autonomous, adaptive and Secure Distribution Protection (a²SDP)

Research Team

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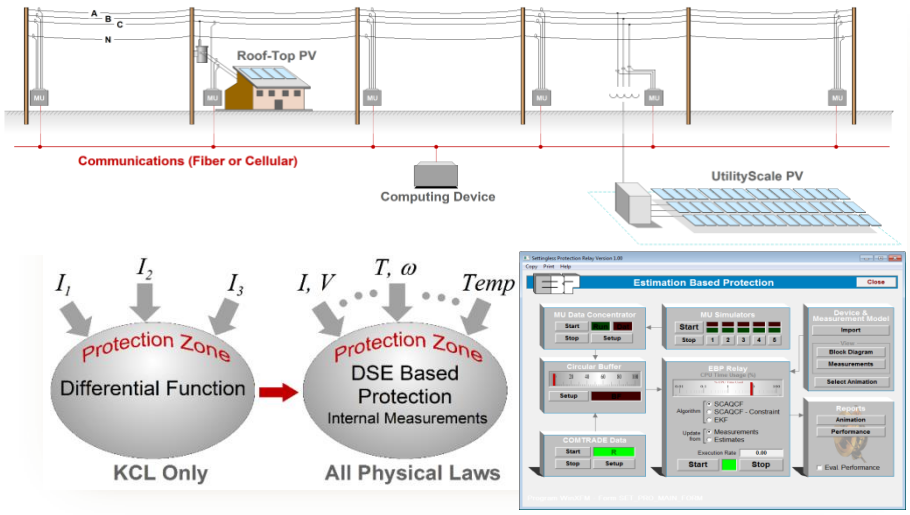
A P Meliopoulos / Georgia Institute Of Technology

Project Summary

An **a**utonomous, **a**daptive and **S**ecure **D**istribution **P**rotection **(a^2SDP)** system for distribution systems with extra high penetration of PV and other DERs. Core technology is the setting-less relay (or Estimation Based Protective (EBP) relay) which is naturally the ultimate adaptive protection system, immune to fault current direction flow or level, waveform distortion or network configuration. EBP relays in totality, provide a validated high fidelity dynamic model of the entire distribution system including PVs and other DERs. The real time model is used to add features to the **a^2SDP** : (a) detection and protection against down conductors, (b) protection of power electronic interfaces, (c) real time distribution system fault locating, (d) distribution system reconfiguration in real time (FLISR), (e) cyber security enhancement by real time intrusion detection and command authentication, and others. The **a^2SDP** will be demonstrated on the systems of Dominion, Southern Company and Avista.



Key Personnel/Organizations

Georgia Institute of Technology

Washington State University

Dominion Energy

Southern Company

AVISTA

Key Milestones & Deliverables

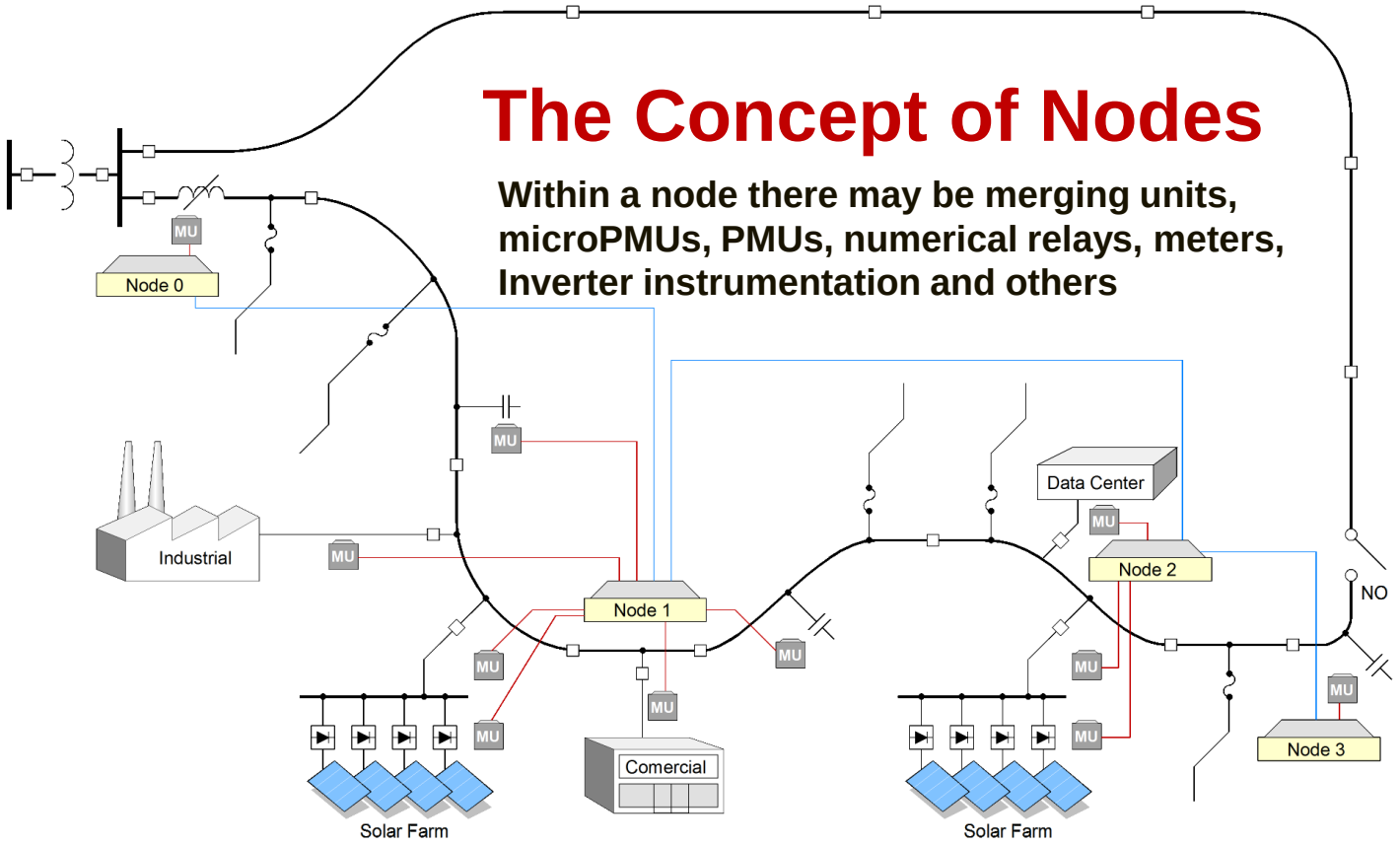
Year 1:	Laboratory demonstration of the key technologies with hardware in the loop.
Year 2:	Factory testing of the **a^2SDP** for the three demonstration sites
Year 3	Field demonstration of the **a^2SDP** for the three demonstration sites

Project Impact

The technology provides a disruptive protection technology for robust solution to the challenges posed by PV and other DERs and at the same time solves existing dangerous protection gaps in distribution systems, such as protection against down conductors. The technology will practically eliminate relay mis-operations and will provide a holistic protection and control to maximize reliability. The industry is seeking solutions to these problems for decades.

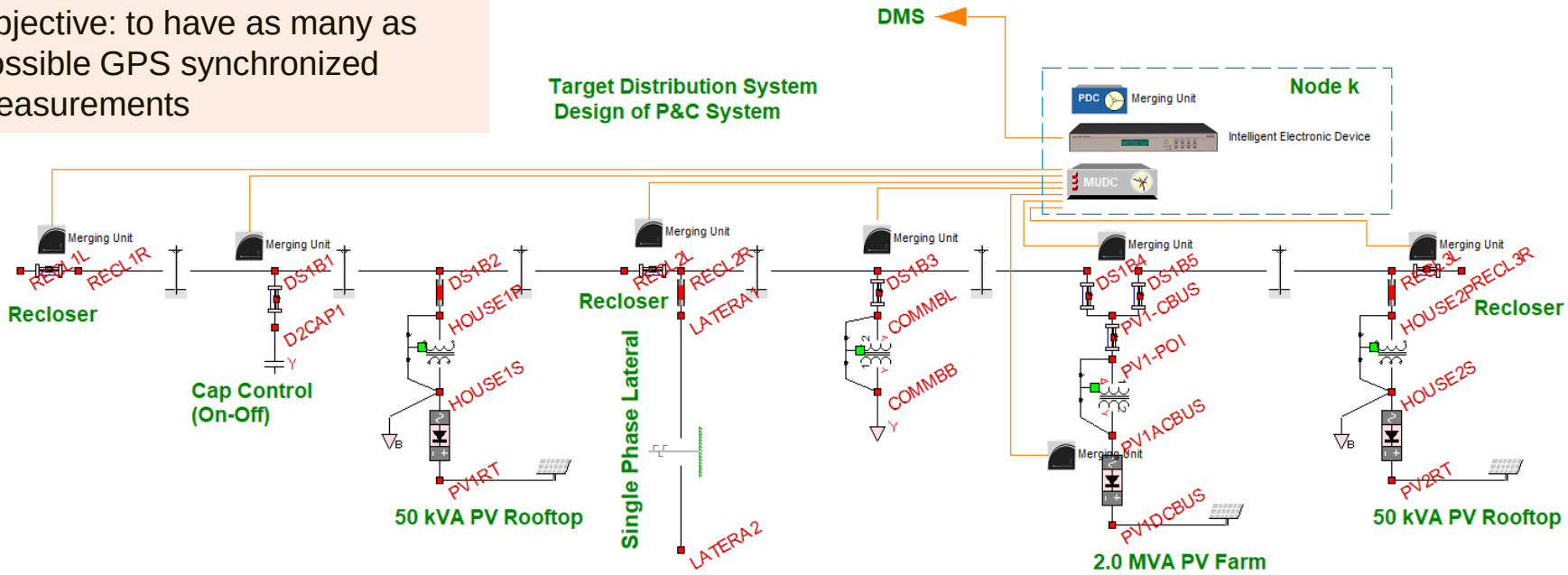
Basic Design and Configuration

Core technology: estimation based protection (EBP) is naturally the **ultimate adaptive** protection system, immune to inverter based resources, low fault currents and omnidirectional flows. Design a system that enables EBP and accommodates the needs for a DMS of an active distribution system (state estimation, fault locating, reconfiguration, optimization, and other.)



Basic Design and Configuration

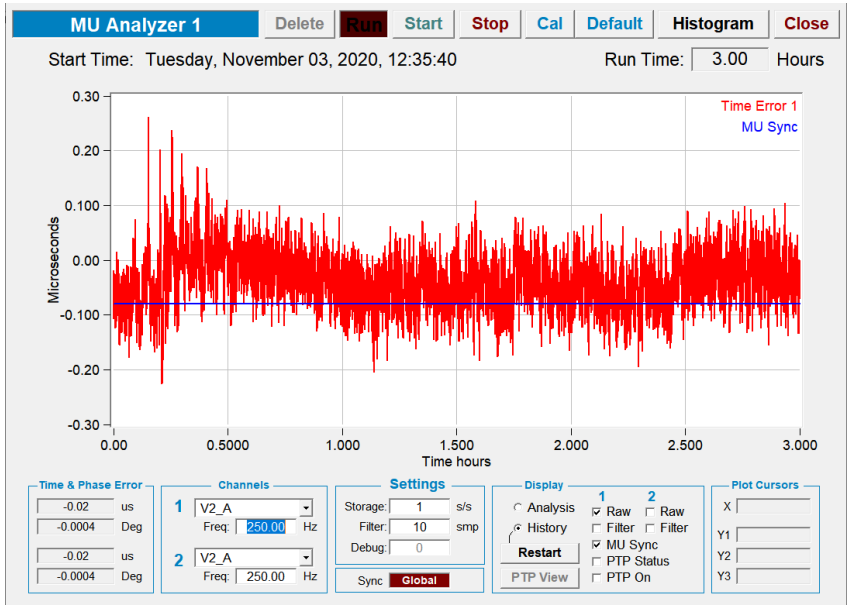
Objective: to have as many as possible GPS synchronized measurements

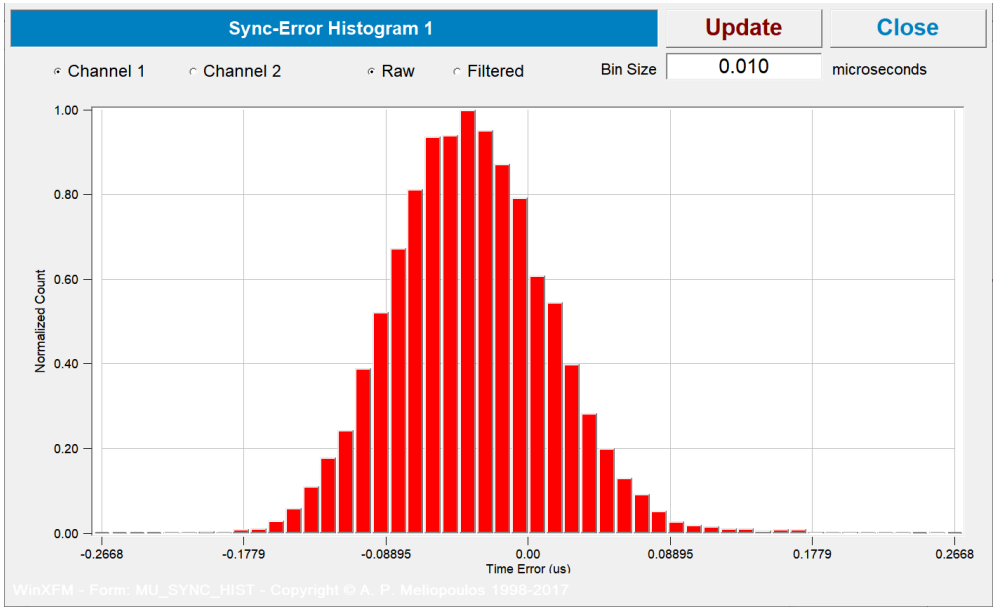


Example of a node and the associated part of a feeder. The feeder section associated with this node includes three reclosers, two house clusters with 50 kVA rooftop PVs, one utility size PV farm, a commercial building and a voltage correcting capacitor bank. The node monitoring and control equipment includes an Ethernet switch, a GPS antenna/receiver, and a computer. Along the feeder section seven data acquisition systems (merging units) are located. The design is flexible to accommodate any system.

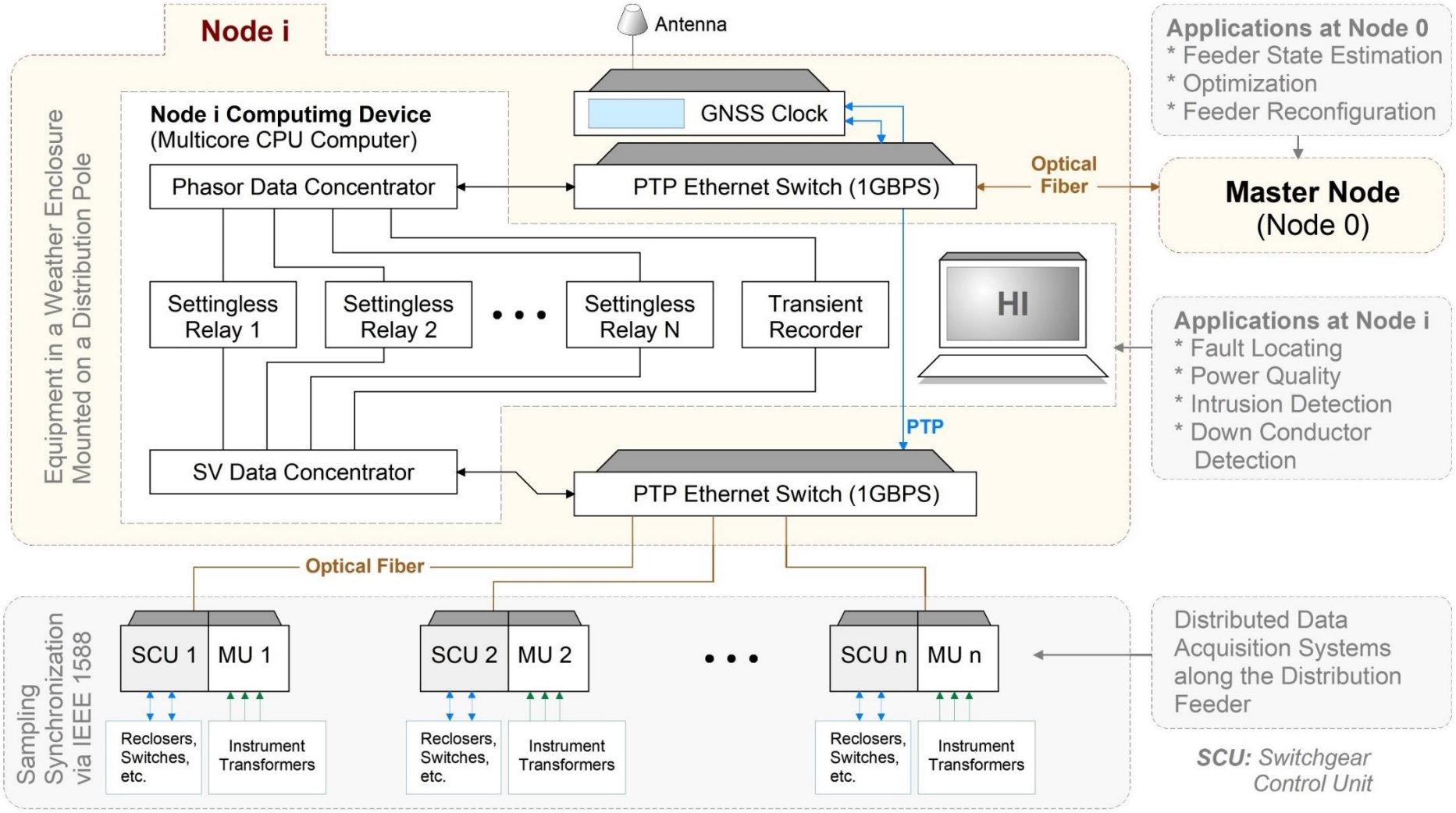
GPS Synchronization Testing

Master-Clock: Ruggedcom with IRIGB from SEL
Ordinary Clock, Power Profile, 2-Step, Power Profile, P2P
Merging Units connected via 1500 m optical cable
Error Below 0.3 us





Network Node Organization: Local a2SDP



Key Objectives

Dynamic state estimation based protection (EBP, aka setting-less relay) promises robust solutions to known problems: **immune to known problems**: (a) direction of fault current flow; (b) reduced levels of fault currents; (c) waveform distortion and any changes outside the protection zone; (d) characteristics of inverter contributions, i.e. suppressed neg and zero seq currents; and (e) changing topologies and characteristics as resources are switched in and out.

Provides a secure and dependable solution to existing protection gaps, for example down conductors (**First reliable down conductor detection system**).

Provides reliable distribution system visibility at fast speeds (running distribution system state estimation **once per cycle**).

Real time fault locating and feeder reconfiguration in real time after fault occurrence.

Provides real time full observability model for any application.

Demonstrations, Field Testing

The proposed technology will be demonstrated on three feeders with substantial PV penetration (Dominion, Southern Company and Avista), covering three geographical areas with diverse solar patterns.