Distributed Power System Stability Enhancement Framework

NASPI Work Group meeting
March 22-23, 2017
Gaithersburg, MD

Alexey Danilin
Pavel Kovalenko
Viktor Litvinov

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- Power system and industrial automation
- Business Analytics, Data Warehousing and Big Data
- Information Security and Compliance

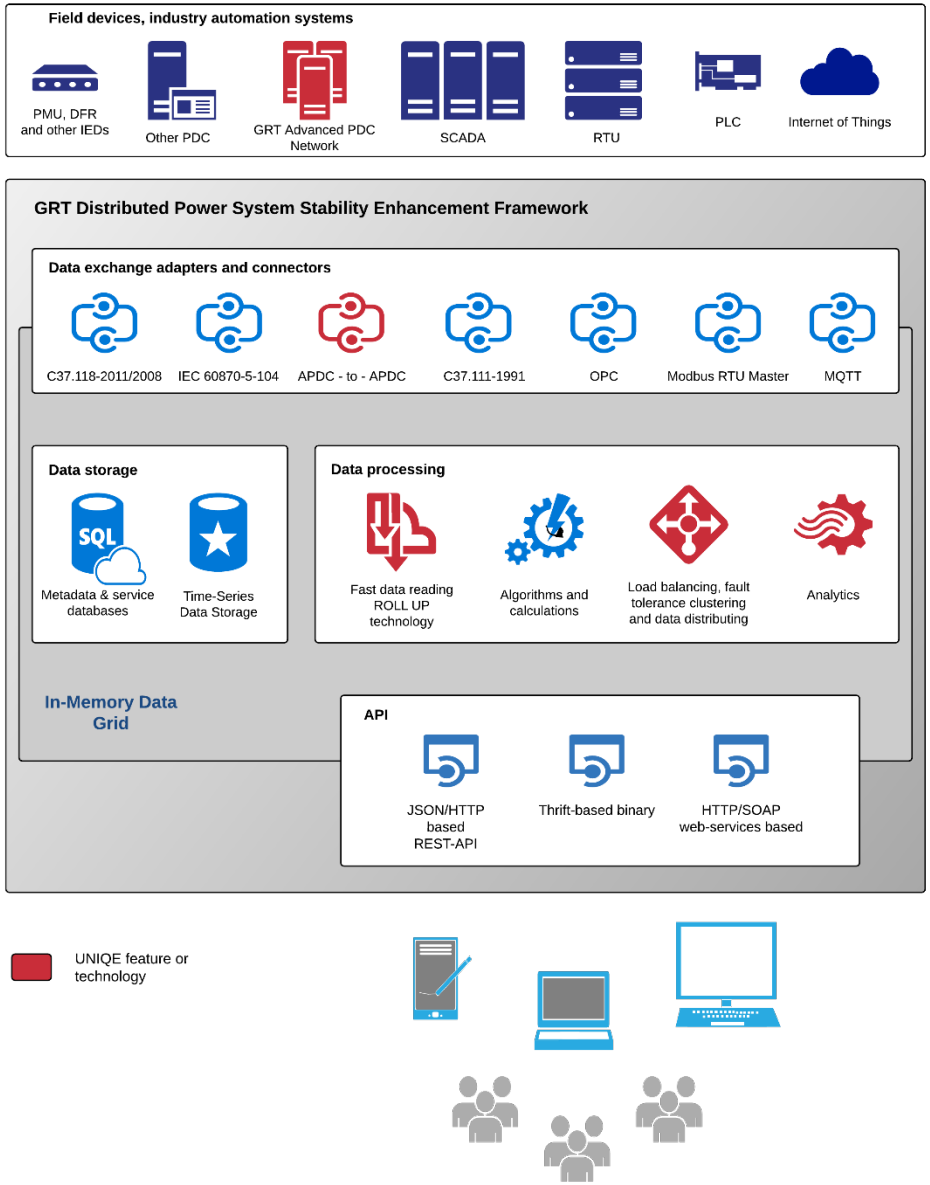
GRT Sample Clients

Outline

- Distributed Platform PowerLink
- Energy solution - Advanced PDC (APDC)
  - Architecture
  - Performance
  - Applications
- Distributed APDC network
- Applications

PowerLink - Distributed Platform

- PowerLink is Industrial IoT platform for Power industry that provides data processing automation, analytics, process monitoring and control
- PowerLink is the set of components which provides fast, easy and effective way to rapidly deploy and integrate new IIoT applications within existing infrastructure.
- Connects multiple data streams for advanced analytics that extract actionable, real-time business insights
- Enables high speed computation using in-Memory Data Grid
- Provides distributed data repository that unifies data from the different data sources of various data types - structured and time series
- Utilizes flexible APIs

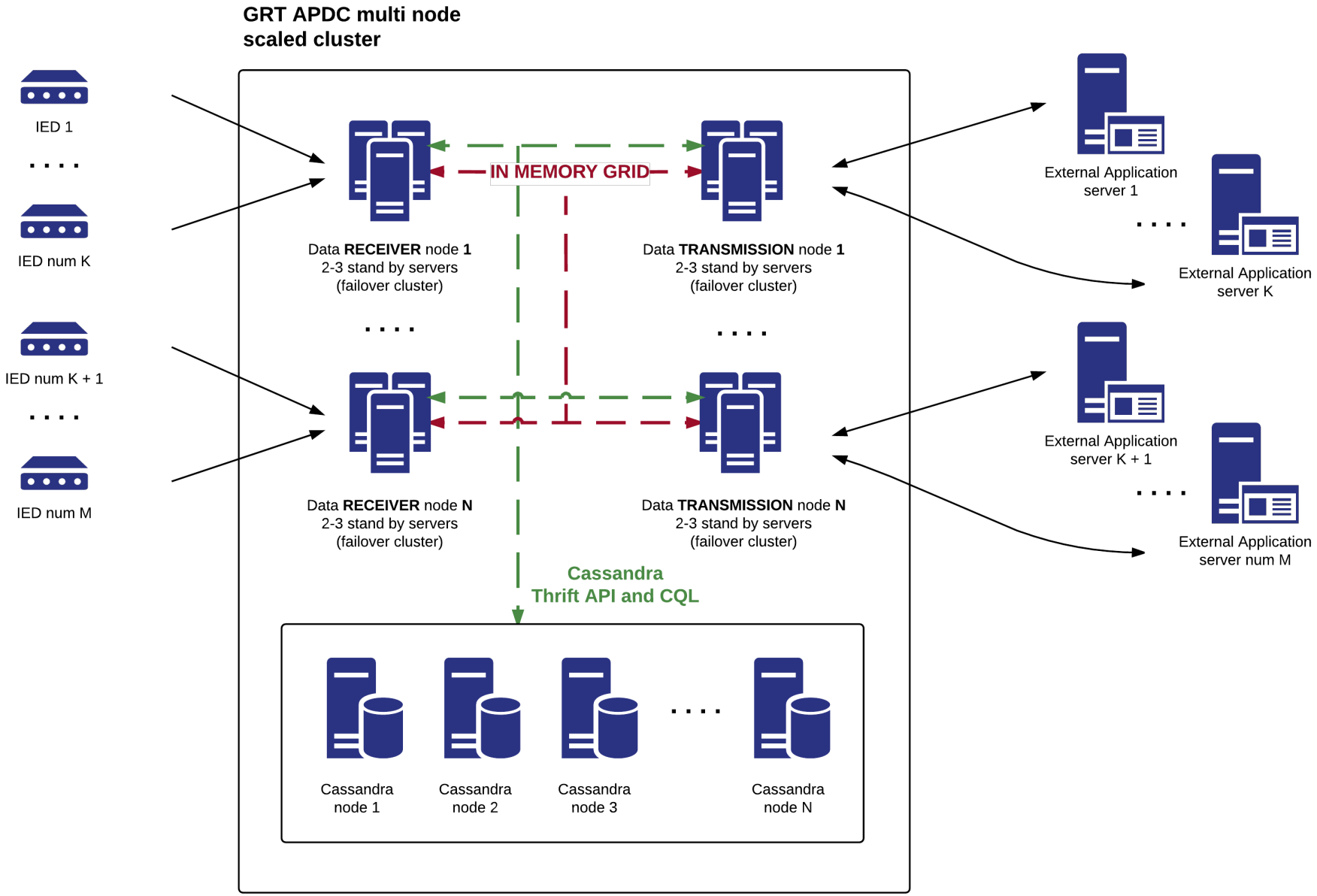


PowerLink components

Distributed, fault tolerant with load balancing capabilities:

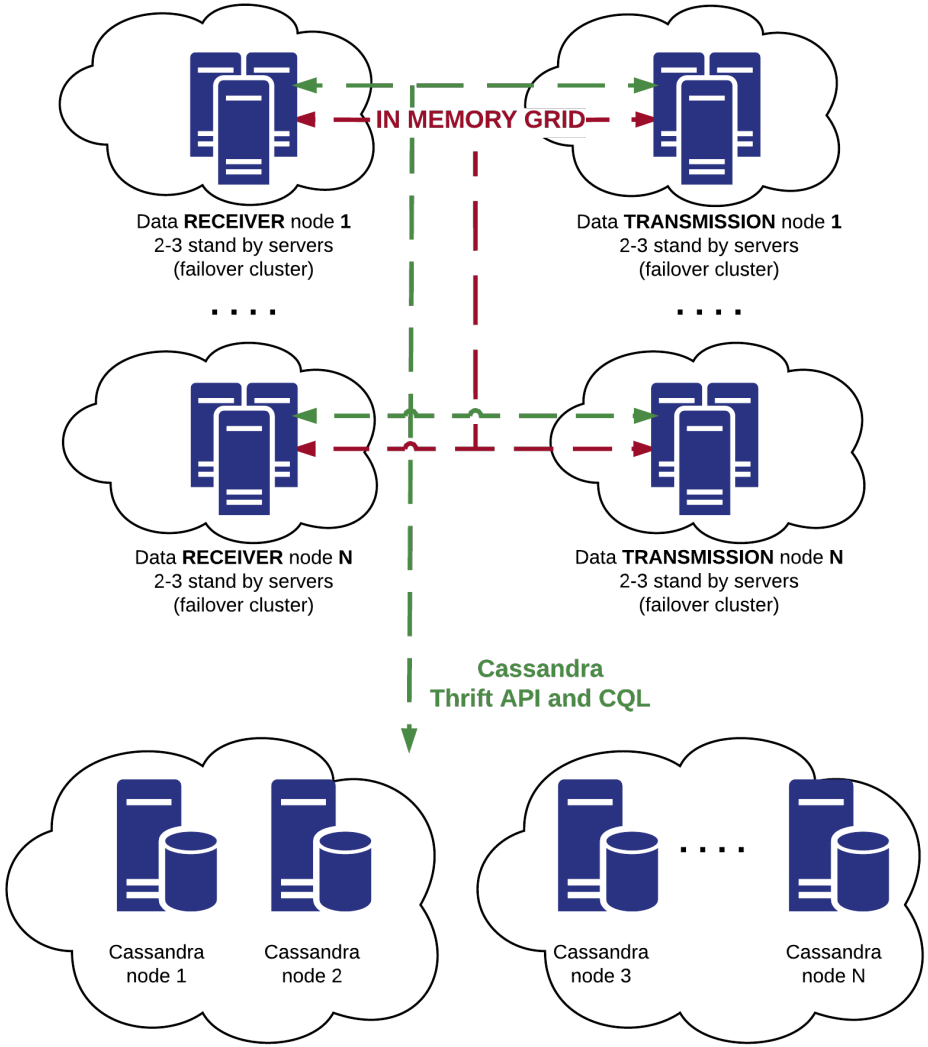
- In-memory grid- HAZELCAST based
- Lighting fast query processing
- Unlimited scalability
- Data streaming
- Time-series data storage (Apache Cassandra™ based)
- Separate Topology storage (IEC 61970/61968 CIM compatible, Apache Cassandra™ based)
- Supports majority interfaces for IoT adapters
- Component based builder for advance analytics
- Rapid application environment
- Flexible dashboard/report builder
- **API** (JSON/HTTP based REST-API, Thrift-based binary, HTTP/SOAP web-services based)
- Visualization (ZK Framework based) – Palette single window style user interface (supports geographical maps, 2D-graphics, radar diagrams, indicators, single-line electric schemes, alarm events time line, phase portrait, speedometer-style indicators etc.

PowerLink scaling architecture



PowerLink cloud based scaling architecture

GRT APDC multi node CLOUD scaled cluster

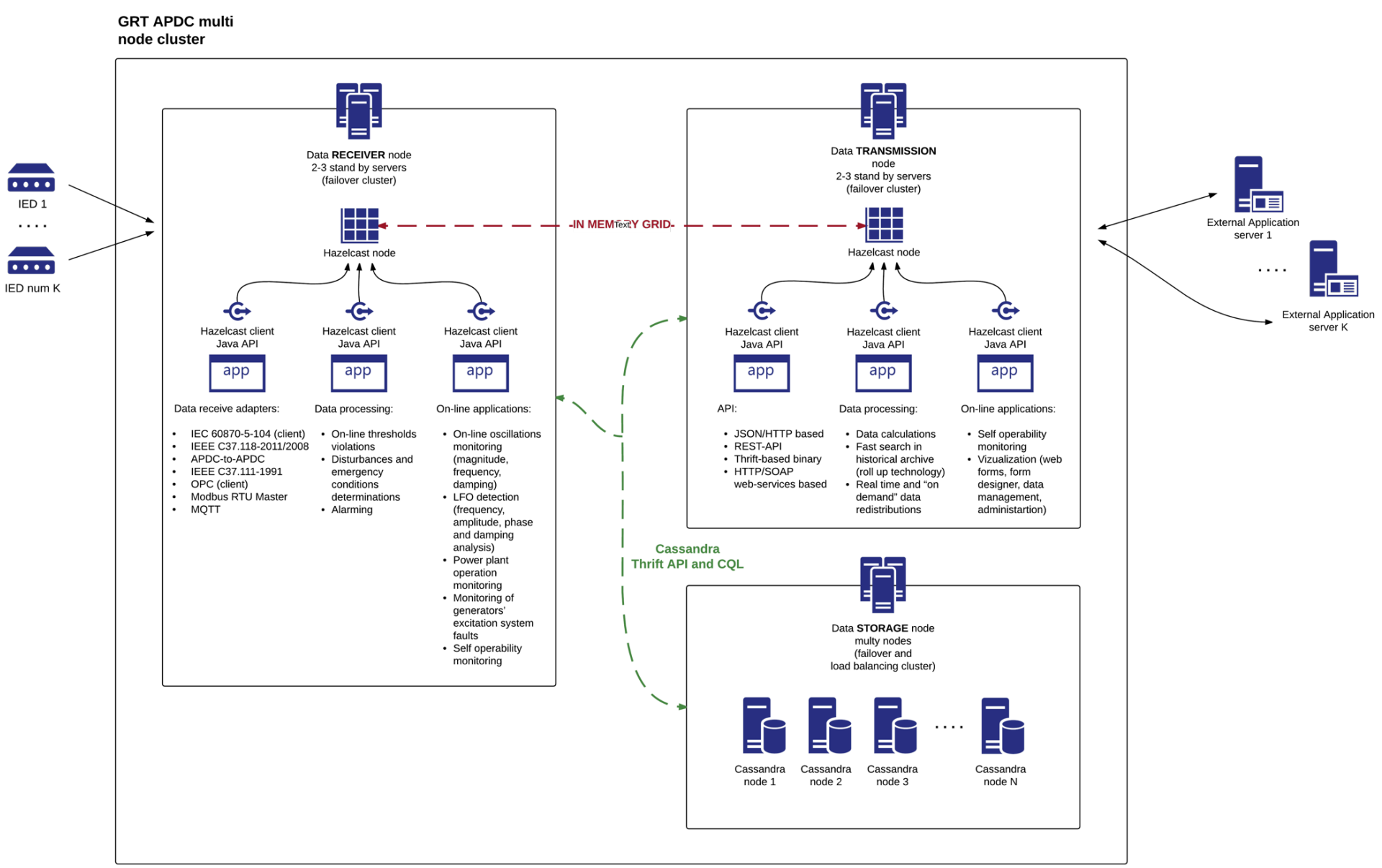


Modern Energy solution - APDC

Provides real-time data collection from various sources (PMU, RTU – SCADA, DFR and other IEDs) with high performance (hundreds thousands of measurements per second), scalability and fault-tolerance and distributed nodes cluster capabilities.

- **High performance** (sampling rate of 50-200 measurements per second for one channel)
- Multi stream technology (virtually unlimited data streams simultaneously)
- **Distributed Historian** with high speed data ingestion and extraction
- **Fast search** in historical data (roll-up technology based)
- Cluster solution for **load balancing and fault tolerance**
- **Scalability** (data distribution between all cluster servers)
- **Highly customizable** architecture
- Power system stability enhancment **applications**

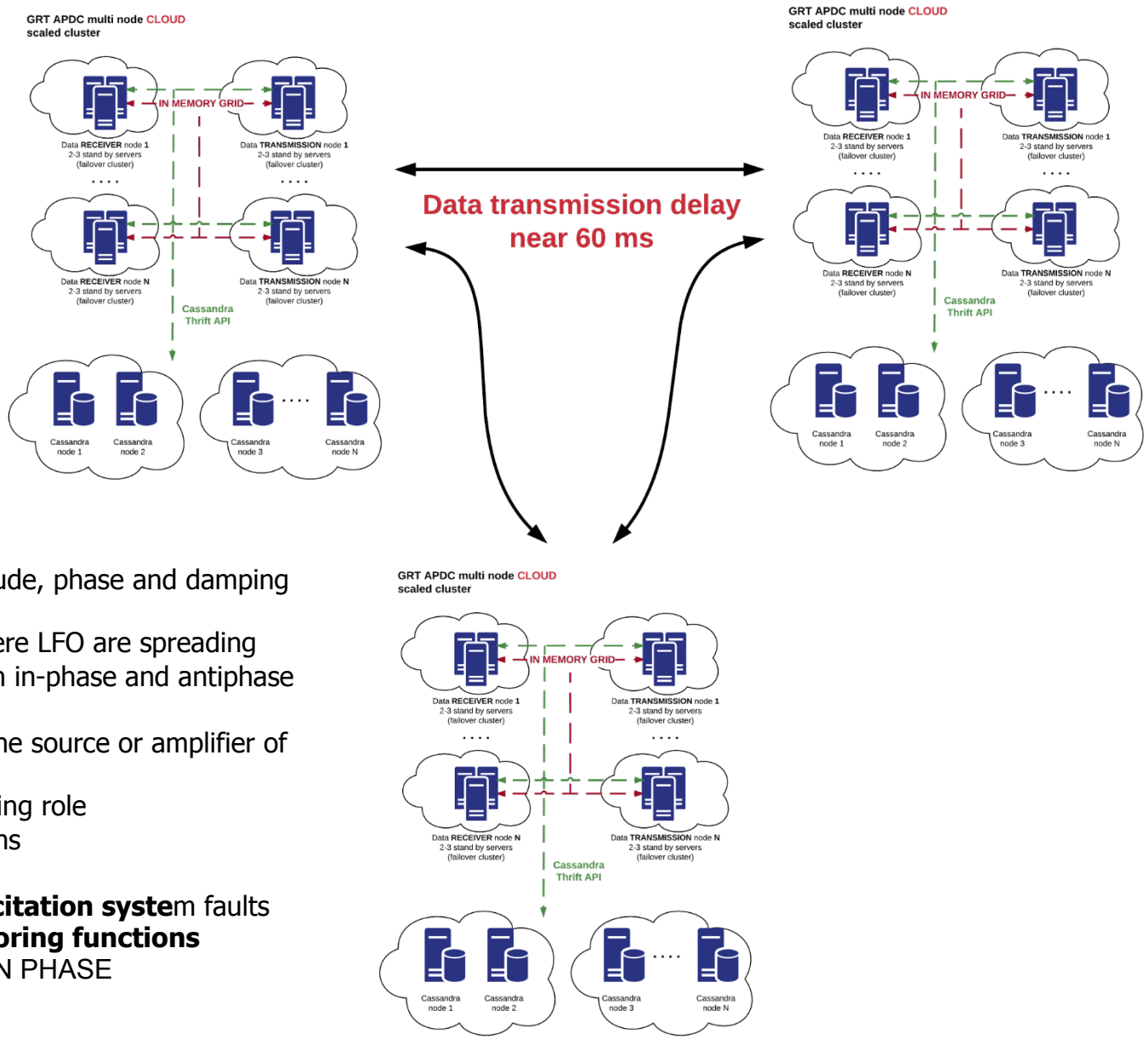
APDC architecture – PowerLink based



GRT APDC cloud based NETWORK

The cloud-based implementation of the distributed multi-tier **WAMPACS** architecture that covers a network of PMU's and Control Centers (the latency between network nodes is near 60 ms and less)

APDC-2-APDC technology



- LFO detection (frequency, amplitude, phase and damping analysis)
- Power system area detection where LFO are spreading
- Power system area detection with in-phase and antiphase oscillations
- Generators detection which are the source or amplifier of LFO
- Analysis of generators LFO damping role
- LFO power and energy calculations
- LFO spread visualization
- **Monitoring of generators' excitation syste**m faults
- **Power plant operation monitoring functions**
- NEW APPLICATIONS IN DESIGN PHASE

APDC Implementations

- **The distributed PDC network** has been in service since 2009
  - 10 control centers as distributed PDC network (System Operator of Russian Unified Power Systems) and 50 are planned until 2020
  - More than 25 power plants (with APDC)
  - More than 15 high voltage substations
  - Supports OTHER PDC vendors solutions
- Industrial plants

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TATNEFT

OGK-2

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ГАЗПРОМ
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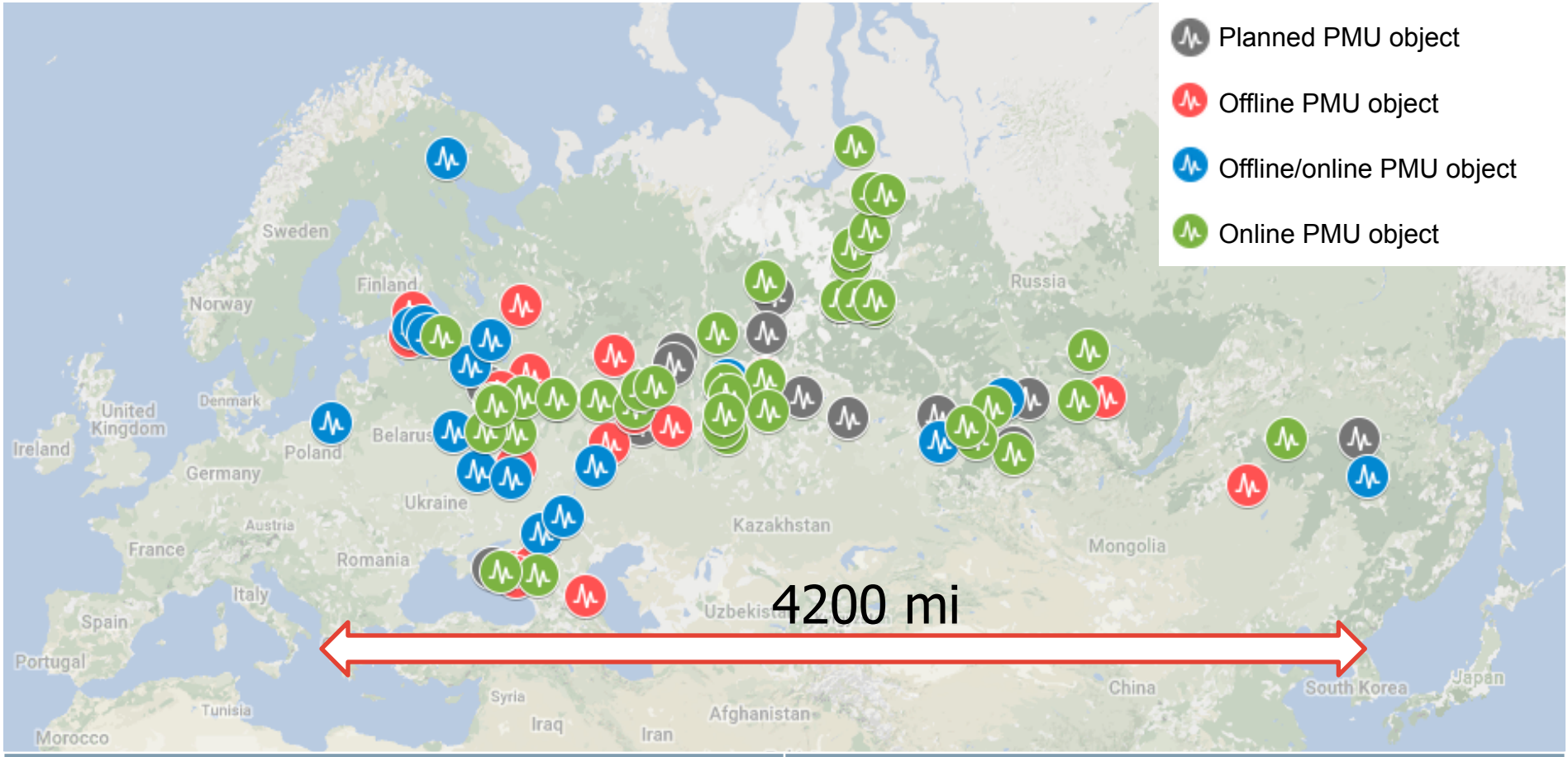
APDC-based WAMS in Eastern Europe Power System



PMUs			Objects		
Total	Online	Generators	Total	Power plants	Substations
544	312	187	82	51	31

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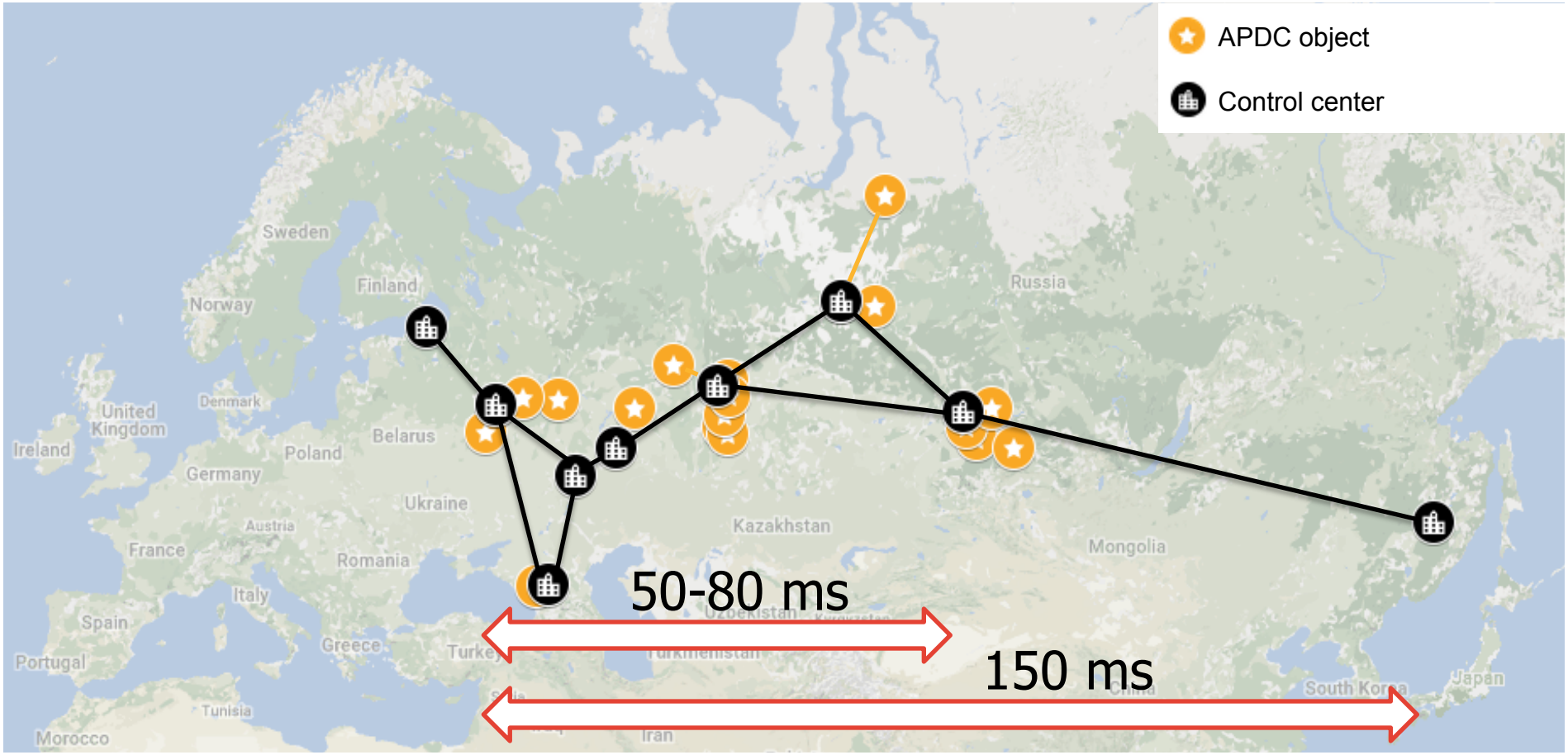
APDC-based WAMS in Eastern Europe Power System



24 object APDC installations, 10 control center installations
3-month raw data storage

APDC capabilities

- **Peer-to-Peer Distributed data exchange (APDC-to-APDC)**

- C37.118-2011 (server)
- Real time data exchange based on UDP (unicast, multicast) with low latency
- Real time data exchange based on TCP
- Web-services to provide data on demand

- **Data source adapters**

- C37.118-2011/2008 (client)
- IEC 60870-5-104 (client)
- OPC (client)
- Modbus RTU Master
- MQTT
- Data exchange by COMTRADE and CSV (files)

- **Power System Models Database inside**

- Conducting equipment models storage (one-line bus-bar electric schemes)
- Grid models (database contains topology information, system links, equipment characteristics) and visualization
- CIM compatible (CIM/XML RDF import/export is supported)
- IEC 61970-453 (CIM Based Graphics Exchange) diagrams storage

APDC performance

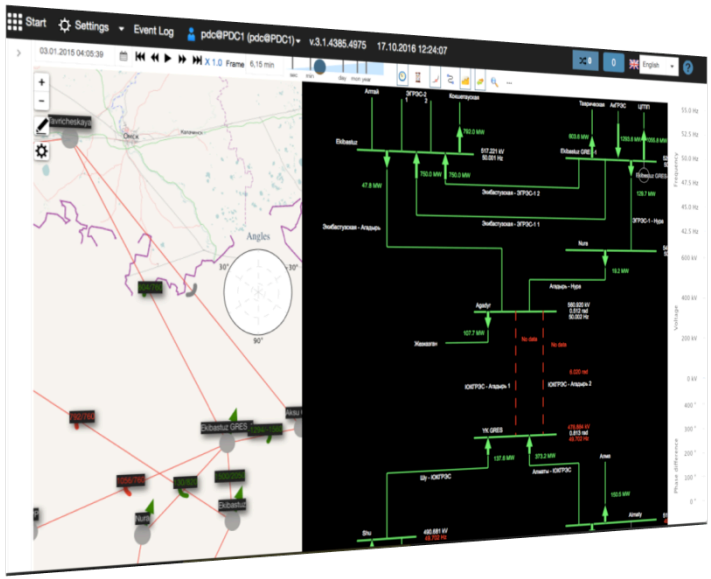
APDC is a HIGH performance data processing system.

Here is a low level hardware configurations example (it is just a laptop):

- OS Microsoft Windows, Intel Core i5 4 cores, 2.67 GHz, RAM 16 GB, HDD WDC SATA 500 GB 7200 RPM, 16 Mb cache
- Data resolution: 50 Hz
- In parallel mode: reads 130 000, writes 130 000 per second

APDC visualization

- Based on HTML 5, WebGL and JavaScript
- No setup procedures – easy to use and support
- Multi-layer local and global views
- **Display forms constructor (can be configured for control center operators, power system engineers and technologists)**
- Single-Line Diagram electrical schemes constructor (IEC 61970-453 CIM Based Graphics Exchange compatible)
- IEC 61968 and IEC 61970 compatible power system database model
- Geographical maps visualization layer
- 2D-graphics, radar diagrams, indicators, alarm events time line, phase portrait, gauges etc.
- «Replay» function provides the capability to view past events step-by-step as if they happened in real time



APDC - Security

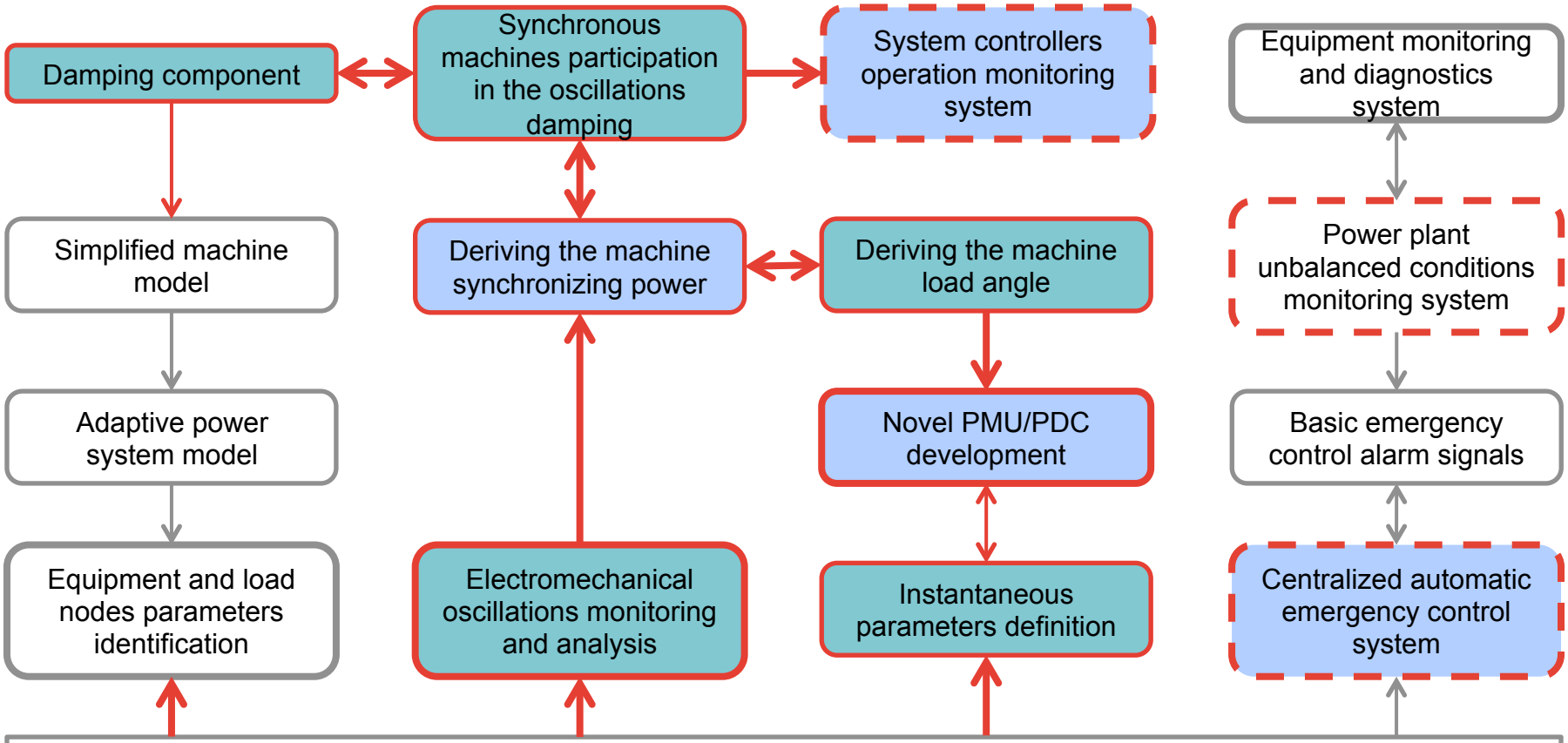
- Authorization and authentication at the user interface and API level
- Digest and NTLM/Kerberos authentication supports (with Microsoft Active Directory integration)
- Authorization by user groups
- Data exchange between nodes and other informational systems provides by independent data streams (dedicated ports and limitations provided by active network equipment)
- Every type of data (metadata, configuration settings, logs, measurements) has own storage and could be protected by OS functionalities
- Web: Login\password over HTTPS

APPLICATIONS

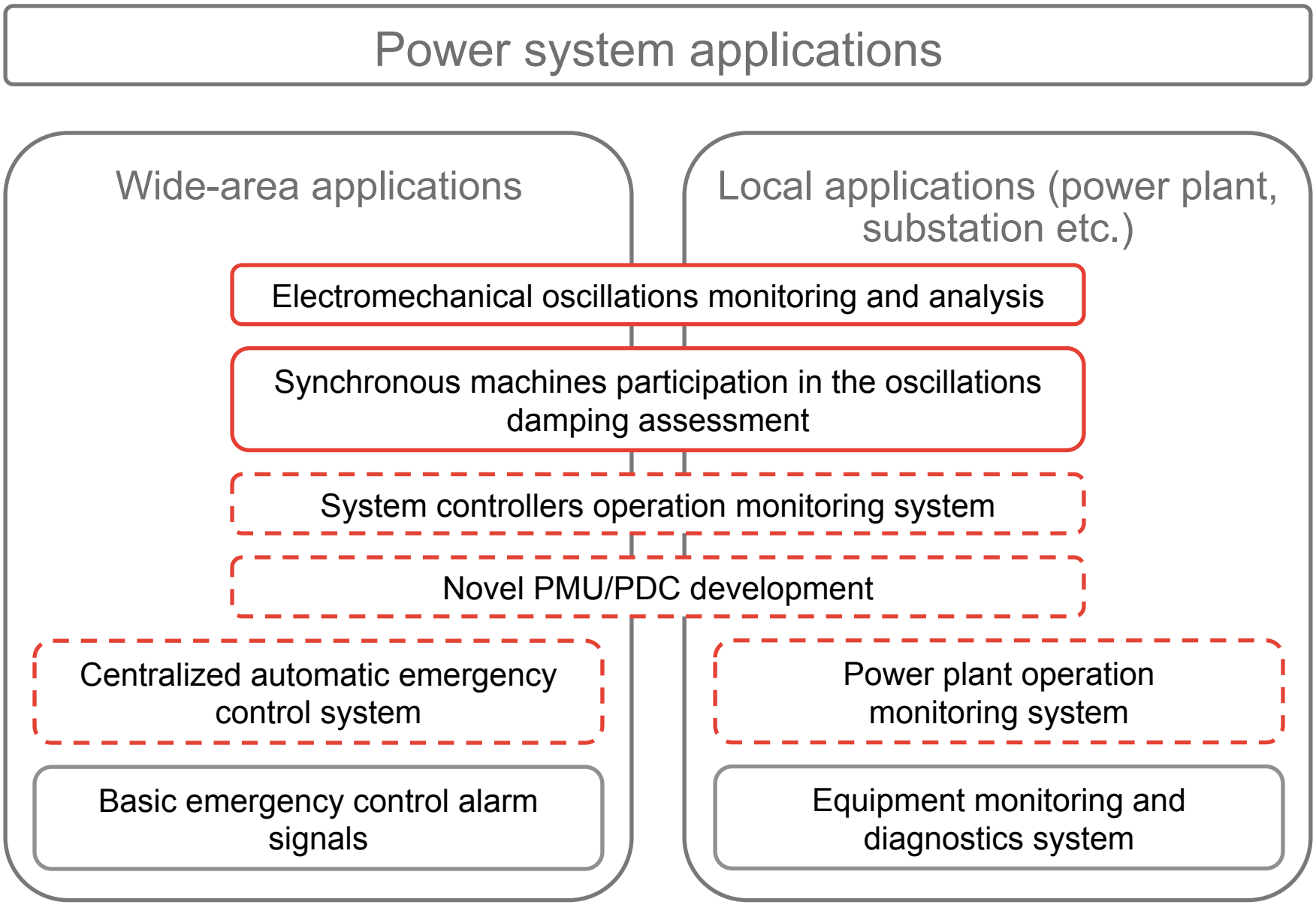
Please visit our talk at

Thursday, March 23, 2017
Session 5: Generators and Equipment
"PMU-based Power Plant Operation Monitoring and Innovative PMU implementation"

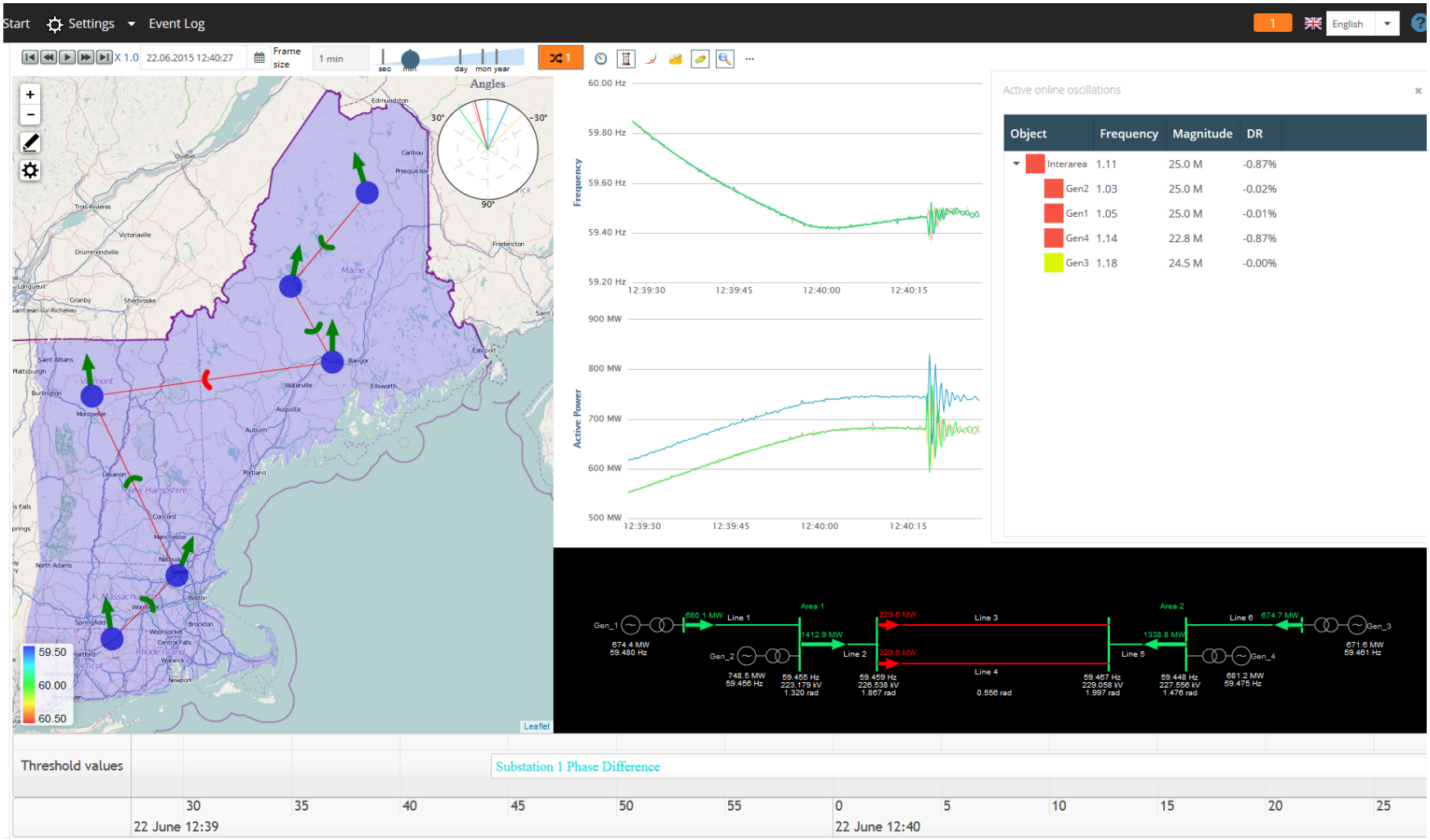
Synchronized Phasor Measurements Applications



Phasor measurements data applications

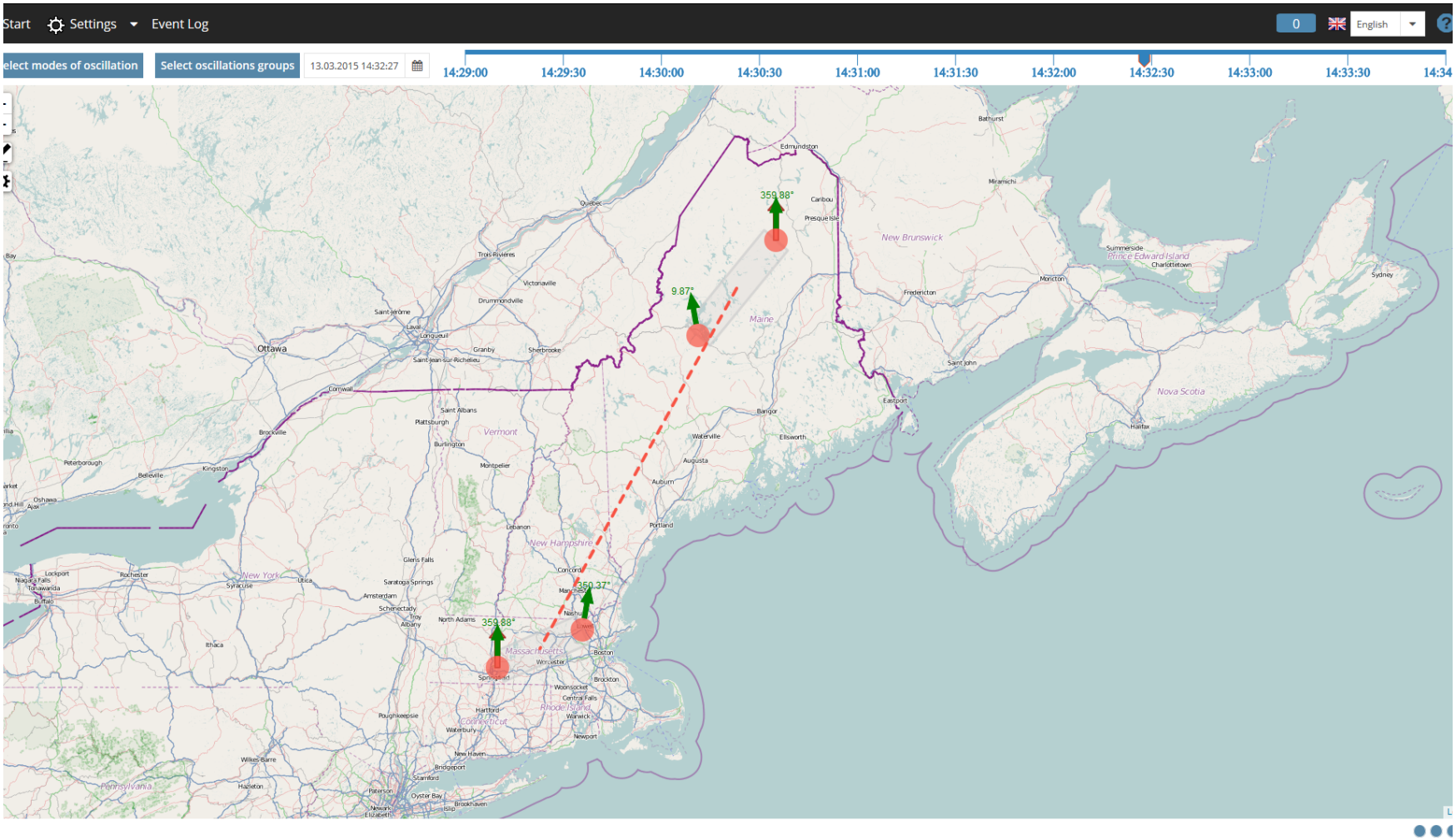


Electromechanical oscillations monitoring software
Online monitoring tool



Online LFO monitoring visualization

Electromechanical oscillations monitoring software
Geographical visualization



Geographical representation of the in-phase and antiphase objects oscillations

PowerLink-APDC Highlights

- Highly customizable scalable platform for building WAMS using multi stream technology
- Distributed historian with very fast search and data export capabilities
- Advanced PDC
- A suite of Power System stability enhancement PMU-based applications
- Advanced visualization features
- Implemented in a very large geographically distributed system spanning more than 2000 miles with very low latency

Q&A

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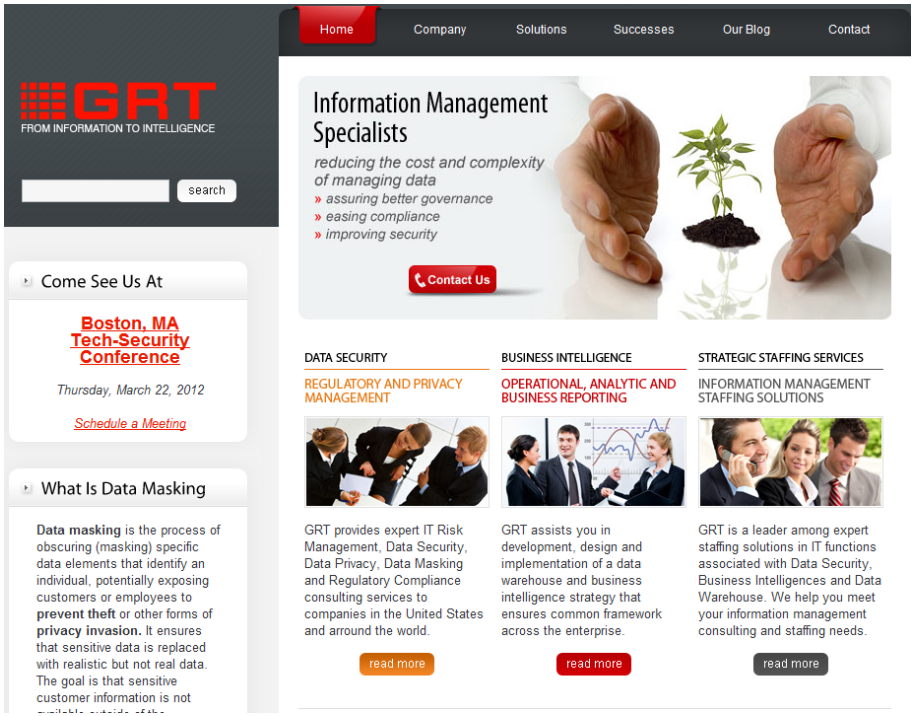

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