CLEANING UP THE INDUSTRIAL IOT (IIOT) EDGE

THE EDGEX FOUNDRY PROJECT INTRODUCES OPEN SOURCE IIOT ARCHITECTURE TO SIMPLIFY & ACCELERATE EDGE COMPUTING DESIGNS FOR VENDORS & CUSTOMERS ALIKE

SUMMARY

One of the most critical challenges to navigate when designing, developing, and deploying Industrial Internet of Things (IIoT) solutions is the mish-mash of standards that must be comprehended to connect all the things. The IIoT environment never comprehended ubiquitous connectivity and is comprised of countless tools, development and operating environments, and connectivity standards. Combine these factors with an infinite number of potential industrial use cases across a myriad of vertical markets, and developing solutions that can quickly provide return on investment becomes a nightmare. How then do we get consistency or standardization to allow developers to deploy working IoT solutions quickly and easily while still allowing platform, hardware, and service providers to differentiate and monetize their value-add?

Moor Insights & Strategy (MI&S) recommends that both vendors and operations-focused organizations looking to develop and implement highly scalable and cost effective IIoT solutions consider the newly formed EdgeX Foundry hosted by the Linux Foundation. This vendor-neutral open source project is chartered to deliver a flexible, industrial-grade software platform that can quickly, easily, and securely deliver interoperability between things, applications, and services at the network edge, across a wide range of IoT use cases.

THE MISH-MASH OF INDUSTRIAL IOT

IoT is not a homogeneous thing but a collection of technologies rooted in embedded systems and machine-to-machine communications across countless vertical applications. Industrial IoT designs encompass hundreds of proprietary and open source software platforms, using a wide variety of methods to connect endpoints and applications in both greenfield (newly built) and brownfield (legacy) opportunities. This complex landscape can be overwhelming to customers trying to architect a single system, much less integrate an IoT solution into their full operation. In addition, IoT designs often require the integration of multiple systems and technologies, making it necessary for a diverse set of system integrators (SIs) and partners to work together. The current fragmented landscape has resulted in a patchwork of custom solutions that

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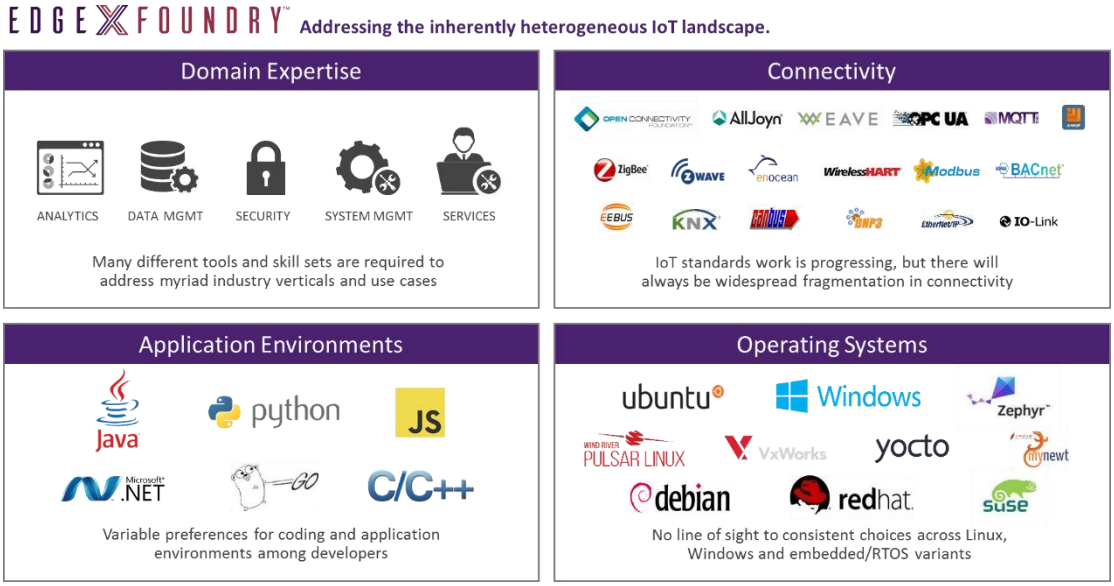
hinder time to ROI and the overall growth of the IoT industry. IIoT designers are forced to become familiar with a plethora of:

- Tool sets
- Application development environments
- Operating systems
- Connectivity types including both standard and proprietary protocols
- Cybersecurity defenses
- Industry-specific standards

FIGURE 1: THE MISH-MASH OF IIOT



Source: EdgeX Foundry

Those trying to implement industrial solutions are rightly confused. And technologies are not the only thing changing. The entire IIoT system architecture has evolved, and the present and future are focused on pushing data collection and analytics closer to the physical sensors, moving compute, storage, and networking closer to end devices and complicating designs further.

Several standards / alliance activities have recently sprung up in an attempt to simplify architectures and make the developer's job easier. The OpenFog Consortium and Industrial Internet Consortium have emerged to develop reference architectures and test beds for IoT solutions from the edge to the core / fog to the cloud. More traditional standards bodies focus developing IoT standards in a single part of the architecture, usually at the level of the things or for a given industry, such as the OPC Foundation,

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Open Connectivity Foundation, Zigbee Alliance, EnOcean Alliance, Thread Group and others, however the activity in all these alliances and consortia have yet to significantly reduce market fragmentation or move the IoT towards simpler solutions.

MI&S believes that while it is important to embrace the ongoing development of standards, the IoT market is too complex for there to ever be a single connectivity standard or data model. What is necessary is a solution that brings both standards and consortia together in a tangible way to produce a real architectural solution. For IIoT to be successfully implemented across a wide range of industry applications, there must be a focus on bringing order to this chaos. MI&S believes that "the edge" is where the most promise lies for this standardization. The industry cannot become economically viable, much less scale, if every edge implementation is unique. The ability to rapidly **integrate** and **interoperate** a wide mix of best-in-class ingredients is especially needed at the network edge where myriad devices must connect with applications.

SCOPING THE PROBLEM

Beginning in 2015, Dell, in conjunction with several partners and customers, began to focus on resolving the problem of connectivity for industrial IoT applications. Dell's belief was that addressing key interoperability challenges at the edge, where "north meets south" and "east meets west" in a distributed IoT fog architecture, was key to speeding up industry adoption and deployments. The target is to:

- **Deliver** not a specification, but rather a highly-scalable, industrial-grade open source edge software platform (including reference design) that could be hosted on edge devices such as hubs, routers, gateways, and servers
- **Provide** best-in-class industrial-grade security, manageability, performance, and reliability while still maintaining extensibility
- **Enable** a rich ecosystem of plug-in components that could quickly and easily deliver interoperability between things, applications, and services, across a wide range of use cases
- **Satisfy** platform, hardware, and software providers of any size, as well as the end customer

By enabling an open and modular IoT architecture based on cloud-native principles (loosely coupled microservices) the project goal was to unify developers, technology vendors, and customers around a single interoperability foundation, without replacing existing standards and still allowing for innovation and commercialization of differentiated value.

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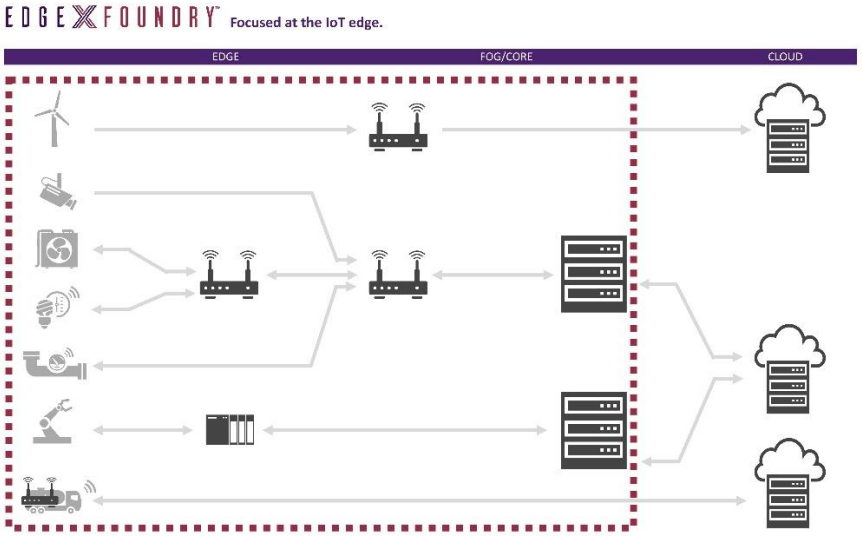
FIGURE 2: THE IIOT EDGE



Source: EdgeX Foundry

The goal was ambitious from the beginning. Attempting to satisfy all these needs—including gaining consensus across the industry—complicated the design tremendously. It meant support of any microprocessor architecture, operating system, and development environment. IIoT architectures are still in flux, so the design had to comprehend the flexibility to support future IoT standards, connectivity stacks, and technologies. IIoT database and software models are evolving as well, so the capability of running anywhere in the IoT fog in a tiered model, potentially even in the cloud, had to be supported. Finally, it takes many different "pieces" to construct IIoT designs, so supporting the partner ecosystem (*i.e.*, allowing open source or proprietary extensions such as analytics, security, system management, connectivity, and usability to simply and easily be "plugged in") was critical to the successful adoption of this architecture.

INTRODUCING EDGEX FOUNDRY

In April 2017, the EdgeX Foundry Project was launched under the Linux Foundation. The initiative is aligned around a common goal: the simplification and standardization of the foundation for edge computing architectures in the Industrial IoT market, while still allowing the ecosystem to add significant value. The core of the new project is over 125,000 lines of code donated by Dell, developed with feedback from its partners, customers, and even competitors. The EdgeX project has already garnered a broad membership base of IIoT supporting companies (both large and small) that is continuing the development of the architecture and code base.

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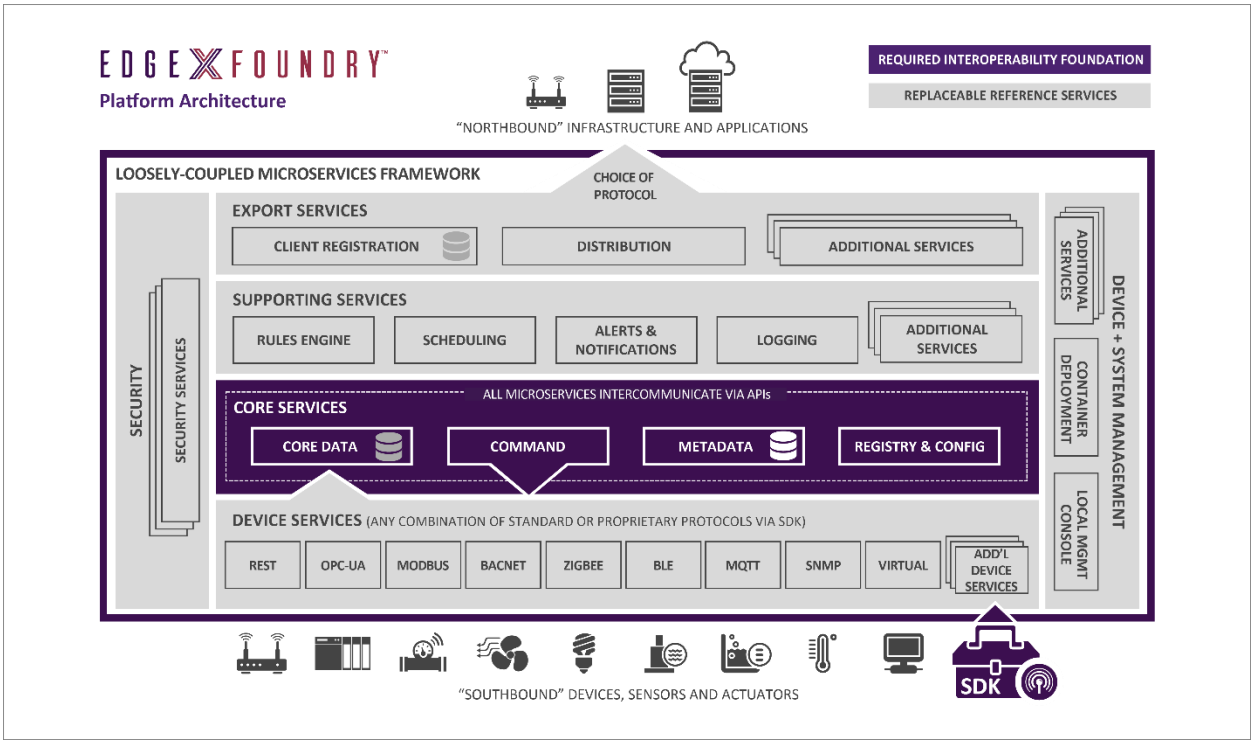
FIGURE 3: THE EDGEX FOUNDRY PROJECT ARCHITECTURE



Source: EdgeX Foundry

Key tenets for the EdgeX Foundry Project include:

- Provide a flexible microservices architecture that can support the use of any combination of heterogeneous ingredients plugged into a common interoperability foundation
- Be agnostic to hardware CPU (*e.g.*, x86, ARM), OS (*e.g.*, Linux, Windows, Mac OS), and application environment (*e.g.*, Java, JavaScript, Python, Go Lang, C/C++) to support customer preferences for differentiation
- Allow services to scale up and down based on device capability and use case
- Enable support for any combination of device interfaces to normalize connectivity protocols (both existing standards and proprietary) into a common API
- Allow functionality to be distributed across multiple edge hardware nodes (Figure 4) or across processors within a given node
- Enable reference microservices (*e.g.*, northbound message bus, rules engine, database) to be quickly replaced with a preferred open source or proprietary alternative

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- Support best-in-class industrial-grade security, manageability, performance, and reliability while still maintaining extensibility
- Support drop-in replacements of microservices or entire subsections with more performant versions without requiring architectural changes (*e.g.*, enabling a developer to replace a Java-based microservice with one written in Go Lang while not having to replace the entire solution)
- Allow for additional community improvements that enable performance metrics (*e.g.*, to support hard real-time operation)

The EdgeX Foundry code base is intended to provide a full edge software platform (reference design) comprised of an interoperability foundation (required set of core microservices) plus a set of optional reference microservices. This architecture allows designers the option of implementing the core platform “as is” or the ability to replace the optional reference services with preferred alternatives or services that provide specific value for their solution.

At a high level, the **required** interoperability foundation is comprised of the following elements:

- **Core Services**: A collection of microservices that ensures interoperability between Device Services and surrounding services through common APIs
- **Device Service SDK**: Defines common means to create interoperable application-level device interfaces using preferred connectivity protocols (both existing and new open standards as well as proprietary)
- **Deployment Framework**: Establishes the rules for how services are deployed (*e.g.*, Docker, Snaps, VMs) and intercommunicate (*e.g.*, REST, MQTT)
- **System Management and Security Reference Implementation**: Establishes APIs and reference implementation for system management and security as a foundation for community-developed value add

Key to the EdgeX Foundry Project is a planned certification program to be hosted by the Linux Foundation. While anyone can take the Apache 2.0-licensed code base and create their own instantiation of a full edge platform or value-added microservice, the power in EdgeX Foundry is overall system compatibility. Certification and logo usage will be maintained by the EdgeX Foundry Project. To use the EdgeX trademark, vendors must have the Project certify any commercial value-add they build with the core framework to validate that the core APIs were followed. This certification will provide customers and partners the assurance that they are interoperable with other providers and that they have an open, secure, and trusted foundation at the core of their solution.

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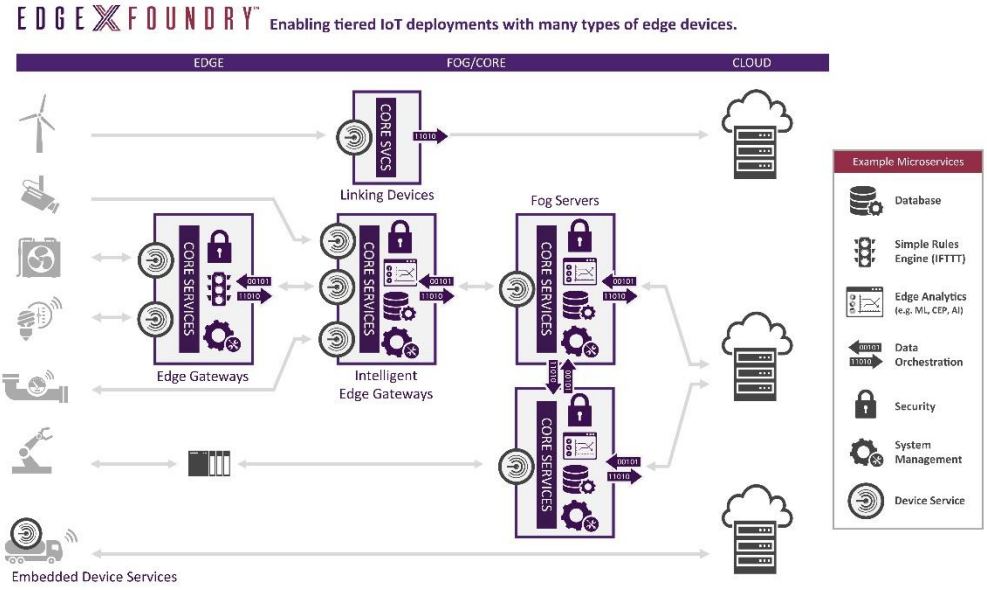
FIGURE 4: TIERED DEPLOYMENT OF EDGEX FOUNDRY



Source: EdgeX Foundry

MI&S believes the required EdgeX platform foundation provides key benefits to the IoT ecosystem:

1. Vendors of all sizes and types can still design and sell differentiated products focused on their intellectual property and simply "plug-in" to the existing framework
2. IIoT customers can safely mix and match plug-compatible vendors based on the exact needs of their system designs

WHAT'S IN IT FOR THE EDGEX FOUNDRY PROJECT MEMBERS?

As shown by the initial member list, MI&S believes there is strong incentive for vendors to join and / or provide compatibility with the EdgeX architecture.

VALUE-ADDED SOFTWARE / IOT PLATFORM VENDORS

The discussion of IoT platforms is often the most difficult one for real-world IIoT solution implementations. While many individual open source IoT-enabling software components already exist, there is no fully integrated, highly extensible open source platform foundation for edge and fog computing. Given the wide number of both standard and custom protocols and connectivity methods, the market is rife with implementations that are highly customized, not allowing vendors or enterprises to gain the benefit of scale.

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Commercial companies like ClearBlade, Foghorn, and SAP have developed complete end-to-end IIoT solutions, but there is a need for an industry-wide open source framework that drives interoperability. The EdgeX Foundry platform framework provides a single core structure, allowing IoT software vendors to focus on differentiated applications and services, rather than reinvention, often in factors outside their area of expertise. Further, the EdgeX project has already spawned new companies with complementary offerings. IOTech, for example, is a vendor-neutral Operational Technology (OT) specialist provider committed to contributing to the baseline open source framework while offering commercially supported subscriptions that adhere to the foundational architecture.

Security Providers

Holistic security, from edge devices to gateways to cloud, is one of the most critical aspects of IIoT systems. Since the beginning of conversations surrounding IoT, the need to secure the entire system has been the beneficiary of a tremendous amount of discussion. Many of the current organizations, including the Industrial Internet Consortium have not only focused on security but also recommended frameworks. Key to the EdgeX Foundry and participating security vendors such as ForgeRock and Mocana is that the EdgeX platform provides a consistent baseline to implement security that ensures the safety and reliability of systems. The platform implements a holistic security model as part of its core framework, embedding the comprehension of security from the beginning of the design while also allowing vendors to provide value via plug-ins. MI&S believes this forced comprehension of a security solution provides EdgeX Foundry users with a safer, more secure design.

Silicon, Hardware, & Operating System (OS) Vendors

Silicon, hardware, and OS vendors such as AMD, Analog Devices, Canonical, Dell, and Opto22 will be better able to:

- Provide solutions that focus on their specific value and differentiation rather than having to comprehend areas outside of their expertise or control
- Standardize on an abstraction via open source software, reducing their design costs and increasing scale
- Plug into a ready-made partner ecosystem already providing analytics-driven value and a robust security and management foundation that also creates pull for their own related assets

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SERVICES PROVIDERS

System integrators (SIs) such as Mobiliya already provide services to stitch together the fabric of IIoT solutions. By being able to choose from a broad ecosystem of EdgeX-certified plug-and-play devices, SIs will be able to help customers implement IIoT solutions and integrate them into their OT and IT systems faster, knowing they will interoperate securely.

WHAT'S IN IT FOR THE INDUSTRY?

MI&S believes the IIoT industry will benefit greatly from implementation of the open, vendor-neutral EdgeX Foundry platform architecture. Currently, designs require significant customization and offer no guarantee of re-use moving forward. The EdgeX Foundry Project will allow enterprise IoT applications to choose from many best-in-class software, hardware, and services providers based on their specific needs. The open source architecture will allow operations customers the ability to:

- Standardize on a single overall interoperability foundation across the edge of the IoT solution stack, reducing support costs and increasing security through a predictable baseline
- Remove risk and fear associated with potentially making the wrong choice and being locked into a single solution or tool chain
- Choose from a wide range of vendors and system integrators based on their specific needs, knowing that the overall system will function. This simplified build vs. buy analysis allows them to focus on true value.
- Know the architecture will scale based on both current and future needs of their systems

CALL TO ACTION

The Industrial Internet of Things encompasses a vast array of different use cases and market places. Moor Insights & Strategy believes one of the key factors holding back designs in the enterprise is the perception that there are too many choices to safely and easily implement an IIoT system that will provide a return on investment in a reasonable timeframe.

MI&S believes the EdgeX Foundry Project fundamentally changes the dynamics of the market. For operations customers, it provides an architectural framework based on open source tools enabling best-in-breed vendors, both large and small, to implement

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plug and play solutions that are highly tailored for their application—with security built in. For vendors, it simplifies their focus to do what they do best: simplifying connectivity without reinventing standards and allowing them to plug into the system simply and easily, minimizing customization for every design. For the IIoT marketplace, MI&S recommends that both vendors of IIoT solutions, including hardware, software, and devices, as well as those implementing industrial applications, look to the EdgeX Foundry Project within the Linux Foundation as a source of compatibility solutions for their future implementations.

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