IoT: The Electric Grid's Final Frontier

Jake Varghese, Sridhar Chandrashekar, Mani Vadari

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Meet the Author:

An IEEE Fellow, electricity industry visionary, and leader, Dr. Mani Vadari delivers strategic services to a global set of utilities, vendors, and service providers seeking deep subject matter expertise in setting the business and technical direction to develop the next-generation electric/energy system. As a Business Architect, Dr. Vadari has been delivering solutions focusing on Transmission/ Distribution/ generation operations, Energy markets, and Smart Grid for over 35 years. In addition, he is an Adjunct Professor at Washington State University and an Affiliate Professor at the University of Washington. He has published two popular books, "Smart Grid Redefined: Transformation of the Electric Utility" and "Electric System Operations – Evolving to the Modern Grid, 2nd Edition", in addition to over a hundred industry papers, articles, and blogs. His books are serving as textbooks at several universities in the US and around the world

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IoT and IoT-enabled platforms are harnessing intelligence from the grid edge, bringing remote monitoring and analytics capabilities to support electrification.

As the grid evolves, the biggest changes are happening at the edge. People are installing roof solar panels, buying electric vehicles (EVs), and installing home and building automation. These new categories of smart devices require a robust software backbone to help monitor and control the devices. For a utility, all of this is leading to an increased amount of uncertainty in basic things such as generation (from solar panels), and load (smart homes and buildings, EVs). These grid-edge technologies belong to a broad genre under the moniker of the internet of things (IoT). They generate massive volumes of data often inaccessible by the people responsible for monitoring and operating the grid, thereby leaving them bereft of critical operational insights.

Short Tutorial on IoT:

IoT is a global system of devices, sensors, actuators, and controllers, interconnected and operating over computer networks and accessible over the internet.

IoT is the central nervous system of the connected world ushering in unprecedented visibility and awareness into the operational behavior, health of all systems in this connected workflow. IoT enables rapid, ongoing data-driven intelligent decision-making that is transforming all industries and segments. IDC predicts an installed base of 212 billion connected things by 2020. GlobalData forecasts spending on IoT technologies will reach US$318 billion by 2023.

IoT presents a set of new challenges. The sheer volume of data flowing into the systems and the associated workflow orchestration can be daunting.
A successful IoT strategy starts with targeted proofs of concept that rapidly demonstrate value allowing for investment to scale quickly. An IoT platform that seamlessly scales from proof-of-concept to enterprise-grade workloads is a key success indicator.

A high performing IoT Platform includes:
- Device authentication and connectivity
- Intelligent edge processing
- Hyperscale cloud services
- Responsive user interface
- Predictive, preventative analytics and actionable insights
- Automated end-to-end monitoring, fault detection and remediation
- Integrations with existing enterprise applications
- Rapid Application Development

Two Use-Cases: Nano/Microgrids and Commercial Buildings:

The authors have selected nanogrids and commercial buildings to demonstrate how edge intelligence coupled with hyperscale cloud-based systems can analyze and generate actionable insights using real-time data.

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Nano and microgrids:

A <u>microgrid</u> is a localized group of electricity sources and loads normally operating connected to and synchronous with the traditional distribution grid (macrogrid) but can also disconnect and function autonomously as geographical or economic conditions dictate. A nanogrid is smaller; its scope involving powering most components in a house.

A typical nanogrid includes:
- *Energy sources such as solar panels or diesel generators*
- *Batteries to store energy*
- *A charge controller to regulate voltage and current generated by the solar panel*
- *Charging outlets to power appliances such as lights, cellphones, and refrigerators*

Keeping energy production humming and effective requires 24x7 monitoring of overall system health and, if remote, the landscape and distances make physical access to the system by licensed technicians impractical.
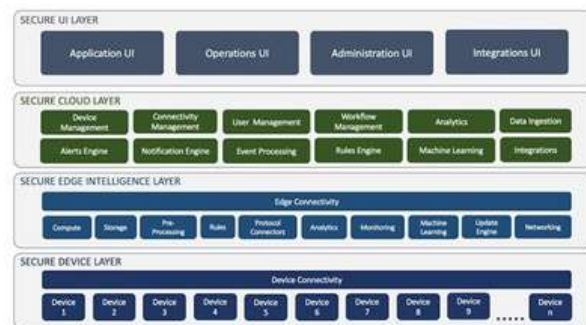

Figure 1: IoT Reference architecture.

A cloud-based, automated, real-time remote operations management system continuously monitors the system and proactively detects situations that could compromise system efficacy. It conducts automated root cause analysis and sends automated alerts with relevant operational logs to engineers who review the data, troubleshoot situations remotely, and determine if a system has deviated from normal behavior.

Figure 2 shows multiple pieces of real-time information plotted over various time horizons. Notice the blue line dipping precipitously portending an impending failure scenario. Engineers can remotely define precise instructions for local technicians arming them with specific details needed to solve the problem.
In return, the end user's service experience is seemingly uninterrupted availability of their nano grid.

Figure 2: Trend of key data captured and presented for analysis.

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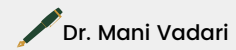
Commercial buildings:

USGBC states that buildings account for 40% of national carbon dioxide (CO2) emissions. Energy efficient buildings have 34% lower CO2 emissions, consume 25% less energy and 11% less water.

Commercial buildings come with a heterogeneous ecosystem of devices that don't communicate with each other. Each device category has an IoT-like solution leading to a Frankenstein-like ecosystem with isolated data islands. Building automation systems, considered central to smart building initiatives have severe limitations including limited data (HVAC and lighting controls) collection which often stays internal.

Cloud-native, IoT operations management solutions seamlessly connect to the building controls network to automatically collect, identify, and map the data using artificial intelligence (AI) models. This solution requires minimal effort to set up and configure; no changes to the existing IT network, policies, or tools are required. Data is securely collected, transported, unlocked, stored, and managed.
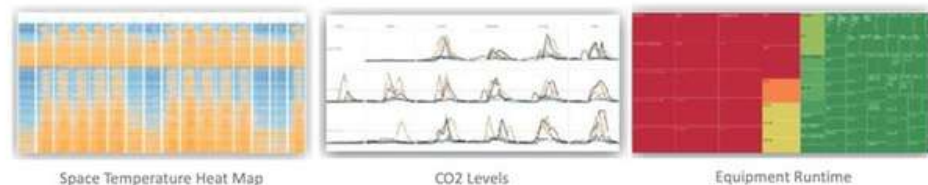

Space Temperature Heat Map · CO2 Levels · Equipment Runtime

Figure 3: Key outputs of the IoT solution for a building.

The rich data collected facilitates rapid insight generation by focusing on areas that need attention. Figure 3 shows tenant comfort metrics like space temperature, CO2 levels, and equipment run times to identify poorly managed equipment. A holistic view of the entire building helps users quickly identify and address problematic areas.

Key Takeaways:

- *Next-gen solutions will move us away from manual processes to the world of information technology (IT)/operational technology (OT) using automation, enabling decisive action through actionable intelligence.*
- *Next-gen cloud-based IoT systems provide full historical data retention and data independence.*
- *IoT is reshaping smart grids. Today's utility receives limited to no behind-the-meter (BTM) information. Decisively embracing IoT-initiated digital transformation will enhance all segments of the energy value chain.*
- *IoT-driven transformation starts by running proofs of concept using an enterprise-grade IoT platform in targeted areas with clearly stated goals.*

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Conclusion: Journey into the Final Frontier:

With maturing technologies, enterprise and consumer expectations regarding IoT are rapidly evolving and becoming mainstream. Energy services and other providers need to determine mechanisms to leverage insights generated from always-connected systems.

Consumers are increasingly becoming sophisticated and leveraging network-connected, distributed energy resources (DERs) to not only address their energy needs independently but also become energy producers.

IoT and IoT-enabled platforms are making a difference in developing and underdeveloped economies by bringing remote monitoring and analytics capabilities to support electrification which in turn raises the economic productivity of those historically disenfranchised communities. All of this sets us up well in the fight against climate change where optimization of energy usage leads to a reduction in CO2 levels. Technologies exist today to support these capabilities and add significant flexibility in data management and interfacing with other enterprise systems.