

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

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



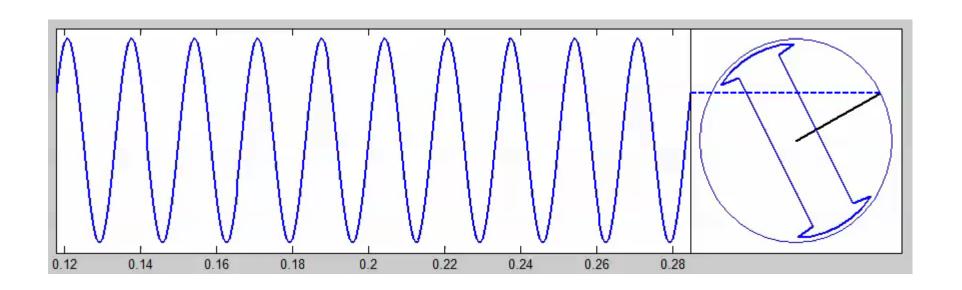
Quasi-Stationary Phasor Approximation

Limits both SCADA and Synchrophasors

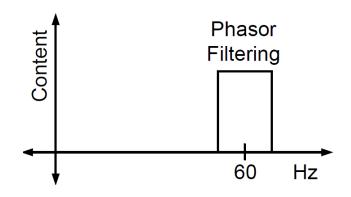
$$x(t) = A\cos(\omega t + \theta) \rightarrow \bar{X} = Ae^{j\theta}$$
 (1)

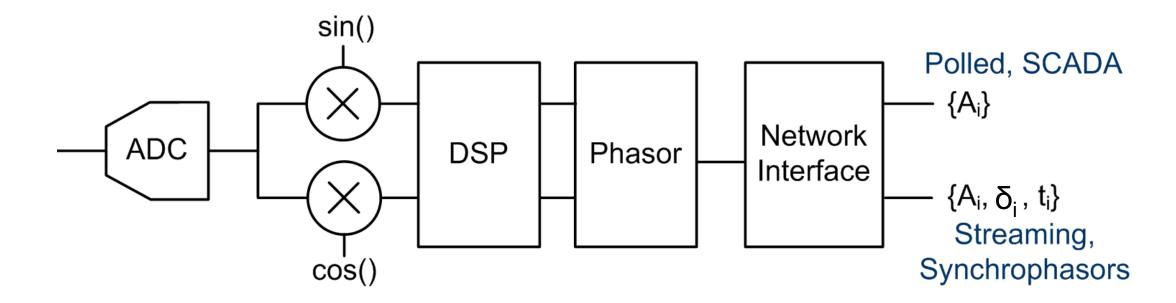
$$x(t) = A(t)\cos(\omega t + \theta(t)) \rightarrow \bar{X}(t) = A(t)e^{j\theta(t)}$$
 (2)

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

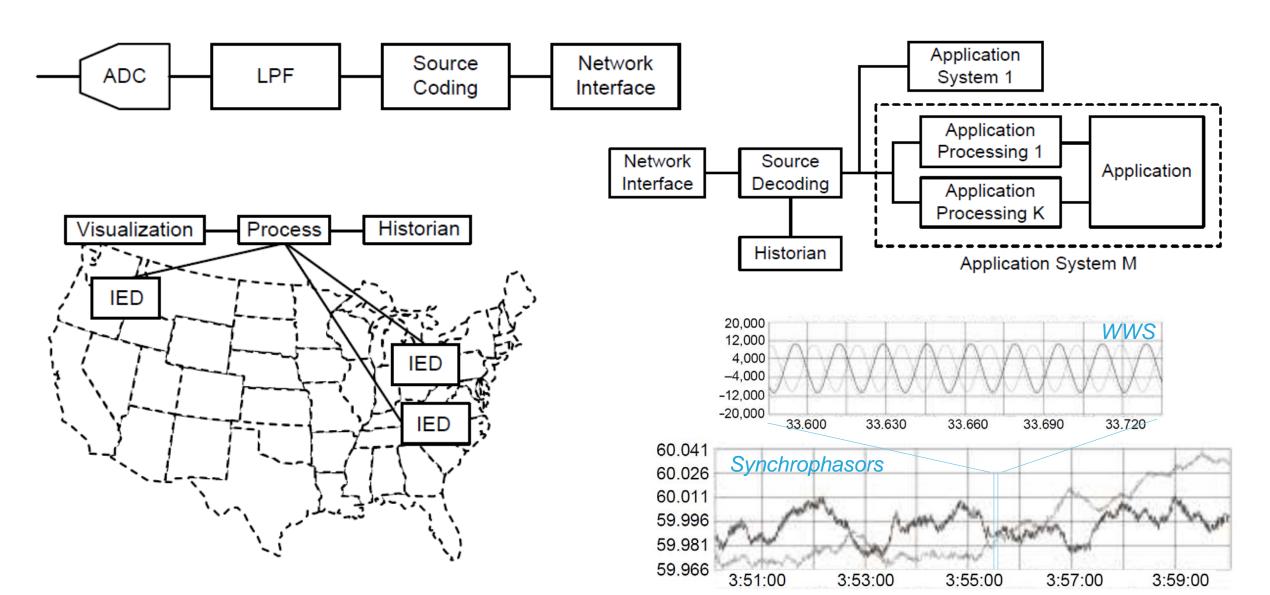


Phasor Measurement Unit Implementation

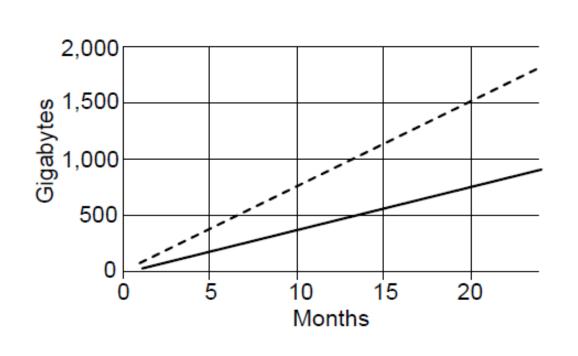


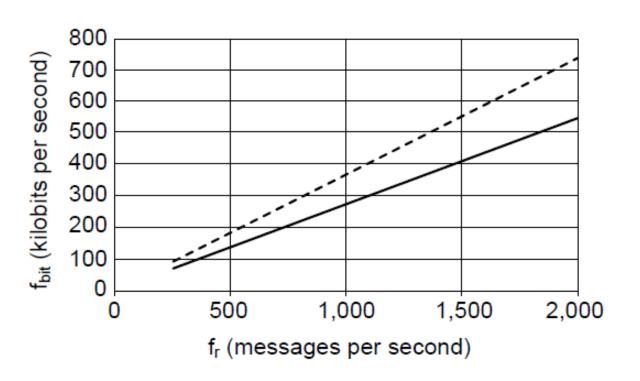


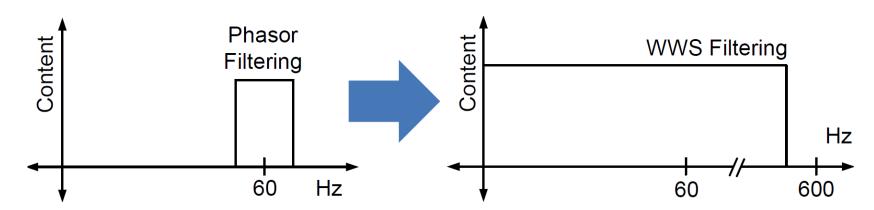
Is This Limitation Still Necessary? In 2015 SEL Build A Demonstration System



Data Rates and Storage



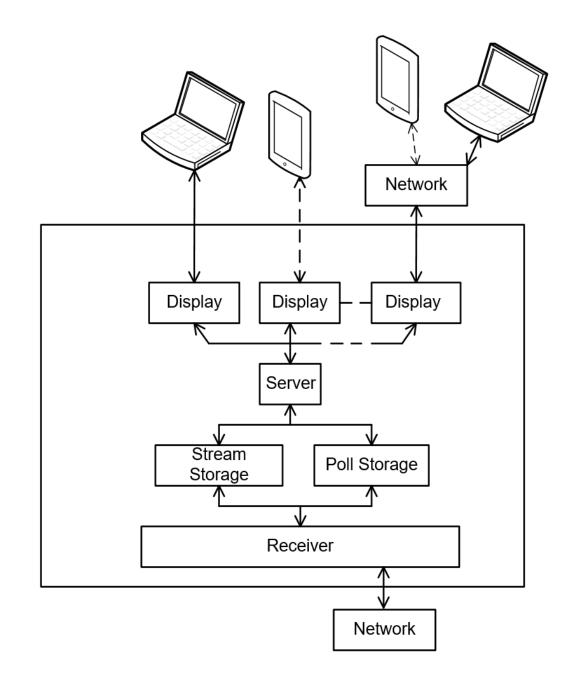




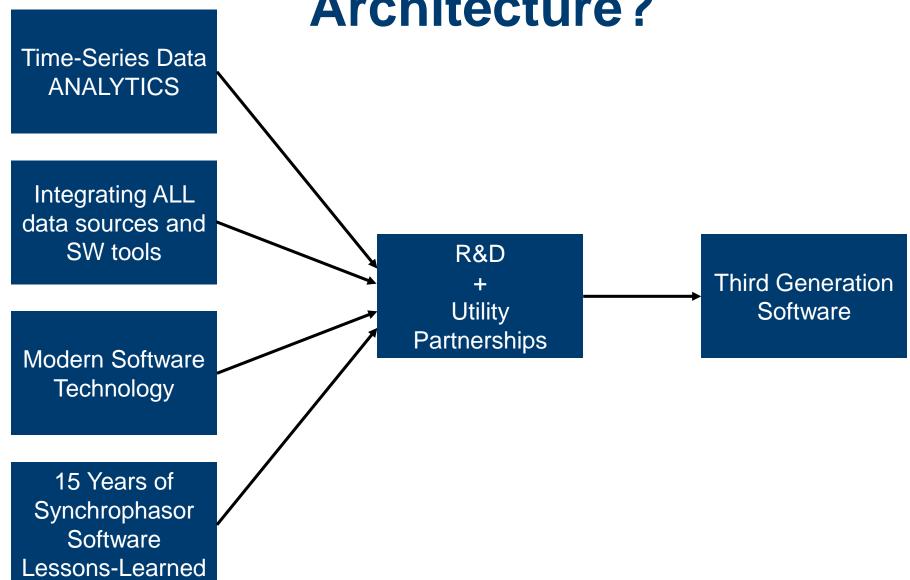
Improving Reliability and Resilience

- 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

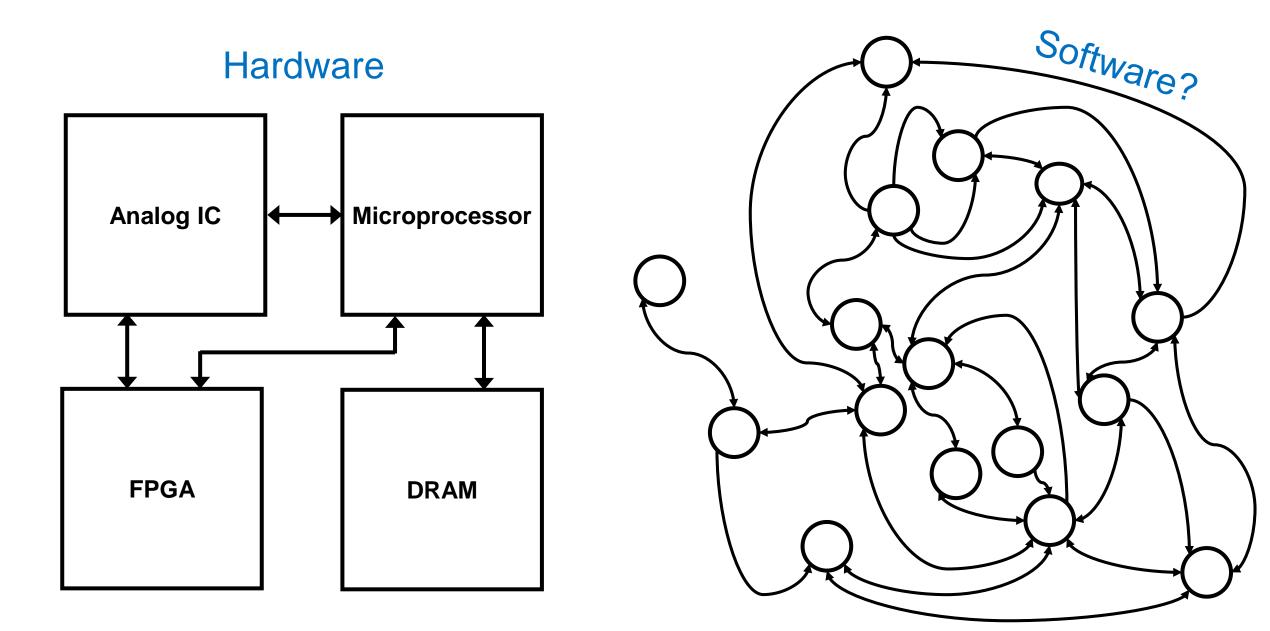
Non-Streaming Point-On-Wave



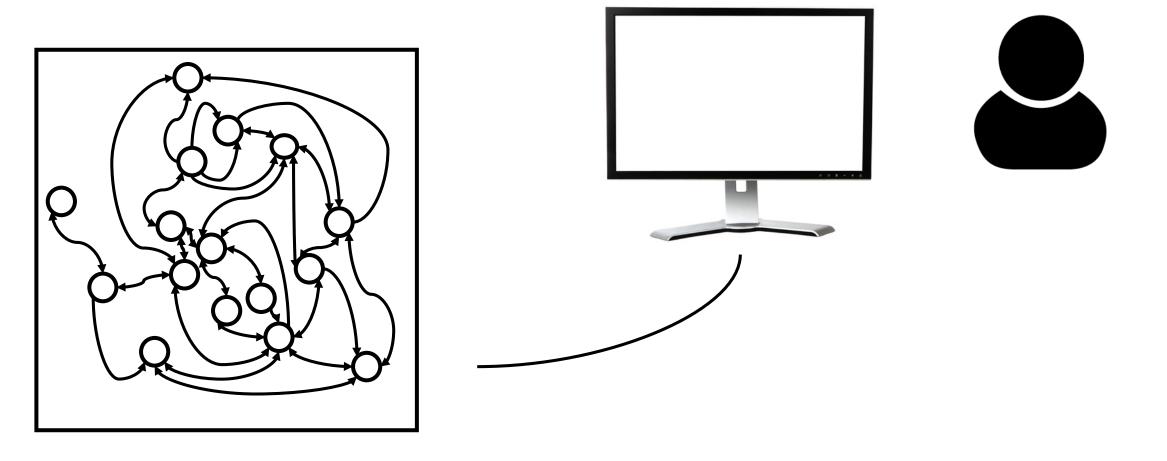
How To Build A Point-On-Wave Software Architecture?



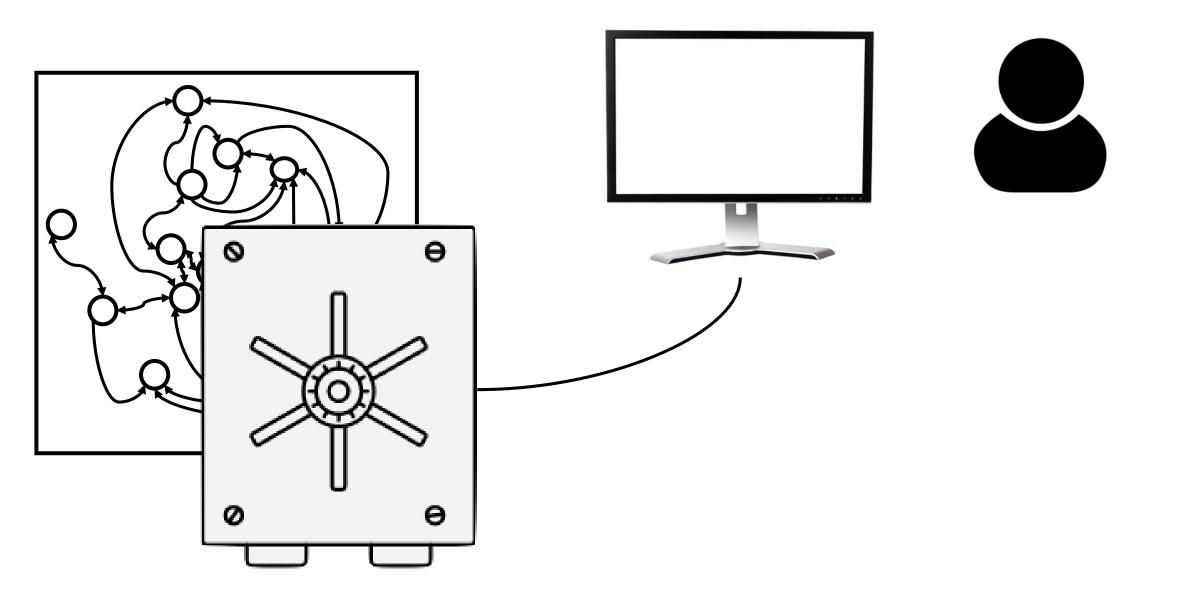
Why Can't Software Look Like Hardware?



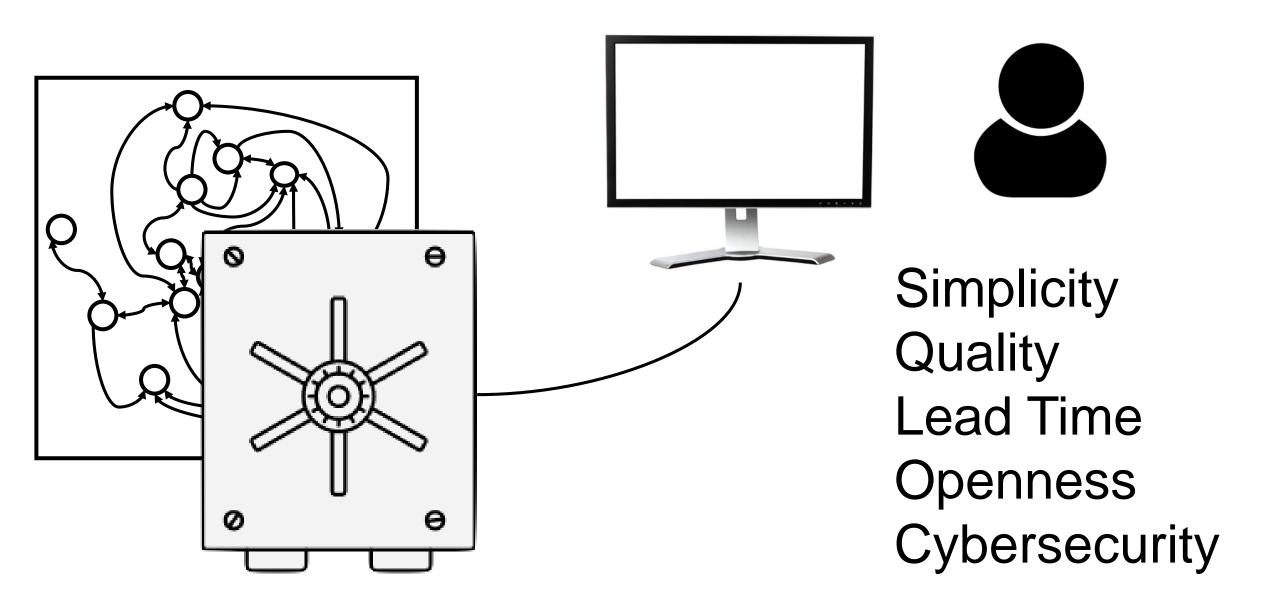
Why Would The User Care?



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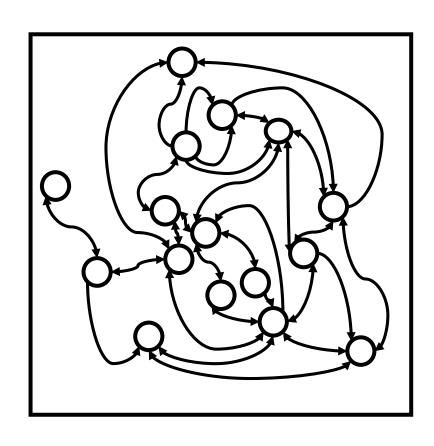


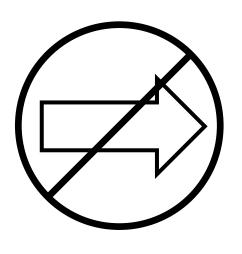
Why Would The User Care?



I Want Independently Manageable Applications!

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

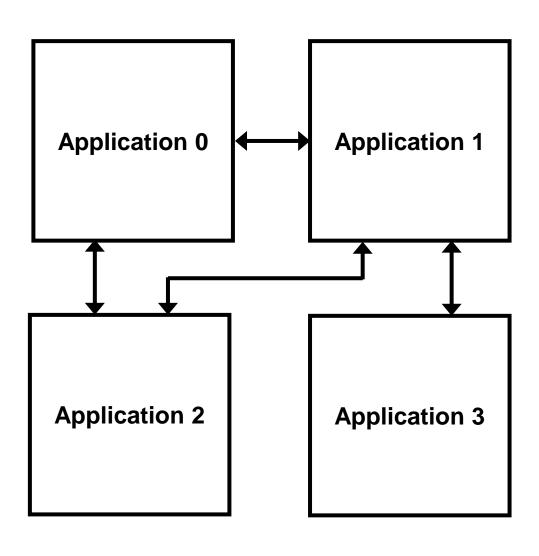






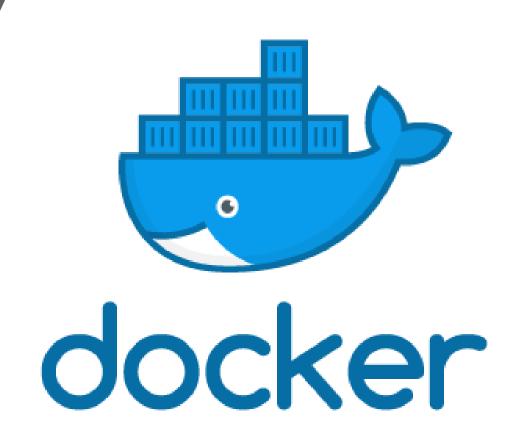
Microservice Architecture

Software

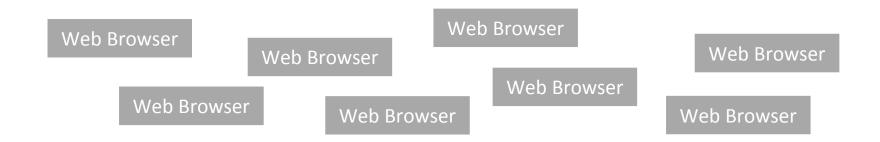


Now Containerize

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



Redundancy and Reliability



Example Applications















	Container Technology	ainer Technology							
Operating System	Operating System	Operating System							
Server Hardware	Server Hardware	Server Hardware							

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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.