Federation over SSH

Part 1

1. INTRODUCTION

Federation is a well established technology is DETER and is widely used for experimentation. We recently started to explore using federation in the DEFT consortium to model energy cyber physical systems distributed across three federated testbeds at PNNL, UIUC and ISI. This note presents an empirical characterization of a DETER federation link between the ISI DETER testbed located at Marina del Rey, CA and the UIUC DETER testbed located at Illinois.

The empirical characterization of the federated link can be used to inform the energy cyber physical models developed as part of the DEFT consortium. The DEFT consortium is exploring dependent, time synchronized CPS models that will span the across the three testbeds. Such models are delay sensitive. Hence it is important to quantify the delay properties of the underlining cyber substrate so that the models can correctly designed for this environment.

As seen in Figure 1, the DETER federation framework sets up an ssh tunnel between the two testbeds. All traffic between the testbed nodes, nodedeter and nodeuiuc, is subsequently transfered over the tunnel by directly bridging the the end node to the ssh tunnel using a federation *tap*.

In this note, based on the ISI–UIUC federation as an example, we show that DETER federation link reports a latency measurement average which is 45 times higher than the underlying internet link. The impact of this latency is also seen in the applications running on the end nodes. This increased latency makes it challenging to design delay sensitive and time-synchronized applications for energy cyber physical systems.

We discuss our empirical evaluation methodology in Section 2 and our results in Section 3. In Section 4, we discuss possible directions that we can follow to get more insight into the properties of the federation substrate and improve its performance.

2. METHODOLOGY

The Methodology used here is very similar to [2]. We are using a active UDP probing mechanism to characterize the federation link. A burst of 5 UDP packets of size 46bytes with a *inter burst time* of 50msec were sent from nodeuiuc located in UIUC deter testbed to nodedeter located at ISI deter testbed. Upon arrival of the each UDP packets, nodedeter records the timestamp and sequence number of the UDP packet. Measurements were conducted for a period of 24 hours, starting from mid night of March 30th 2014 to mid night of March 31th 2014 along path (B) and for a period of 10 hours, starting from 2am of March 26th 2014 to noon of March 26th 2014 along path (A)

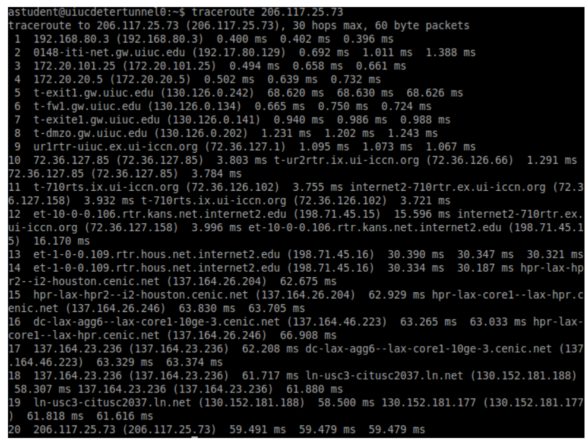

Figure 2: The output from *traceroute* between UIUC and ISI

2.1 Connectivity

We use traceroute to characterize the path between UIUC and ISI. The traceroute from UIUC to ISI, (shown in Figure 2) indicates the path from UIUC to ISI first traverses a few servers at University of Urbana champaign, then traverses throught Internet2 server at Ann Arbor, Michigan, Cenic network at Cypress, CA and finally traverses Los Nettos (`http://www.ln.net/`), a small regional ISP, that provides connectivity to USC/ISI.

2.2 Perfomance metrics

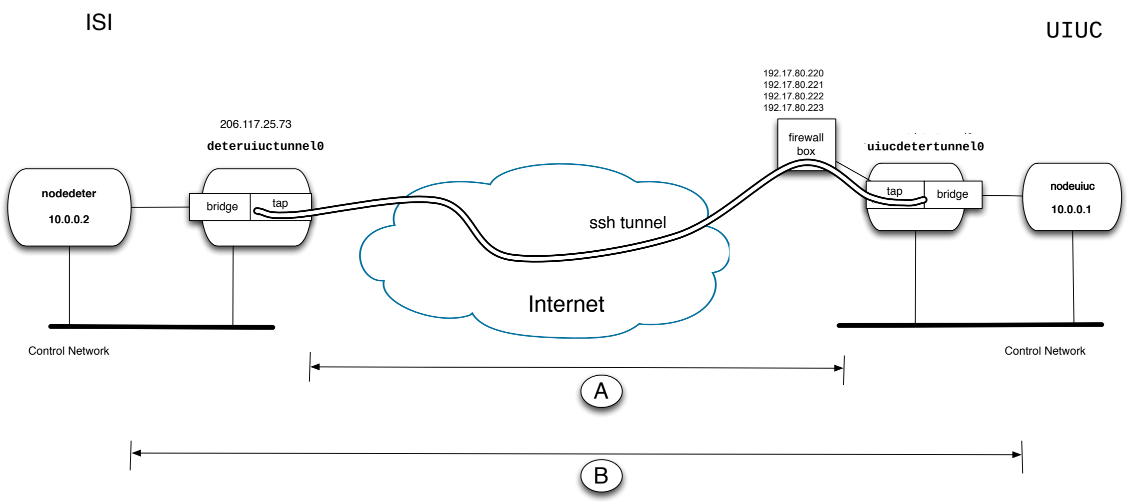

Figure 1: A conceptual representation of the federation link between ISI and UIUC

In our study we have used the following metrics to characterize the federation link.

2.2.1 Packet loss

We identify the loss by observing the gaps in the sequence numbers of UDP probing packets. We use a metrics called *bursty loss size*, which is defined as the maximum number of consecutive packets missing between two in-order packets. It does not necessarily mean that the *bursty loss size* of packets are actually lost, These packets might resurface later as an out-of-order packet or may be actually lost. The actual packet loss is given by a metric called *actual packet loss* which indicates the actual loss of UDP packets between nodedeter and nodeuiuc.

2.2.2 Packet delay

Ideally we need to measure the one way delay, but this is limited by the clock synchronisation at deter testbed at ISI and deter testbed in UIUC. Hence we measure the round trip time using the UDP packets used for probing. The RTT calculation here is similar to what was done in [1] Each UDP probe packet sent is timestamped and sequenced. Let us assume a packet P1 sent at time t1. P1 reaches nodeuiuc at t2. nodeuiuc will now consrtuct UDP packet P2 which includes two time stamp values t1 and t2-t3(time spend in nodeuiuc system) where t3 is the time at which the nodeuiuc sends P2. Let P2 reach nodedeter at t4. Once P2 receives nodedeter, it estimates the round trip time between nodedeter and node uiuc using the following formula **RTT = t4-t1-(t3-t2)**. We estimate the rtt for one in every ten packets the nodeuiuc receives.

2.2.3 Jitter

Initially we calculate the inter-arrival time of the packets received at nodeuiuc using which we proceed to calculate the jitter. Jitter is calculated for both in-order and out-of-order packets.

In order packets.
Two in order packets arriving one after the other at nodeuiuc may belong to same or different bursts. If the packets belong to same burst burst then the inter-arrrival time is equal to the jitter. Where as if the packets belong to different bursts then the jitter is calculate as shown:
jitter = (inter-arrival time) - (burst difference * *burst inter time).*

Out of order packets.
If an out of order packet arrives at nodeuiuc, first we find an UDP packet that was received with highest, but lower than the out of order sequence number received. Find the inter-arrival time between these two packets and then calculate the jitter using the equation used to calculate jitter for in order packets.

2.3 Measurements

We use the *customtool* we have developed to measure the round trip time(packet delay), bursty loss size, jitter, Actual packet loss across the interconnect between ISI and UIUC.

We conduct two types of measurements indicated as A and B in Figure 1. First, the path A measures the round trip time between the two testbed end points. These are externally visible IP addresses, for each testbed. They are configured or discovered as part of the federation framework. This path represents the Internet path between the two federated testbeds. This path excludes the ssh tunneling overhead between the two locations.

The second path, B measures the end to end round trip time. It measures the round trip time between the two end hosts, nodedeter and nodeuiuc, which are the first hop nodes on the testbed experiment topology. These are the end points that are visible to the experiment. The network topology does not have any additional latency configured between the tunnel nodes and these first hop nodes on the testbed. Hence in addition to the latency incurred on the link across the Interent on path A, this measurement also records the latency incurred due to the ssh tunneling between the two federated locations.

In Section 3, we report all the measurements along two paths; (a) between UIUC-ISI along path A, (b) between ISI-UIUC along path B.

3. RESULTS

3.1 RTT measurements

Figure 3 reports the round trip time measurements between ISI-UIUC along the paths B and figure 4 reports the round trip time measurements between UIUC-ISI along the paths A. The x-axis shows time, plotted in one hour period. The y-axis shows the round trip time in microseconds as reported by the our *customtool* measurements. Each + represents one measurement.

We make the following observations. First, the path B has a high range of round time time measurements as compared to path A. the statistics for both the paths are as shown in the table 1

Table 1: RTT measurements in microseconds

Case	A	B
Mean	63993.6875	83056.60
Maximum	687663	23040523
Median	61341	63820

3.2 Jitter

Figure 5 reports the round trip time measurements between ISI-UIUC along the paths B and figure 6 reports the jitter measurements between UIUC-ISI along the paths A. The x-axis shows time, plotted in one hour period. The y-axis shows the jitter in microseconds as reported by the our *customtool* measurements. Each + represents one measurement.

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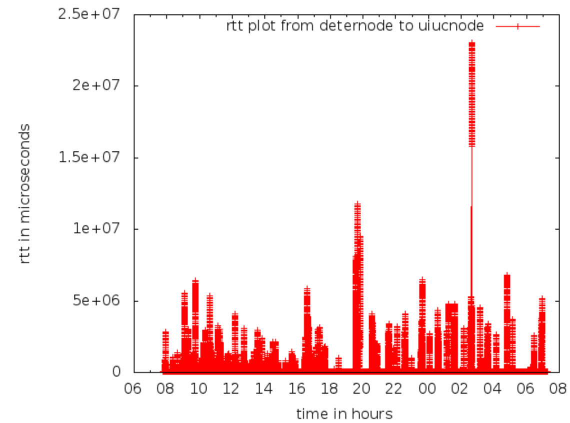

Figure 3: RTT measurements between nodedeter and nodeuiuc

the statistics for both the paths are as shown in the table 2

Table 2: jitter measurements in microseconds

Case	A	B
Mean	180.774506	49.548035
Maximum	22474798	627559
Median	4	5

3.3 Packet Loss

Figure 7 reports the *bursty loss size* measurements between ISI-UIUC along the paths B and figure 8 reports the *bursty loss size* measurements between UIUC-ISI along the paths A. The x-axis shows time, plotted in one hour period. The y-axis shows the *bursty loss size* in packets as reported by the our *customtool* measurements. Each + represents one measurement.

We make the following observations. First, the path A has a high range of *bursty loss size* as compared to path B. the statistics for both the paths are as shown in the table 3. Table depicts that there were only 3 burst loss occured along path B.

Table 3: *bursty loss size* measurements in packets

Case	A	B
Number of bursts	52834	3
Mean	2.042511	582
Maximum	1025	1452
Median	2	162

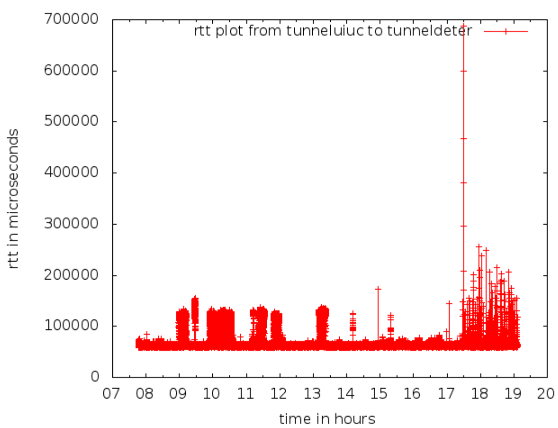

Figure 4: RTT measurements between tunneluiuc and tunneldeter

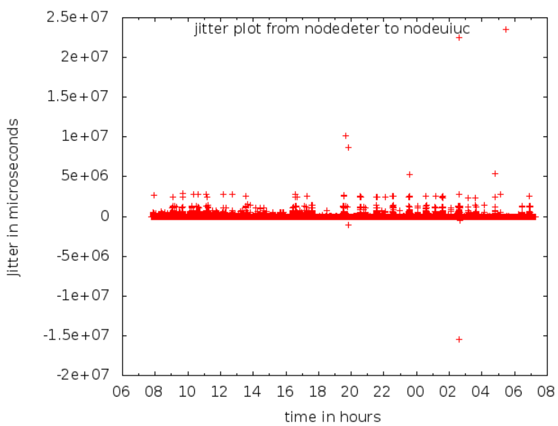

Figure 5: Jitter measurements between nodedeter and nodeuiuc

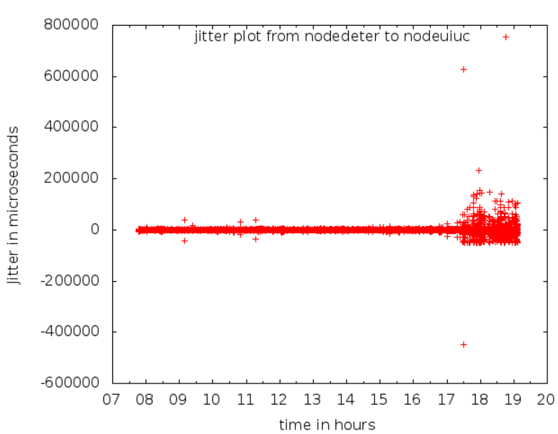

Figure 6: Jitter measurements between tunneluiuc and tunneldeter

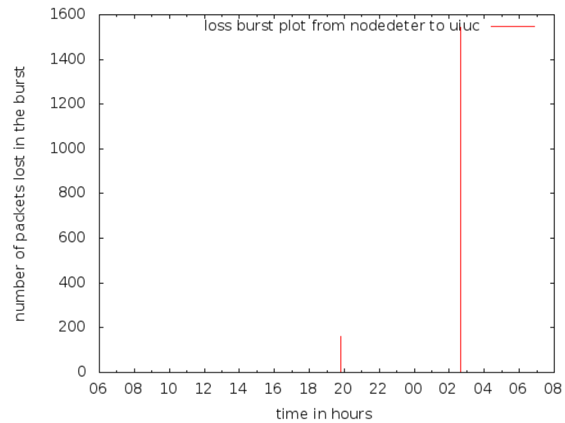

Figure 7: ***bursty loss size*** **measurements between nodedeter and nodeuiuc**

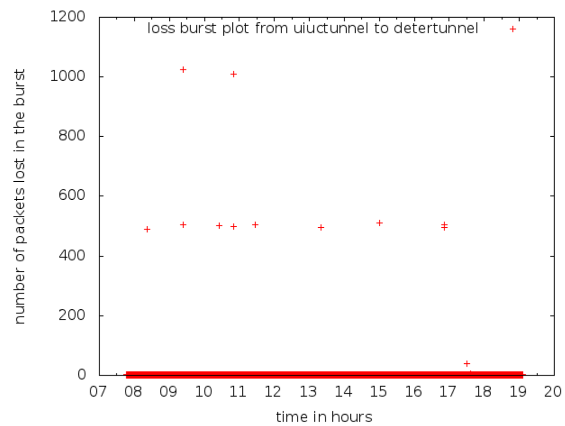

Figure 8: ***bursty loss size*** **measurements between tunneluiuc and tunneldeter**

4. OBSERVATION AND PATH FORWARD

We are currently exploring what causes the high delay and jitter along path B and the absence of such variation along path A. It can be attributed to the tcp used in ssh tunnelling along B. We are also trying to characterize the link along path A by repeating the experiment for various burst size and packet sizes. We need to measure the bandwidth along path A and path B.

5. REFERENCES

[1] S. Floyd et al. A reliable multicast framework for light-weight session and applicatoin level framing, 2000.

[2] F. Wang et al. A measurement study on the impact of routing events on end-to-end internet

path performance. SIGCOMM '06, 2006.

6. CODE AND SCRIPTS

Entire code contents are present in a tar file called **submission.tar** the tar file includes the following folders:

AnalysisCodes :- Includes the C++ codes which was use to calculate the packet loss and jitter of the measured data.

CustomTool :- Include the C++ code files used for UDP probing and calculation of RTT.

GnuScripts :- Includes the gnuplot scripts to plot jitter, packet loss, RTT and out of order packets.