



Streaming Time-Series Platform for Power System Operations Reliability and Resilience

Dr. Greg Zweigle
NASPI Conference – April 16, 1:45-2:00



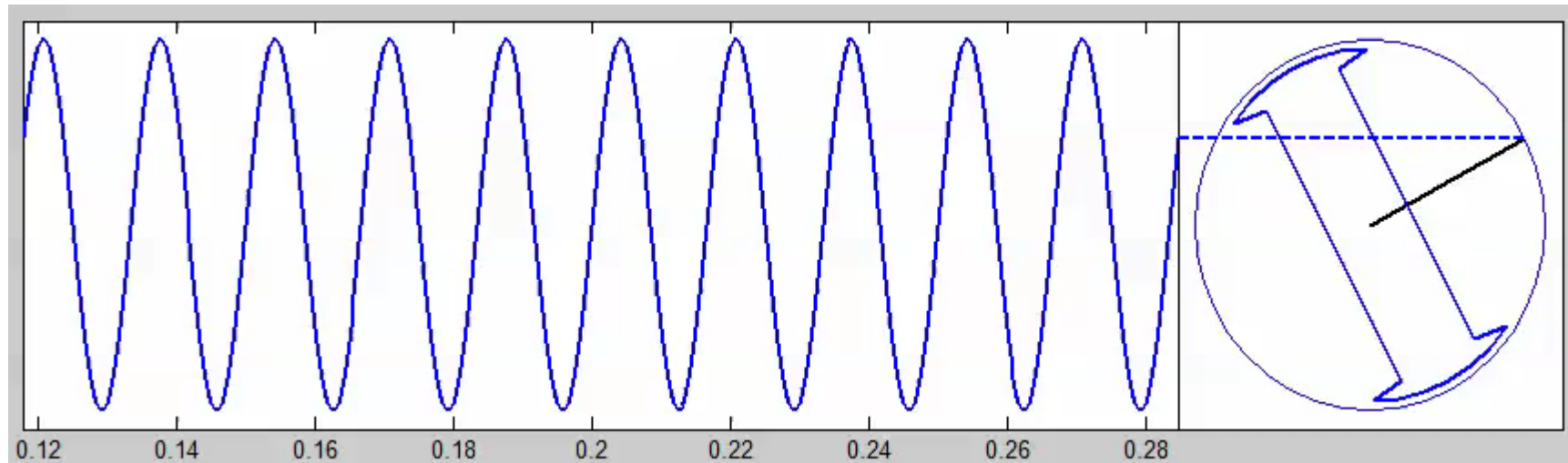
Quasi-Stationary Phasor Approximation

Limits both SCADA and Synchrophasors

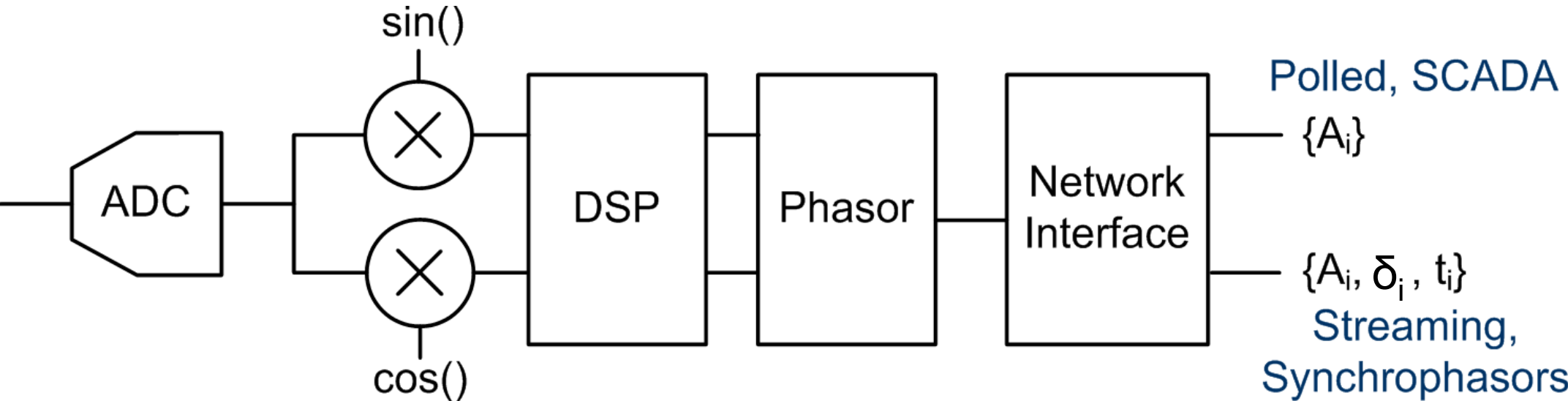
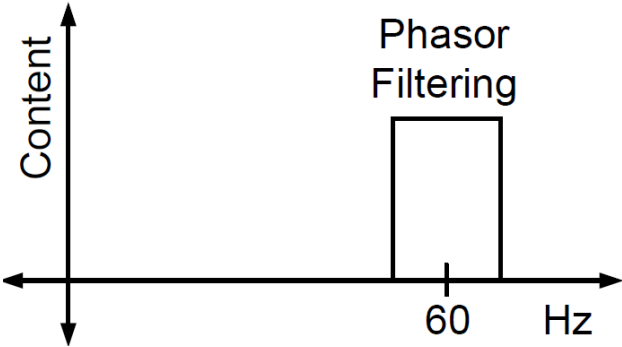
$$x(t) = A \cos(\omega t + \theta) \rightarrow \bar{X} = Ae^{j\theta} \quad (1)$$

$$x(t) = A(t) \cos(\omega t + \theta(t)) \rightarrow \bar{X}(t) = A(t)e^{j\theta(t)} \quad (2)$$

$$x[KT_s] = A[KT_s] \cos(\omega KT_s + \theta[KT_s]) \rightarrow \bar{X}[KT_s] = A[KT_s]e^{j\theta[KT_s]} \quad (3)$$

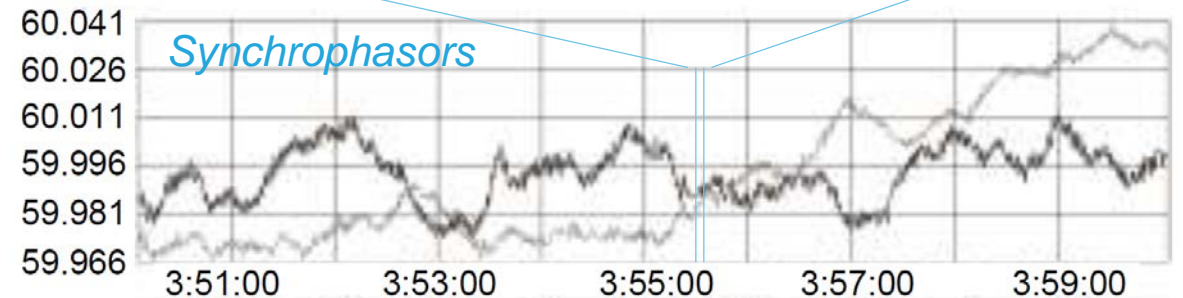
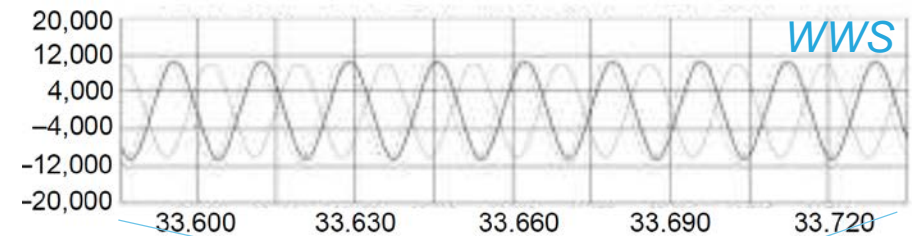
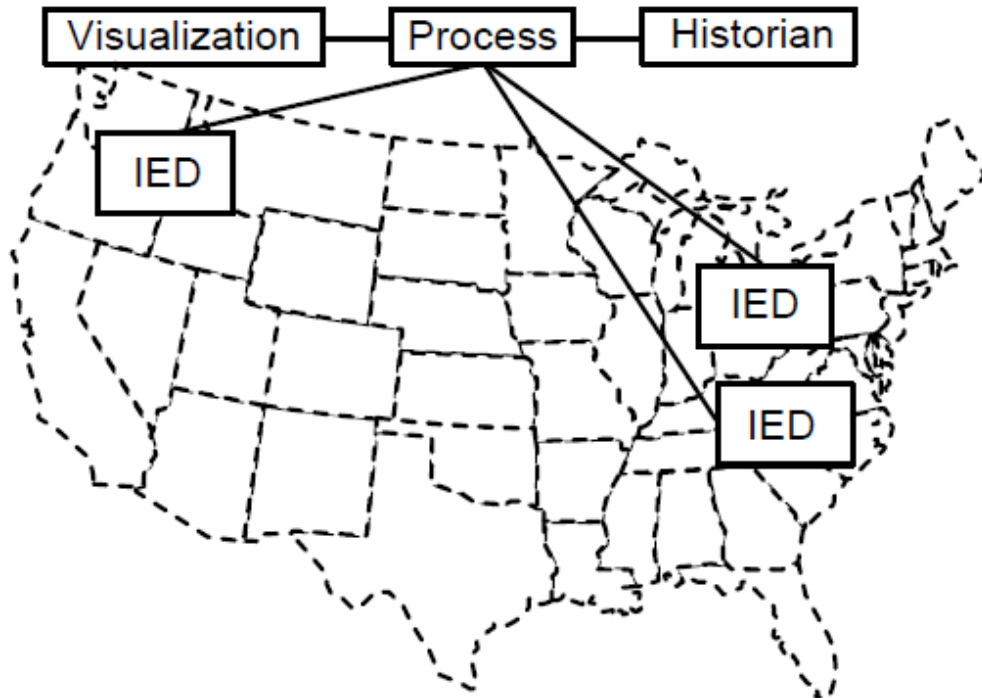
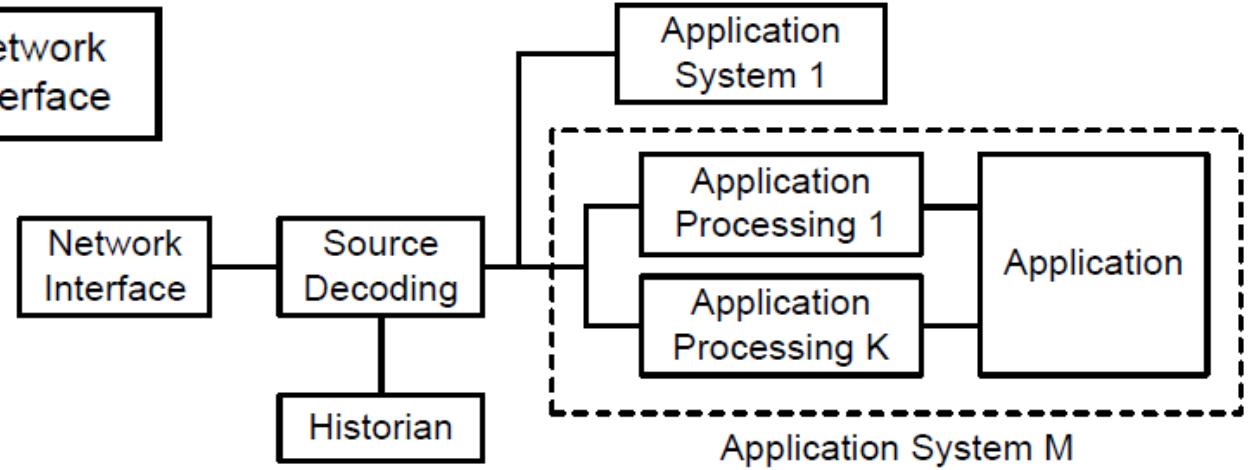
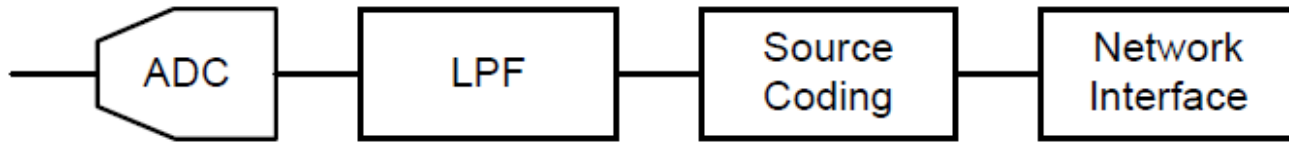


Phasor Measurement Unit Implementation

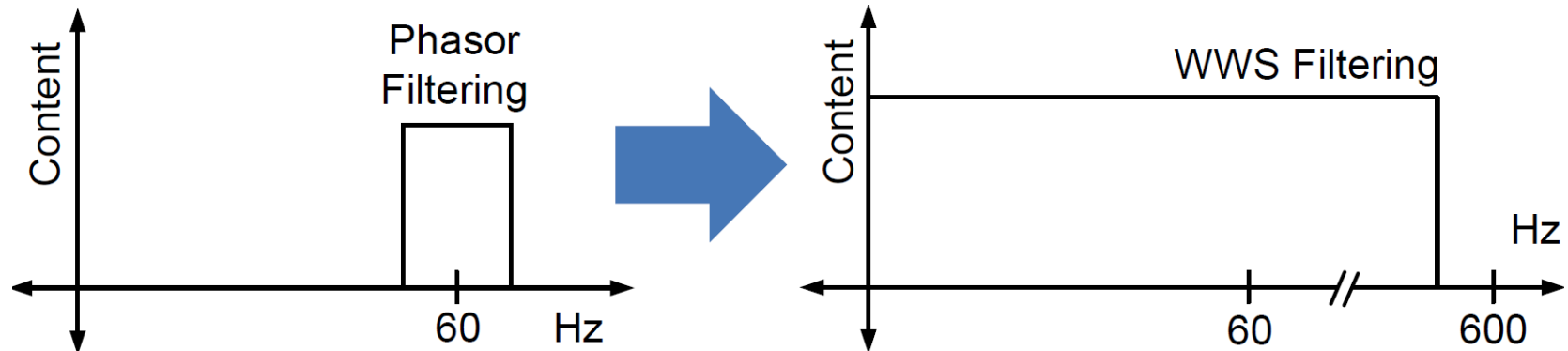
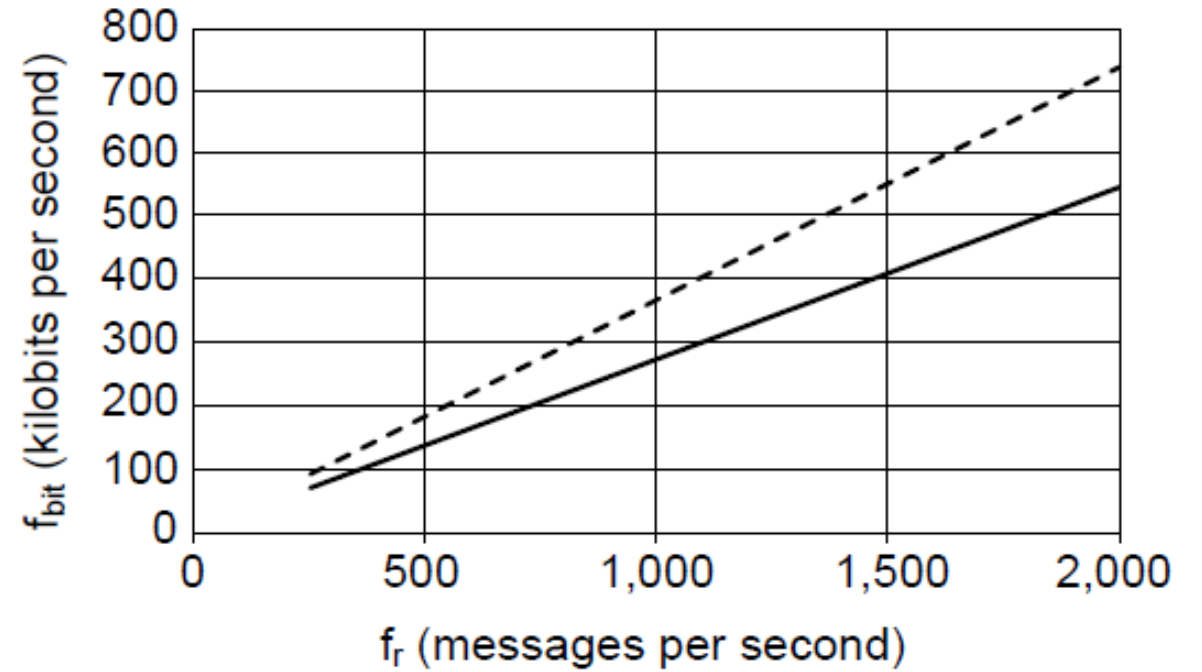
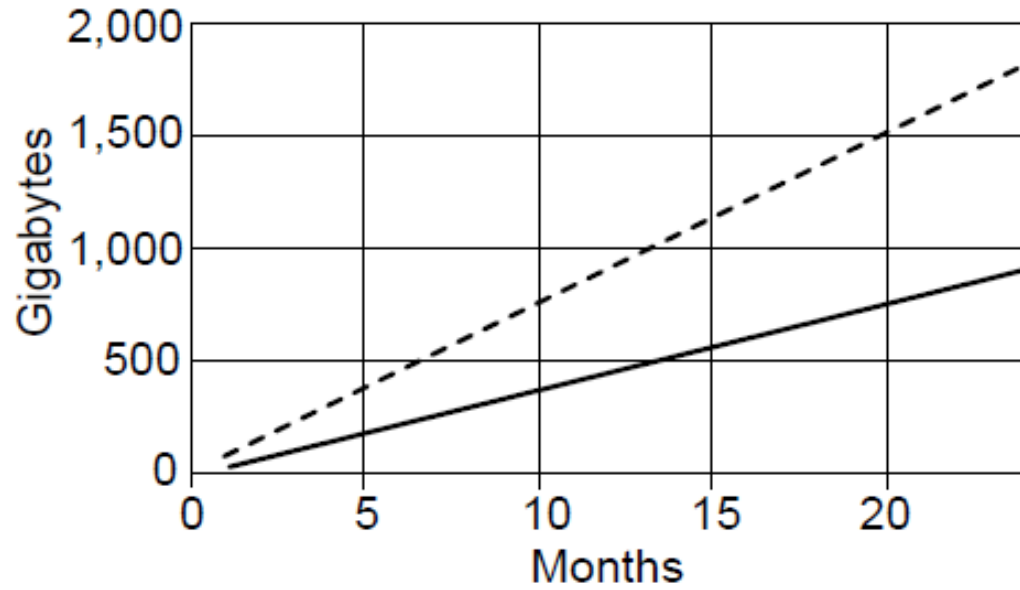


Is This Limitation Still Necessary?

In 2015 SEL Build A Demonstration System



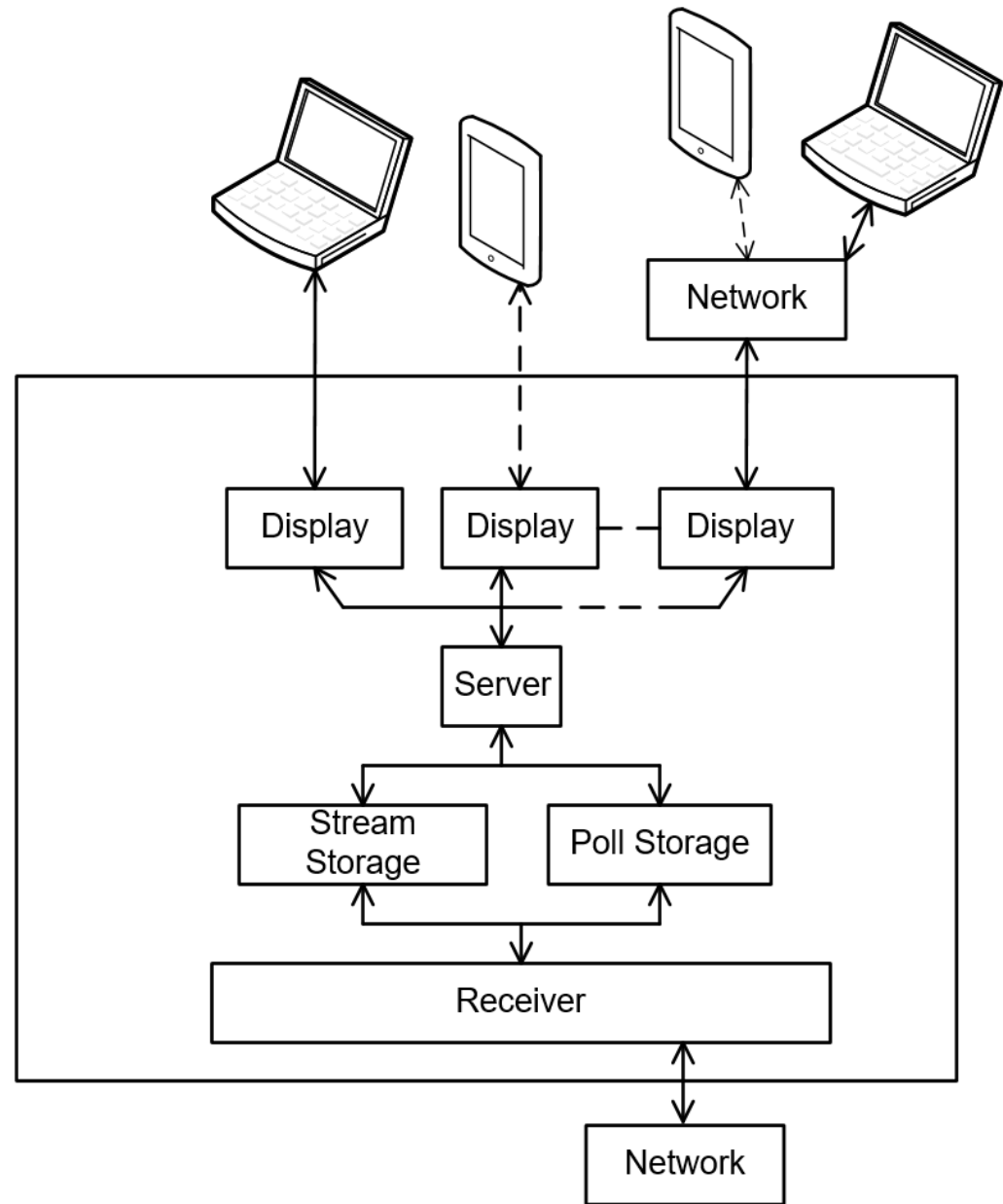
Data Rates and Storage



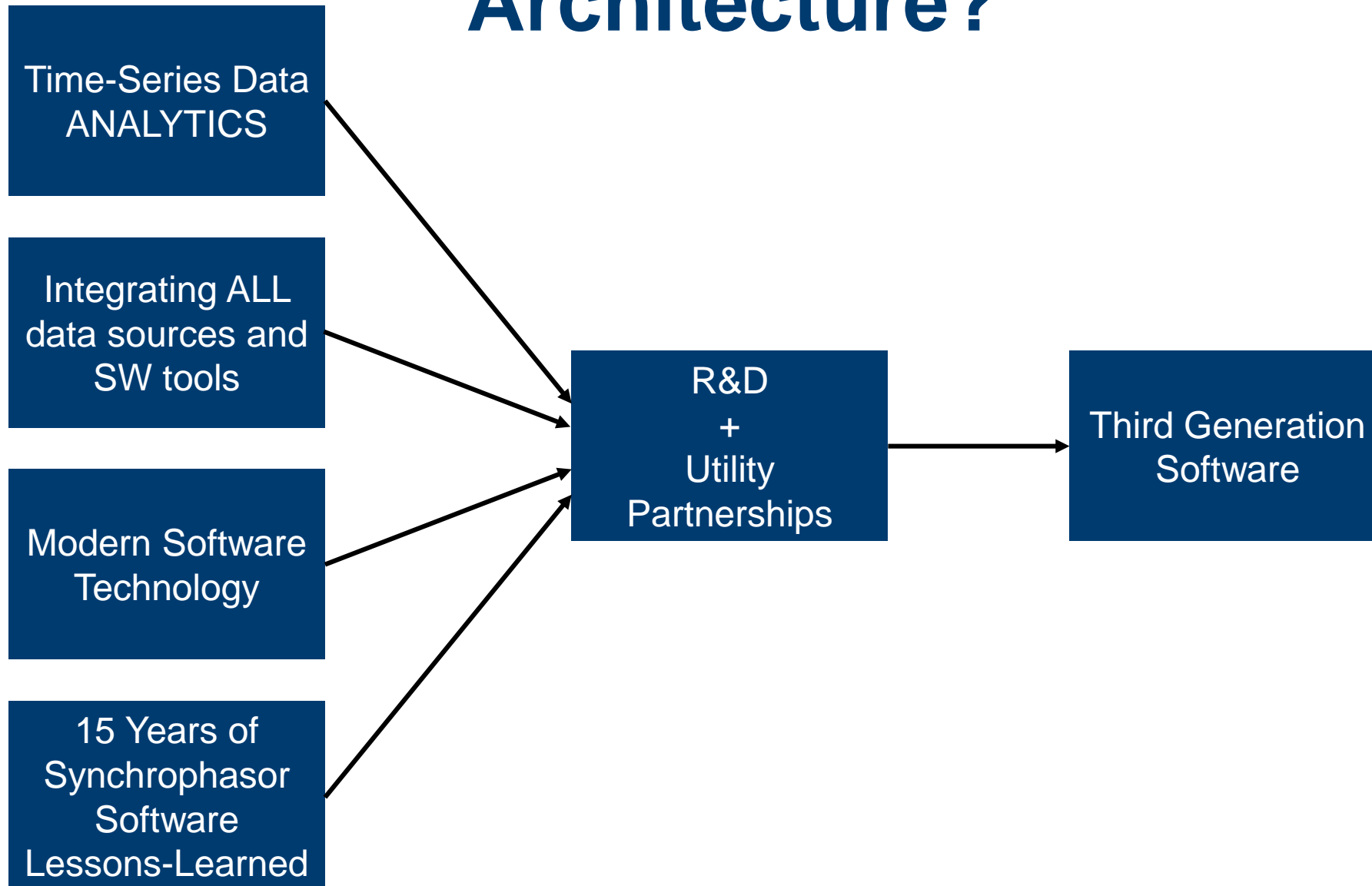
Improving Reliability and Resilience

- Subsynchronous Oscillations
- System Event Analytics (RT and offline)
- Inverter Event Analytics (RT and offline)
- Geomagnetic Disturbances
- Improved Model Validation
- Improved Modal / Oscillation Analytics
- Real-Time Analytics for Situational Awareness
- **NOT 'sine-waves' displayed for operators**

Non-Streaming Point-On-Wave

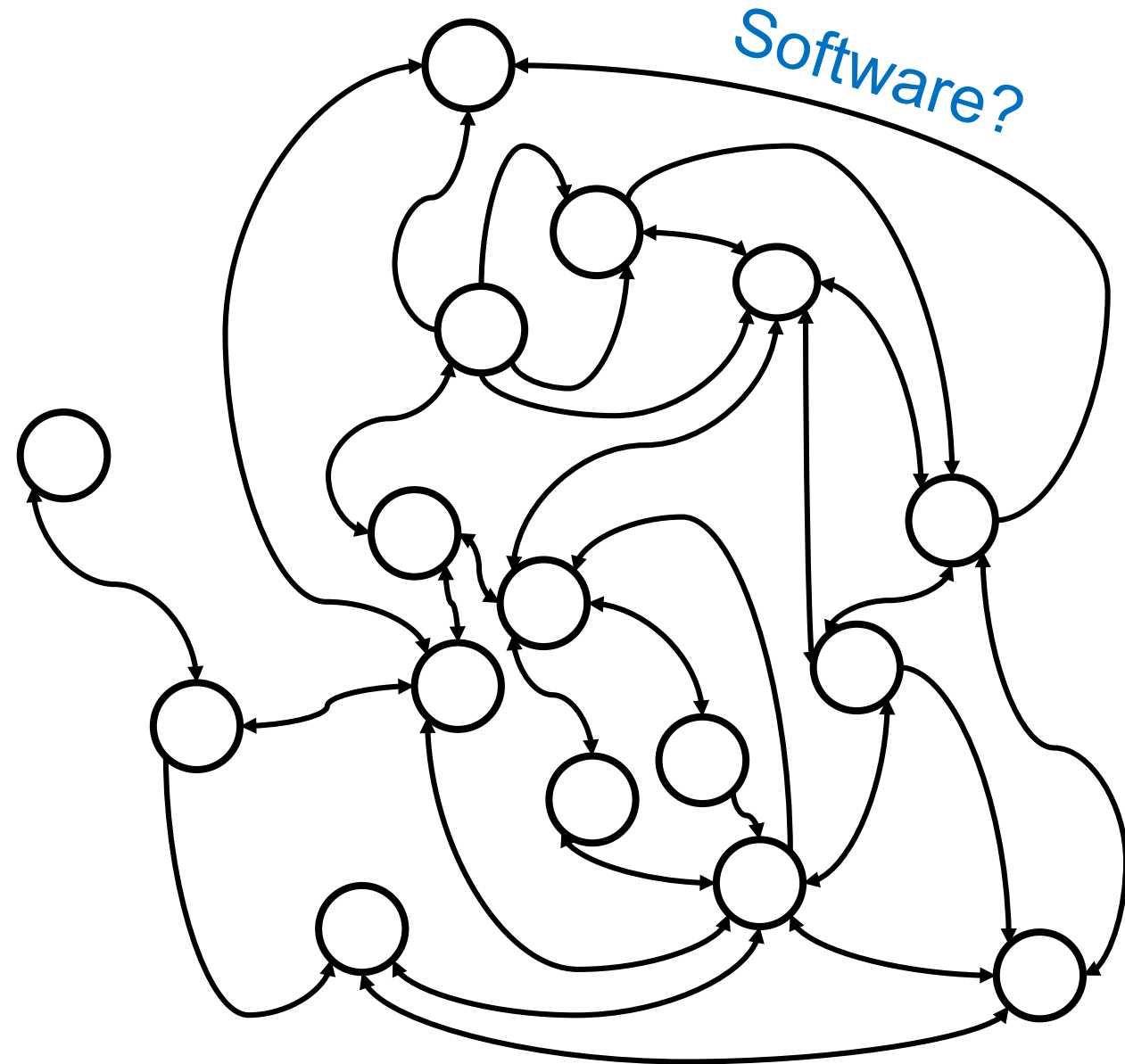
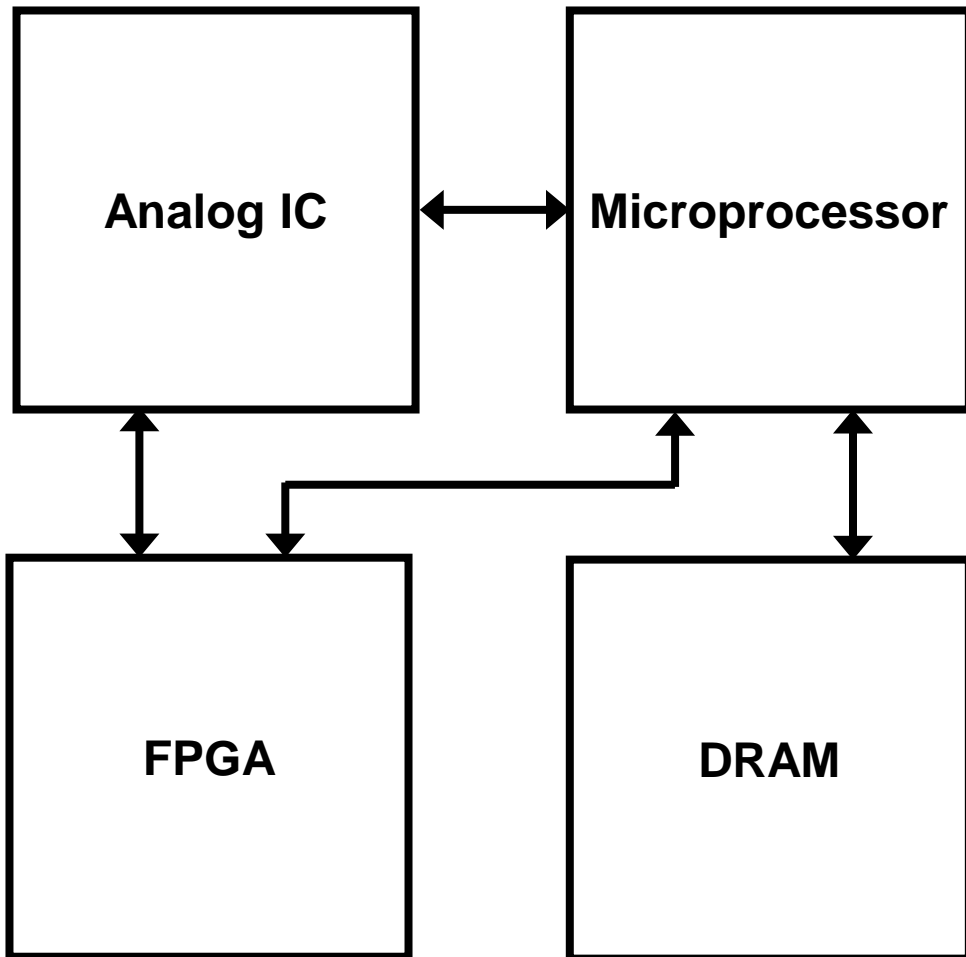


How To Build A Point-On-Wave Software Architecture?

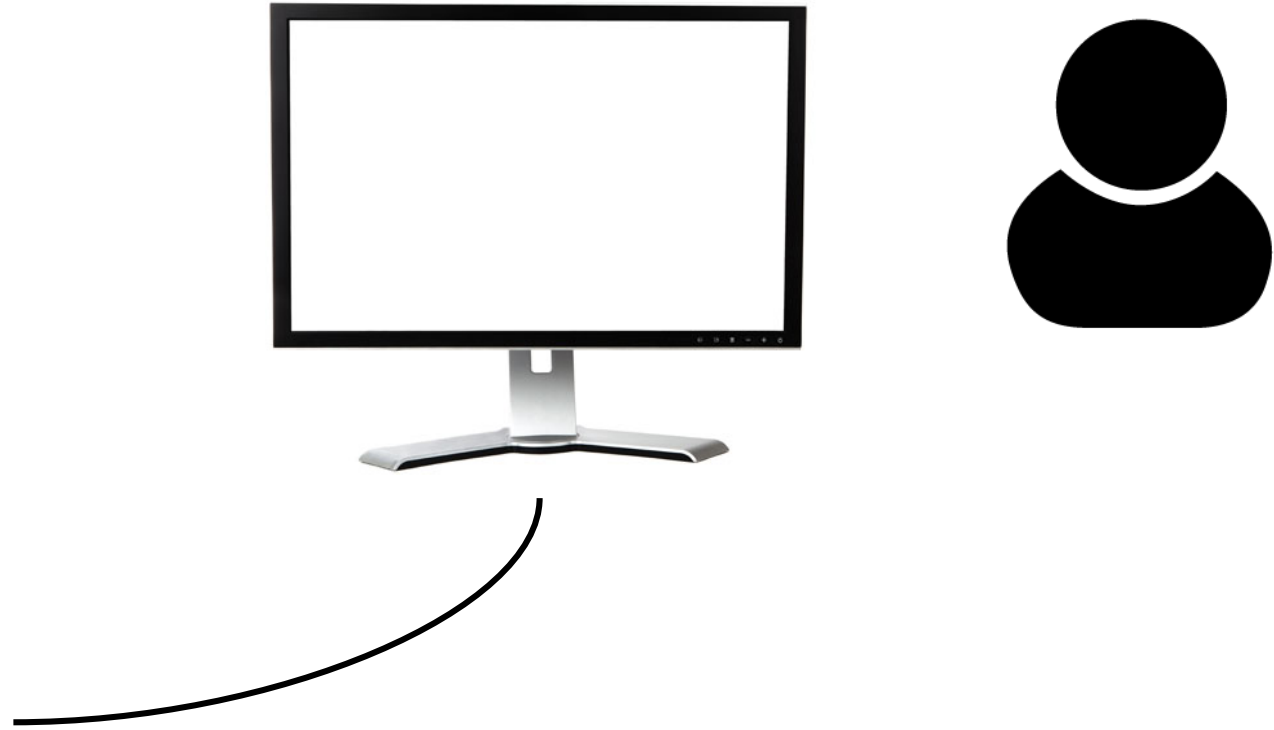
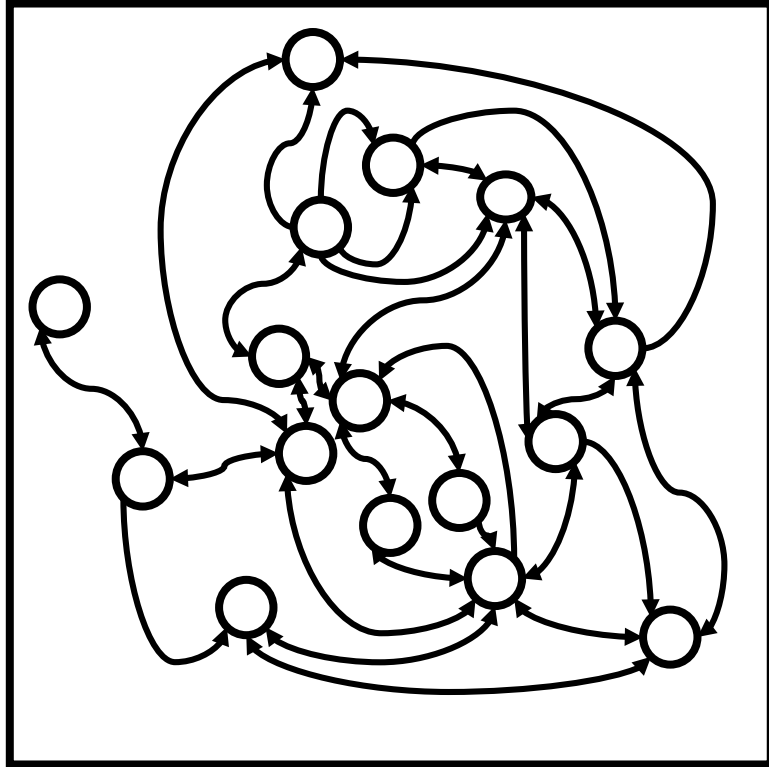


Why Can't Software Look Like Hardware?

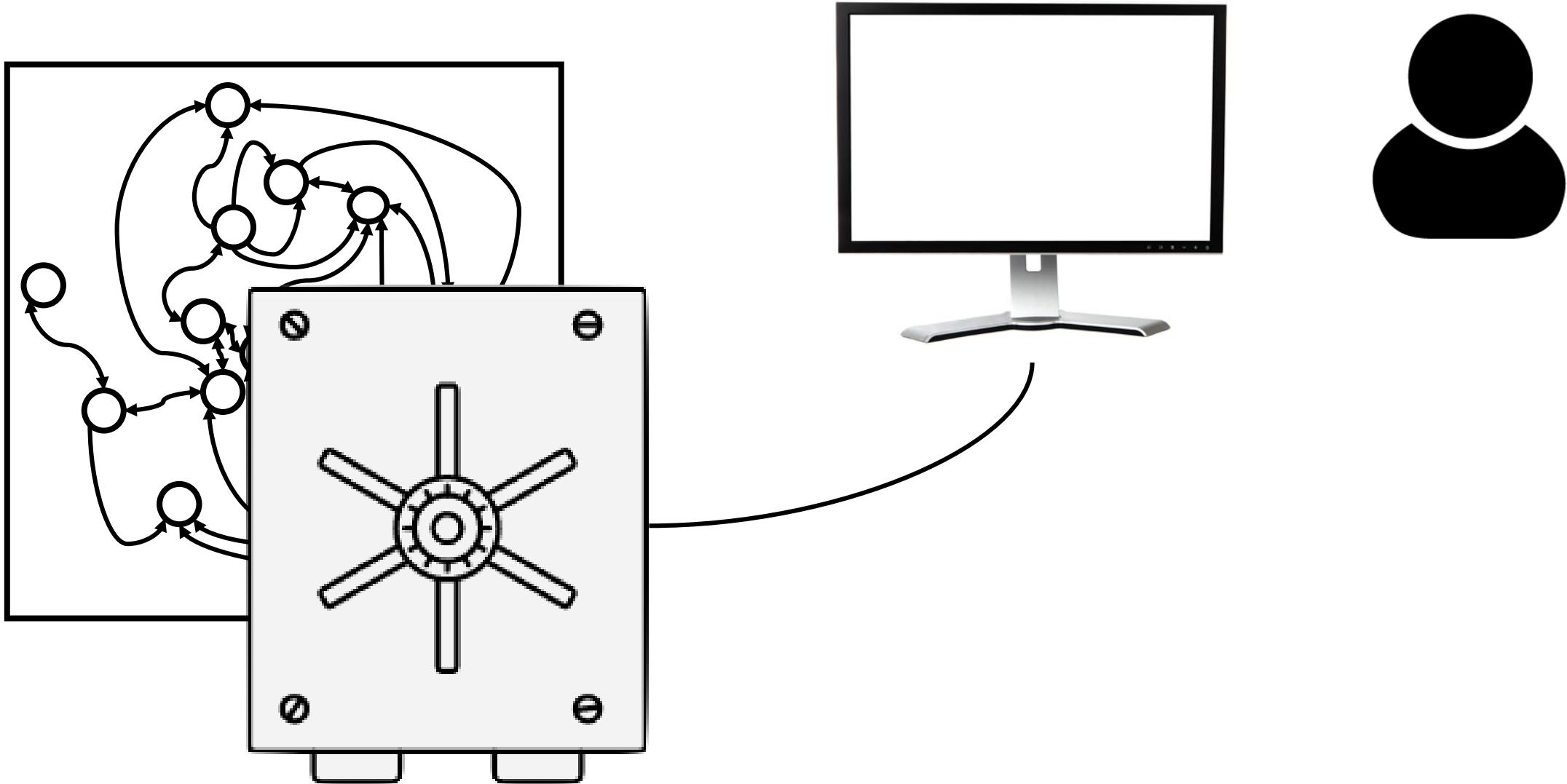
Hardware



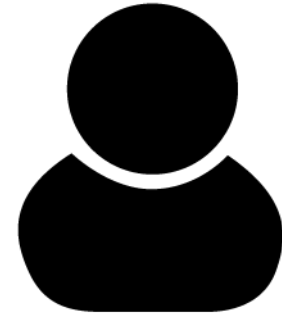
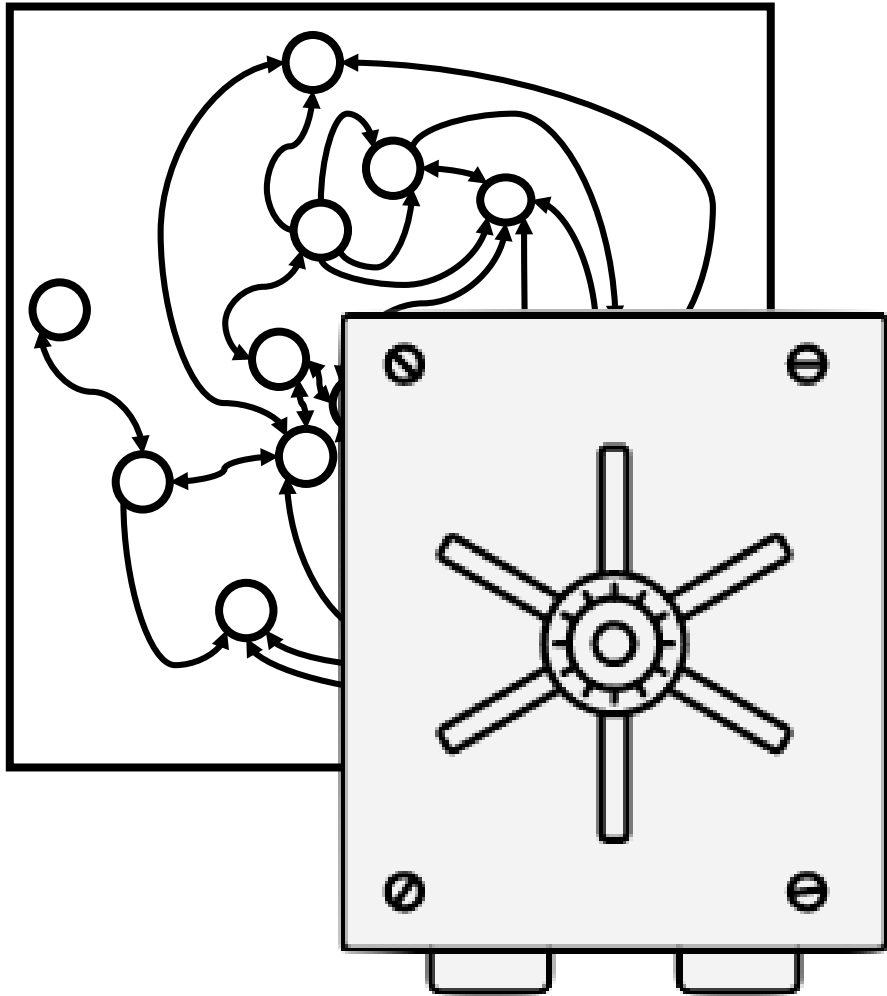
Why Would The User Care?



Why Would The User Care?



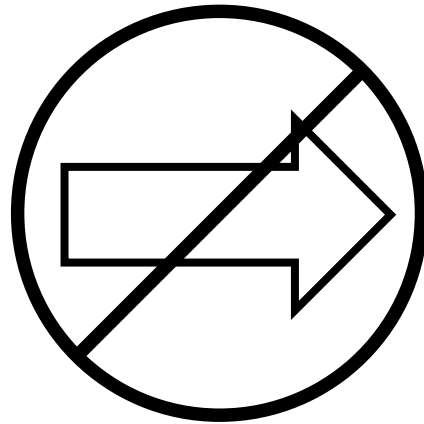
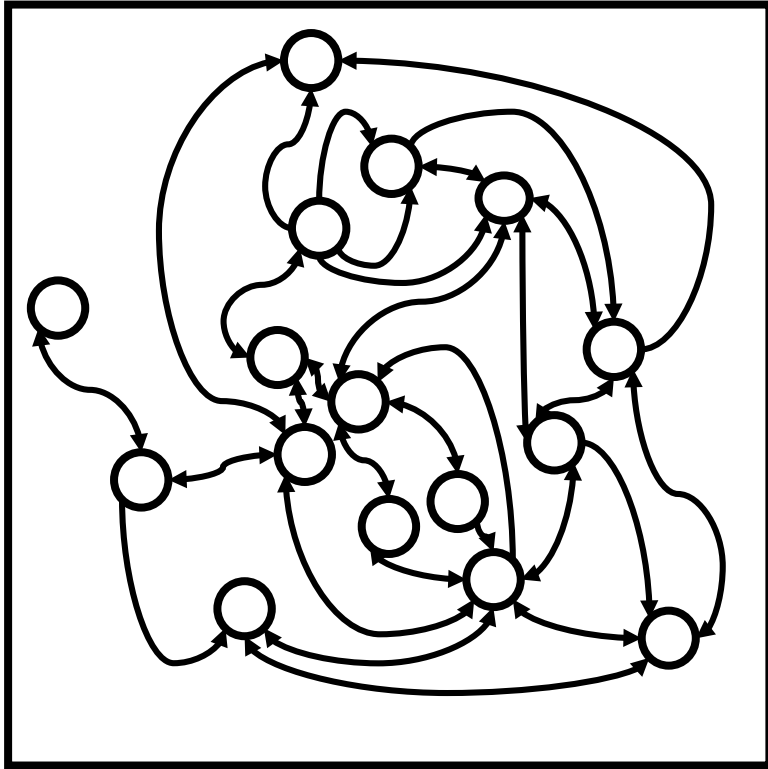
Why Would The User Care?



Simplicity
Quality
Lead Time
Openness
Cybersecurity

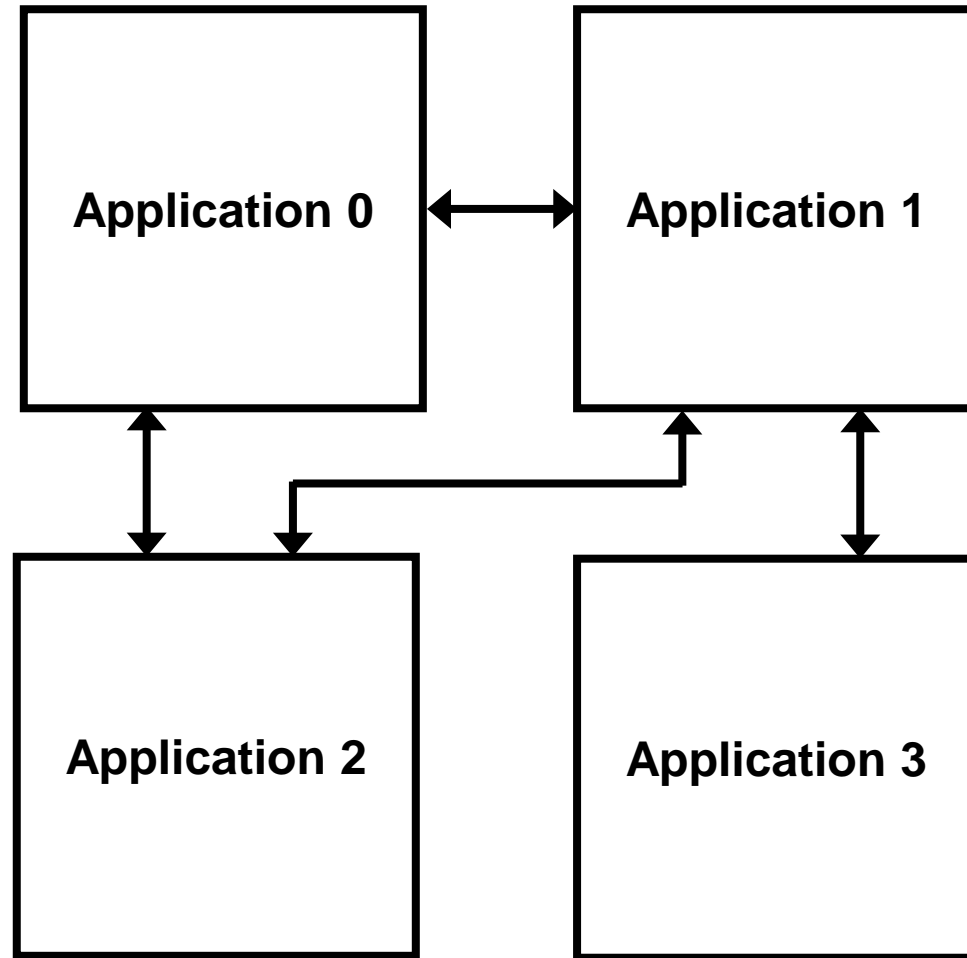
I Want Independently Manageable Applications!

But, non-modular on the inside inhibits modular on the outside.



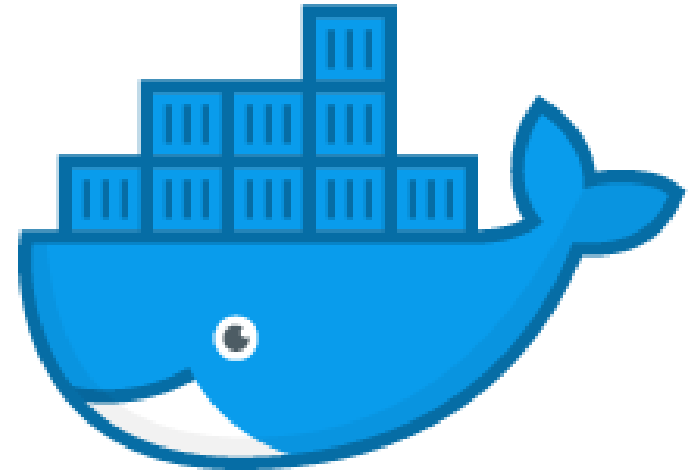
Microservice Architecture

Software



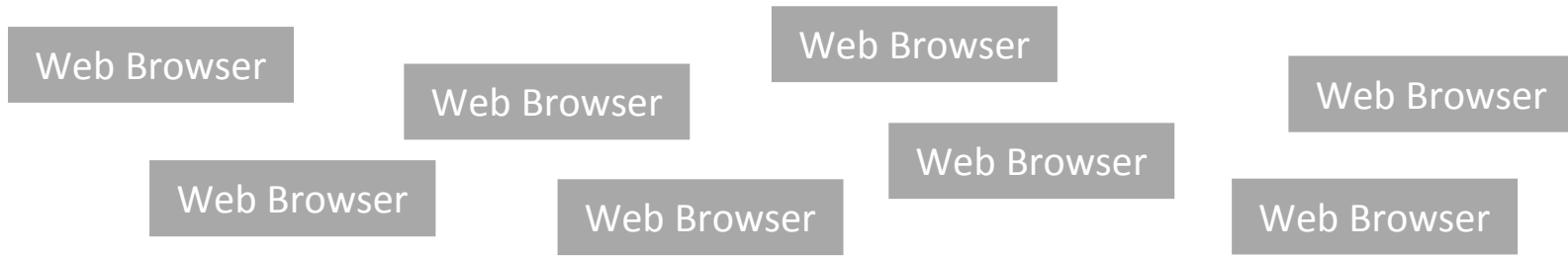
Now Containerize

- Cybersecurity
- Distributed Architecture
- Applications run across multiple servers
- Automatic load balancing
- Redundant Web Servers
- System grows as needed

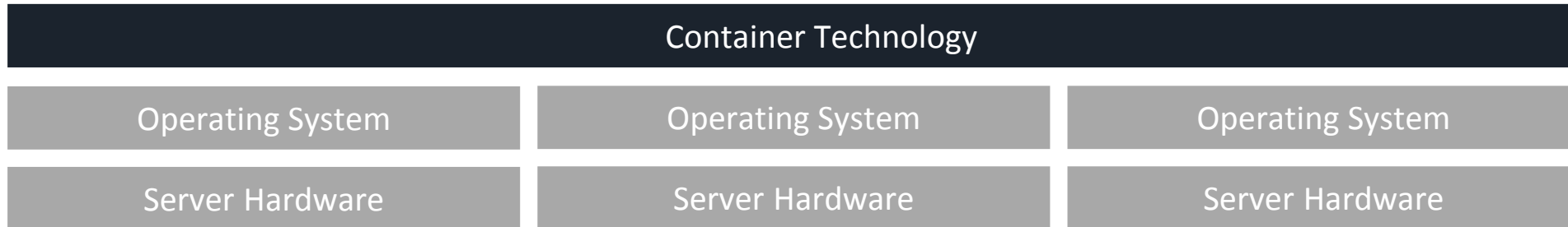
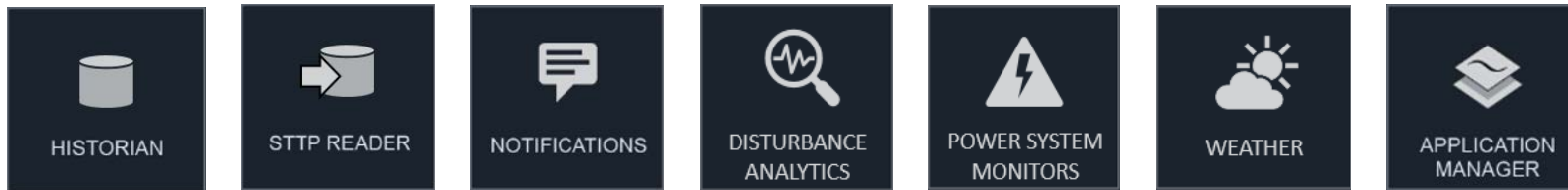


docker

Redundancy and Reliability



Example Applications

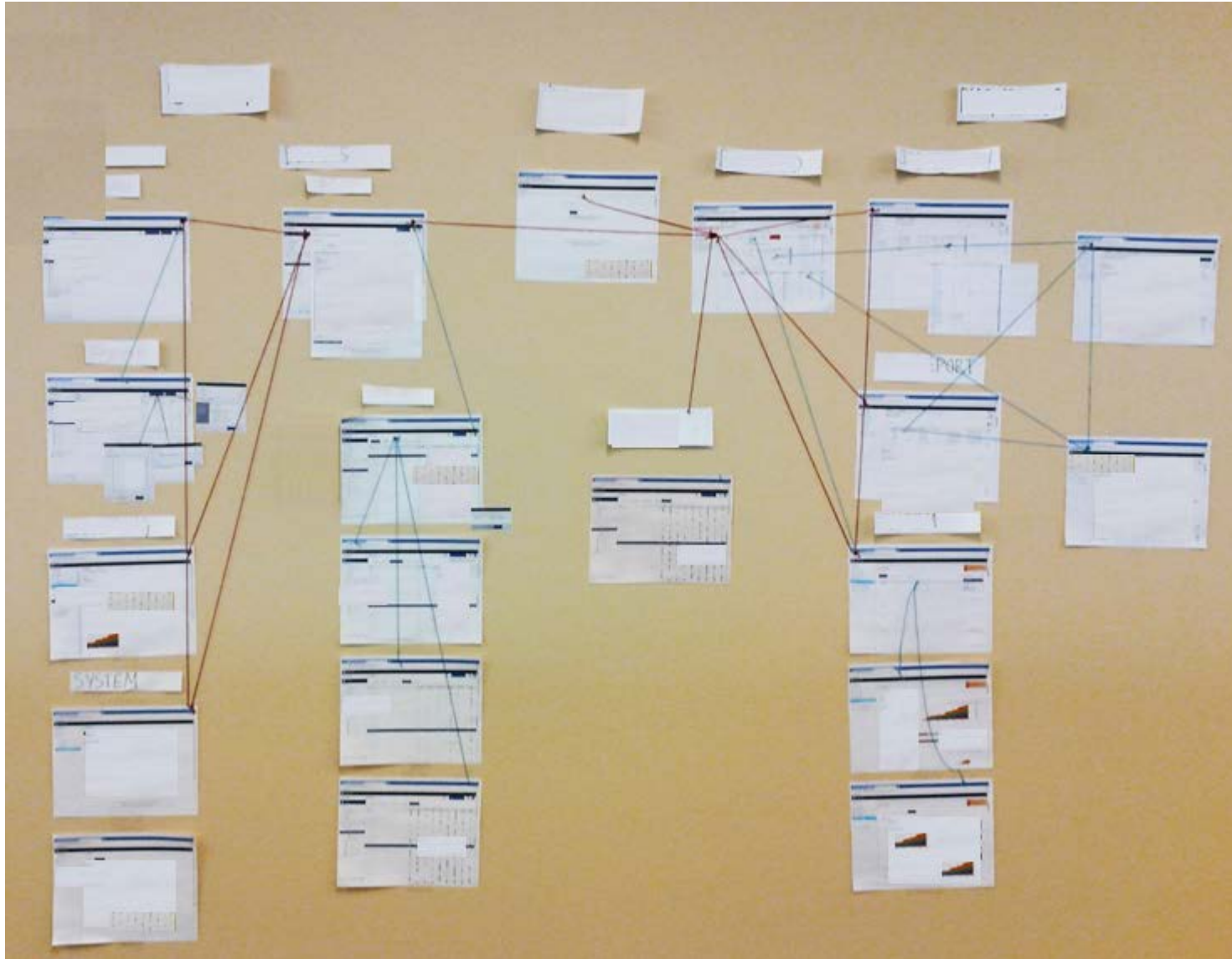


Point-On-Wave

High Performance

Database Technology

UI/UX Best Practices



Interviews
Storyboarding
UI Engineering
Use Cases
Personas
Prototyping
Usability Testing

Beautiful Design
Consistency
Intuitiveness
Easy-to-use

Software solutions must focus on making electric power system operations safer, more reliable, and more economical.

Reference for Point-On-Wave Test System

G. Zweigle, “A wide-area wide-spectrum big data system”, *IEEE Power and Energy Society General Meeting*, July 26 – 30, 2015.