Distributed Power System Stability Enhancement Framework

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from information to intelligence
Premium IT Services

Information Management Specialists

Design, Develop and Deploy digital transformation solutions for InterConnected World.

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

GRT APDC multi node scaled cluster

Data RECEIVER node 1
2-3 stand by servers
(failover cluster)

Data TRANSMISSION node 1
2-3 stand by servers
(failover cluster)

Data RECEIVER node N
2-3 stand by servers
(failover cluster)

Data TRANSMISSION node N
2-3 stand by servers
(failover cluster)

Cassandra
Thrift API and CQL

Cassandra node 1
Cassandra node 2
Cassandra node 3
Cassandra node N
PowerLink cloud based scaling architecture

GRT APDC multi node CLOUD scaled cluster

Data RECEIVER node 1
2-3 stand by servers
(failover cluster)

Data TRANSMISSION node 1
2-3 stand by servers
(failover cluster)

Data RECEIVER node N
2-3 stand by servers
(failover cluster)

Data TRANSMISSION node N
2-3 stand by servers
(failover cluster)

Cassandra
Thrift API and CQL

Cassandra node 1
Cassandra node 2

Cassandra node 3
Cassandra node N
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 enhancement **applications**
APDC architecture – PowerLink based

GRT APDC multi node cluster

Data RECEIVER node 2-3 stand by servers (failover cluster)
- Hazelcast node
- Hazelcast client Java API
  - Data receive adapters:
    - IEC 60870-5-104 (client)
    - IEEE C37.118-2011/2008
    - APDC-to-APDC
    - IEEE C37.111-1991
    - OPC (client)
    - Modbus RTU Master
    - MQTT

Data processing:
- On-line thresholds violations
- Disturbances and emergency conditions determinations
- Alarming

On-line applications:
- On-line oscillations monitoring (magnitude, frequency, damping)
- LFO detection (frequency, amplitude, phase and damping analysis)
- Power plant operation monitoring
- Monitoring of generators' excitation system faults
- Self operability monitoring

Data TRANSMISSION node 2-3 stand by servers (failover cluster)
- Hazelcast node
- Hazelcast client Java API
  - API:
    - JSON/HTTP based
    - REST-API
    - Thrift-based binary
    - HTTP/SOAP web-services based

Data processing:
- Data calculations
- Fast search in historical archive (roll up technology)
- Real time and "on demand" data redistributions

On-line applications:
- Self operability monitoring
- Visualization (web forms, form designer, data management, administration)

- IN MEMORY GRID -

Cassandra
Thrift API and CQL

Data STORAGE node multi nodes (failover and load balancing cluster)
- Cassandra node 1
- Cassandra node 2
- Cassandra node 3
- Cassandra node N

External Application server 1

External Application server K
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 system faults
- Power plant operation monitoring functions
- NEW APPLICATIONS IN DESIGN PHASE
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
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
Please visit our talk at

Thursday, March 23, 2017
Session 5: Generators and Equipment
“PMU-based Power Plant Operation Monitoring and Innovative PMU implementation”
Target: Improving the reliability and stability of a power system through developing and advancing the methods of dispatch and automatic control

Developed applications

Commissioning/Testing phase

Prospective applications
Phasor measurements data applications

Power system applications

Wide-area applications
- Electromechanical oscillations monitoring and analysis
- Synchronous machines participation in the oscillations damping assessment
- System controllers operation monitoring system
- Novel PMU/PDC development
- Centralized automatic emergency control system
- Basic emergency control alarm signals

Local applications (power plant, substation etc.)
- Centralized automatic emergency control system
- Power plant operation monitoring system
- Equipment monitoring and diagnostics system
- Basic emergency control alarm signals
- Novel PMU/PDC development
- System controllers operation monitoring system
- Electromechanical oscillations monitoring and analysis
- Synchronous machines participation in the oscillations damping assessment
Electromechanical oscillations monitoring software
Online monitoring tool

Online LFO monitoring 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
Thank You
GRT Corporation

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Q&A

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