GridCloud

Cloud-hosted high-assurance system to monitor the electric power grid

sponsored by the Department of Energy ARPA-E program

Goal

Demonstrate a cloud-scale monitoring infrastructure able to host "smart grid" applications: the code that will make the power grid "smart"

Use cases

- Routine balancing of loads and generation
- Grid protection
- Analysis and adaptation after topology changes
- Integration of renewable energy

Challenges

Cloud lacks consistency, assurance, and timing guarantees. Industry demands very strong control over data flow with provable security.

Status

We're using Isis^2 to manage a structure in which replicated data permits high assurance reactive smart-grid monitoring and control. GridCloud features state estimation and GridStat software from Washington State University.
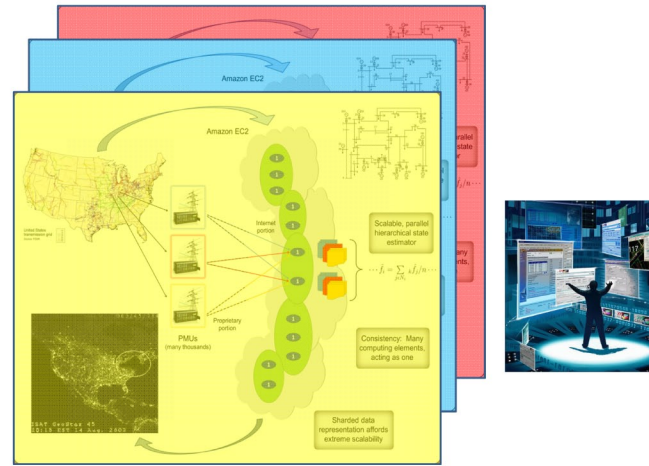
GridCloud enables

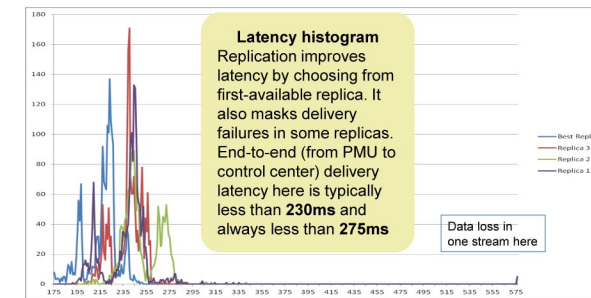**Large-scale, distributed power system applications in the cloud**

Low-latency and high-reliability using replicated data streams and application processes

‣Key GridCloud technologies
- ISIS and Dmake to manage a large number of processes running in the cloud
- GridStat to provide multi-cast and rate filtering
- Hierarchical Linear State Estimator (HLSE) as example application

Control Center SE Results
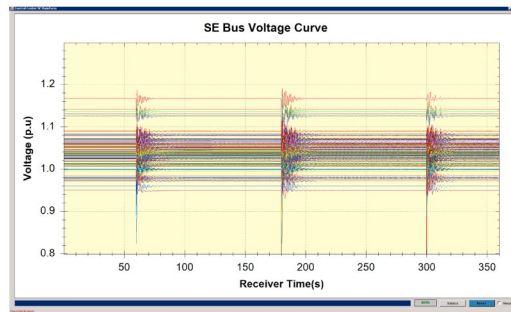
The HLSE uses EC2 Cloud resources to quickly and reliably do full-system SE 5 times per second with thousands of PMU data streams as input

Latency histogram
Replication improves latency by choosing from first-available replica. It also masks delivery failures in some replicas. End-to-end (from PMU to control center) delivery latency here is typically less than **230ms** and always less than **275ms**

Data loss in one stream here

	Aggregate Data Rate (Mb/s)	Total Connections	Substation SEs
Mar '13 12-bus (1 replica)	2.92	98	12
12-bus (3 replicas)	**8.75**	**294**	**36**
Oct '13 179-bus (1 replica)	46.93	1,577	127
179-bus (3 replicas)	**140.79**	**4,731**	**381**
Spring '14 6K-bus (3 replicas)	~570	~18,000	~3,000

‣2014 goal: Demonstrate GridCloud in a real-world setting, such as the regional transmission network for the North East USA

Definitions

PMU

A sensor (synchrophasor) used to measure voltage and phase angle of a power bus

Hierarchical Linear State Estimator (HLSE)

Code that computes local power grid state at substations using PMU data as input and computes global state at the control center by combining substation SE results

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www.cs.cornell.edu/Projects/Gridcontrol/

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