



Smart City Testbed

Chen-Ching Liu

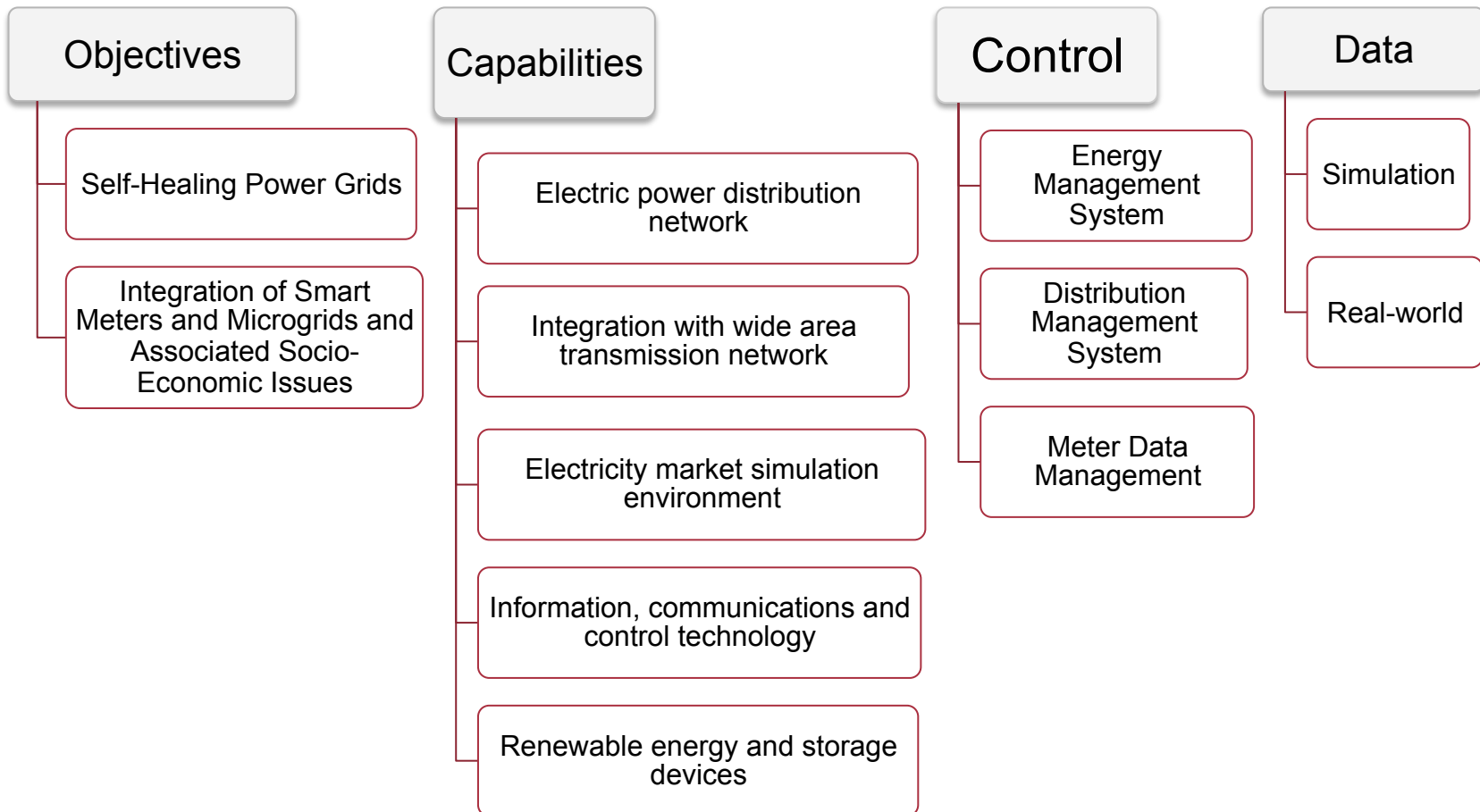
Anurag Srivastava

Adam Hahn



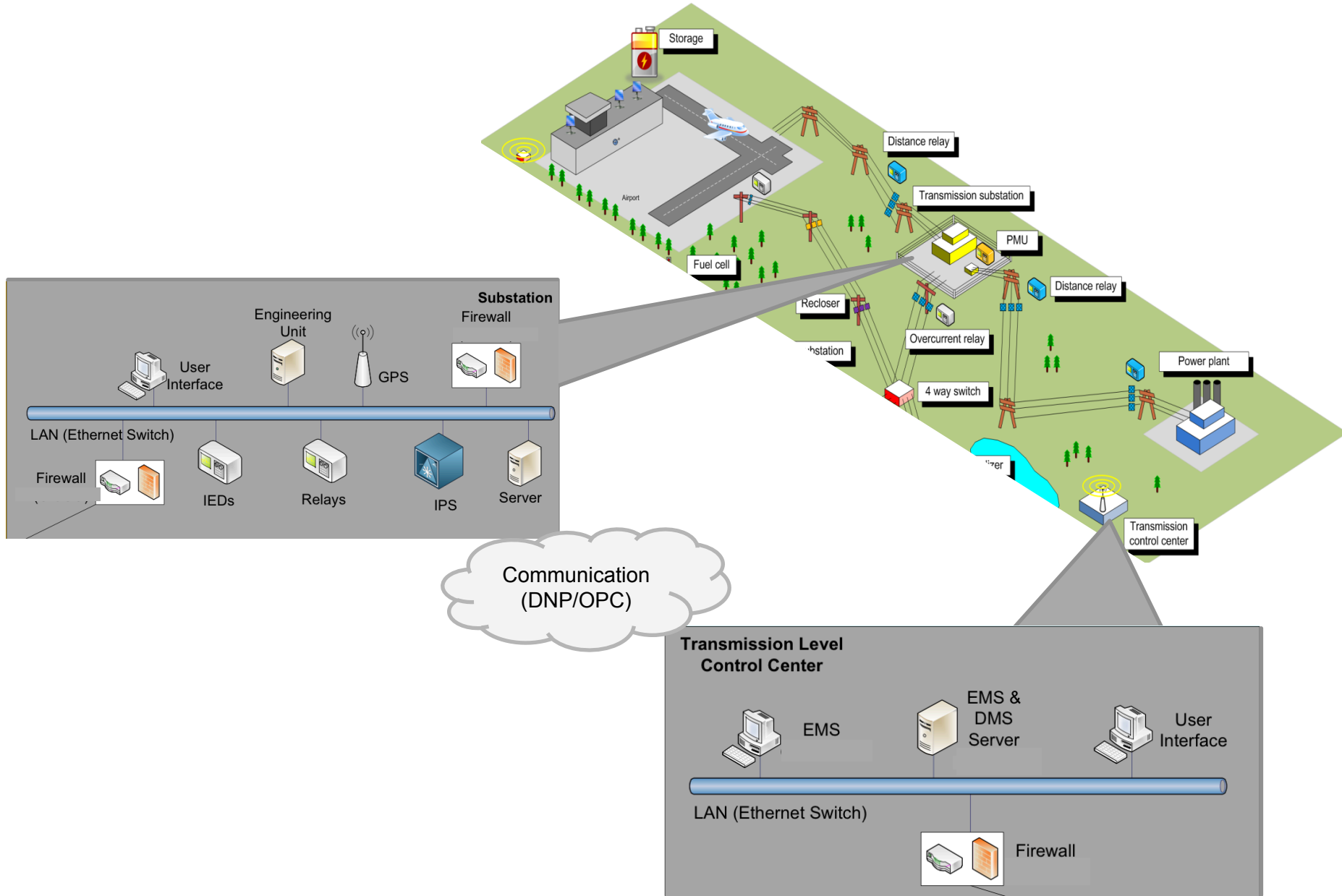
Testbed Overview

Comprehensive research and collaboration testbed spanning across all power system domains



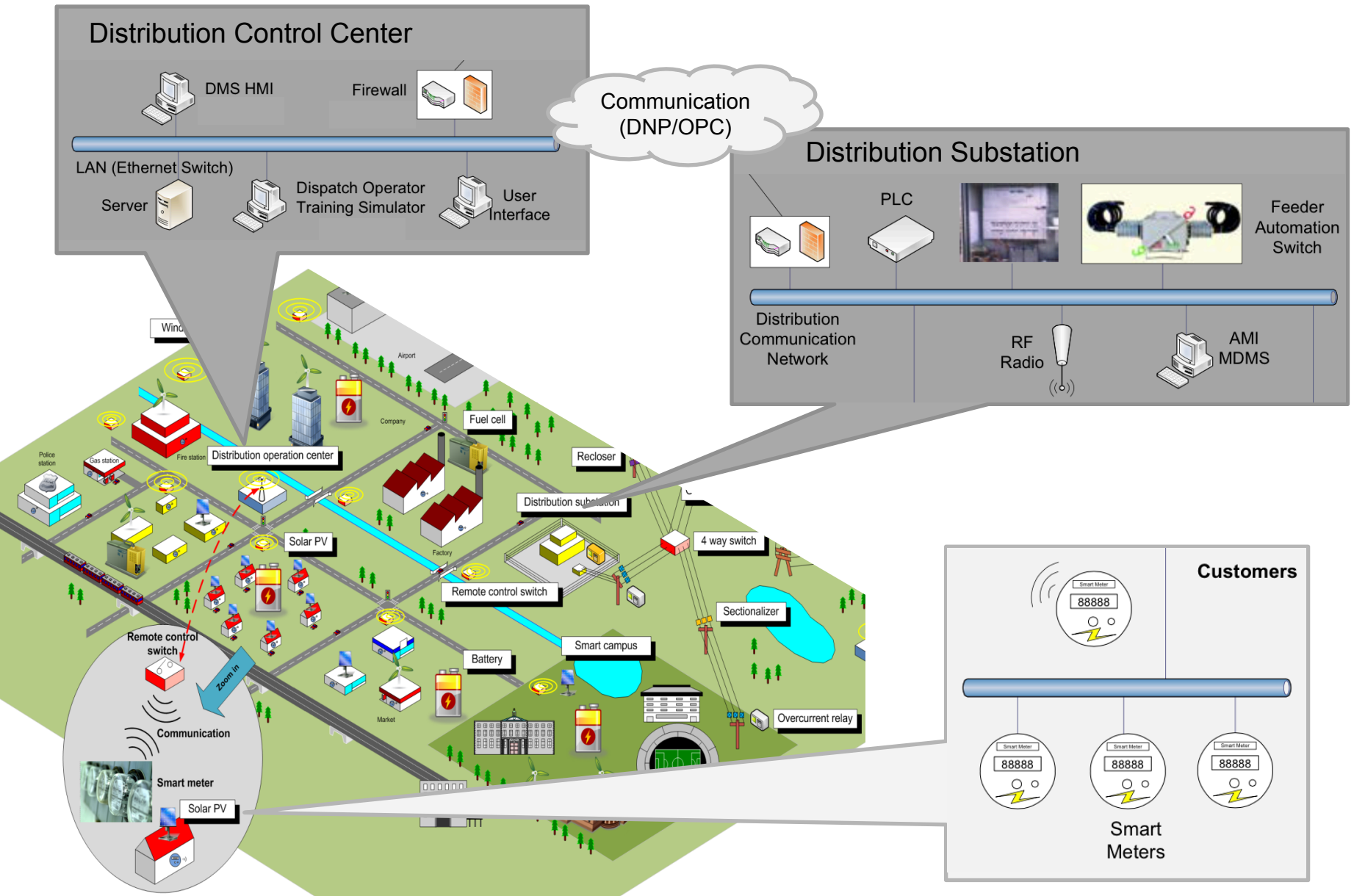


Transmission





Distribution





Smart City Testbed





Smart Grid Demonstration and Research Investigation Lab (SGDRIL)

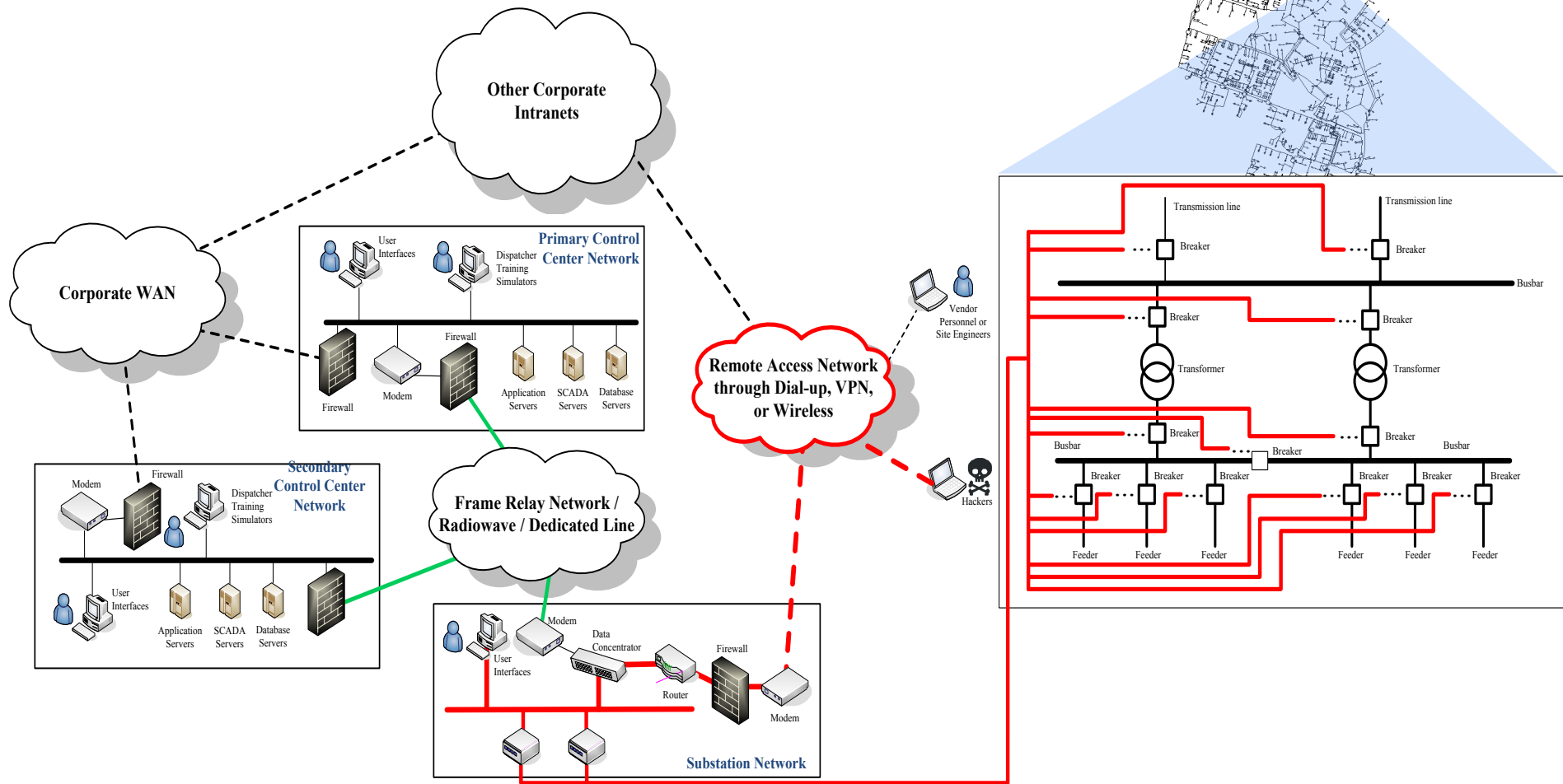
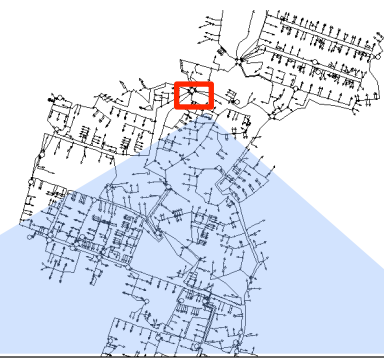




Use Case #1: Substation Intrusion Detection

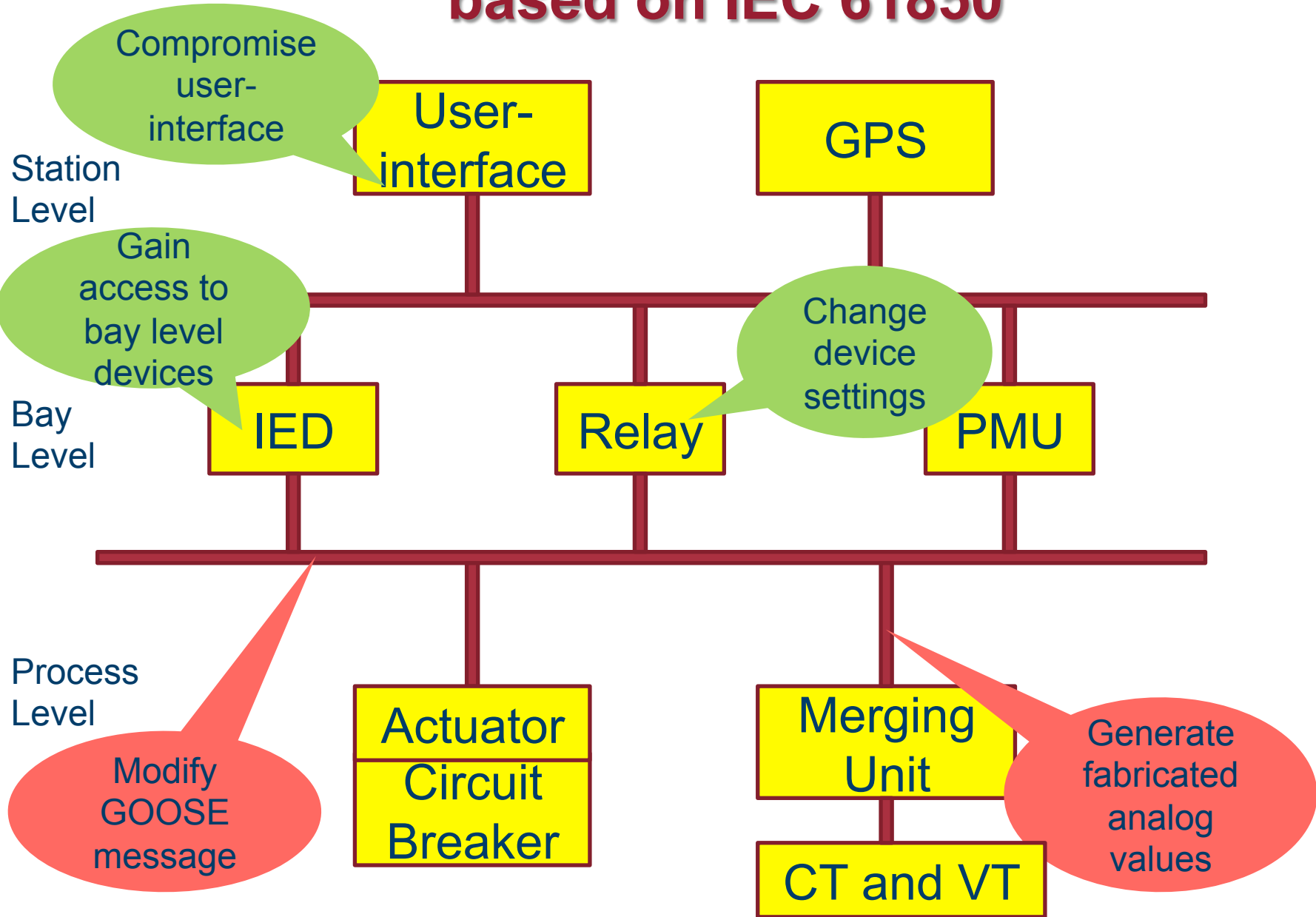


Intrusion into a substation network





Potential threats in a substation based on IEC 61850





Relays

Protection IED: Relay

WASHINGTON STATE UNIVERSITY
Energy Systems Innovation Center

Protection IED: Overcurrent Relay

Operation: **Normal**

Current Values [A] RMS:
Ia: 5.02
Ib: 5.01
Ic: 5.03

Setting Values [A]:
Instantaneous: 125
Time overcurrent: 30

Circuit Breaker Status: **CLOSED**

Close

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Protection IED: Relay

WASHINGTON STATE UNIVERSITY
Energy Systems Innovation Center

Protection IED: Overcurrent Relay

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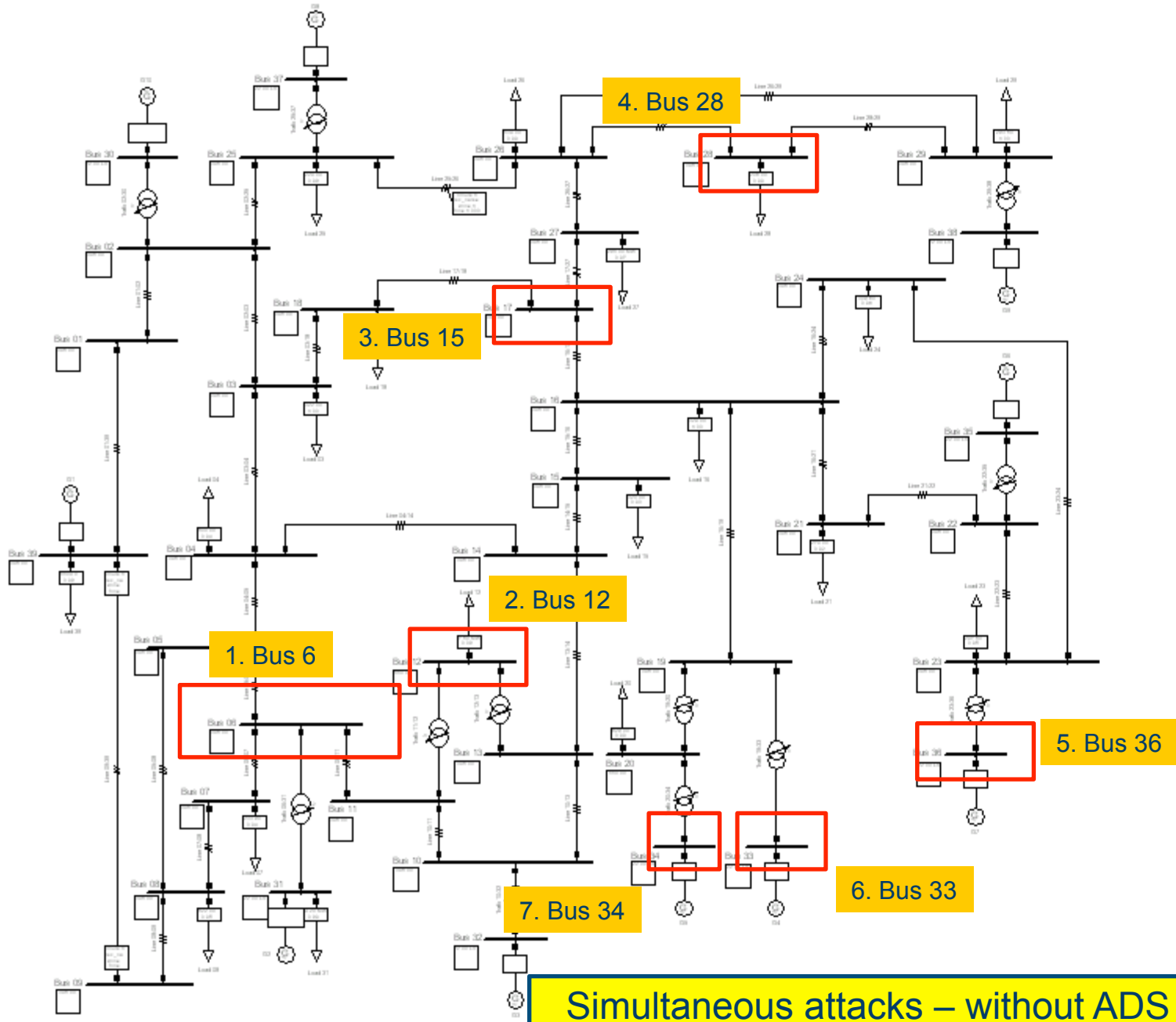
Circuit Breaker Status: **OPEN**

Close

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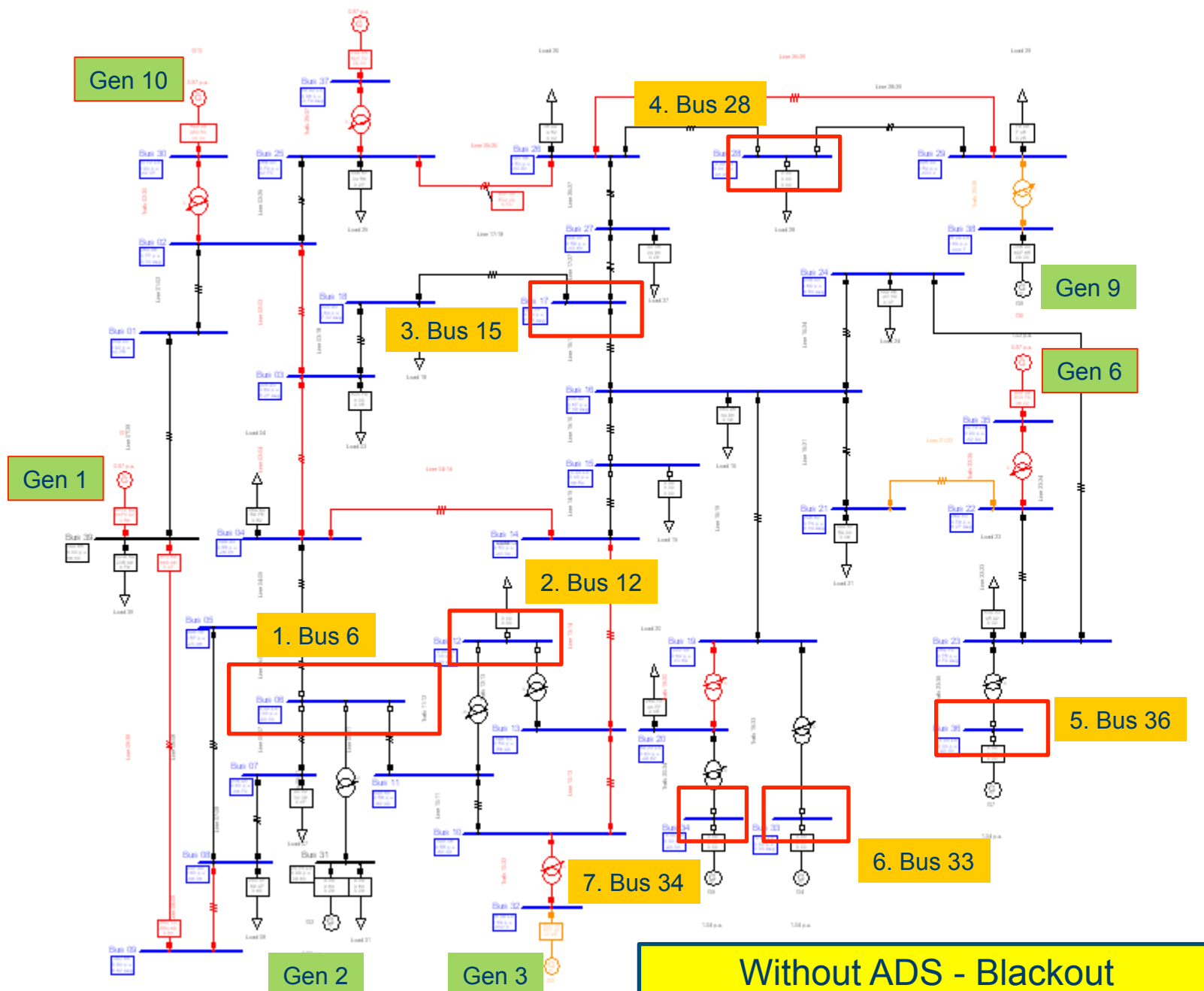


IEEE 39 bus system (DigSILENT)



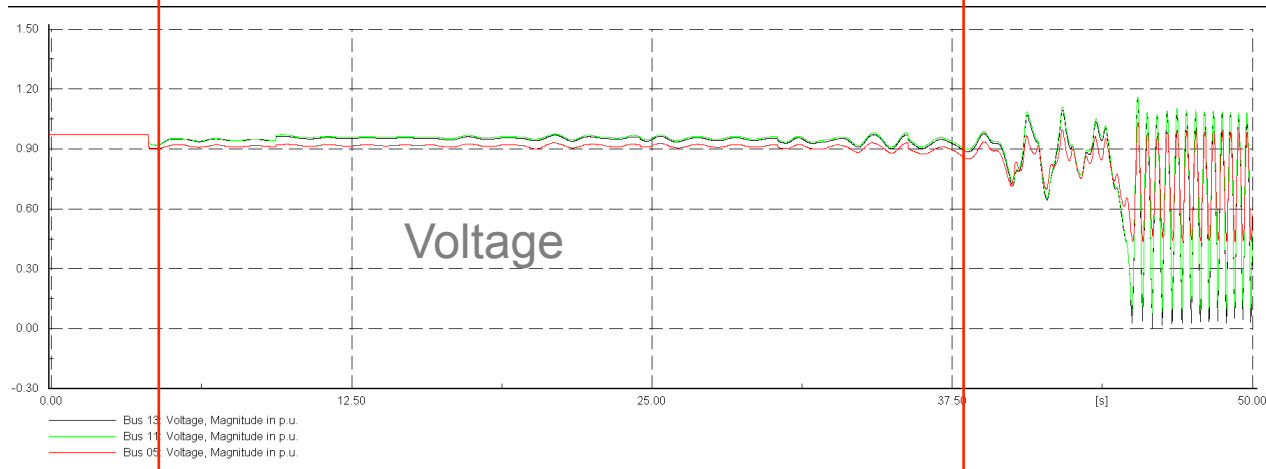
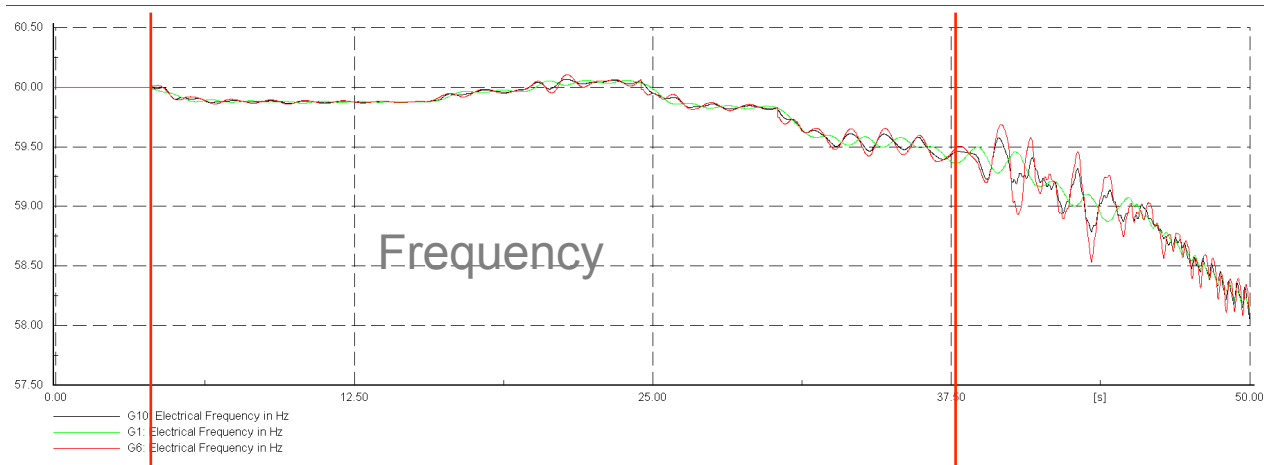


IEEE 39 bus system (DigSILENT)





IEEE 39 bus system (DigSILENT)



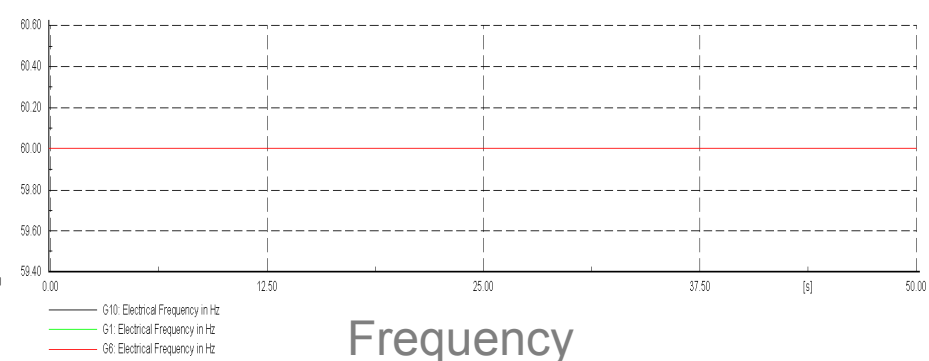
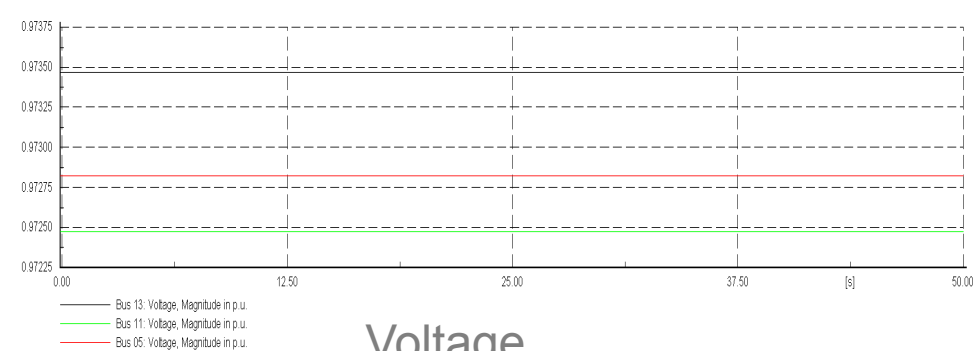
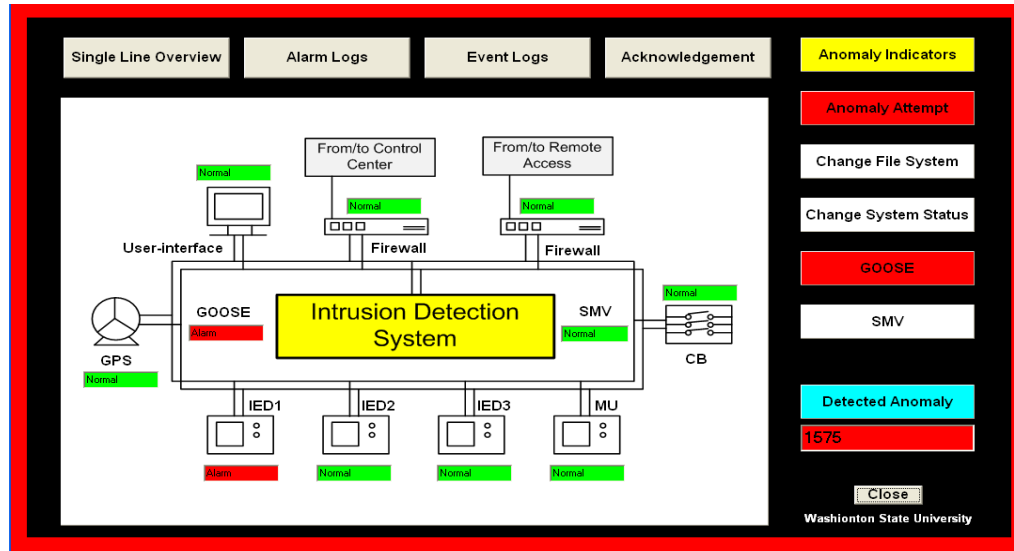
Attack Start

Attack End

Without ADS - Blackout



IEEE 39 bus system (DigSILENT)



With ADS - Normal



Use Case #2: Wide Area Applications



PMU Testing



Analog Test Signals

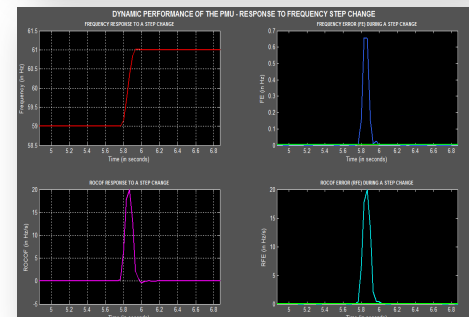
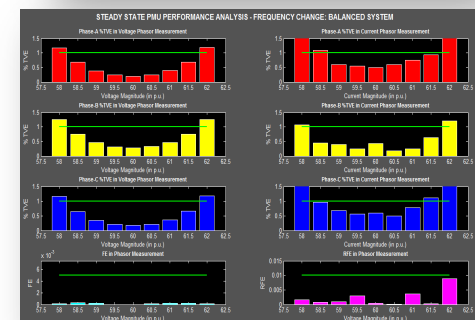
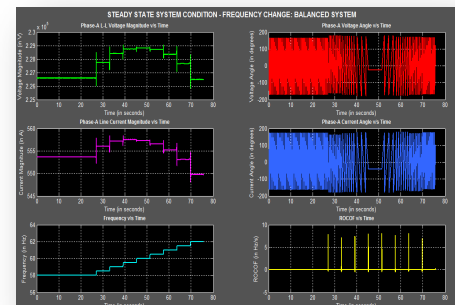
Test PMU

C37.118.1 Data

C37.118.1 Data

Phasor Data Concentrator (PDC)

.csv Data (Offline)



RTDS



OP5600 32-Core

Up to 3000 nodes
at 50us
(1000x 3Ø Buses)

PMU Performance Analyzer

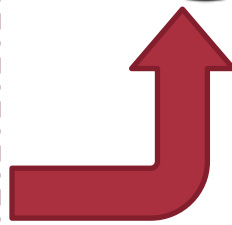
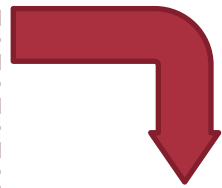
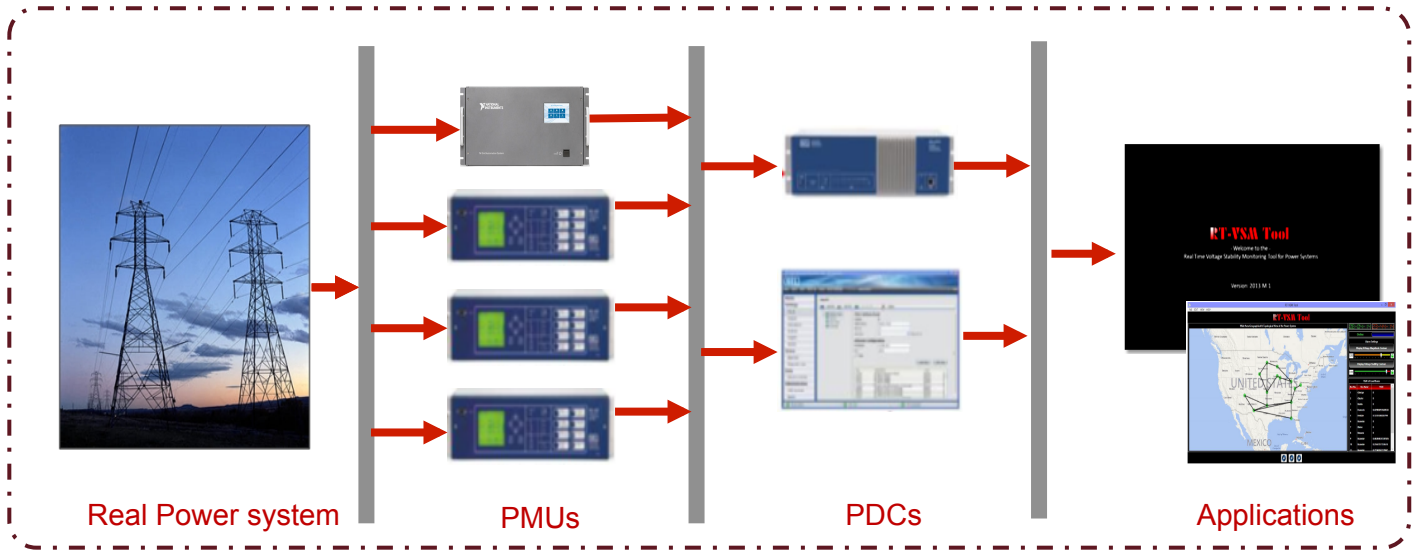
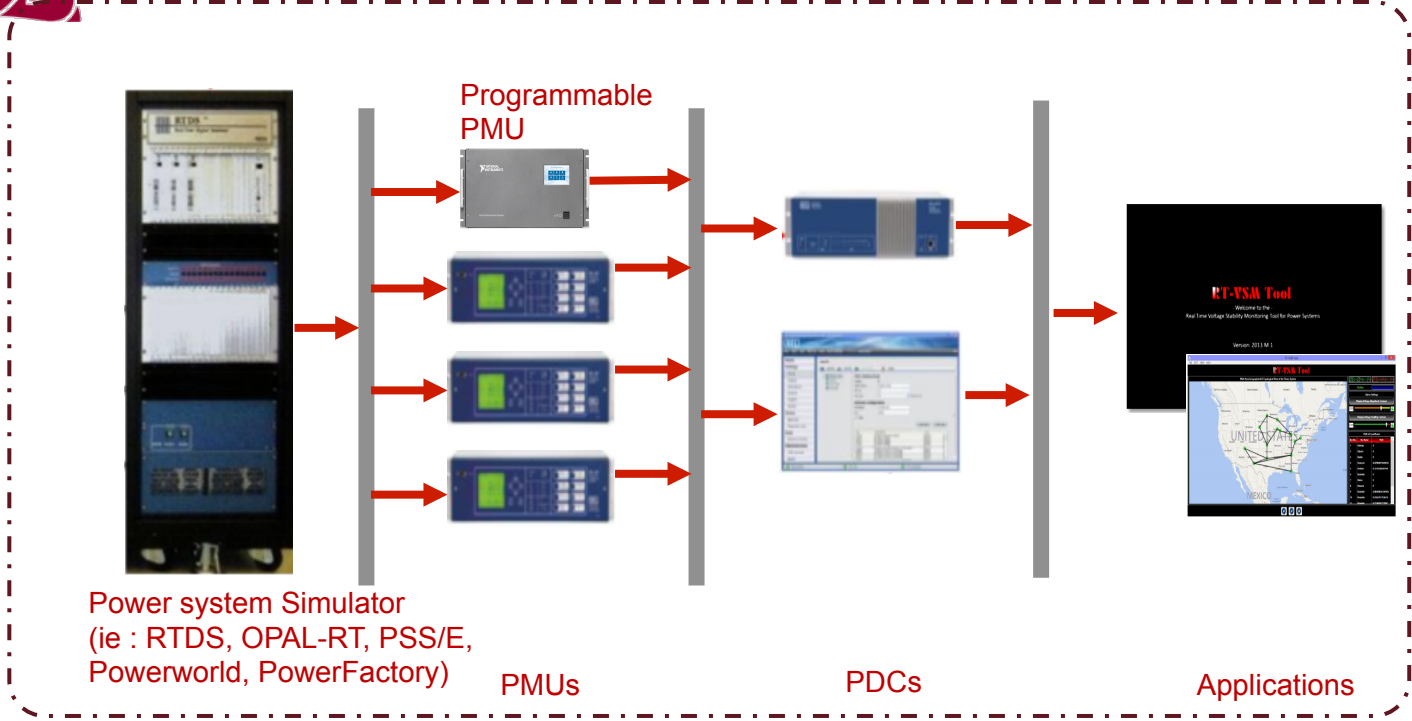
- Welcome to the -
Tool for Analyzing the Performance of Phasor Measurement Units (PMUs)

Version: PPA.2013.1

Automatically
generated
PMU test report



Testing of Synchrophasor Applications

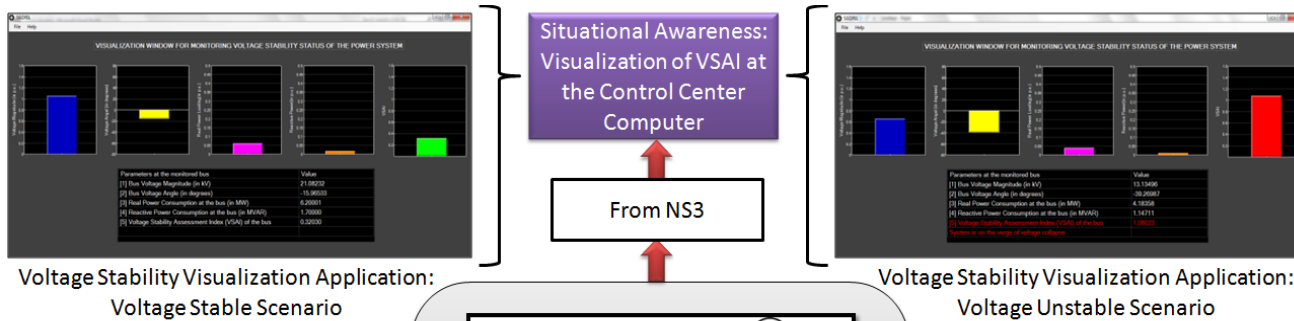




Use Case #3: Cyber-Physical Analysis



Cyber-Physical Analysis

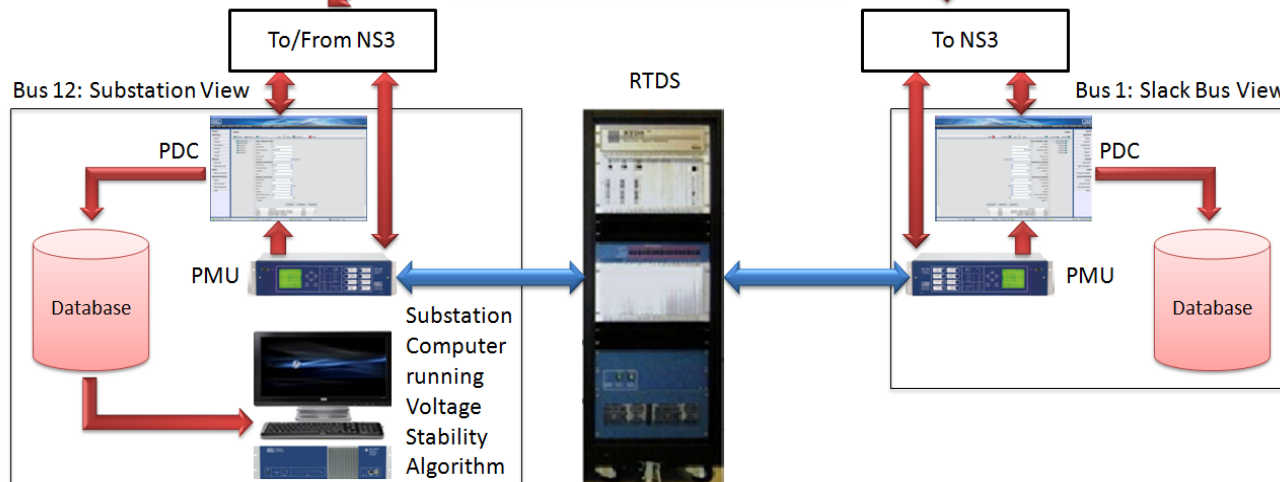
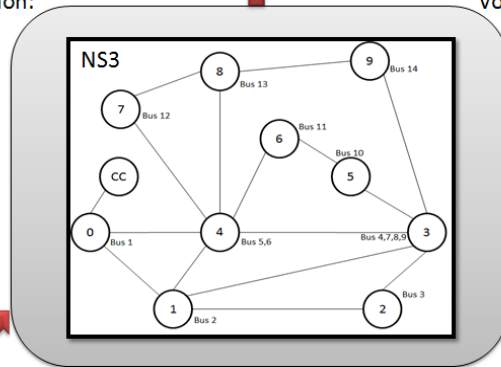


Communication Delay in IEEE-14 Bus Test Case

From Gateway	To Gateway	Propagation delay (in ms)
Bus 12	Bus 1	1.26955
Bus 12	Control Center	1.46955

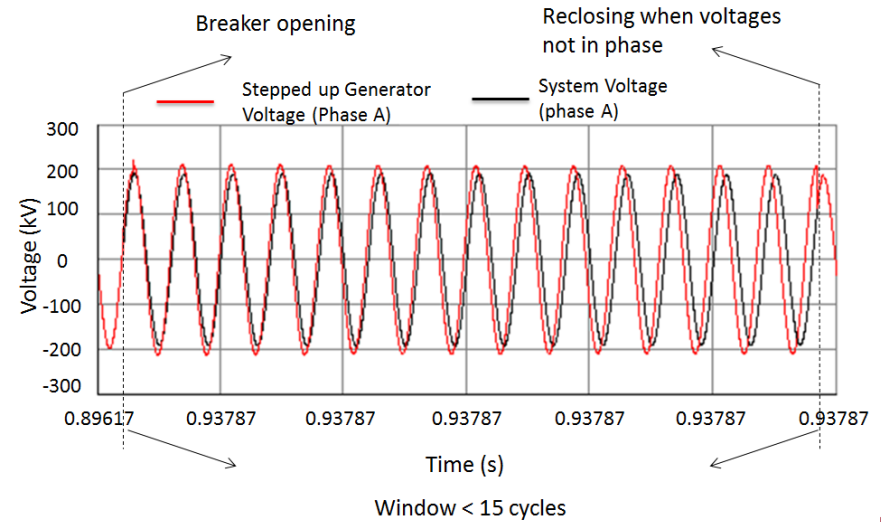
Communication Delay in IEEE-30 Bus Test Case

From Gateway	To Gateway	Propagation delay (in ms)
Bus-30	Bus-1	1.85426
Bus-30	Control Center	2.05426

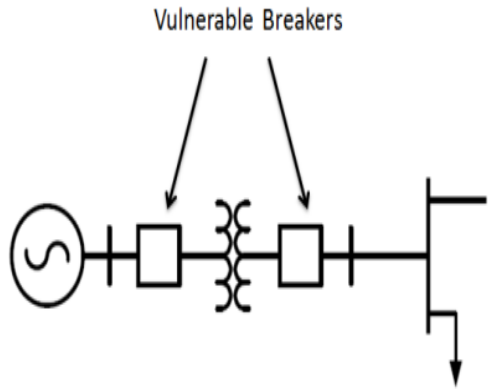
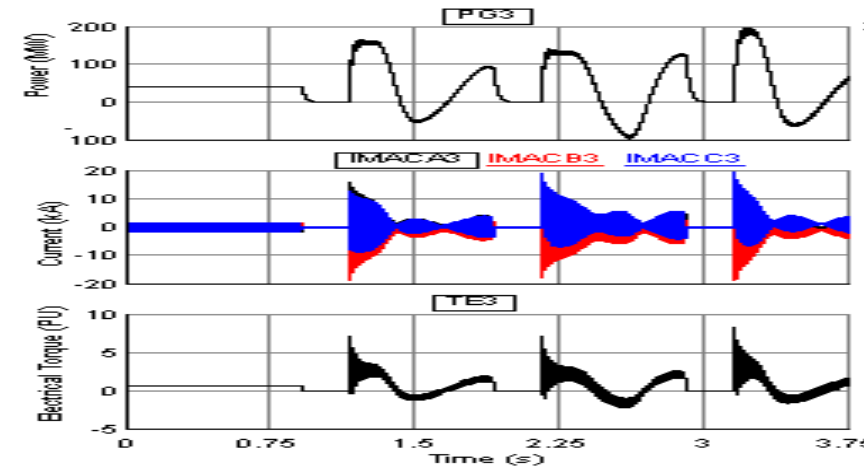




Real Time Simulation for Aurora Attack



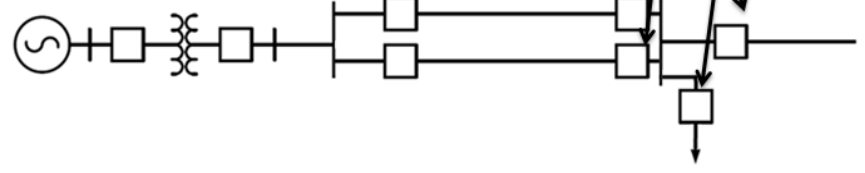
Breaker opening and out of synchronism reclosing



Aurora attack with local beaker opening



Vulnerable Remote breakers



Aurora attack with remote beaker opening



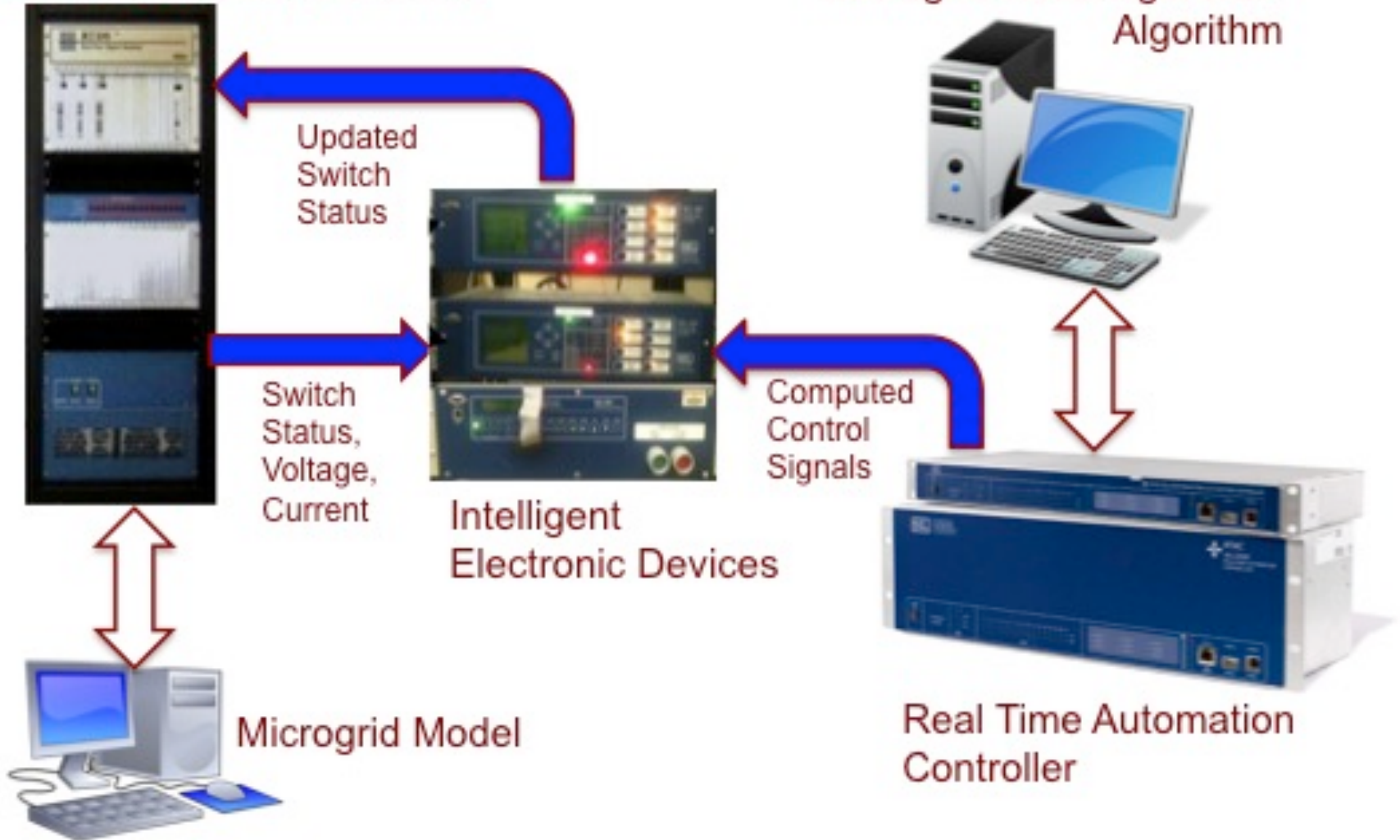
Use Case #4: Microgrid Control



Real Time Energy Management and Control for Microgrid

Real Time Power Grid Simulator

Microgrid Reconfiguration Algorithm





Thanks

