All Eyes on the Edge: Transformation of Industrial Enterprise Data

Practical Insights to Leverage the Benefits of the Edge

A White Paper by FreeWave and Frost & Sullivan

FREEWAVE

FROST & SULLIVAN

50 Years of Growth, Innovation and Leadership

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EXECUTIVE SUMMARY

Edge computing is poised to radically disrupt industrial enterprises and manufacturers. Over the past century, there have been three major computing revolutions in industrial applications: mainframes, client servers, and cloud computing. The fourth major computing revolution, happening now, is edge computing.

Each revolution is defined by its ability to fundamentally increase the amount of usable data collected, analyzed, and applied. Edge computing improves upon cloud computing and previous computing paradigms by offering shorter latencies, robust security, responsive data collection, and lower costs. These unique abilities have solidified its place as a foundational technology for industrial enterprises of the future. Edge can be applied across a range of applications, including autonomous assets, remote asset monitoring, data extraction from stranded assets, autonomous robotics, autonomous guided vehicles, smart factories, and smart campuses.

Each computing revolution produces a flurry of market changes, operational improvements, and business transformations, and the edge will be no different. Enterprises are beginning to expect faster computing capabilities, interoperability, compute flexibility, and dialed-up operational efficiency. Competition will also heat up as companies try to differentiate themselves operationally through effective edge computing deployments. Frost & Sullivan predicts that around 90% of industrial enterprises will utilize edge computing by 2022. As technology drives the destruction and expansion of traditional business models, the edge will play a crucial role in helping industrial enterprises bridge the current divide between extracting data and creating value.

90%

of industrial enterprises will use edge computing

The market is awash with many edge solutions, but very few have a compelling track record, a strong portfolio, and differentiated solutions. With over 25 years of experience, FreeWave is one of the market leaders in Industrial Internet of Things (IIoT) and edge computing. FreeWave's portfolio of edge solutions, easy integration with application developers, and customer-centricity in shifting from SCADA to IIoT platforms sets it apart from its peers.

FreeWave also uniquely understands the challenges that enterprises face when transitioning to the edge. FreeWave's philosophy is that this transition is a continuum with many gradual steps and long-term build-outs that require a low initial investment.

FreeWave has built this philosophy directly into its products. Its solutions can be neatly integrated into current enterprise solutions because they do not require an initial removal of existing infrastructure. Its solutions are future-proofed through consistent updates and its products are extensible, meaning that any implementations can be extended and grown over time.

In order to help you better understand the edge and leverage it within your enterprises, Frost & Sullivan has structured this paper to cover the following areas:

- The importance of edge computing for industrial enterprises and manufacturers
- The emergence of an edge computing ecosystem
- Practical insights on how to deploy the edge
- Industrial user cases and outcomes experienced

WHY IS EDGE RELEVANT IN TODAY'S INDUSTRIAL ENVIRONMENT?

The Dawn of a New Computing Paradigm

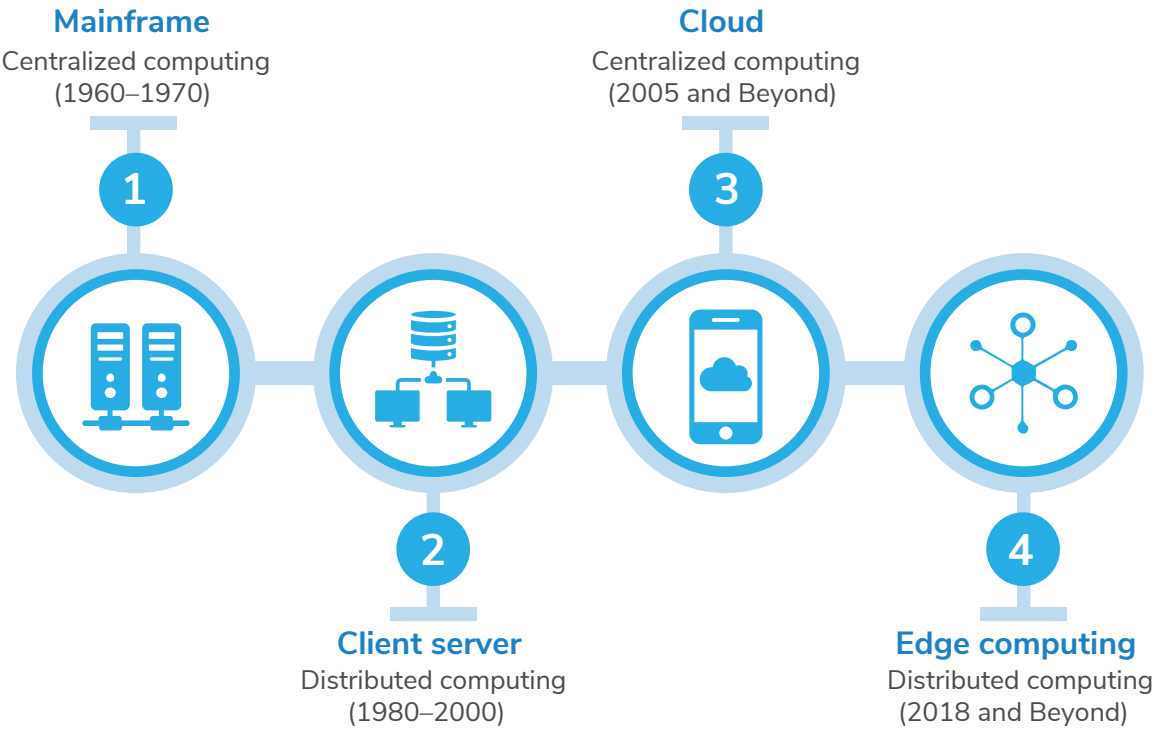
Data is the cornerstone of modern business transformation. Industrial enterprises continually look at new data collection mediums and data analysis technologies to drive improvements across the value chain from design, operations, maintenance, and supply chains.

Since the early 2010s, IIoT and cloud computing have led this charge by blending distributed data collection with centralized data analysis. These have resulted in rapid innovation, cost reduction, and a transformation in competitiveness. However, the resulting solutions have proven to be insufficient and, in key ways, incompatible with each other primarily due to the latency gap that currently exists between the cloud and connected industrial devices. Industrial enterprises are looking to leverage technologies like the edge to become more responsive and thereby make precise changes that will help them sustainably increase profitability, productivity, and safety.

Evolution of Computing

Just as each computing evolution before it, the move to the edge will happen in steps and become a continual process of growth. Frost & Sullivan expects that the journey towards the edge will be unique to each organization. FreeWave's perspective is that the journey towards the edge will be a continuum involving hybrid approaches and a long-term perspective.

EXHIBIT 1: EVOLUTION OF COMPUTING



Source: Frost & Sullivan.

The Journey from Centralized to Decentralized Computing

The journey towards the edge will, for most, begin as an extension of their current cloud computing solutions. To this end, many organizations will maintain a hybrid model that combines a centralized cloud infrastructure with decentralized edge analytics. Frost & Sullivan predicts that as many as 85% to 90% of enterprises will optimize for the use of these hybrid models over the next few years.

The longstanding benefits of the cloud will not be completely disregarded, however. The use of a hybrid model will lead to a rise in low latency on-site edge computing systems that include the use of powerful off-site cloud computing analysis capabilities.

Still, a strong push towards the edge is inevitable given its many benefits over cloud computing:

EXHIBIT 2: CLOUD COMPUTING VERSUS EDGE COMPUTING

REQUIREMENT	CLOUD COMPUTING	EDGE COMPUTING
LATENCY	High	Low
DELAY JITTER	High	Very low
LOCATION OF SERVER NODES	Within internet	At the edge of the local network
LOCATION AWARENESS	Probable	Possible
GEOGRAPHICAL DISTRIBUTION	Centralized	Distributed
NUMBER OF SERVER NODES	Few	Very large

Source: Frost & Sullivan.

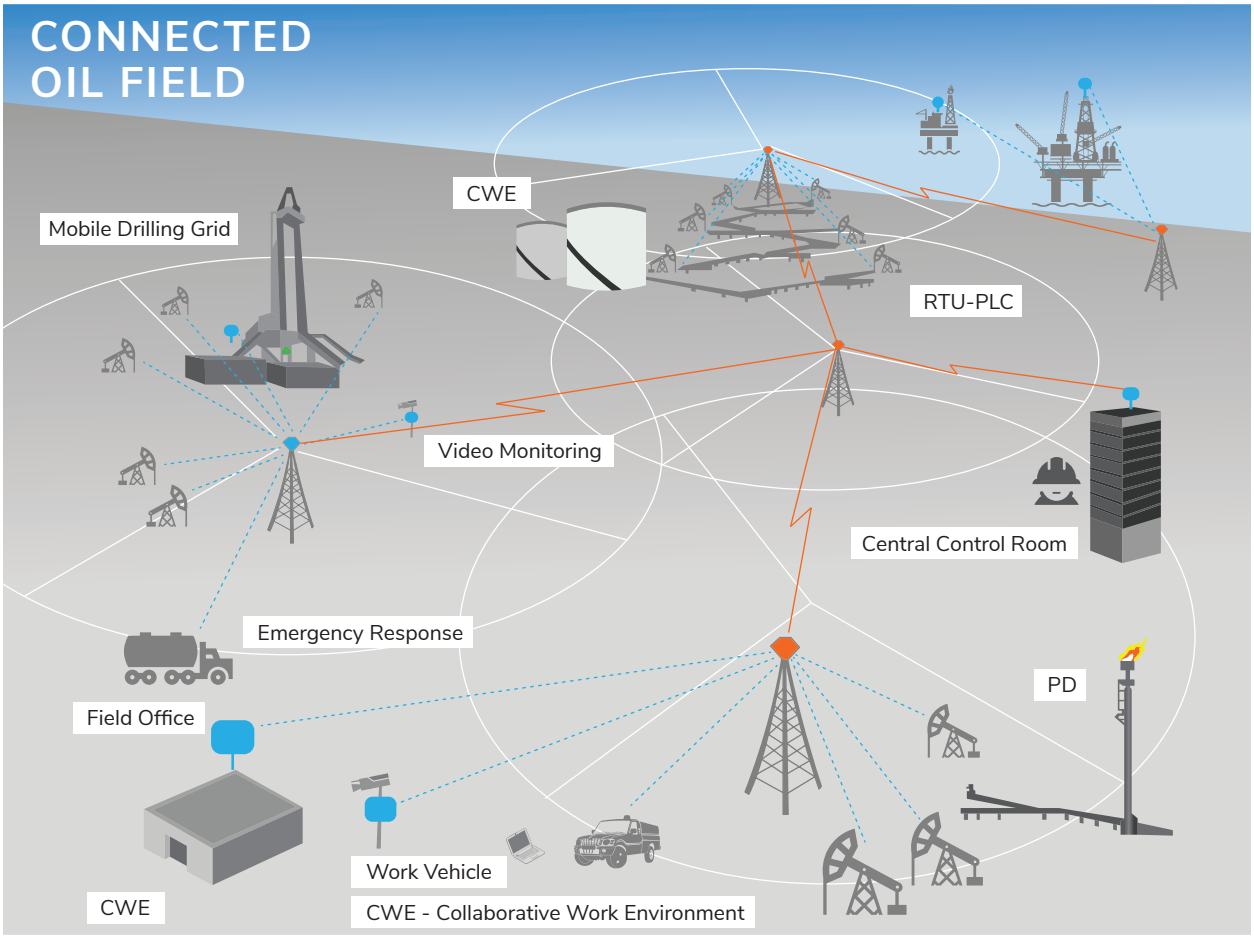
Cloud computing faces severe technological limitations, due to limited bandwidth support in remote areas and its centralized processing of various de-centralized data sources. As a result, core foundational challenges of cloud-based processing have developed in the following areas:

EXHIBIT 3: CHALLENGES OF CLOUD-BASED PROCESSING

Source: Frost & Sullivan.

As a case in point of cloud-based processing challenges, let's examine upstream oil and gas. As oil drilling becomes more difficult, customers look to leverage digital technologies to reduce the rising costs of hydrocarbons, while effectively balancing the elements of risk, safety, and operational efficiency. The exhibit below shows the degree of complexity involved in an upstream operations space:

EXHIBIT 4: UPSTREAM OIL & GAS OPERATIONS



Source: www.pboilandgasmagazine.com/the-digital-oilfield-now-and-forever/.

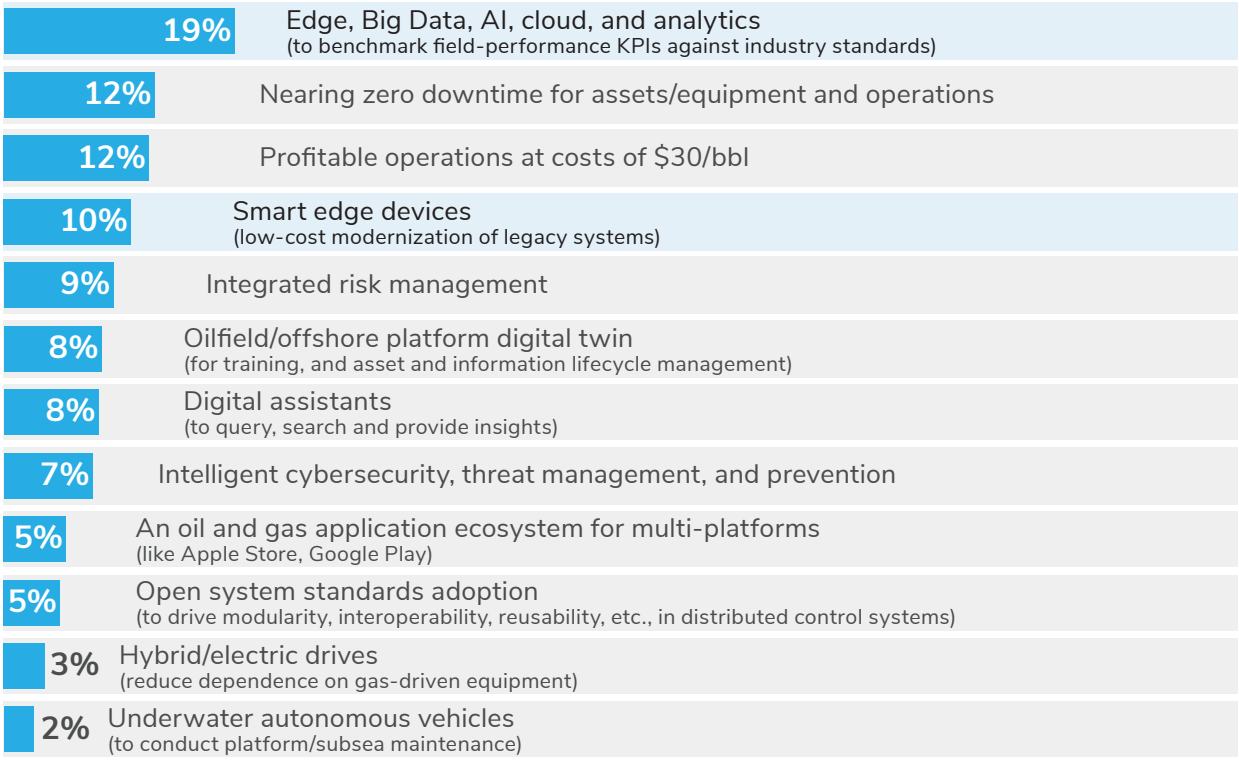
Some challenges the oil and gas industry faces include high volumes of data, a declining skilled workforce, safety issues, driving returns on capital employed, maximizing cash flow, and reducing costs while achieving compliance. The industry has long collected distributed data and channeled it to centralized locations for analysis. However, edge computing is poised to introduce a paradigm shift in data collection, storage, processing, and decision-making.

Edge computing technology places control functions and computational power closer to the data source (i.e. closer to "the edge"). In essence, the edge involves a push towards distributed on-site computation and away from centralized off-site computation in the cloud. Distributed on-site computation enables faster storing, processing, communicating, and decision-making.

Frost & Sullivan performed a survey across 35 oil and gas companies on what the future holds for them. The results, shown in the exhibit below, indicate that the edge converging with other

technologies is the top technology customers are looking to adopt in order to improve operational performance, OEE, asset performance, and productivity.

EXHIBIT 5: TECHNOLOGIES AIDING WITH UPSTREAM DIGITAL TRANSFORMATION



Source: Frost & Sullivan.

The edge is transformative and is well positioned to unlock benefits that were previously inaccessible for industrial enterprises. Frost & Sullivan that expects 1.7 billion IIoT devices will be connected to edge solutions by 2020. Additionally, at least 30% of computing will be pushed to the edge by 2025.

This rapid growth in edge computing can be attributed to recent developments in:

- **Ruggedized Hardware:** This allows for edge computing in harsh environments across a range of industrial applications, such as oil and gas operations.
- **Mission-critical Reliability:** Mission-critical operations can now make use of edge computing.
- **Widespread Adoption of Autonomous Assets:** Autonomous assets are heavily tied to the use of edge computing due to their requirements for lower latencies, faster analysis, and more distributed control and management.
- **Decline in Skilled Labor:** This decline has led to a trend of employees with fewer skills managing more complex assets. In the energy industry, at least 50% of the workforce is eligible for retirement over the next 5 years. This will create a technology consumption gap that is widening between increasing complexity in assets and available workforce. This will drive a change from centralized computing and analysis to de-centralized computing driven by smart hardware and algorithms.

The following are the key benefits of edge computing:

LATENCY REDUCTIONS

On-site computing reduces the significant lag times associated with central cloud computing system. Every second matters and the loss of time equates to the loss of money. For instance, autonomous utility assets in hazardous zones can only be managed in real time through low latency interfaces.

STRONG SECURITY

Edge security can be effectively managed across all layers of data, from the hardware layer, to the communication layer, cloud layer, and continuous life cycle management. The edge can help improve compliance with a myriad of regulations like IEC62443, NERC-CIP v5, NIST standards. It also allows customers to better manage patches and certification across various edge deployments from one centralized location.

QUALITY OF SERVICE

Hardware servicing is easier to manage with on-site devices distributed near key data sources and control mechanisms because each device's location is well known and system-wide catastrophic failure is less likely in distributed systems.

QUALITY OF ANALYTICS IMPROVEMENTS

More data can be analyzed and at a faster rate due to at-source computing. For instance, distributed applications, including remote oil fields, smart grids, and pipeline monitoring, previously had significant bottlenecks due to centralized data processing.

INTEROPERABILITY

Interoperability between cloud environments and IIoT devices is easier to manage with edge computing devices positioned in between.

COST

Operational and data management costs are lowered because the data resides within the device itself. Infrastructure costs for network transmission are also lowered. In oil fields, data from a well can be analyzed immediately, leading to faster equipment issue detection and downtime reduction. Preventing downtime can potentially save up to $1 million dollars per hour.

DIALED-UP OPERATIONAL EFFICIENCY

Transparent, effective, and faster access to data enables more impactful analysis that bubbles up higher into corporate organizations and spurs broader operational decision-making.

ENHANCEMENT OF BUSINESS MODELS

Edge analytics enables manufacturers to uncover new business opportunities and business models through the rapid collection and analysis of high-fidelity data that previously went uncollected, often due to cloud computing bottlenecks. This allows organizations to see correlations in data and push those insights back to the edge for business transformation.

In addition, particular edge computing solutions should satisfy three core requirements:

- **No 'Rip & Replace' Required:** An edge computing solution should not require extensive installation and removal of previous hardware.
- **Future Proof:** An edge computing solution should be supported with routine vendor updates, have a history of past product support, and be compatible with future hardware solutions.
- **Extensible:** Edge computing hardware should be capable of operating at various scales and allow for a continued, incremental rollout over years.

EMERGENCE OF AN EDGE COMPUTING ECOSYSTEM

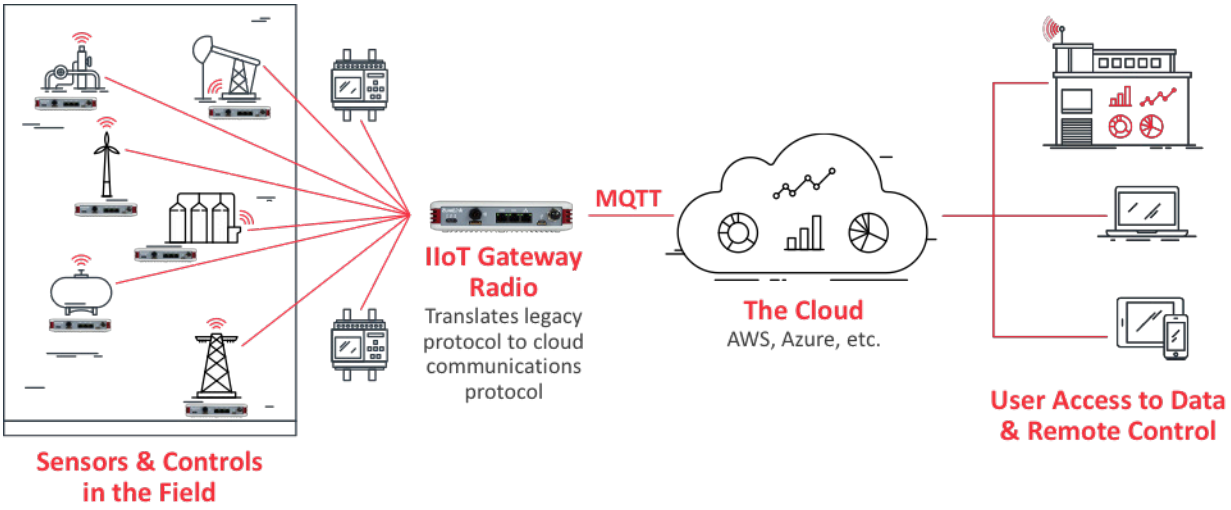
Edge Computing Ecosystem Overview

Edge computing emerges from several key components and from companies working in harmony to ensure real-time data exchange and measurable outputs. These hardware components include:

- **Edge sensors and controls:** data collection and control devices
- **Edge connectivity:** includes IIoT gateways and communication technologies
- **Edge computing:** includes processing capacity sufficient to perform on-site edge application execution (basic analytics or filtering) and storage capacity for temporary data collection and aggregation
- **Application Software:** Application-specific tools to drive data analysis and management
- **Security:** Protection and encryption of hardware, communications, cloud compute, and continuous life cycle management

Below is a broad outline of a system design incorporating edge computing in a hybrid cloud environment:

EXHIBIT 6: DATA MANAGEMENT WITH EDGE COMPUTING



Source: FreeWave

Breakdown of Edge Ecosystem

Edge Hardware

The edge hardware ecosystem can be broken down into three core components: sensors and controls, connectivity, and computing. This ecosystem is led by companies with deep expertise in embedded systems, communications, and IoT devices. Leading vendors include FreeWave, which emphasizes openness, security, extensibility, and easy installation.

> The edge hardware ecosystem can be broken down into three core components: sensors and controls, connectivity, and computing

SENSORS & CONTROLS

The edge begins first with data collection and ends with deep data insight and control. In order to facilitate data collection and the resultant feedback control, enterprises need to utilize solutions capable of sensing and controlling various parameters, including process data (e.g., temperature, pressures, flow), asset data (e.g., vibration, downtime), and environment data (e.g., weather, emissions).

CONNECTIVITY

Edge connectivity is essential for maintaining consistent data streams, transmitting data back to initial processing centers, and communicating between devices. Strong connectivity solutions should offer a wide range of frequency bands on which to communicate, a wide range of data transmission rates, a wide range of communication distances, and significant form factor variations. Connectivity devices should have encryption built in.

COMPUTING

Edge computing hardware provides intelligence through data processing and application server capabilities. This includes light processing capabilities that are meant as the initial touchpoints for data analysis and control. Users may require many design variations for edge computing hardware, including open board or ruggedized options and wired or wireless options.

APPLICATION SOFTWARE

A core part of the edge ecosystem is application developers who build software to analyze and manage data. These applications are purpose-built to manage the varied application needs of any industry. Applications can range from managing a rod lift well, to rotating asset performance management, and to emission data analysis. The beauty of the edge is its extensibility to host application-specific software within edge hardware. Industrial enterprises may work with application developers to build specific data management and analysis platforms to support their specific needs. This allows customers to reduce risk and prevent themselves from being signed into multi-year, proprietary, and rigid life cycle service contracts.

Application developers can leverage the edge ecosystem to develop software tools and scale them across various SCADA platforms available across the market. Developers include companies such as Cirrus Link Solutions, Wonderware, and ClearSCADA. Recently, a new open-source consortium called The Edge Application Developer Project Group was formed with the goal of developing universal, open-source standards to be used by application developers. As the industry embraces these shifts, the edge will empower customers to leverage standardized edge hardware, like that of FreeWave,

while enjoying the flexibility to integrate dynamic industry application requirements through algorithms. Application developers generate these algorithms. Hence, it is important for customers to partner with solution providers who can bring together a full portfolio of hardware, application software partners, security, and have an extensive track record deploying edge solutions.

SECURITY

Given the sensitivity of the underlying data and controls, security is a critical requirement across all ecosystem areas. Fortunately, managing security in the edge follows core principles similar to those that IT professionals are already intimately familiar with. The core security layers in the edge include the hardware layer, the communication layer, cloud security, and continuous life cycle management.

Hardware security is typically managed through on-board embedded cryptographic keys called Trusted Platform Modules. The communications layer used to send data between devices can be secured through encryption and certificates. The cloud security layer involving communication between the edge and cloud can be secured through additional encryption and use of certificates. Lastly, continuous updating and patching is essential. All of these security protocols are already well understood and implemented by IT professionals.

In the next section, we will evaluate the steps to deploy the edge.

HOW TO DEPLOY THE EDGE

The Coexistence of SCADA and the Edge

For many industrial enterprises, especially in industries utilizing distributed assets, SCADA stands as the current data capture, control, analysis, and communication technology. Though this technology has proven its use throughout its decades of deployment, new IIoT-based edge computing brings a wealth of benefits that exceed SCADA's capabilities. Below is an outline of capabilities of SCADA versus IIoT-based edge computing:

EXHIBIT 7: SCADA VS IIoT-BASED EDGE COMPUTING

	SCADA	IIoT-BASED EDGE COMPUTING
INTEROPERABILITY	Cumbersome to integrate new equipment	Easy to integrate new equipment
COST	High cost for licenses, communication mediums, upgrades, and servers	Lower cost due to use of on-premise computing and a lack of licenses
DATA INSIGHTS	Limited ability to poll data in high resolution, time syncing issues due to round robin polling	Easy to time sync event-based data, orders of magnitude higher resolution and input accuracy
SCALABILITY	Costs increase sharply per user added	Cloud use makes scaling easy
SECURITY	Mostly runs on Windows OS, access through use of VPNs	Security standards such as SSL and HTTPS, encryption, certificates, platform agnostic solutions

Source: Frost & Sullivan.

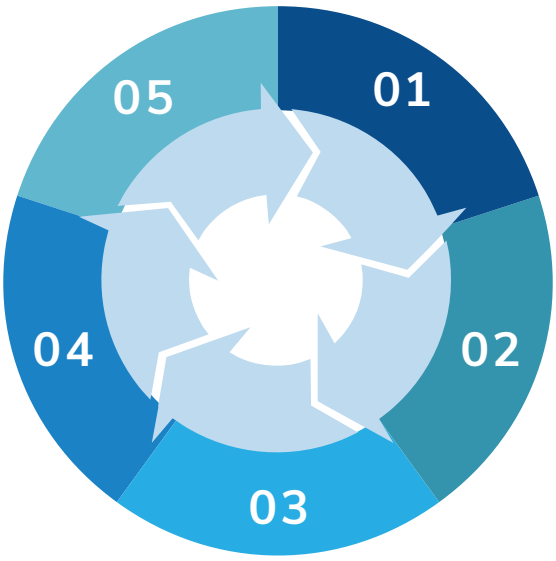
The transition from SCADA to IIoT-based edge computing will bring with it an upgrade to newer open protocols such as TCP/IP and Ethernet, which are easier to integrate. SCADA's computing dependence on a centralized server will be augmented with the edge's distributed computing modules, allowing for a faster response and a lower chance for system-wide failure. The edge can help to process time-sensitive information, while SCADA can help to analyze historical data and provide long-term trend analysis. Both are important to an organization, as a myopic view will restrain an organization from understanding the potential impact of long-term implications.

Even though trends are moving industrial enterprises towards the edge, SCADA will continue to coexist in the foreseeable future. Edge and SCADA coexisting will yield rich and significant operational benefits to organizations.

Edge Deployment Model

The journey towards the edge will occur in several key steps. Below, Frost & Sullivan outlines a transformation model detailing key considerations for customers making this transition:

EXHIBIT 8: 5 STEPS TO A SUCCESSFUL EDGE IMPLEMENTATION



CONNECT ASSETS

Start by connecting your assets. Attach sensors wherever required. This first step is about collecting and analyzing data.

INVEST IN EDGE INFRASTRUCTURE

Install edge computing solutions, including edge sensing, edge computing, and edge connectivity. Integrate with legacy infrastructure, including SCADA.

SECURE DEVICES

Configure security options for all connected devices. Secure existing access control. Check often for software updates.

APPLICATION DEVELOPMENT

Develop software applications to take advantage of edge hardware. Find development partners.

RAPID ITERATION

Business processes related to edge computing need to be revisited frequently. Deliver insights from the data sources to deep within the organization.

Source: Frost & Sullivan.

As detailed above, this transition will encompass assets, edge infrastructure, security, application development, and rapid iteration. Frost & Sullivan recommends that industrial enterprises start small with their initial implementations. This will provide companies with enough proof points to realize the value of edge computing to their organization and draft a strong plan for future implementation. Once value has been proven, the technology can be scaled up rapidly.

Industry Examples

Frost & Sullivan expects edge computing to have a broad impact across industrial enterprises and industries.

- Original equipment manufacturers (OEMs) will be changed by edge computing. OEMs need real-time monitoring and analysis of frontline machinery, equipment, and systems to optimize operations. Due to the competitive environment, manufacturers must differentiate their solution offerings in order to exploit the huge opportunities offered by IIoT.
- Analytics paired with edge computing will also provide significant benefits to OEMs and system integrators. By integrating analytics at the edge, these companies can perform local decision-making and gain valuable insights in order to increase efficiency and throughput. Analytics can be performed using advanced predictive and prescriptive analytics at the edge, making analytics faster, more effective, and more efficient.
- In utilities, the edge can be used for risk assessment by remotely analyzing and monitoring sites to predict disasters, and prevent catastrophes.
- In industrial manufacturing, manufacturers can remotely and autonomously monitor the health of production facilities in order to implement predictive and preventative maintenance. This data can be used to alert technicians of potential problems, devise a maintenance schedule, and prevent unscheduled downtime.
- In upstream oil and gas, the edge can be used by offshore oil rigs to gather, monitor, and process data on-site without requiring a centralized cloud infrastructure located off-site.

FreeWave has been at the forefront of edge and steering innovation across a wide spectrum of industrial markets. It provides a uniquely rugged open platform with integrated controls and communications capabilities.

Edge Computing Case Studies

Case studies of FreeWave outlining customers' realized benefits are highlighted below:

ACCUFLOW NODE-RED REPORTING APP

CHALLENGE	SOLUTION	OUTCOME
AccuFlow needed data from pressure sensors at oil and gas sites	Developed a custom app using Node-RED and ZumIQ on a ZumLink 900MHz radio (Z9-PE)	App eliminated manual data collection and lowered response time, saving AccuFlow $15,000/year
It currently sends a resource to manually collect daily data	App collects data and emails a daily report	Node-RED and writing the program themselves saved about $5,000 in development costs
Analysis, decisions, and responses are significantly delayed		

Source: FreeWave.

WATER SYSTEM

CHALLENGE	SOLUTION	OUTCOME
Water plant needed to boost operational efficiency and lower costs Integrator chose Inductive Automation for new SCADA solution Required an intelligent radio network for wireless data transmission	Deployed Ignition with Ignition Edge MQTT and ZumIQ on ZumLink 900MHz radios By placing Ignition Edge on the radios: • Data update rates increased by 10x • Polling servers were eliminated • Additional gateways were eliminated	Gateways saved $600 x 20 units = $12,000 for the project No monthly fees for cellular $30 x 20 units x 12 months = $7,200 saved annually No costly polling engines and increased data visibility

Source: FreeWave.

FACTORY AUTOMATION

CHALLENGE	SOLUTION	OUTCOME
3x surface mount technology (SMT) machines that are key to the efficiency of the factory Lacked real-time usable machine efficiency data Needed data-driven management, not manual/visual observation	Node-RED app developed and deployed on ZumIQ App Server App collects uptime data and displays pertinent uptime stats Dashboard is displayed prominently via HD monitor on floor	Savings of $50,000 in software costs Throughput improvement of 25% Floor display encourages constant improvement (Kaizen)

Source: FreeWave.

STRATEGIC CONCLUSIONS

Industrial enterprises and manufacturers around the world are rapidly embracing digital transformation to become smarter, faster, and simpler. It is imperative that industrial enterprises streamline operations, embrace newer ways of closing the widening time gap between data extraction and meaningful value creation, and continuously improve their position among competitors.

The next generation of smart technologies, smart factories, and connected enterprises will require the flexibility, power, and extensibility of edge computing platforms. The edge will spur rapid innovation across various applications in the manufacturing value chain.

Like cloud computing and IIoT before it, edge computing will expand across industrial enterprises and make way for new business opportunities, new business models, and new competitive disruption. This will result in radical transformation across the corporate structures and value chains of all industrial enterprises for the foreseeable future.

FROST & SULLIVAN

NEXT STEPS ›

- **Schedule a meeting with our global team** to experience our thought leadership and to integrate your ideas, opportunities and challenges into the discussion.

- Interested in learning more about the topics covered in this white paper? Call us at 877.GoFrost and reference the paper you're interested in. We'll have an analyst get in touch with you.

- Attend one of our **Growth Innovation & Leadership (GIL)** events to unearth hidden growth opportunities.

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