Extending Enterprise to the Edge

EXECUTIVE SUMMARY

There is a lot of hype around the Internet of Things (IoT), especially with so many solution providers claiming to have end-to-end solutions. But when end users take a closer look at these solutions, there are often missing pieces. Shortcomings are common in the realms of device connectivity, manageability, scalability, and security issues, as well as analytics and integration with business applications—especially for industrial companies that employ a variety of networks and device types in their facilities.

This comes as no surprise to end users surveyed by Frost & Sullivan, who reported that legacy system integration and lack of standardization are two of the top four apprehensions for companies seeking to digitize their operational facilities per Industry 4.0.[1]

As respective leaders in information technology (IT) and operational technology (OT), Oracle® and Wind River® have a vested stake in bridging the IT/OT divide. The two companies have collaborated to deliver an end-to-end platform that provides a secure communications path from edge to cloud. The solution enables industrial companies to spend less time managing device connectivity, manageability, and security, and more time extracting valuable insights from their data.

This white paper describes the key processes and software components of an end-to-end solution by going under the hood of the one developed by Wind River and Oracle. This joint solution is driving digital transformation by overcoming connectivity issues with the end goal of alleviating the burden on IT and OT personnel. These components range from small, low-power microcontrollers using free software platforms to high-end data analytics platforms using dynamic application insertion strategies like Network Functions Virtualization (NFV). Strategies for provisioning, managing, and decommissioning cloud-connected devices will also be discussed.

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UNLOCKING BUSINESS VALUE

The transformative potential of IoT lies in its ability to drive growth and create value with new business models and new revenue streams that otherwise would not be possible.

The key to this value lies in connecting the edge to the enterprise with a properly designed end-to-end IoT solution that efficiently bridges the worlds of IT and OT, giving stakeholders the data and device visibility they need while increasing operational efficiency. An example of this is an industrial robot that seamlessly communicates with enterprise resource planning (ERP) software. In the case of failure, the robot immediately requests the ERP to issue a ticket and assign it to a repair technician. Based on the error codes received, the technician will know exactly what repairs need to be made and may even be able to troubleshoot the robot remotely via a secure portal.

> This device-to-cloud solution provides an enterprise IoT platform that enables device lifecycle management, analytics, and application integration to drive digital transformation. The heart of this transformation is the sensors, devices, and systems that form the connection between the physical and digital worlds.

CONVERGING IT AND OT INFRASTRUCTURE

Wind River and Oracle collaborated to develop an end-to-end IoT solution to help industrial companies achieve IT/OT convergence by providing a secure data pathway between industrial devices and the cloud (see Figure 1).
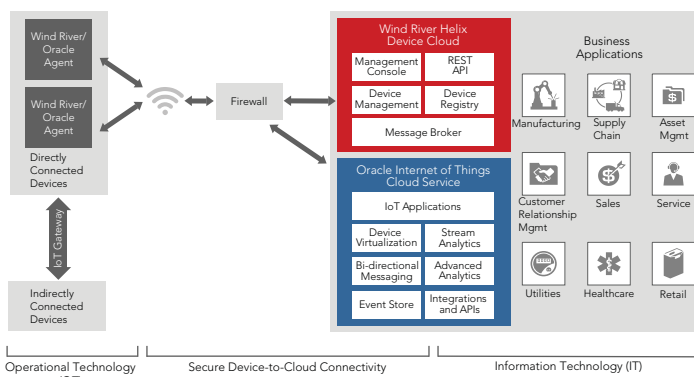

Figure 1. Oracle and Wind River joint end-to-end IoT solution

The left side of Figure 1 shows the OT infrastructure, consisting of industrial devices and networks, IoT gateways, and a firewall. The integrated Wind River and Oracle agent—installed either on industrial devices themselves or on IoT gateways—provides secure communications with two clouds: Wind River Helix™ Device Cloud and Oracle Internet of Things Cloud Service, as depicted in the middle of Figure 1. The right side shows the IT infrastructure comprising the Oracle services and enterprise apps used by business customers. The solution also has various dashboard, visualization, and business logic tools to enable stakeholders to use the system efficiently.

The following sections describe the solution's key processes and software components.

DEVICE-TO-CLOUD-AND-BACK CONNECTIVITY

The Wind River and Oracle agents connect to two clouds, establishing two bidirectional paths:

- Management path to Wind River Helix Device Cloud for device lifecycle management
- Data path to Oracle Internet of Things Cloud Service for telemetry and analytics

Today, the agents run on several operating systems: Wind River Linux, VxWorks®, and Windows®.

Agent Overview

Wind River/Oracle agent comprises several services called by a flexible application programming interface (API). The services enable software applications on an industrial device or IoT gateway to interact with Device Cloud and Oracle Internet of Things Cloud Service, and also be used by end users to create customized functions. Before the services can be utilized, however, a device must first connect to the two clouds using the agent.

"Push Button Integration"

The following flow can be automated, occurs in minutes, and requires no human intervention.

The device (with an agent) appears to the two clouds as a web client on a standard port, sparing the IT department the need to open a new port. Figure 2 shows how the agent sends the first message to Device Cloud in a firewall-friendly manner, working outbound with standard security and protocols. When the device connects for the first time, the agent and Device Cloud exchange

a certificate, a tunnel is created, and encrypted data is exchanged. The agent sends a list of properties and supported services. In order to optimize response rate, an always-on, SSL-secured connection is maintained, which is generally considered preferable to periodic heartbeat messages.
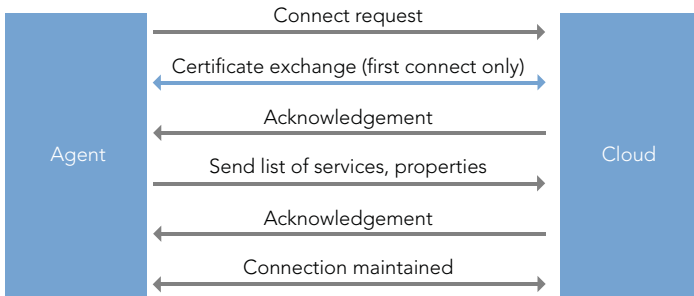

Figure 2. Process for a device connecting to a cloud

The agent connects to Oracle Internet of Things Cloud Service in a similar manner.

Agent Services

The agent (shown on the left side of Figure 3) connects devices to the Device Cloud management platform. Once connected, the following services are available:

- **Telemetry:** Sends and receives device data to and from the cloud
- **File transfer:** Enables ad hoc northbound and southbound transfer of files (e.g. logs, configurations, test codes)
- **Commands and scripts:** Executes scripts or application function callbacks
- **Remote access:** Gives device access to authorized personnel (e.g. command line sessions)
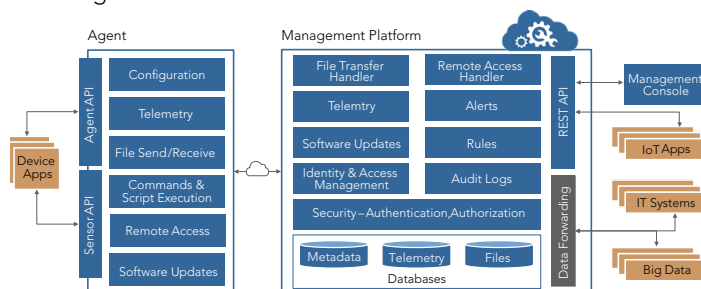- **Software updates:** Updates applications, operating system, and agent

Figure 3. Device Cloud functional representation

DEVICE-TO-CLOUD CONNECTIVITY: MANAGEMENT PATH

Industrial companies require tools for device lifecycle management that provide the ability to deploy, monitor, service, manage, update, and decommission a wide range of devices. Device Cloud addresses this need with a web-based management console that supports these processes, among others. The solution also provides RESTful APIs, enabling IT and OT professionals to build vertical-specific IoT solutions and integrate disparate enterprise IT systems quickly.

Device Management Services

With Device Cloud, industrial companies can easily build device management capabilities into their infrastructures and greatly reduce the complexities of rolling out large-scale device deployments. The following describes some of the available Device Cloud services:

- **Deploy:** Connect devices to the cloud. Devices are provisioned via a startup.bin file, authenticated via certificate exchange, and configured via network settings in the OS.
- **Monitor:** Record device-related information. Data is collected on device health (CPU, memory, etc.), operations (pressure, speed, etc.), connection status, and alerts.
- **Service:** Diagnose and repair devices remotely. Device application log files and historical trend data are analyzed, then a tunnel is established to allow secure, remote device access and repairs (e.g. settings changes, push updates, etc.).
- **Manage:** Track device properties and changes. The agent reports device properties and other inventory information useful for understanding what is running in the field.
- **Update:** Deliver content and software updates. Updates can be made to files, application software, the agent, and even the OS kernel.
- **Decommission:** Remove devices from the system. Devices can be deactivated (with agent files remaining), returned to a factory default state or deleted from the cloud, or decommissioned with all device data erased.

Cloud Rules

End users can set conditions and trigger actions to instruct Device Cloud to respond automatically to data and device changes without manual intervention. Actions include issuing a device command, creating an alert, sending an email, or forwarding data to another cloud.

DEVICE-TO-CLOUD CONNECTIVITY: IOT PLATFORM DATA PATH

In many industrial companies today, OT and IT systems are not integrated. Oracle Internet of Things Cloud Service solves this problem by bridging the gap. Specifically, Oracle Internet of Things Cloud Service extends the business applications and processes to the physical devices. It does so by providing value around three main pillars: connect, analyze and integrate.

- **Connect:** Device Virtualization abstracts device connectivity to create a software representation of a physical device, allowing business applications to interact with the device without worrying about connectivity protocols, communication networks, or online/offline states. Oracle IoT Cloud Service synchronizes the state of the virtual device with that of the physical device. This synchronization is built on bi-directional communication between the device and the cloud service. Before secure messages can be exchanged, a trust relationship must be established between the application and the devices. Oracle and Wind River have worked together to ensure an end-to-end security framework is put in place before messages are exchanged.
- **Analyze:** Connected devices stream data to the Cloud Service and this data needs to be analyzed. Oracle IoT Cloud Service offers two levels of analytics based on the device data. First, it includes a streaming analytics component that can be used for event processing to find patterns in the data or to check if certain thresholds are crossed. Unlike traditional event processing systems, Oracle offers a simpler, business-friendly user-interface for event processing. Second, it offers a Big Data-style analytics engine to perform advanced analytics that is capable of joining streaming data from devices with contextual data from business applications. Using advanced analytics techniques like machine learning and predictive algorithms, useful insights are derived that can significantly impact business decisions.

- **Integrate:** Once analysis is complete, actionable insights are derived that then need to be connected to business applications before any action can be taken. Oracle IoT Cloud Service natively integrates with several Oracle business applications such as Oracle E-Business Suite, Oracle JD Edwards Enterprise One, and Oracle Service Cloud. In addition, IoT Cloud Service integrates with Oracle Integration Cloud Service with adapters for many popular non-Oracle applications as well. In addition, custom applications can be built using the REST APIs offered by IoT Cloud Service.

IOT APPLICATIONS

Oracle IoT Cloud Service offers built-in IoT applications to address common use cases such as asset monitoring or production monitoring. There are three main components:

- **Engage:** These applications include a dashboard-like interface to monitor the status and locations of the assets and interact with them for control purposes. Dashboards are also used to track business events/incidents created in business systems such as ERP or CRM applications.
- **Execute:** This is the core of the application including the data models, business logic, predictive algorithms, machine learning systems, and contextual data. Business rules are also configured and evaluated in this component.
- **Extend:** The application is extended for each customer so the app can be customized and configured for specific business needs. Using the application extensibility framework, common tasks such as setting up the application, integrating IoT assets, and UI customizations can be accomplished easily.

These IoT applications can greatly simplify IoT deployments and accelerate time-to-value.
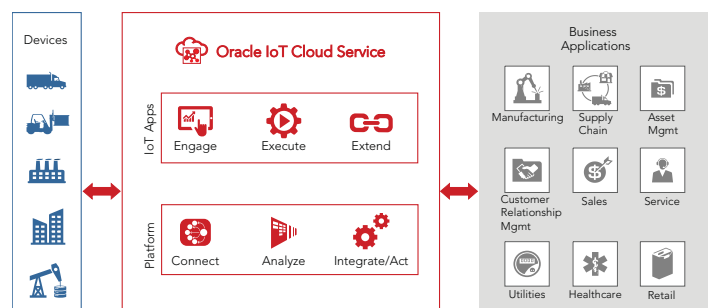

Figure 4. Oracle IoT Cloud Service functional representation

DEVICE MODEL OVERVIEW

A device model is at the heart of Device Virtualization, which creates a software representation of a physical device. IT systems are not designed to deal with issues such as complexity of devices, protocols through which devices connect, connectivity status (online/offline), or battery power status. These applications simply interact with the software representation of a device and Device Virtualization takes care of synchronizing the software state with the physical world.

DATA ANALYTICS AND INTEGRATION

To derive maximum value from IT/OT convergence, shop floor data must be collected, analyzed, and integrated with enterprise applications to generate new insights that increase operational efficiency. As discussed previously, Device Cloud and Oracle Internet of Things Cloud Service play important roles in device management and data collection. For the analyzing, integrating, and securing of industrial data, Oracle Internet of Things Cloud Service provides several key capabilities:

Data Analytics

Oracle Internet of Things Cloud Service performs real-time, Big Data, predictive analytics that enable organizations to identify new services and improve customer satisfaction.

Its business-focused visual approach to real-time analytics on data streamed from devices enables end users to:

- Select raw data streams from devices to use as input to the analytics

- Choose a data analysis pattern to apply to streams, via a user-friendly interface

- Route analyzed streams to integrated cloud services or enterprise applications

Integration

Oracle Internet of Things Cloud Service ensures the right data is available for the right application at the right time to reduce the total cost of ownership in industrial environments.

It integrates devices and business data with enterprise applications and processes using open interfaces and pre-integrations with Oracle's platform-as-a-service (PaaS) and on-premises enterprise applications. End users can enrich streams with device metadata to add an additional layer of context for use by enterprise applications or powerful business intelligence engines of Oracle Business Intelligence Cloud Service.

End-to-End Security

Oracle Internet of Things Cloud Service provides a secure environment of trusted devices, secure communications, and lifecycle management.

It includes security mechanisms for managing the trust relationships needed to make all devices part of a secure IT/OT converged solution.

- Each device is assigned a unique identity, with security credentials prevented from being reused across devices.
- Authentication is enforced prior to communication with any device or enterprise software.
- Transport-level security protects against snooping or corruption from the outside.
- Device metadata and lifecycle states (e.g., Registered, Disabled) are managed.

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ORACLE SERVICES AND ENTERPRISE APPLICATIONS

Oracle Internet of Things Cloud Service extends access to real-time IoT data across a wide range of service and enterprise applications many industrial companies are already using to accelerate innovation, increase productivity, and lower costs. These applications include:

- **Oracle E-Business Suite:** This comprehensive package of integrated business applications enables organizations to make better decisions, reduce costs, and increase performance. Users gain access to new data-driven insights and drive actions from IoT data, enabling delivery of innovative new services faster than competitors and with less risk.
- **Oracle Asset Tracking:** This application provides tracking, visibility, and control of globally dispersed assets, and seamlessly integrates with Oracle operational and financial applications. With Oracle IoT Cloud Service, benefits include asset-tracking optimization with in-flight IoT data.
- **Oracle's JD Edwards EnterpriseOne:** This powerful, fully integrated ERP software suite with over 80 application modules, end-user reporting, and personalization capabilities allows a simplified way to collect and act on IoT data, adding value to users' company assets, manufacturing operations, projects and services, and supply chain.
- **Oracle Transportation Management:** This application manages all transportation activity throughout a global supply chain, resulting in reduced freight costs, optimized service levels, and automated processes. With Oracle IoT Cloud Service, benefits include more analytics-based transportation intelligence, fleet management, and proactive maintenance that can reduce costs, increase efficiency, and ensure compliance.

CONCLUSION

The possibilities enabled by IoT in industrial settings are endless. Tapping that potential starts with the convergence of IT and OT. Connectivity issues have made this convergence difficult, which is why Wind River and Oracle jointly developed an end-to-end solution.

Through push button device integration, this solution makes it easier to connect existing devices to powerful analytics and business intelligence engines in the cloud. It also implements industry-leading security to protect networks and data. With this solution, companies can get the right data into back-end applications quickly, making better business decisions faster and responding to changing market conditions in real time.

REFERENCES

1. "Internet of Things in the Age of Industry 4.0" web seminar by Frost & Sullivan industry analyst Karthik Sundaram, http://ww2.frost.com/event/calendar/internet-things-age-industry-40/?eID=1003. July 15, 2015

For More Information

Visit Oracle at: cloud.oracle.com/iot
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