Cyber Physical Resiliency Experimentation and Assessment Using Federated Testbed

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OBJECTIVES

- Identifying experiments that could benefit from federated resources and understand needs.
- Evaluating experimental needs to balance scalability, fidelity, complexity, and cost.
- Developing interfaces and a management architecture that will allow for federated experimentation.
- Validating and quantifying results of federated experimentation against localized results.

KEY CHALLENGE -

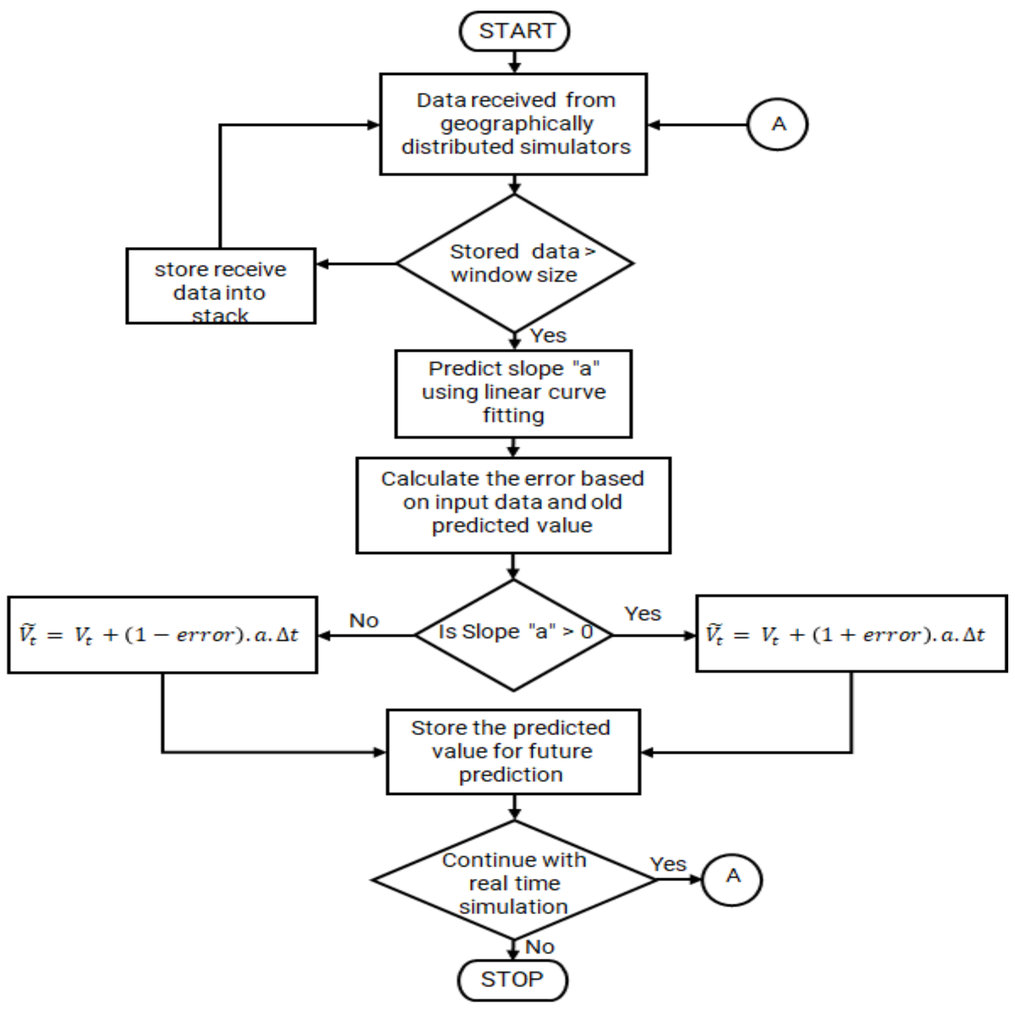
1. Co-simulate transmission and distribution systems in *different real time simulators OPAL-RT & RTDS.*
2. *Simulator compatibility issues*
3. *Latency management*

METHODOLOGY

- Developed an IEEE-13 node test feeder as a distribution system on RTDS.
- Transmission system with 179 bus is developed in OPAL-RT HYPERSIM.
- Established a communication channel between OPAL-RT/RTDS using VILLASnode to transmit and receive data in real time.
- VILLASnode provides a gateway for processing and forwarding simulation data between real-time simulators. At the core, it acts like a client/server application to connect simulation equipment and software.

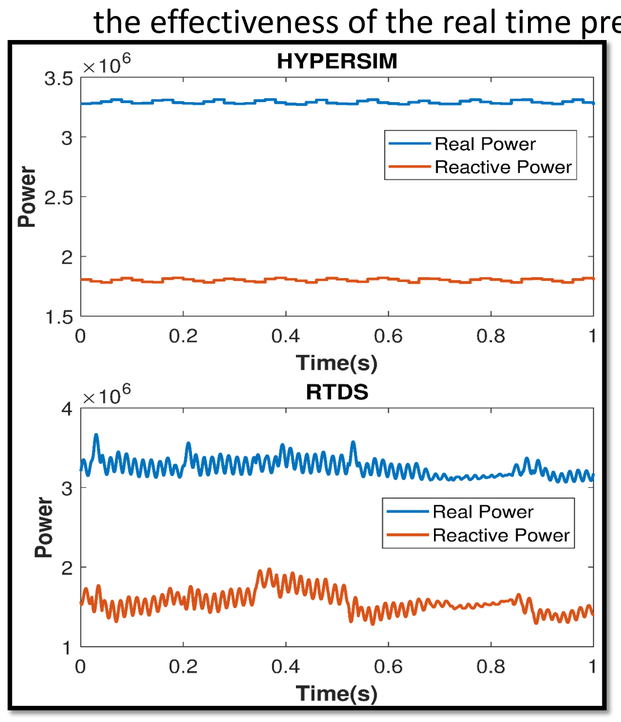
LATENCY MANAGEMENT

- Geographically distributed real time simulations may lead to inaccuracies and instability due to communication latency.
- The simulators perform simulations in the order of milliseconds to microseconds, whereas data latency for communication of geographically distributed could be as high as few hundred milliseconds.
- To address the above-mentioned issues with communication latency, a linear curve fitting technique is used as the real time predictor.

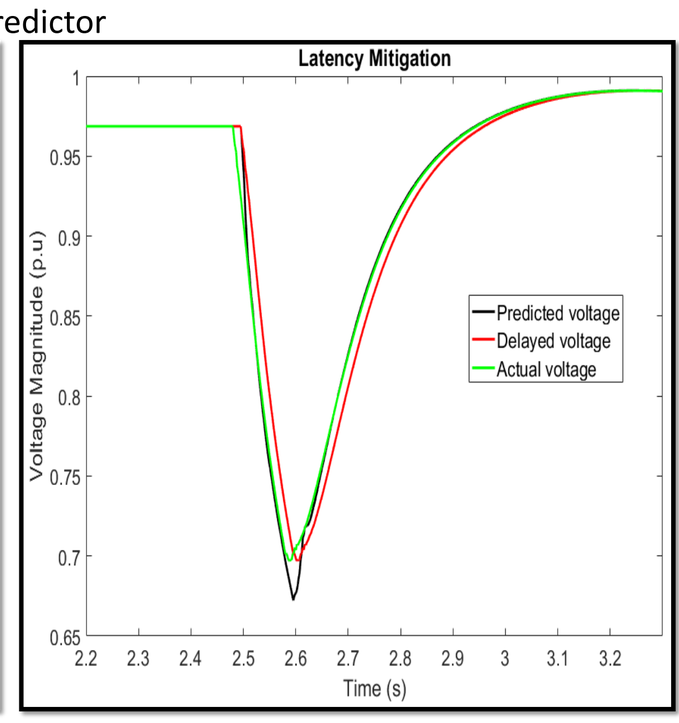


OBSERVATIONS

- Distribution test feeder connected on Bus 106 of transmission system
- Three phases to ground fault is created in transmission system to evaluate the effectiveness of the real time predictor



Co-simulation Test



Latency management using linear prediction

RMSE, COR and UEI for three phase fault

3-phase fault	V_{RMSE}	V_{COR}	UEI
Latency case	0.0080	0.9790	0.9855
Prediction case	0.0025	0.9984	0.9988

USE CASES

- Cyber Physical Resiliency studies
- Study of transmission-distribution interactions
- Effect of renewables and storage systems on transmission grid
- Study of slow-moving dynamics, such as voltage stability analysis

INTERACTION WITH OTHER PROJECTS

- We're interested in collaboration with industry and vendors to get feedback on our models, techniques and use cases.
- We look forward for industry advice on developing more realistic use cases for testing and validation on the testbed.

FUTURE EFFORTS

- We are currently working on implementing additional use cases for cyber physical resiliency metrics testing and validation.
- Hardware in loop simulations consisting of PMUs, relays and controllers with the federated testbed.
- Interfacing simulators dispersed geographically at UIUC and WSU.

ACKNOWLEDGEMENT

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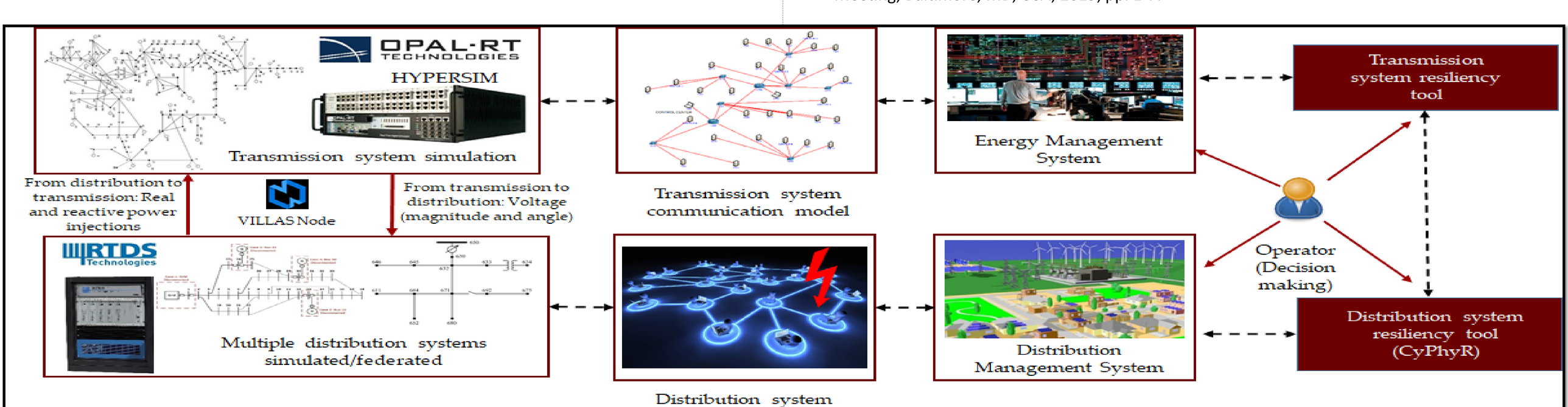

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