a route with a destination in Washington, D.C.

While there are multiple explanations for this data, such as errors, and while there could be noise in this data, the most parsimonious explanation is that there is an instantaneous network link between Arlington and Austin. Such a network link is possible using quantum communication. A side effect of such communication is that quantum encryption prevents the data being read in transit.

There have already been media reports that China is operating a quantum communication link between the ground and space. They appear to have a satellite with a quantum communication link. That report was made in spring of 2017, almost a year after Intrepid Net Computing discovered a similar link in the public Internet in the United States.

Biography

Dr. Kirkpatrick has a bachelor's in computer science from Montana State University-Bozeman, a master's and a Ph.D. in computer science from the University of California, Berkeley. As a former computer science professor, Dr. Kirkpatrick is an expert in deterministic and statistical computer algorithms, and his main application area is the field of computational genetics. Due to market pressures, Dr. Kirkpatrick has applied these skills to computer security. Intrepid Net Computing takes a data science perspective on solving challenging security problems.