SUMMARY OF OUR PRELIMINARY GOOSE RESPONSE TEST

Here is a quick summary of the test.

- We performed a relative device time tagging test to determine the time differences recorded by devices measuring a single event.
- We executed a circuit breaker trip, which was published by a merging unit and then read by the subscribed IEC 61850-configured devices.
- We recorded and analyzed the event recordings to examine the devices' time synchronization.

Key Conclusions

- Some vendor devices worked to our expectations, while others did not.
- Performing three runs of the test showed the smallest difference was 4 ms and the greatest was 12 ms.
- This result was surprising and will require additional investigation.
- The input sequence of events time tagging did not work as expected.
- This was an initial test conducted without having all of our system devices online and configured. Our next round of tests will have all devices configured and individually tested to ensure the sequence of event recordings and time synchronization is working properly.

Welcome to the Q1 2014 edition of the NexStation Lab Report.

Testing in the lab was in full swing this quarter. We completed some preliminary test runs and are preparing for more in-depth testing and analysis next quarter. We are pleased to be able to share some of our preliminary test results in this lab report.

Warning: What follows below is a technical summary of an initial run of three tests. The technical details are likely of interest mainly to engineers immersed in implementing IEC 61850. But since we do also have plenty of non-technical readers of the lab report, if you're looking for a quick summary, peek over to the left-hand sidebar. That will give you the gist.

Preliminary GOOSE Response Test – Multi-Vendor Control and Status of a Simulator

SCOPE OF THE EXPERIMENT

The experiment involved an IEC 61850 GOOSE-configured protection relay (from *Vendor X*) performing a merging unit function to a simulated breaker. Other IEC 61850-configured devices published and received GOOSE messages to control the simulated breaker and receive status feedback. A latching interpose relay performed the simulation function for the breaker, with its coil connected to an output of the *Vendor X* protection relay and its dry contact connected to an input. Additionally, there were several HMIs that received the status and initiated open commands to the breaker using MMS to the *Vendor X* protection relay.

The test executed a circuit breaker trip/open command from the various sources, thereby initiating a change in status of the circuit breaker, which was published by the merging unit and read by subscribed devices. The response time was recorded and analyzed to determine if it could replace a hardwired trip connection.

EXPERIMENTAL METHOD

The following summarizes some of our experimental conditions:

- Each device was configured using manufacturers' software, with the primary means of communication being IEC 61850 GOOSE.
- The HMI software used MMS between the HMI workstations and devices to collect data and send controls.
- Each of the devices received time synchronization using IRIGB from a GPS clock. All computers running the HMI software received time from the same GPS clock using Network Time Protocol (NTP).
- All devices and HMIs were configured to have the various data points recorded in their sequence of events application.
- This first test condition used a simple network connected together using several different managed switch vendors. No artificial noise was introduced to the network, which had less than 1% utilization during the tests. No VLANs or priority of service were used.

EXECUTION

We performed a relative device time tagging test to determine time differences in the devices' recording of the same event. We temporarily connected a control wire from the breaker simulator interpose relay contact to an input on each of the devices. We then closed the contact and observed the input closure times captured by the devices' sequence of events recorders.

We noted that several devices were hundreds of milliseconds off the average. These devices were not included in this test pending further investigation of the causes.

TEST RESULTS

Performing three runs of the test showed the smallest difference between devices was 4 ms and the largest was 12 ms. This result was surprising and will require

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additional investigation of why these time tags varied so much. Prior to the next GOOSE test, we will conduct a more in-depth test and analysis for the device input tag timing.

The following is a summary of our three test runs. Raw data from the testing can be found on the following page of the lab report.

- Test Run #1: We closed the breaker which is hardwired to *Vendor X* and looked at how long it took for the GOOSE subscribers to record the change.
- Test Run #2: We had *Vendor Y* device send a GOOSE TRIP to the breaker via the *Vendor X* merging unit. Then we captured the *Vendor X* publication of the breaker change of state to open.
- Test Run #3: We introduced a new vendor, *Vendor C*, which was not available during the first two tests. The *Vendor C* device sent a GOOSE TRIP to the breaker via the *Vendor X* merging unit. Then, we captured the *Vendor X* publication of the breaker change of state to open.

FUTURE TESTING

In the future, we plan to expand our testing to include the following:

- Conditions:
  - #1 – VLAN 0 Network, no priority and low usage.
  - #2 – Same as #1 with the exception that we will busy the network to a high usage level.
  - #3 – We will re-configure the network and GOOSE connections to include VLANs and priority service with the same high usage level as in #2.
- Execution Order for each of the conditions; each will record a time stamp. This test will be run for each of the vendor devices:
  - Vendor device sends a Breaker TRIP GOOSE to the merging unit
  - Each HMI reads the TRIP request
  - Merging unit receives the TRIP GOOSE
  - Merging unit sends the change of state for the break via GOOSE
  - Each of the vendor devices receive the breaker change of state GOOSE
  - Each HMI reads the breaker change of state

LAB PARTNERSHIPS

Thanks to all the vendors that support our lab and provide needed assistance. It takes a lot of equipment to make this lab possible, not to mention the time vendors dedicate to help us understand their implementation of IEC 61850. The list of equipment and software we have used recently includes: Efacec TPU 220-S, Efacec BCU 500, SEL-421, SEL-487B, SEL-451, SEL-351S, SEL-351R, SEL-2032, SEL-3530, Alstom P446, Alstom P643, GE T35, GE D60, GE F60, ERLPhase L-PRO 4000, ERLPhase TESLA 4000, Siemens 7SL87, Siemens 6MD85, Siemens 7SJ64, ABB REL670, ABB REC670, Basler BE1-11i, Basler BE1-11g, Beckwith M-2001D, and Novatech M571. Network and HMI equipment used includes ASAT DAP-100, Efacec UC 500E, Elipse HMI, Siemens, SICAM, Cisco 2520, RuggedCom, GE, GarrettCom and Moxa, and Arbiter GPS clock.

RAW DATA

The following is the raw data from our three test runs. The first column indicates vendor (1=HMI1, 2=HMI2); the second column describes the event; the third column indicates status (P=Publish, S=Subscribe, M=MMS); the fourth column lists recorded time.

Test Run #1			
X	GOOSE Variable Event; Breaker Closed Sent	P	10:19:40.770
Y	GOOSE Variable Event: Breaker Closed Received	S	10:19:40.772
Z	GOOSE Variable Event: Breaker Closed Received	S	10:19:40.772
A	GOOSE Variable Event: Breaker Closed Received	S	10:19:40.775
B	GOOSE Variable Event: Breaker Closed Received	S	10:19:40.777

Test Run #2			
Y	GOOSE Variable Event; TRIP	P	14:14:08.104
Z	GOOSE Variable Event: Breaker Closed	S	14:14:08.108
X	GOOSE Variable Event: Recv TRIP	S	14:14:08.110
X	Output: Breaker OPEN	P	14:14:08.112
Y	GOOSE Variable Event: Breaker OPEN Recv	S	14:14:08.116
Z	GOOSE Variable Event: Breaker OPEN Recv	S	14:14:08.116
A	GOOSE Variable Event: Breaker OPEN Recv	S	14:14:08.118
B	GOOSE Variable Event: Breaker OPEN Recv	S	14:14:08.120
2	MMS detect Breaker open the from vender X	M	14:14:09.501

Test Run #3			
C	GOOSE Variable Event; TRIP	P	13:26:48.093
1	GOOSE Variable Event: Breaker Closed	M	13:26:48.538
X	GOOSE Variable Event: Recv TRIP	S	13:26:48.094
X	Output: Breaker OPEN	P	13:26:48.098
Z	GOOSE Variable Event: Breaker OPEN Recv	S	13:26:48.102
A	GOOSE Variable Event: Breaker OPEN Recv	S	13:26:48.104
B	GOOSE Variable Event: Breaker OPEN Recv	S	13:26:48.106