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WHITE PAPER

Convergence:

Enabling Intelligence at the Edge

January 2016

THIRD-ORDER CONVERGENCE AND THE INTERNET OF SMART THINGS

The early 21st Century has seen the rise of three important technologies: the cloud, smart devices, and mobile applications. Together, they herald a new age of remote intelligent nodes that not only communicate with each other but analyze high volumes of local real-time data to make collaborative autonomous decisions. It is not the power of the individual technologies that makes this shift possible, but the convergence of all three—a particular combination that enables true intelligence at the edge. This convergence is blurring the boundaries between information technology (IT) and operational technology (OT) disciplines, as the software and applications that manage information processing are no longer entirely distinct from the sensors and equipment related to physical value creation.

DEVICE CONVERGENCE: A TAXONOMY

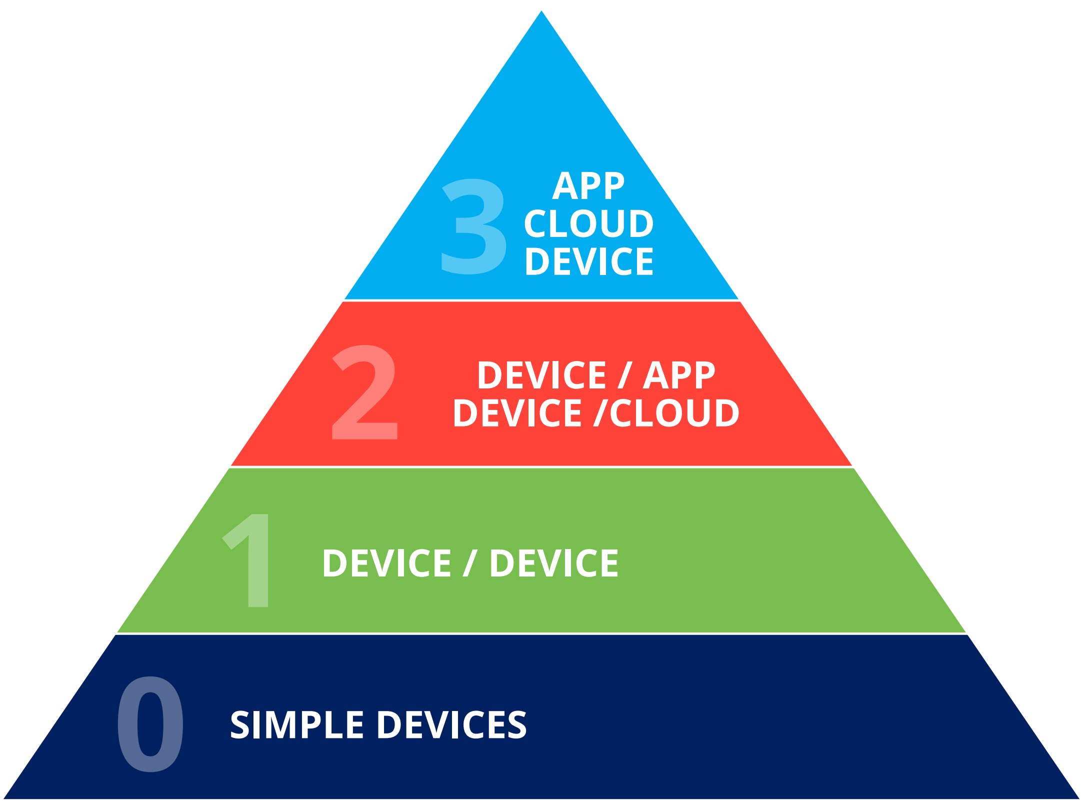
In the beginning, there were stand-alone, single-purpose devices: the traditional electric utility meter, a telephone on an analog line, a remote sensor on a wire, and so on. These specialized devices existed in a world where technicians read numbers from a meter, recorded them in a logbook or on a clipboard, and used the information to make operational decisions and adjustments.

Dedicated, single-purpose devices are giving way to smart, adaptive devices that virtualize capabilities using a platform or API, collect and analyze data, and make their own decisions. This evolution toward true distributed intelligence can be marked by simpler types of convergence that remain important for a variety of applications today.

Converged Devices

It was the convergence of communications-awareness into monitoring equipment that began to make the Machine-to-Machine (M2M) revolution possible and started providing centralized management capability. The integration of network devices with sensors untethered fixed asset management from copper wire, providing rudimentary machine-to-machine communication over private radio and wired or wireless networks.

In the industrial M2M space, one important device convergence is the integration of multiple radios in one wireless device or cellular router to provide seamless connectivity on multiple networks. This allows the device to maintain connectivity while traveling between cell coverage areas served by multiple carriers or to bridge different wireless network types providing new levels of redundancy.



Connected Devices

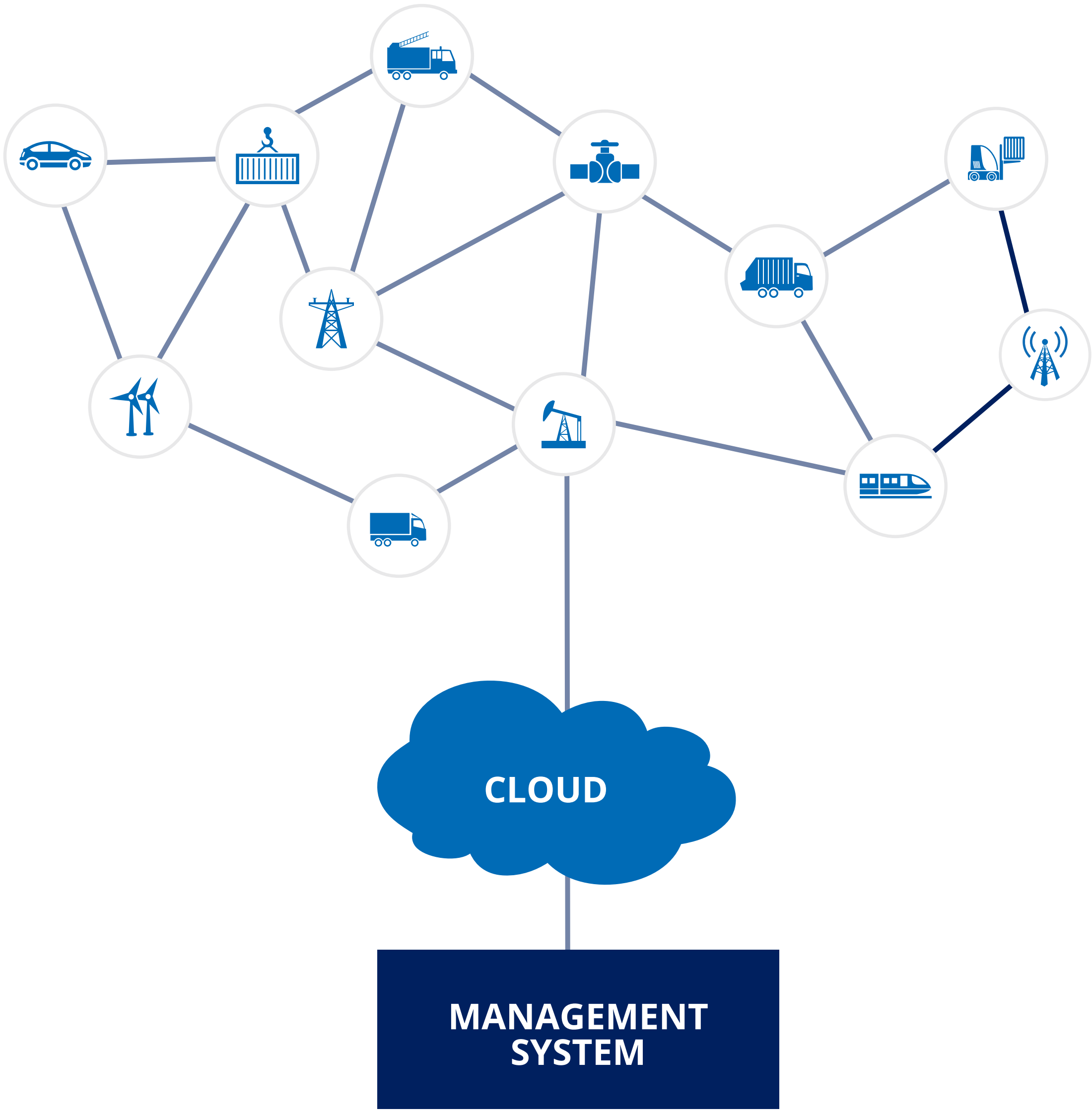
As distinct from modems, routers, and other devices that simply provide connections, a connected device is itself accessible and controllable over IP-based networks. Connected devices make status, health, and other data accessible to a management application hosted in the cloud or on premises at the enterprise. Reports and other information in the application help decision-makers determine which actions to take based on the data.

The emergence of the cloud and the proliferation of connected devices paved the way for the first phase of the Internet of Things (IoT). Formerly stand-alone devices are now connected to external applications that can read information from them and in some cases control them. Making the devices themselves intelligent is not always a priority; it's often enough to have simple remote control, performed by a central application or human operator.

Smart Devices

Simple automation mechanisms have gradually given way to devices that can run decision-making applications themselves. In M2M, smart devices with rudimentary communication ability provide basic remote monitoring and control capabilities and can report information or send alerts when human intervention is necessary. These smart devices can be attached to infrastructure and equipment—from utility poles to vehicles to water treatment plants to vending machines—to enable a central management system to gain information about the status of all assets.

These smart devices don't communicate with each other, nor do they process much data. Although they are connected to networks, often using IP-based protocols, they are not truly cloud-connected and don't expose APIs that virtualize tangible equipment. However, they include many of the building blocks that have made truly connected smart devices possible.



Third-Order Convergence: Smart Connected Devices

Advances in low-power computing and networking are pulling intelligence from the cloud to the edge of the network in the form of smart, connected devices. These devices can host single or multiple applications, make autonomous decisions, and share resources and information with each other. Business decisions are faster because it is no longer necessary to wait for a response from a central management application or operator.

Multiple smart devices can make collaborative decisions based on large volumes of real-time data. This model, known as fog computing, is not a replacement for the cloud, but a complement to it; as data is processed and decisions are made at the edge, pertinent information is backhauled to the cloud for further manipulation. Smart, connected devices act together not just as discrete units but as virtual nodes of a distributed intelligence platform.

In the past, most information culled from sensors or devices was simply discarded. Now, with cooperation between the cloud and the fog, data processed at the edge becomes valuable business intelligence. Transmitting only the interesting information that results from local data processing not only means more efficient use of bandwidth but the capability to collect and analyze much higher volumes of data. This in turn makes even legacy central management systems more effective as the quality of information available is increased by processing at the edge.

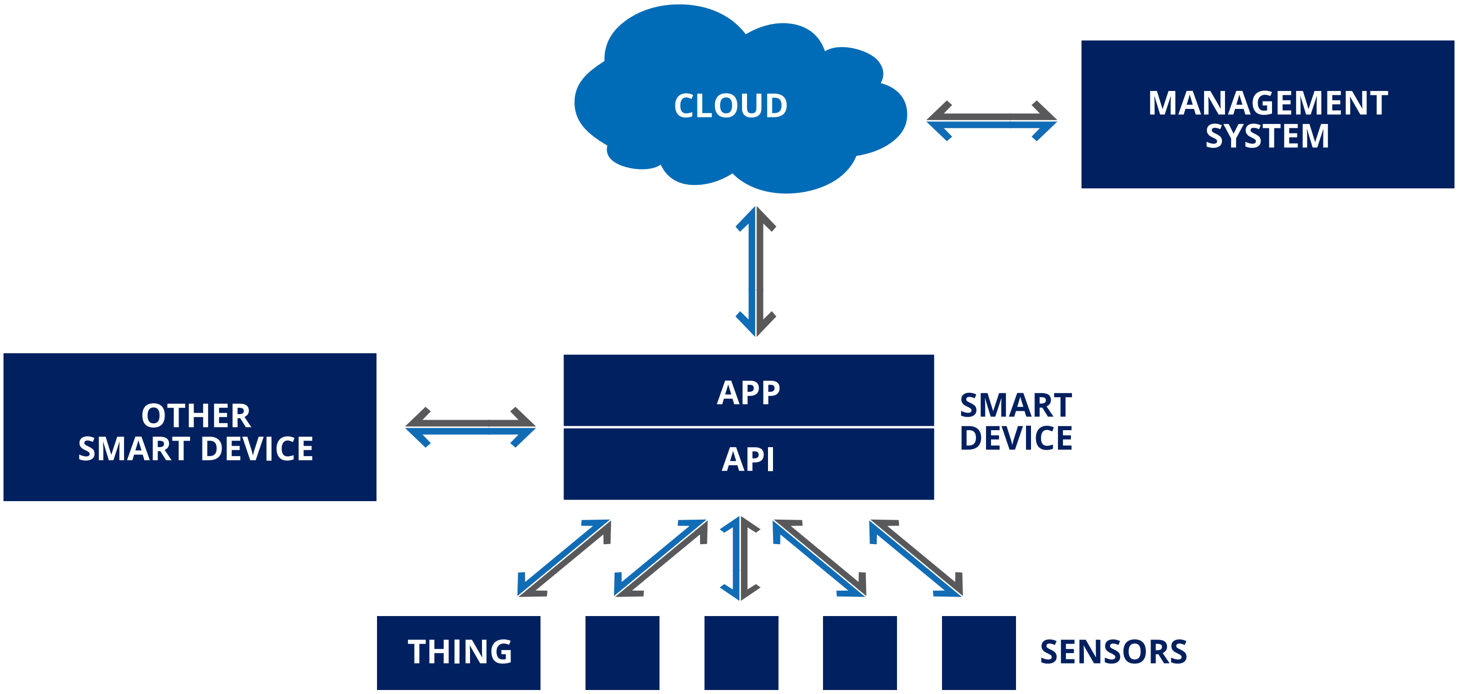
The trend toward intelligence at the edge mirrors some of the shifts that are happening in other big data domains, where the amount of data becomes so large that it can't be moved easily, and the application must be moved to the data instead. This distributed intelligence can reside not just on endpoints, but on switches, routers, gateways, modems, and other components.

THE POWER OF THIRD-ORDER CONVERGENCE

The benefits of always-on, intelligent, cloud-connected devices are enormous. Unlike M2M deployments, which use a network to transmit raw data, a distributed intelligence platform manages an economy of valuable information and insight produced from data as a raw material. Smart devices transmit data more securely and are more adaptable to new functions and applications as opportunities or challenges arise.

Greater Responsiveness

By eliminating the need to get a response from a centralized management system, autonomous decision-making at the edge greatly increases responsiveness in time-sensitive applications. As a bonus, reducing the amount of data transmitted by individual devices can lower network traffic, thereby reducing overall network latency. This is especially beneficial in environments where bandwidth is expensive or constrained, or where data must travel long distances.

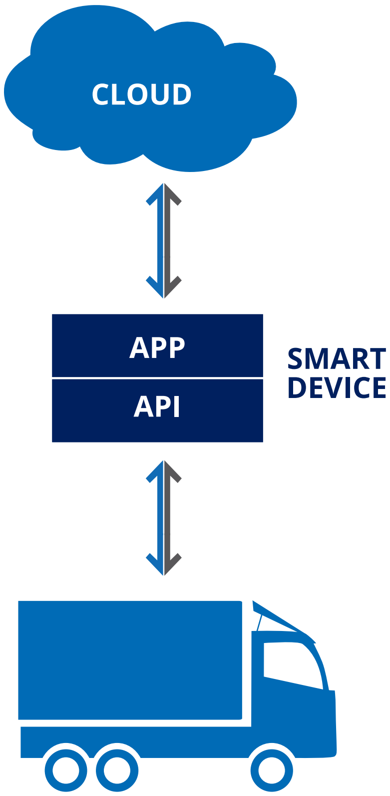


Lower Total Cost of Ownership

Processing more data at the edge can also extend the life of an existing central management system that would otherwise be swamped in massive volumes of data. By virtualizing other legacy equipment, convergent solutions can ameliorate or delay capital expenditures on facility modernization. Because of the flexibility of intelligent devices and applications, upgrades and expansions can often be undertaken incrementally.

Scalability

Distributed intelligence systems can process far greater volumes of data at the edge than any centralized system. In fact, distributed systems scale horizontally: twice as much data can be processed at twice the cost, rather than the exponential cost curve of scaling a single system. More data means better predictive analysis and smarter business decisions.



CONVERGENT SOLUTION ARCHITECTURE

Like traditional M2M solutions, convergent architecture uses sensors, connected to network communication devices, sending data to a central application. In some ways, despite the significant qualitative and scale shifts, convergent solutions need not become forbiddingly complex.

The movement of intelligence to the edge means that the amount of data that can be processed by the system grows by orders of magnitude. Instead of one temperature sensor, for example, a deployment might use ten, or one hundred or more, to gain more comprehensive intelligence about the temperature topography of an operating environment.

Platforms, APIs, and emerging standards that enable interoperability among components and systems from disparate manufacturers make it possible to virtualize nearly everything, making the real world controllable directly from applications, whether on the device or on the cloud.

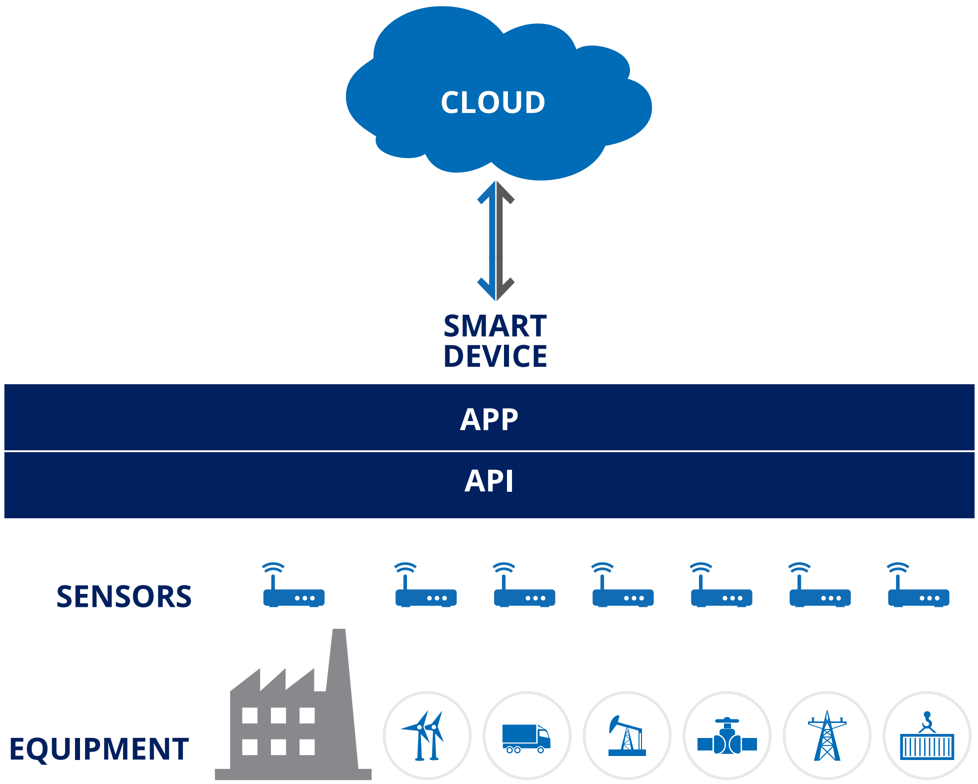
Virtualization of Equipment

Powerful, compact processors have made intelligence portable to the edge of the network by spawning smart, programmable devices at a reasonable cost. At the same time, M2M frameworks have grown to accommodate larger and larger numbers of devices.

A Linux-based cellular router with serial capability (RS-232 via PAD mode) can be programmed to communicate with a specific piece of legacy equipment, effectively virtualizing the equipment by making it available in the digital realm. An application on the router can read status information from the equipment, process the data, make informed decisions in real time, and control the equipment to respond to changing status, health or environmental factors.

Because the application on the router takes action independently, there is no need to backhaul the entire set of data to a central management application. Instead, the router makes the pertinent information available to the cloud or to an enterprise application, and can provide an API for requesting specific pieces of data when additional detail is required.

Many intelligent routers offer varying levels of programmability, from basic threshold-response capability to full Linux development. For example, CalAmp ODP (Open Developer Platform) offers control of serial and I/O ports on a device, access to the device GPS and modem, and direct access to the TCP/IP stack using C/C++, Java, and Linux shell scripts.



Device Interoperability

A distributed intelligence platform must provide not only interoperability between known devices, but the capability to communicate with any device that might be part of the deployment. In the future, communication standards may emerge for physical devices as they have for local and wide area networking. Until then, the key to interoperability is *abstraction*—hiding the unnecessary details of managing a physical object, network or system and exposing only the desired functional properties and information via an API (application programming interface).

Abstraction is a familiar concept to anyone who remembers when connecting to the Internet meant sending codes to initialize a modem, open a connection, and so on. Connection management has largely been abstracted away from the user. All that remains is a "Connect" button that sets in motion all the negotiation that must take place behind the scenes to manage a connection to a chosen network.

When devices are abstracted from each other via APIs, they don't need to know about each other's complex operations. One device can essentially push a specific button on another to achieve a desired result. Even better, the device behind the API can be replaced transparently. As long as the API works the same way, it doesn't matter what physical or virtual object is responding behind the scenes.

Always-on connectivity

To communicate with each other, with the cloud, and with any enterprise applications, devices must be connected using wired or wireless IP communications. The adoption of IPv6 accommodates enough IP addresses to address the billions of connected devices that are coming online.

Legacy equipment can be connected to the Internet using Wi-Fi or cellular gateways that bridge IP communication to public radio, private cellular, serial, or other technologies. These connections rely on partnerships between gateway manufacturers and carriers that can handle a lighter but more dispersed network with large numbers of smart devices.

Applications at the Edge

The real power of distributed intelligence comes from embedded applications that can collect, aggregate and analyze data, make decisions, and take actions. These applications must be smart enough to do more than respond to a sensor value crossing a threshold, and they must run on devices with sufficient processing power, all the appropriate communications protocols and capabilities, including the physical durability for the environment in which they're deployed. Applications can be created by in-house development teams, solutions developers, or third-parties to optimize performance for unique environments.

CONCLUSION

While traditional architectures are still valuable today, smart connected devices have ushered in a new way of thinking about interaction with the physical world. While the full potential continues to unfold, it is possible even now to create distributed intelligence at the edge of nearly any networkable site, fleet, or physical plant to drive business decisions with real-time data.

Because of the flexibility of existing cellular routers, modems and gateways, it is possible to move from a traditional M2M deployment to a distributed intelligence platform incrementally as needed, with manageable disruption and cost.

Until standards emerge and stabilize, the key to interoperability and virtualization is to deploy platform-ready devices with IP-based connectivity and the programmability to expose physical equipment via stable APIs.

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About CalAmp
CalAmp is a proven leader in providing wireless communications solutions to a broad array of vertical market applications and customers. CalAmp's extensive portfolio of intelligent communications devices, robust and scalable cloud service platform, and targeted software applications streamline otherwise complex machine-to-machine (M2M) deployments. These solutions enable customers to optimize their operations by collecting, monitoring and efficiently reporting business critical data and desired intelligence from high-value remote assets.

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