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Advanced Analytics for Smart Grids

Harness the power of advanced analytics to get the most out of your GRID network

Whitepaper

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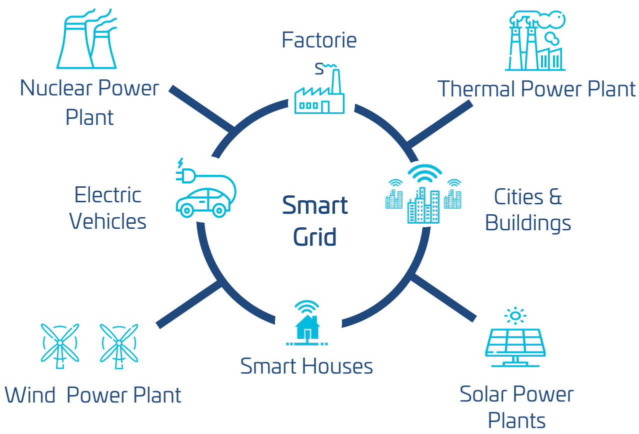
Background

Traditionally, power grids and electricity meters generated very small amount of data; however, as the industry started its transformation, it introduced spectrum of new measures in measurement, communication, data strategy, and storage to offer affordable and sustainable and quality energy services to the consumers. This increased deployment of probing measurement devices. Additionally, data from non-electric sources has generated unprecedented amount of big data in power grids. For the benefit of consumers, service providers, and utility operators; newer as-a-service models using advanced communication and information infrastructure were deployed to allow optimized energy production, transmission, and distribution.



Smart Grid Network (Reference: enisa.europa.eu)

With Energy Independence and Security Act of 2007, the United States introduced that government would support modernization of nation's electricity transmission and distribution system to maintain a reliable and secure electricity infrastructure that can meet future demand growth. It recommended aspects of smart grid that include smart metering, use of digital controls to improve efficiency, reliability, and security of the grid, deployment of smart technologies and other key developments that would enhance the U.S. electric grid.

Similarly in Europe, to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety, European commission has come up with their vision for Smart Grids in 2006 to provide flexible, accessible, reliable (secure), economically viable and greener energy. 3rd European Energy Liberalization Package adopted by EU has since been promoting installation of intelligent meters (smart meters), to reach 80% household by 2020.

Concept of smart grid allows introduction innovative practices such as alternative power generation, smart meter rollouts, network automation, smart asset management, home area network and intelligent power management systems. This requires an AI-based advanced analytics solution at command control centre allowing smart metering data integration with non-standard data sources and normalization of data arriving from disparate data sources at different times and frequencies. The integration of energy production and consumption component through the smart grid enables increased demand response and energy efficiency.

The basic concept of a Smart Grid is to offer an ability to monitor, analyze, predict, and control power distribution network. Ultimately, the aim is to improve profitability and introduce operational automation to enhance operational efficiency as well as improve customer's experience.

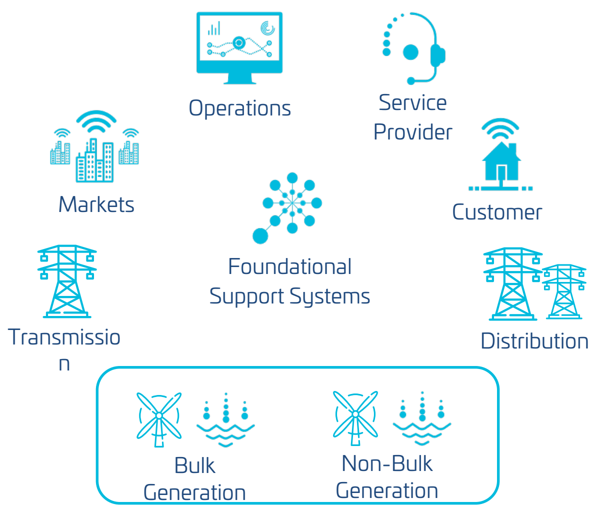
Challenge here is to select an analytics solution that is able to process real-time data arriving at multiple speeds from various touch points. This requirement is somewhat similar to management of telecom network that is truly digitized to offer AI-based proactive operations and preventive maintenance.

Grid Management System (GMS)

The GMS is a system of systems (SOS) which provides a comprehensive grid management solution to address an increasingly complex distribution environment. Typically Grid Management System primarily consists of following features:

Advanced Distribution Management and Energy Resource Optimization

This allows real-time monitoring, electrical system optimization, and self-healing capability for zero-touch automation. There are possibilities to access grid data and manage operations using mobile app.



Smart Grid Domains and Subdomains (Ref: smartgrid.ieee.org)

Improved Outage Management and Situational Awareness

This involves identification of root cause of outage to allow quick restoration of power. Outage Management accurately estimates population impacted and revenue loss. Early warning systems can be deployed to predict potential outages, as well as initiate computer aided dispatch (CAD) to efficiently prepare and coordinate the available resources.

Grid management system of systems provides the ability to consolidate all early warning signals such as customer phone calls, weather warnings, news, and social media feeds in advance.

Proactive Energy Usage Monitoring

Utility companies want to predict and forecast energy consumption in their network. As part of smart grid, they want to analyze historical trends and combine those with external weather data to identify usage patterns and anomalies. This can also be enhanced to provide configurable alerts.

Opex Reduction Using Preventive Maintenance

Identify operations issues more quickly and simultaneously reduce the time it takes to understand and repair issues. This helps avoid unnecessary / duplicate site visits and reduce operations costs significantly.

Big Data Analytics in Smart Grid

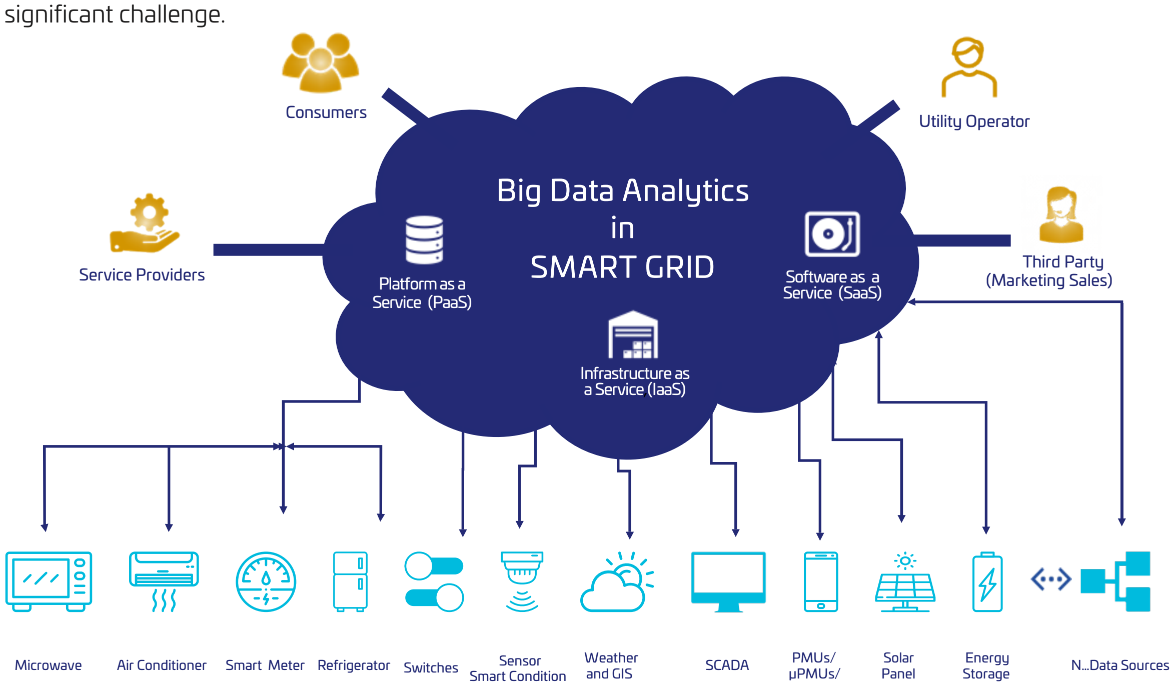
A typical distribution utility deals with data coming from various sources including smart meters, phasor measurement units (PMUs), μPMUs, field measurement devices, remote terminal units (RTUs), smart plugs, programmable thermostats (e.g., transformers, network switches). In addition, asset inventory, supervisory control and data acquisition (SCADA) system, geographic information system (GIS), weather information, traffic information, and social media are essential sources for understanding the behaviour of the grid.

With the number of open source and commercial big data technologies available growing by the day, IT industry is moving faster than one can ever imagine. The complexity of selecting the right technologies and integrating them all while ensuring the best compute efficiency, scaling, and feature richness can be overwhelming. Given that overall architecture is evolving to smart meters connected via wireless technologies like RF or LTE, complimented by underlying fibre network or home area network; there is a need for telecom grade management system. This requires full fault-tolerance, capacity management, alarm management, and performance management capabilities along with predictive capabilities; now that presents you with a significant challenge.

While management of big data adds lots of challenges, it also presents new opportunities to monitor, detect, operate, manage, predict, remediate, and automate all systems. The challenge here is to harness all this big data to augment entire spectrum of decision making in a smart grid. Requirement is not only to have reporting and monitoring capability but also to have an ability to gather real-time insights, perform trend analytics based on historical data, and predict future conditions in order to make intelligent decisions.

Smart grid typically allows two-way communication between the central controllers and local actuators as well as logistic units to respond to urgent situations of physical elements or quickly changing electric demand. This is similar to typical telecom network where engineers at the centralized data centre can remotely configure, monitor, and manage network.

In traditional network architectures, collecting data from these distributed portions of the network often requires a large amount of transport capacity to move the data from the source to the analytics platform.



Digital Transformation Model for Smart Grid Network

Transport requirements and storage for all this data have often been cost prohibitive and a key limiting factor in deploying analytics on a broad scale. The ability to collect data at the network edge while simultaneously reducing the data in a lossless and real-time way, is critical in making use of data that was too costly to collect and transport in the past.

Compute-first architectures that utilize intelligent collectors to perform a data triage process, so the high-value portions of the data stream are collected and analyzed while the remaining data is discarded help alleviate this problem. In distributed networks this is often performed at the point of collection. This reduces the cost of transport and storage while speeding the analytics process, providing insights at the right time for the right cost.

With billions of records of data generated every day, companies are in the process of migrating to cloud storage to reduce their operational costs and improve overall efficiencies. There are also initiatives on moving to open source architectures. It is no trivial task to operationalize this blend of various technologies, open source/proprietary architectures in a production environment and it cannot be accomplished overnight.

SQL Compliant Data Streaming Processing

Over the past decade, innovation in Big Data software has proceeded at an amazing pace, including the development of NoSQL key-value stores, column-oriented databases for multi-dimensional analysis of time series data, Elastic, Logstash, Kibana "ELK" stack for analyzing text-based data such as log files and machine learning libraries with algorithms optimized for Big Data and finally SQL over streaming for real-time streaming applications. Some smart grid operators have invested in their in-house data lake storing Big Data repositories.

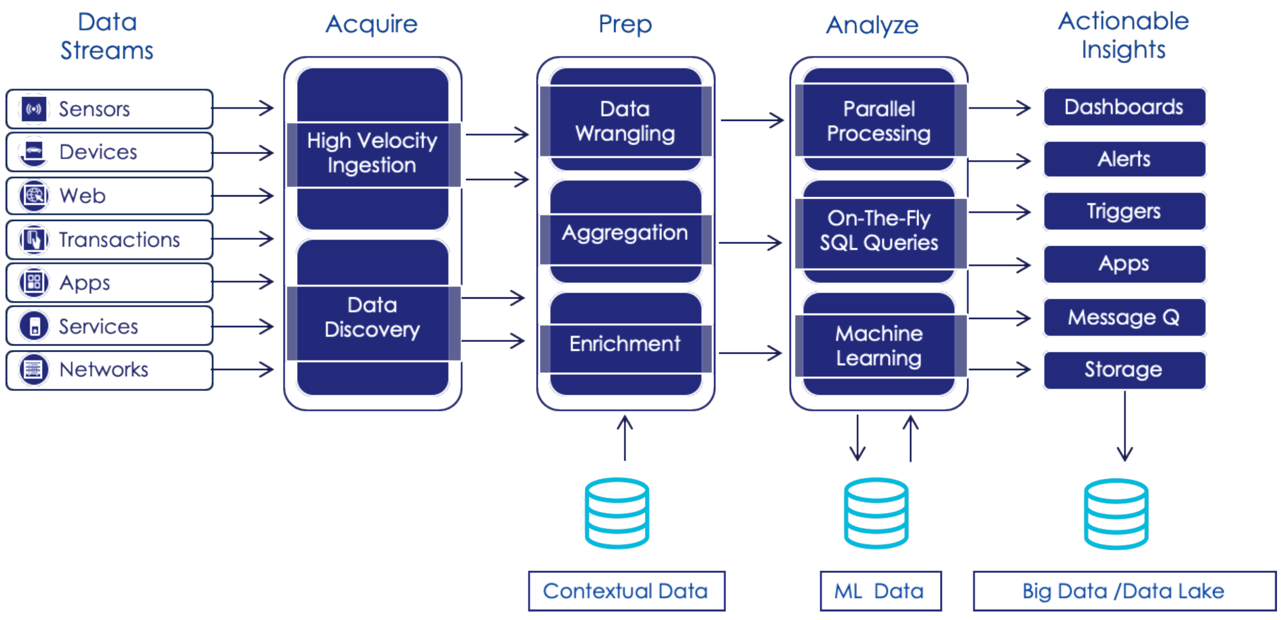
Understanding the 5V's of big data - volume, velocity, variety, veracity and value; requires careful data curation, transformation, wrangling and normalization during data ingestion process.

Data transformation might involve translating and combining data from different sources into a single record or enriching raw data with additional data from other sources. While a handful of raw data types might be stored directly in a repository without modification, it is usually necessary to transform or enrich collected raw data before storing.

Due to the volume of sensors and their geographical distribution, much of the IoT/sensor data often remains trapped at the edge in separate silos, making it costly and complex to monitor edge devices. A full ANSI Standard SQL compliant data stream processing offers an extensive set of operators for querying streaming data. This allows correlation of data arriving on different media in different formats at different speeds, creating integrated or stitched data records.

Users can then simply issue SQL queries which express the correlation through JOIN or UNION or similar statements. However, in order to make it future friendly, data processing platform needs to support very small hardware footprint with low latency and high performance.

SQL over streams technology allows seamless access to ingest, search, and contextualize data stored on a wide range of media in many formats including:



ANSI Standard SQL Compliant Smart Grid Data Analytics Platform

Media:

- Natural Streaming Data (File System, HTTP,SFTP)
- Messaging Systems (Kafka, Pulsar, Kinesis, MQTT, RabbitMQ, ActiveMQ)
- Commercial Relational Databases (Microsoft SQL Server, Oracle, Teradata, IBMDB2)
- Open Source Relational Databases (MySQL, Postgres)
- NoSQL Databases (MongoDB, Cassandra)
- Cloud Databases (Snowflake, Amazon Aurora, Amazon RDS, Amazon Redshift, Amazon DynamoDB)

Formats

- Structured Text based content (CSV, XML, JSON)
- Structured Binary based content (Protobuf, Avro, Parquet, ORC)
- Vendor Proprietary content (Spider Cloud CPER, Ericsson CTUM)
- Semi-structured Text via regular expressions
- Unstructured Text via natural language processing plugins
- Relational Data
- No SQL Data

This allows correlation of data arriving on different media in different formats at different speeds, creating integrated or stitched data records. Users can then simply issue SQL queries which express the correlation through JOIN or UNION or similar statements.

Some of the high value use cases to target are:

Truck Roll Reduction for Preventive Maintenance

- Millions of network, telemetry and customer events per day are ingested and correlated from multiple disparate sources such as customer calls, trouble tickets, network alarms, and radio frequency data.
- These data streams are normalized and joined together with data-at-rest such as device type, firmware version and network topology, to create an enriched set of events and performance data.
- Identify operations issues more quickly and simultaneously reduce the time it takes to understand and repair issues. This allows operator to avoid unnecessary / duplicate site visits and reduce operations costs significantly.
- Automatically identify anomalies in the baselines using advanced machine learning techniques; that lead to incidents, and routinely uncovering what standard threshold alerting systems fail to detect.

Proactive Energy Usage Monitoring

- Using network automation, classification of thousands of daily alarms and events into clusters of alarm families, isolation of root alarm and its probability to cause an incident and identification of root cause and fix faults.
- Correlation of DT and consumer meters to assess energy usage, determine anomalies and create an alert. This information can also be correlated with historical billing information to detect any indication of revenue fraud.
- Utility companies want to predict and forecast with right level of accuracy the energy consumptions in their network.
- Analyze historical trends and combine with external weather data to identify usage patterns and anomalies.

Revenue Assurance & Uplift

- Identify distribution transformers and time slots of highest power theft.
- Build fine grained segment patterns to identify consumers that are committing theft.
- Identify transmission losses.
- Build segment level consumption patterns to identify misuse of discounted connections.
- Identify and upgrade customers with higher connected load.

What-If Analysis

- Customers want to reduce their total energy usage and cost by selecting optimum plan based on their usage and time of usage of specific appliance.
- Usage data from the utility company to identify various energy plans and time-based energy signatures of consumption for every customer who subscribes to smart metering plans.
- This helps customers with improved customer experience, proactive billing support.
- Solution helps energy company to predict energy consumption more proactively.

Complement In-house Talent with Proven Vendor Expertise

Developing, deploying and maintaining real-time analytics solutions for operational intelligence is challenging for service providers and large enterprises alike. Software engineers, solution architects and data scientists need the relevant operational experience coupled with proven Big Data expertise. Commercially supported Big Data as well as open-source software are readily available from multiple vendors, but Big Data talent is in short supply across all industries. Smart grid operators therefore need a technology partner in this digital transformation journey with proven abilities in delivering telecom or IOT grade analytics solutions.

The Smart Grid for The Next Generation

Today's grid has been in use for almost a century now. Therefore, any research and investment into smart grid is going to pave the way for our future. In order to achieve sustainable development, models for electricity grids have to allow for changes in technology, values, the environment and its commerce. In order to support microgrids and virtual grids of the future; utilities are adapting telecom like distributed architectural model. We already have technologies and know how of smart meters that offer communication via RF, HAN or even the choice of 3GPP LTE network. With AI-based intelligent analytics solutions, these smart meters are therefore poised to become a gateway for access to the grid of the future.

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