IEEE/NIST Timing Challenges in the Smart Grid Workshop
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Time Synchronization Requirements and Challenges for Power System Applications
Aaron Martin and Brett Aguirre, Bonneville Power Administration
More and more, the reliability of the electric grid depends on intelligent electronic devices (IEDs) that require high accuracy time synchronization to operate quickly, reliably, and securely for all types of power system events and conditions. IEDs such Phasor Measurement Units (PMUs), traveling wave fault locators, and line differential relays are manufactured with complex algorithms, sophisticated schemes, and programmable logic that depend on high accuracy time synchronization. The 60 Hz frequency of electric power grid dictates that micro-second accuracy is necessary for proper indication and operation of PMUs and Line Differential relays. As the data from these systems are aggregated together via Ethernet, the importance of an approved test plan allows utilities to be confident that the substation Ethernet clocks they choose for their timing needs, are not only compliant, but they are certified.

Precision Time Protocol (PTP) for Substation Synchronization at PG&E
Dr. Vahid Madani, Pacific Gas & Electric

Use of Precision Time Profiles in Distribution Systems
Anthony Johnson / Brendan Russell, Southern California Edison
With the advent of highly accurate, ubiquitous time available it is possible to change the method of distribution automation. It will be possible to enhance customer reliability while optimizing the configuration of the grid. The presentation will discuss how Adaptive Protection and Time Synchronized control can operate together to overall improve utility operations.

Precise Timing in Dominion's Electric Transmission System
Robert Orndorff, Dominion Virginia Power
This presentation will discuss how precise timing is used on Dominion's electric transmission system. In recent years, more and more substation devices and applications rely on precise timing. Additionally, there are Federal regulations (PRC-002-2) that mandate precise time synchronization on the Electric Transmission system. The increasing use of devices that require precise timing as well as the regulations have caused us to focus on having accurate time available inside the substation. Several areas will be covered in this presentation:

- Applications and devices that use precise timing.
- Issues at Dominion with timing and testing we have performed.
- Discussion of our past and present substation timing infrastructure and our plans for the future.

Timing Security Assessment and Potential Solutions

Glen Chason, EPRI

EPRI's Timing Security Assessment and Solutions project provides a progressive approach for addressing cyber security vulnerabilities in precision timing systems used in mission-critical utility operations. Project results are expected to provide significant power industry and public benefits, focused on improved power grid reliability and resiliency. Increasingly integrated synchronized operations lead to improved safety, flexibility, and reliability of electric power delivery. In addition, the results are expected to help build confidence in disparate sources of sensor data, such as smart inverters, and enable optimal, autonomous management of Distributed Energy Resources (DER) assets in utility grids.

The new learnings are expected to include:

- Developed guidance and methodologies for assessing cyber security vulnerabilities in systems relying on synchronized timing. This guidance and these methodologies can help equipment vendors and utilities improve the reliability of system operations and continuity of electric power delivery.
- Identify proactive methods for analyzing vulnerabilities.
- Develop guidance for selecting equipment and adopting practices deploying mitigations that will reduce the likelihood and duration of malicious manipulation of system timing infrastructure.

Testbed Capability at the Pacific Northwest National Laboratory

Jeff Dagle, PE Chief Electrical Engineer, Electricity Infrastructure Resilience

PNNL's Testbed Capability combines innovative technology with interdisciplinary teams to overcome electricity infrastructure challenges in the path towards grid modernization. Grid modernization is rapidly digitizing and networking the energy value chain, converging cyber and physical energy and controls that increasingly exchange information with grid that powers all our nation's critical infrastructures. As a result, securing our nation's electricity infrastructure becomes mission critical for the Department of Energy in its role as the day-to-day Federal interface for sector-specific activities to improve security and resilience in the energy sector. To support this mission, PNNL has a number of world-class test beds that can be leveraged by researchers and their partners. PNNL's test bed efforts benefit from close cooperation with industry and leverage tools, technology and findings from DOE-OE supported initiatives such as the North American SynchroPhasor Initiative (NASPI), Cybersecurity for Energy Delivery Systems (CEDS) and the Grid Modernization Lab Consortium (GMLC). Specifically, PNNL has previously hosted testing of synchrophasor susceptibility to GPS spoofing and will share the results of these tests, lessons learned, and future research directions at the workshop.

GPS Timing in Critical Infrastructure

Sarah Mahmood, DHS

Accurate position, navigation and timing (PNT) is necessary for the functioning of many critical infrastructure sectors. Precision timing is one aspect that is particularly important for key sectors such as the electric grid, communication networks and financial institutions. Currently, the primary source of distributed and accurate timing information is through GPS. However, GPS signals are susceptible to both unintentional and intentional disruption. DHS discusses their risk management strategy and supporting programs for PNT vulnerabilities within critical infrastructure.

A DOE Research Laboratories View on Time Synchronization Needs and Challenges

Terry Jones, ORNL

We present a breakdown of timing needs from the perspective of the Department of Energy's (DoE) research arm. Our analysis includes: (a) performance factors; (b) security concerns; (c) resiliency aspects; and (d) business considerations. Our performance discussion includes quantitative requirements for timing uncertainty and scalability of design. Timing security includes ways to detect and defeat known cyber attacks. Among the items including in our resiliency discourse is support for multiple clock sources, inter-clock source communication, and uptime requirements. For business considerations, we elaborate on aspects related to the "investment versus payback" decision that utilities will need to make for all new technology deployments.

Time Distribution: Current Technologies and Future Visions

Dr. Marc Weiss, NIST Time and Frequency Division

This talk will cover the current and potential future technologies for distributing and measuring time across wide areas including GNSS, telecom network distribution technologies, WWV, and TMAS. A mention of capabilities of local clocks for holdover will be done. Potential future technologies include eLORAN, other ground-based RF timing systems, and other satellite systems such as Iridium. The future need for distributed time will be increasingly used in critical infrastructure. Providing multiple sources will provide a means of redundancy and also as a check for potential anomalies with the primary source.

Clock Ensembling for Resilience

Dr. Dhananjay Anand, NIST Software Systems Division

This talk will cover theoretical underpinnings and initial progress on a research project intended to cross validate GNSS based timing against a belief filter comprised of low-cost oscillators organized as a maximum likelihood ensemble estimator (MLEE). In order to support other research efforts in residual and threshold based anomaly detection, we focus on the convergence properties of the ensemble. In particular, we will present results of our preliminary investigation along three formulations of the MLEE. The first being an Ensemble Kalman Filter applied to a linear voltage controlled oscillator (Type-1 PLL), the second is a mean-field coupling model for non-linear oscillators and the third considers clock models with discontinuous differential inclusions (Type-2 PLL).

Detecting Anomalies in Time and Frequency Data

Dr. Judah Levine, NIST Time and Frequency Division

The talk will cover the techniques that we have developed for detecting anomalies in time and frequency data. We use these techniques in evaluating the digital time stamps received from network time servers over the Internet, in computing the ensemble average of the atomic clocks that define and realize the NIST time scales UTC(NIST) and TA(NIST), and in comparing clocks at remote locations by using data from global navigation satellite systems in common view, where multiple ground stations receive data from the same source at the same time. The details of the implementation depend on the application, but all of the methods are based on a statistical comparison of the data that have been received with the expected results based on previous data and the statistical characteristics of the local hardware. In some applications, the statistical comparison is made more robust by the availability of nominally identical data from multiple remote sources.

PTP Power Profile Conformity Assessment
Bob Noseworthy, University of New Hampshire InterOperability Lab (IOL)

Timing in Telecommunications
Carmine Chase, CenturyLink