Architecting Tomorrow's Electrical Grid

White Paper

Energy Industry

Distributing computing intelligence is a necessary step in the transformation of the electrical network to enable utility operators to do more with their existing energy capacity

The electrical utility industry is experiencing paradigm shifts across the globe, brought on by growing pressure to do more with their existing energy capacity while integrating clean energy sources. Regulators, along with the public, expect the industry to facilitate consumers in making informed decisions that save energy and respond to environmental concerns. The industry must also help accelerate efforts by customers to adopt up-and-coming energy technologies such as solar photovoltaics (PV), wind generation and plug-in hybrid vehicles. As a result, utilities are responding with new programs that address renewable energy generation, demand-side management and intelligent distribution.

With energy demand growing, the smart grid provides opportunities for utility operators to transform their electrical networks. By using Intel® technologies, which provide higher levels of scalability, performance, energy-efficiency and serviceability, next-generation equipment can offer utilities improved energy management and lower operating costs.

Why Distributed Intelligence?

As the grid grows in complexity, utility operators need intelligent agents that make real-time decisions that directly affect operational efficiency dispersed throughout the electrical network. Network architectures based on distributed intelligence enable intelligent agents to aggregate information from various local systems, such as smart meters, automatic feeders and substations. Consequently, agents have enough context awareness to safely and effectively control the grid system. When these systems communicate over Internet Protocol (IP), they benefit from industry standards that deliver reliable and cost-effective networks with plenty of headroom.

Distributed intelligence is essential for increasing the capabilities of tomorrow's grid. With respect to *energy generation*, computationally intensive simulation models are used by renewable energy plants to better predict energy demand and factor in weather conditions, information required to address intermittency issues and reduce reserve capacity. *Energy distribution* infrastructure requires high-performance substations in order to optimize service voltage and phase in real-time, thereby improving energy efficiency. *Energy consumption* is easier to manage when home monitoring systems have sufficient computing power to implement conservation programs, such as demand-side management services. Using platforms based on Intel® silicon components, equipment manufacturers can develop more intelligent systems capable of distributing intelligence and decision making throughout the grid.

Intel® Solutions. Ready for Tomorrow's Grid

Intel's standards-based embedded building blocks are ready to enable more intelligent equipment within the grid, spanning huge turbines that generate energy, control systems that distribute power and smart meters that monitor end-user consumption. These software-compatible products allow equipment manufacturers to develop a scalable family of reliable products running off a common code base, thus saving development cost. The high-performance Intel® Core™ processor family with multi-core technology supplies the computing horsepower needed to run protocol stacks, protocol conversion and data preprocessing algorithms in today's and tomorrow's power systems. Intel® Atom™ processors can be used in fanless systems designed to satisfy strict EMI/EMC and form factor requirements. In all, systems with Intel® processors deliver predictable performance and ease troubleshooting, even for non-IT personnel.

Supporting this wide range of equipment types, Intel processors, chipsets and advanced technologies provide many capabilities that can be applied to the regeneration of the electrical utility industry. These technologies, which are built into Intel silicon components, improve remote management, virtualization and security, thereby enabling equipment manufacturers to better address the requirements of next-generation power grids. As a result, utilities and network operators can enhance their ability to manage, maintain and protect their energy infrastructure by using Intel technologies such as:

- **Intel® Active Management Technology[1] (Intel® AMT):** Improves remote diagnostic and repair capabilities, helping to increase equipment availability.
- **Intel® Virtualization Technology[2] (Intel® VT):** Improves software reliability by isolating application code and helping to prevent dangerous interactions.
- **Intel® Trusted Execution Technology[3] (Intel® TXT):** Enhances grid security by preventing any node from executing malicious software.

For more information on Intel® product technologies, visit www.intel.com/technology/advanced_comm.

Energy Trends Increase Embedded Computing Requirements

Regulatory and market realities are requiring a new way of thinking for utilities, and the use of standards-based building blocks to build out the grid will drive greater plant efficiency, higher renewable energy production and more advanced conservation programs.

Greater equipment consolidation: Looking to minimize network complexity, utility operators expect equipment manufacturers to consolidate traditional single-function devices on the grid network onto a more open modular and high-performance platform.

Transition from analog to digital: Data will be communicated across multiple networks, which necessitates that control platforms have the computing power to perform more protocol conversions and data pre-processing, so all the data doesn't have to go over LAN.

Faster responses to weather conditions: Renewable energy sources require the computing power to evaluate changing weather conditions, like wind direction and sun intensity, and respond by adjusting the position of turbine blades and solar panels in real-time.

More sophisticated demand management programs: Utility operators are implementing energy conservation initiatives, such as time-of-day usage fees and dynamic pricing, which will benefit from intelligence distributed throughout the grid.

Needed: Flexible and Scalable Open Modular Platforms

Each element on the grid will demand a particular set of features; however, most elements can often be designed using a single-processor architecture with exceptional scalability, upgradeability and flexibility.

- **Large processor selection:** With a wide choice of processors, it's straightforward to scale designs to meet the right price-performance.
- **Single code base:** Equipment manufacturers can easily upgrade designs when the processor family is completely code compatible.
- **I/O flexibility:** Open modular systems, supporting multiple standard busses, allow designers to satisfy a wide range of I/O requirements.
- **Reliable supplier:** Chip manufacturers, with a reputation for delivering long life cycle products, help preserve equipment manufacturers' development investments.

Why Intel for Equipment Manufacturers?

Equipment manufacturers are depending on mature and capable development tools to deliver advanced equipment for tomorrow's grid. They can turn around designs more quickly and cost effectively with Intel®-based platforms, which are supported by an established array of open and interoperable development tools.

- **Open development environment:** Robust and interoperable development tools lower R&D and test and validation efforts.
- **Open modular systems:** There's no need to overhaul hardware and software with every new design because the scalability, upgradeability and flexibility make it easy to add new features, as needed.
- **Same development and production platforms:** Use the same hardware and software throughout the development chain, as opposed to some proprietary platforms where developers must use different platforms to write, simulate, assemble and test code.
- **Choice and flexibility:** The Intel® Embedded and Communications Alliance, Intel's extensive third-party development network, can dramatically cut the time and cost to develop solutions by offering a wide choice of applications, software, operating systems and technical expertise (intel.com/go/eca).

Energy Platforms in the Network

Energy Generation (Wind Turbines): Guide vanes play a critical role in a wind turbine system because they tell the controller the direction of the wind. Controlling the vane's pitch, rotation and functions, rugged embedded Intel® architecture platforms allow guide vanes to respond to changing wind conditions in real-time without human intervention. Controllers based on energy-efficient Intel® processors, such as Intel® Core™ i7 processors, are sealed, fanless and designed to withstand demanding environmental conditions and ensure maximum mean time before failure (MTBF). Altogether, an average wind turbine has as many as ten microprocessors, some of which are used for redundancy.

Energy Distribution (Control Systems): Substation control systems monitor and control all relevant operating sections of an electrical distribution network, either as local control systems providing distributed intelligence or as higher-level control systems managing all the stations in the supply network. These platforms can benefit from the computing horsepower supplied by Intel Core and Intel® Xeon processors that perform real-time monitoring, analysis and control of electricity transmission and distribution networks. When intelligence is distributed throughout the grid, soft programmable logic controllers (soft PLCs) can respond quickly to events and minimize production downtime associated with network disturbances. Distributed intelligence, throughout the grid and its end points, enables optimized levels of automation and decision making at each link in the chain. It also facili-tates greater communication, visibility and collaboration across the entire grid.

Energy Consumption Monitoring (Smart Homes): Home energy management (HEM) systems facilitate the implementation of energy-savings programs that benefit both consumers, through lower electricity bills, and utilities, through avoided generation, distribution and emission costs. For example, systems will collect and display detailed information about overall electricity consumption and usage patterns for appliances, allowing consumers to better monitor consumption. Still, the success of energy demand reduction programs hinges on engaging home users, who need innovative user interfaces that provide useful alerts and displays (e.g., peak time and peak usage) and make it easier to control devices. Small, intelligent metering systems, based on the Intel® Atom™ processor, can be designed with an attractive and energy-efficient multi-function display device that is centrally located within the home.

Why Intel for Utility Operators?

As utility operators push the technology envelope to enable innovation, they need to ensure the software applications they deploy have a long, useful life. Extending the life cycle of software, Intel® Architecture Processors offer a processor upgrade path and power-efficiency while supplying the computing performance required for advanced applications.

- **Performance headroom:** Intel processors with multi-core technology supply the computing power required for today's applications, as well as the headroom to run additional applications demanded in the future.
- **Preserve software investments:** Since Intel® architecture processors are software compatible and share key security and manageability features, utility operators can be confident their existing applications will run on next-generation platforms while delivering a secure, manageable environment, which saves future development and validation cost.
- **Power-efficiency:** Intel processors deliver the CPU speed necessary to run the most demanding applications and reduce power consumption when the processing workload decreases.
- **Supplier stability:** Intel has been delivering embedded silicon products with long life cycle support (seven years) for over 30 years; and as a result, Intel has earned its strong reputation as a stable and value-added supplier.

Summary

In order to meet the high expectations for tomorrow's grid, utility operators need to distribute computing intelligence, which allows decision making near the sources of information and point of control. Facilitating this architectural transformation, equipment manufacturers are developing standards-based systems with more computing power and reliable IP connectivity, which lower costs and increase product flexibility. When systems are based on Intel processors, manufacturers and utility operators have the necessary computing horsepower as well as the ability to reuse software on multiple platforms, today and tomorrow.

Leveraging Intel's technology leadership, commitment to quality and volume manufacturing capabilities, the energy industry can boost the intelligence of the grid in the fastest and most cost-effective manner. Intel platforms satisfy the computing requirements across many aspects of energy infrastructure, including energy generation, distribution and consumption monitoring systems.

[1] Intel® vPro™ technology includes powerful Intel® Active Management Technology (Intel® AMT). Intel AMT requires the computer system to have an Intel AMT-enabled chipset, network hardware and software, as well as connection with a power source and a corporate network connection. Setup requires configuration by the purchaser and may require scripting with the management console or further integration into existing security frameworks to enable certain functionality. It may also require modifications of implementation of new business processes. With regard to notebooks, Intel AMT may not be available or certain capabilities may be limited over a host OS-based VPN or when connecting wirelessly, on battery power, sleeping, hibernating or powered off. For more information, see www.intel.com/technology/platform-technology/intel-amt/.

[2] Intel® Virtualization Technology requires a computer system with an enabled Intel® processor, BIOS, virtual machine monitor (VMM) and, for some uses, certain platform software enabled for it. Functionality, performance or other benefits will vary depending on hardware and software configurations and may require a BIOS update. Software applications may not be compatible with all operating systems. Please check with your application vendor.

[3] No computer system can provide absolute security under all conditions. Intel® Trusted Execution Technology (Intel® TXT) requires a computer system with Intel® Virtualization Technology, an Intel TXT-enabled processor, chipset, BIOS, Authenticated Code Modules and an Intel TXT-compatible measured launched environment (MLE). The MLE could consist of a virtual machine monitor, an OS or an application. In addition, Intel TXT requires the system to contain a TPM v1.2, as defined by the Trusted Computing Group and specific software for some uses. For more information, see http://www.intel.com/technology/security.

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