# IIoT and the keys to actualizing the decentralized energy revolution

*Potential applications of distributed systems and the critical nature of interoperability in a modern, decentralized grid*

Specialist Consultants
to the Electricity Industry

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# About the author

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John Camilleri is a Principal Architect with PSC in North America. Over the last 25 years, he's had in-depth experiences in the evolution of renewables, distributed generation, microgrids and developing real-time systems to manage them. John has a Master of Science degree in Electrical Engineering and enjoys developing and leveraging new technologies to optimize the electrical grid.

# Introduction

## Innovations in power generation, storage, and transmission technologies are forcing a shift away from centralized power generation towards a distributed, decentralized model.

Utility operations are presented with new challenges related to security and controls; how they respond will shape the future of the decentralized energy landscape. This eBook investigates the potential applications of distributed systems, as well as the role of interoperability in actualizing the decentralized energy revolution.

Growing penetration of renewable devices and inverter-based controls are driving a need for intelligence at the grid edge. Active management will be required to fully leverage the distributed power technology of the future, with increased telemetry data and low latency coordination between devices, enabling bi-directional power flow.

# Grid edge and distributed systems

## Apps at the edge

The *grid edge* refers to the electrical distribution network down to devices in the field and represents a wide array of technologies and operational requirements. Today, the edge includes a growing number of software applications supporting various functions – think of mobile apps for the power grid, and you will see we are on the precipice of a revolution.

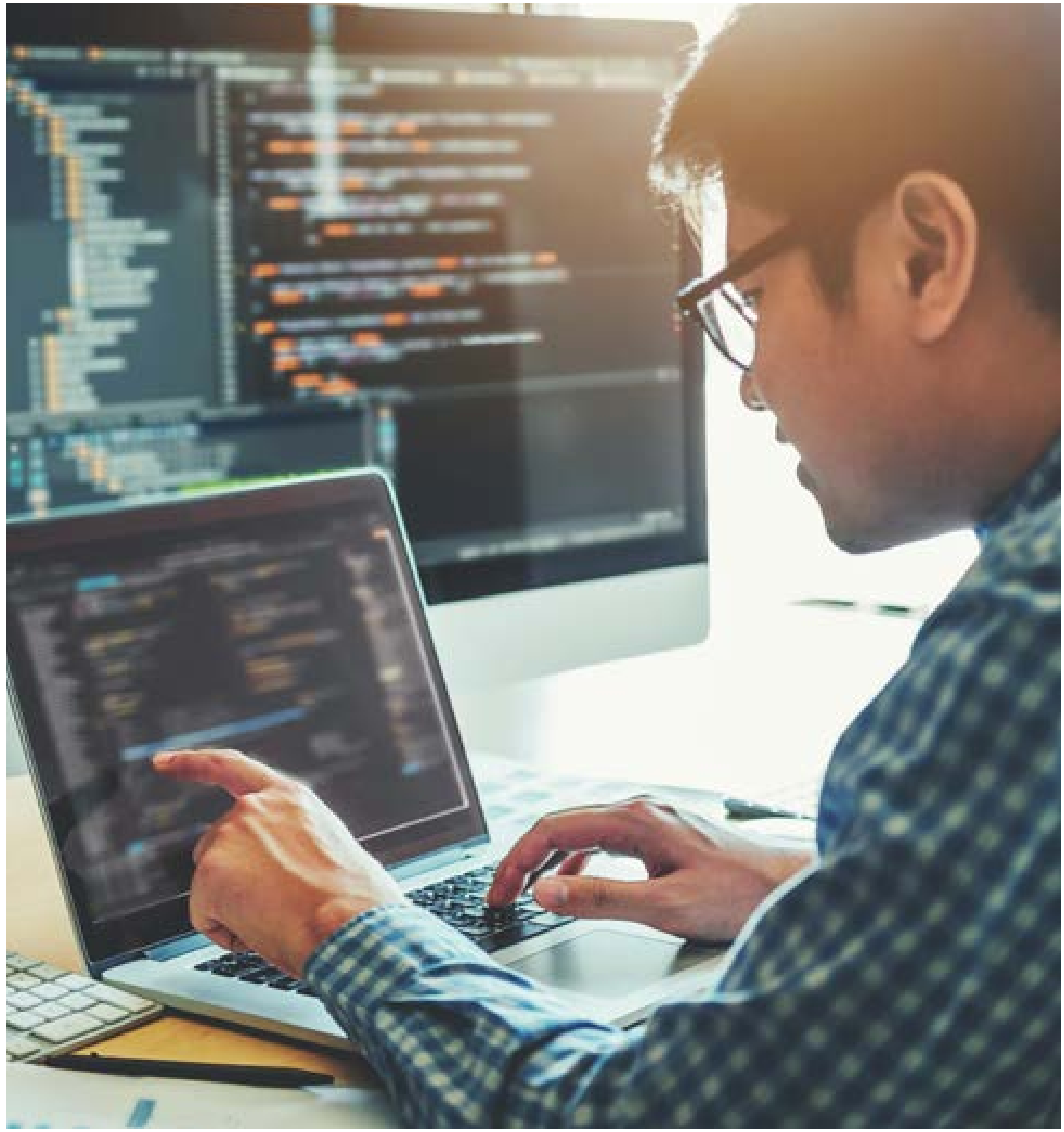
Intelligence at the edge spans the range of simple to complex functions that can optimize and analyze data and perform command and control. This is the role of the app. With the deployment of more advanced devices such as battery management systems, controllable loads, and non-dispatchable generation, coordination and optimization of these resources in the field are critical to achieving the balance of analytics in a centralized operation center vs. real-time telemetry and control in the field.

## Advantages and challenges of decentralization

With a centralized solution, the volume of data being collected produces latencies that are not conducive for implementing certain levels of control and operation in the field. Security in centralized systems may be more familiar, but it does not necessarily offer more security than a distributed system. Data in motion, from the field, still needs to be secured. The endpoint, where the data is collected, is typically a difficult-to-secure IT device in a centralized deployment scheme. Access control for such endpoints is typically generalized for a team to work on without specific identities being enforced. Endpoint devices have rudimentary authorization models – if they exist at all.

Forcing a distributed approach is an opportunity to drive better security controls and conform to modern best practices for both cyber and physical security. Clearly, there are security controls and processes that can and should be implemented. In general, the utility operations IT environment is running on borrowed time regarding cybersecurity measures in the field.

Distributed systems come with a host of challenges. The sheer number of instances increases the administrative requirements for deployments and updates. Securing these distributed services requires a systematic approach. The drive for distributed systems pushes the level of interoperability between systems, plug and integrate approaches, and rethinking the application space.



## A modern grid recognizes all stakeholders

Although distributed systems present their own challenges, there is an opportunity to leverage modern software deployment and management approaches to create a significant advancement that will enable the general public to be part of the decentralized energy revolution. Kickstarting the market by articulating business value and finding the right nexus of industry players is the key business challenge.

# Real world applications of a distributed system

## Distributed power system applications

Distributed systems in the energy space can be applied to serve many objectives. The following list provides some potential applications.

- ✓ **Transactive energy:** Requires machine-to-machine interaction between two business entities to execute a transaction.
- ✓ **Microgrids:** Opportunity to provide in-field analytics and distributed control functions.
- ✓ **Renewables:** Support the data collection of customer side renewable deployments that support utility operational insight.
- ✓ **Better use of capital assets:** In-field optimization of assets for better performance and utilization or simply enabling fine-grain control.
- ✓ **Multi-vendor solutions:** Create an interoperability nexus by allowing multi-vendor solutions.
- ✓ **Enabling competition:** Innovation by allowing open access to data and the ability to tackle smaller-scoped problems.
- ✓ **On-premises energy management solutions:** Support optimal control of on-premises energy resources and loads based on global control directives
- ✓ **Predictive maintenance:** AI applied in the field to detect anomalies and report back

It is important to note that with a distributed system approach, incremental rollouts reduce complexity and cost. Even more important is the ability to stack the benefits once you have the interoperability platform in place.

## IIoT considerations for a distributed approach

*Industrial Internet of Things* (IIoT) platforms are becoming available to achieve some of these goals. As with any system design, evaluating the requirements is complicated and worth the investment if you tie those requirements to testing and verifiable customer needs. When considering these types of platforms, you should consider this as evolving technology so future requirements tend to be fuzzy. This may lead you to one of the key design principles, "minimal functionality," to ensure the solution is not over-engineered.

The above application of IIoT deserves some consideration. Various architectures can be applied to each application area. With distributed architectures, you need to consider several things at first:

1. **Workload:** Where do you want the compute power to be and why?
2. **Communications:** What are the latency and bandwidth requirements?
3. **Management:** How will you manage the distributed devices remotely?
4. **Security:** What security vulnerabilities does the system have and what is the threat model?

> *"When considering these types of platforms, you should consider this as evolving technology so future requirements tend to be fuzzy."*

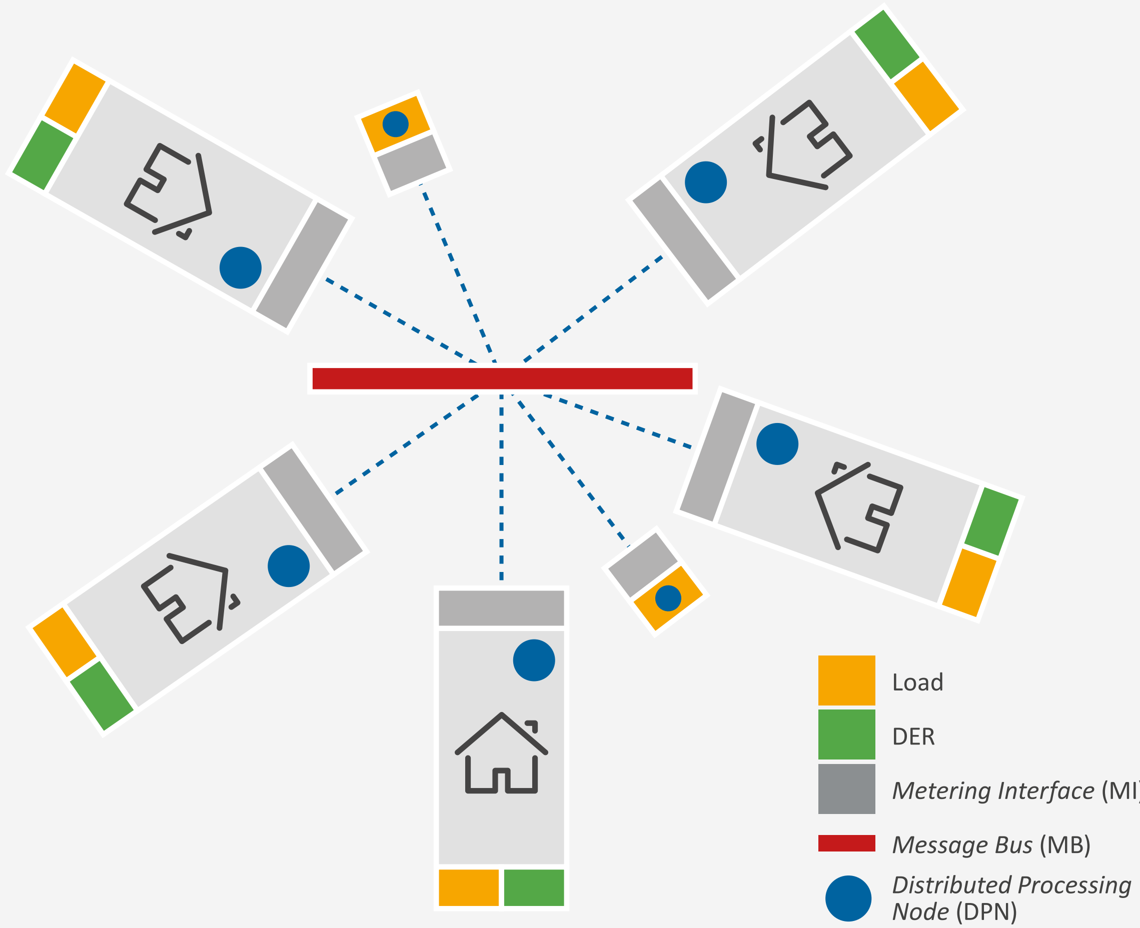
## Hypothetical IIoT architecture

The following notional architecture demonstrates a distributed approach for transactive energy.

In this diagram, residential homes have their own DER and Load. A *Distributed Processing Node* (DPN) that may be integrated into a smart meter provides monitoring (and control) of each resource and communicates on the message bus for pricing signals to ramp up or ramp down. The DPN acts as a mini-control aggregator. The price signals submitted by other residential or commercial DPNs in the location, including devices like community energy storage, residential community solar or charging stations are consumed by each peer.

Once the infrastructure for communication and processing is in place, the logic performing business rules can be updated over-the-air like your cell phone. Layered applications can then be distributed to support other functions as needed to meet the customer requirements. Landis+Gyr's developer studio is one example of this approach.

***Notional Architecture for Transactive Energy***



# Interoperability in a decentralized grid

## Interoperability will bring us closer to the grid edge

The current power industry vendor landscape evolved to provide vertically integrated utility solutions. There is a need for some siloing around the purchasing of physical assets due to procurement and risk management issues. The recent Executive Order on US Bulk-Power System highlights another risk that utilities must manage while still striving for interoperability. The obvious challenge is that when a utility chooses a hardware vendor for field devices all the way down to the communication layer, they have to be mindful of the software interoperability and manageability over time since hardware and software have different lifecycles.

Software in the electric utility industry has not traditionally provided open, unfettered access to data. But ultimately, accessing the data and acting upon it in a timely manner is paramount to being able to innovate and provide new solutions at the grid's edge.

## Economic drivers

In the commercial space, economic drivers push solutions to reduce cost and provide more benefit. The emergence of IIoT in the medical and vehicle solution space is moving fast, driven by single-vendor holistic solutions. Interoperability can be limited, considering these solutions are initially being driven by those who own or manufacture assets and the software that controls them. Standardization is a common approach to harmonizing solutions. As a technological society, we have learned some lessons around interoperability and the economic value it can provide. Entire markets are now supported by platforms-as-a-service like Microsoft's Azure IoT or Amazon's AWS IoT solutions. These vendors may push their own special sauce but work behind the scenes to develop industry standards that will enable the upper levels of the application stack to work seamlessly across various hardware platforms.

## Interoperability standardization

Standards in the power industry have attempted to provide system, syntactic and structural level interoperability. Many of the common protocols such as Modbus, IEEE 1815 (DNP3), or IEC 61850 go a long way to provide interoperability between a control system and the field device, which was the original intent. IEC 61850 was a vast improvement over Modbus and DNP3 regarding the definition of a common model and has been widely accepted for use in Europe and other countries outside the US for substation automation. IEC 61970 (CIM) provides a power system model for equipment and energy data. These are all important steps for interoperability. Efforts to add enhancements and address specifics of renewables and security are ongoing.

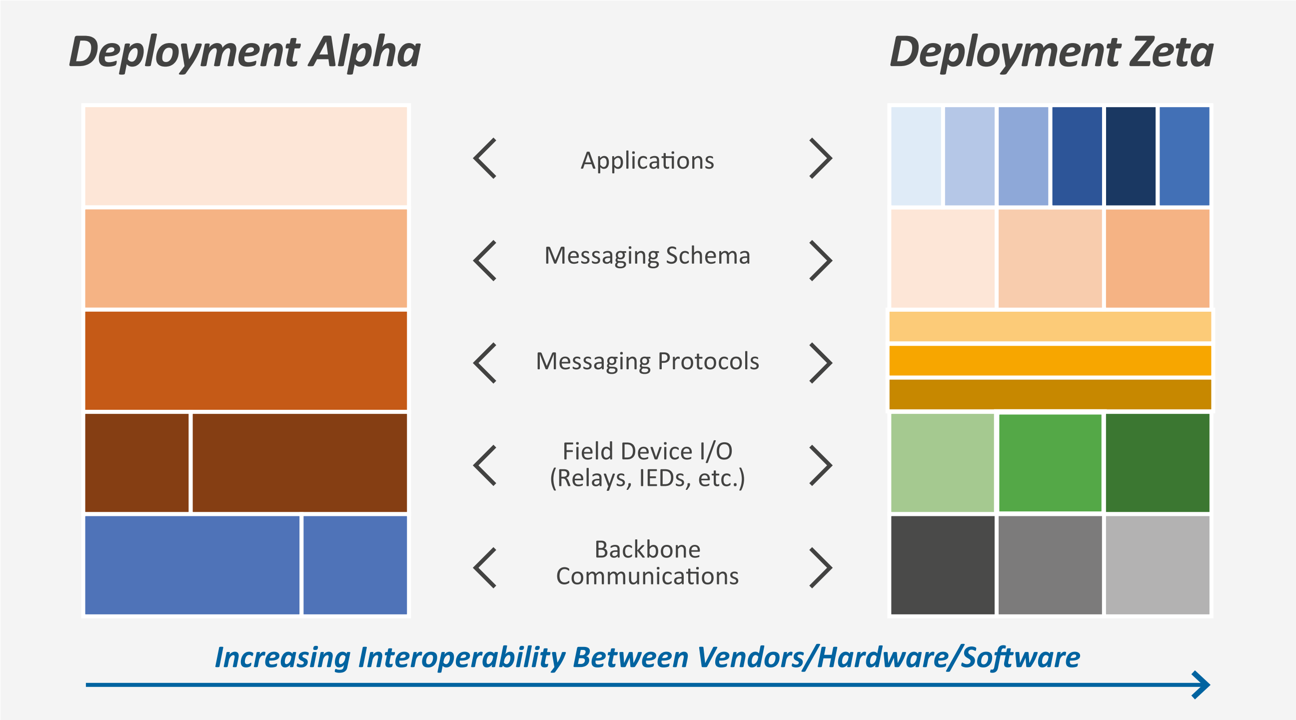
There are new initiatives in the electrical industry such as the North American Electric Standards Board (NAESB) RMQ.26 Open Field Message Bus (OpenFMB (https://openfmb.ucaiug.org/) standard. Supporters of this standard are looking to push interoperability between systems through a common data model and business processes intended to develop vendor-neutral communication based on publish/subscribe technologies.

Moving data from the endpoint device into OpenFMB is currently the focus of groups like UCA International User Group. Supporters of OpenFMB attempt to take the efforts from the previous standards in defining a common model to drive a simpler model of operational data exchange between systems. They target a distributed approach, where appropriate, with the goal of supporting interoperability between multi-vendor systems in the field.

Standardization of these schemas is the real challenge and may be swapped with a de-facto standard schema that the industry or large companies push. Consider the case of word processing, where the de-facto binary format of text documents is Microsoft's DOC format. Since standards bodies typically move slow, this may not be a bad resolution – as it places the burden of managing the schema versioning onto stronger distributed software platforms

## Vendor flexibility

There is clearly a balance between open standards that support interoperability between vendors, and proprietary systems. Competition and necessity eventually push the needle in these areas. As an example, consider two distributed platforms deployed into an electric distribution system. In figure 1, deployment alpha illustrates a highly proprietary stack while deployment zeta illustrates a highly modular stack leveraging interoperability between vendor systems encompassing both hardware and software.




There are a number of solutions available in the market today around intelligent switching, voltage conservation, and others. Of course, there are exceptions to how much of the stack these vendor solutions own – but each solution has significant control over how the layers interoperate. This may provide a solution that is more cost-effective or customizable for the customer in the near term. As soon as you start to decompose the layers the need for industry standards and interoperability between vendors becomes a hard requirement. For example, if you want multiple applications to run at the top of the stack, and you want to use different vendors for those applications, field devices, and communication backbone components, then interoperability is imperative.

To put this into perspective, consider that communication and physical devices in the field demand a very large and long-term capital investment. The ability to leverage these layers for multiple use cases becomes a critical economic factor in the planning of large CapEx projects. Another consideration is the ability to localize a solution. In other words, you may want to focus on various voltage management solutions at one group of substations and support other power quality-monitoring and control functions at another group of substations. The applications may be from different vendors driving best-in-class solutions and all leveraging the underlying communication and field devices from one or more vendors. Clearly, this lowers the procurement risks associated with a single vendor, increases competition, and drives new solutions.

## Semantic interoperability

Two types of interoperability are syntactic and semantic. Syntactic interoperability is where two systems can exchange a common data format. But, for example, if a control system talks to an energy storage system (ESS), the systems are unable to determine how each other functions or how to interact together from the data model. The context of the ESS is built up by humans. Syntactic interoperability allows systems to integrate.

Semantic interoperability allows the control system to identify the communicating device as an ESS and detect what functions it can perform. A key requirement of distributed systems is the ability for the machines to have semantic interoperability, allowing distributed functions to react to new devices and capabilities without direct human intervention. Otherwise, these distributed systems become very brittle due to the human management process required to integrate.

*"Semantic interoperability allows the control system to identify the communicating device as an ESS and detect what functions it can perform."*

# Conclusion

## In summary, technology is not an impediment to energy IIoT solutions.

As end consumers gain visibility and establish a voice in defining the potential value of the distributed intelligence approach, progress will occur driven by true economic pressure. The diversity and prevalence of interoperating components is increasing on the grid edge. The ability to share and fully utilize data between components is necessary for their intelligent management. Advancing interoperability and open interoperable standards will help systems work smarter and more efficiently and ensure that today's technology can interface with future technologies.

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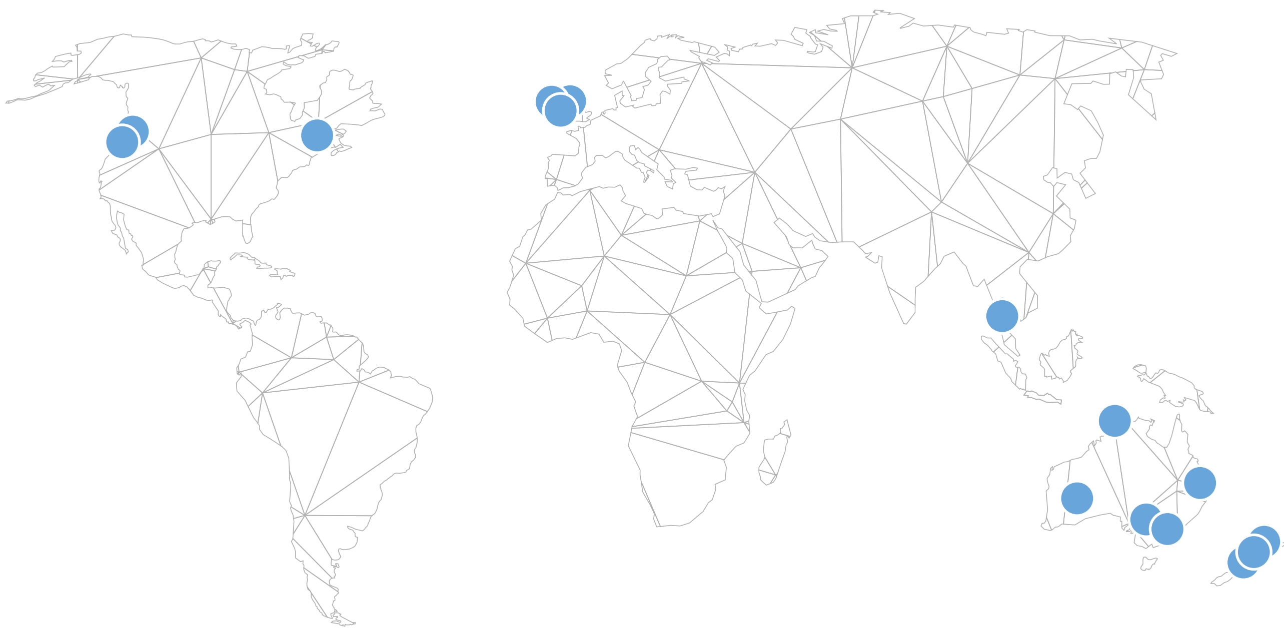

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