Network and Data Management for Grid Analytics

Commercial suppliers are working with utilities to develop a future power grid that will deploy millions of smart meters and other smart grid devices with various data transfer speeds. The resulting data volume will be tremendous. New tools and approaches will be needed to quickly retrieve and analyze these volumes of data so that power operators and planners can make real-time decisions.

Partner with PNNL for innovative tools and technologies that address the gaps in networking and real-time data management. The technologies described here incorporate algorithms, techniques, and software tools to improve a company's existing commercial products or add new ones.

VOLTTRON™: VOLTTRON™ is an agent execution platform that is designed to support distributed control for electric power grids and other industries with large numbers of control points. VOLTTRON™ fills the need for an independent, language- agnostic agent platform with built-in security and resource management. VOLTTRON™ provides resource guarantees for agents in the platform including memory and processor utilization, authentication and authorization services, directory services for agent and resource location, and agent mobility. We chose to design and implement VOLTTRON™ as a platform service and framework that is decoupled from the agent execution environment. A prototype implementation of VOLTTRON™ has been written in Python and we have executed agents written in Python and Java and as shell scripts. See more online.

Distributed Computing Architecture: This system architecture connects distributed power applications and individually running parallel programs to achieve real-time requirements. The architecture consists of an interface layer to wrap the High Performance Computing (HPC) code, data processing toolkits, and middleware pipelines that allow data exchange in the distributed applications. The architecture has an additional feature of partitioning the decomposition of a whole power system model to available HPC clusters to balance the computational and communication costs. The software architecture allows the entire power system model to be partitioned into subsystems based on the sensitivity analysis of bus lines. The computation of the subsystems is further partitioned to available HPC clusters that balance the computation and communication costs. Hence, individual state estimators (SE) run parallel programs to solve non-linear estimation procedures and communicate the intermediate results to their peers. The data exchange is built on top of a high throughput middleware, so that the individual state estimator is well encapsulated by interfaces for data communication and uniquely identified by endpoints. This leads to an extensible design, since the variation to the SE algorithms resulting in different data exchange structures (Harmonic SE versus Dynamic SE) are both allowed.

Real Time Data Management: This tool stores a large amount of streaming data more quickly and efficiently. This algorithm more effectively assigns disk space, reserving a specific space for each block of data, without indexing, based on a calculated formula. Therefore, all search times and disk allocation processes are eliminated. Tests show a 3-4 orders of magnitude increase in "data ingestion performance" over existing database algorithms. This algorithm applies to data streams where the record size is known and is generated continuously in precisely known time intervals. The tool was developed under PNNL's Future Power Grid Initiative (FPGI) to store the very large quantity of data to be generated with Phasor Measurement Units.

Data Ingestion/Curation: This software is a framework for performing scalable data analysis over large-scale power grid data sets. This framework provides a unique ability to perform analysis over complete large-scale power grid data sets, such as the Phasor Measurement Units (PMU) or fast Fourier transform data. The framework consists of a statistical analysis package, running in a robust parallel environment, which is used to define rules that identify subsets of data of interest, for example bad data or data indicating events of interest. These rules can be combined in arbitrary ways, for example, multiple rules may be required to remove all erroneous data from the original data set. When events of interest are identified, they are classified within known event types, and the collection of event metadata and underlying data references are stored in a relational database. These higher level metadata descriptions of the events can then be used to quickly respond to queries from either users or other applications, or this information can be displayed in a visual format.

GridOPTICS™: This is a novel software framework for integrating a collection of software tools developed by PNNL's FPGI into a coherent, powerful operations and planning tool for the power grid of the future. GridOPTICS™ enables plug-and-play of various analysis, modeling and visualization software tools to improve the efficiency and reliability of the power grid. To bridge the data access for different control purposes, GridOPTICS™ provides a scalable, lightweight event processing layer that hides the complexity of data collection, storage, delivery and management. A significant challenge is the requirement to access large amounts of data in real time. GridOPTICS™ Software Architecture provides a flexible framework that makes data storage, analysis and data passing between applications easy.

Fenix™ (Framework for Network Co-Simulation): Any co-simulation framework must manage the exchange of information as well as the synchronization of the clocks between simulations. The Fenix™ framework for network co-simulation addresses the drawbacks of other known co-simulation frameworks. Specifically, Fenix™ provides a capability allowing all simulations to speculate whether they can forego time synchronization for a certain period without loss of simulation accuracy. Further, it allows speculative multithreading at runtime, without compiler assistance. It also provides novel time synchronization algorithms which take into account network traffic delays if a network simulator is part of the co-simulation.

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