

An Oracle White Paper
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Internet of Things: Role of Oracle Fusion Middleware



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Executive Overview

Billions of devices or “things” connected to the Internet are already driving consumer behavior and intelligent industry solutions across both consumer and enterprise applications. Devices are expected to replace traditional data sources (enterprise apps, web apps, mobile device, B2B end-points) to become the main source of data for an enterprise. This data could be from products, enterprises, or the operating environment. Turning this data into valuable, actionable information—and securing it at the right time and in the right form—is likely to be a big challenge for any industry. These challenges present themselves as potentially huge opportunities for businesses equipped to deal with all the accompanying complexities.

Businesses need to not only deal with the vast amount of data from various physical assets in real time, but also translate that data into meaningful and actionable information so it can be consumed by enterprise applications to drive core business processes. Middleware is absolutely crucial for building and deploying IoT applications. It spans multiple services, including developer tools, integration services, business intelligence, collaboration, and content management.

This white paper focuses on the role of middleware, which forms the core of any Internet of Things (IoT) architecture. The four sections of the paper focus on:

- The key challenges companies are facing today in acquiring, consuming, managing and securing the vast amount of data created from a multitude of devices in real-time
- How middleware fits in the overall IoT architecture
- The role of key middleware components to help businesses derive value from IoT solutions, including a look at Oracle Fusion Middleware products
- How customers have benefitted from middleware, including real use cases across remote service management, smart cities and automation, and telecommunication

Introduction

Historically, data was generated from predictable sources, stored in storage systems and accessed for further processing. This data was correlated, filtered and analyzed to derive insights and/or drive well-constructed processes. There was little ambiguity in the kinds of data, the sources it would originate from, and the routes that it would follow. However, with the Internet of Things, the complexity of dealing with data coming from various sources is far higher. Although some companies are able to extract all this data by configuring massive amounts of devices over different interfaces, the real value of this data lies in the ability to exploit it in real-time and respond instantaneously.

There are many opportunities to extract value from data that result in significant improvements across industries such as automotive, industrial manufacturing, smart utilities, oil and gas, high tech, healthcare and professional services. However, the rapid growth in the number of intelligent devices and the demand for business process agility and execution presents many challenges.

- **Scalability:** IoT solutions need to scale from everyday use cases to extremely high velocities of data and event throughput, potentially with latencies measured in microseconds rather than seconds of response time. Applications require extracting maximum value from highly dynamic and perishable data and processing the data much faster in order to take timely action.
- **Integration.** Data from devices will need to be analyzed and actions will need to be taken based on that data. These actions could trigger alerts or invoke corrective processes before routine issues snowball into disasters (examples include flight delays, parts replacements, fire emergencies, etc). These actions will impact critical business processes requiring integration with operational systems, from enterprise resource planning (ERP) and customer relationship management (CRM) to specialist vertical applications.
- **Security.** Addressing security and privacy concerns is important in the connected world. IoT solutions capture a wealth of information across various physical assets. The data gathered from those assets needs to be protected from misuse while maintaining the privacy of the devices (and of the individuals supplying the data). Other challenges include authorizing specific assets with limited applications and/or data and being able to dynamically provision access based on pre-defined policies and credentials.

Middleware for IoT: Reference Architecture

As devices become connected and the Internet of Things becomes ubiquitous, the multitude of devices will enable companies to improve customer service, offer newer products or streamline existing processes. Middleware plays a key role in acting as a bridge between such edge devices or things and enterprise applications.

So, what should an ideal middleware platform look like? Let's review the IoT reference architecture and the role of a middleware platform step by step.

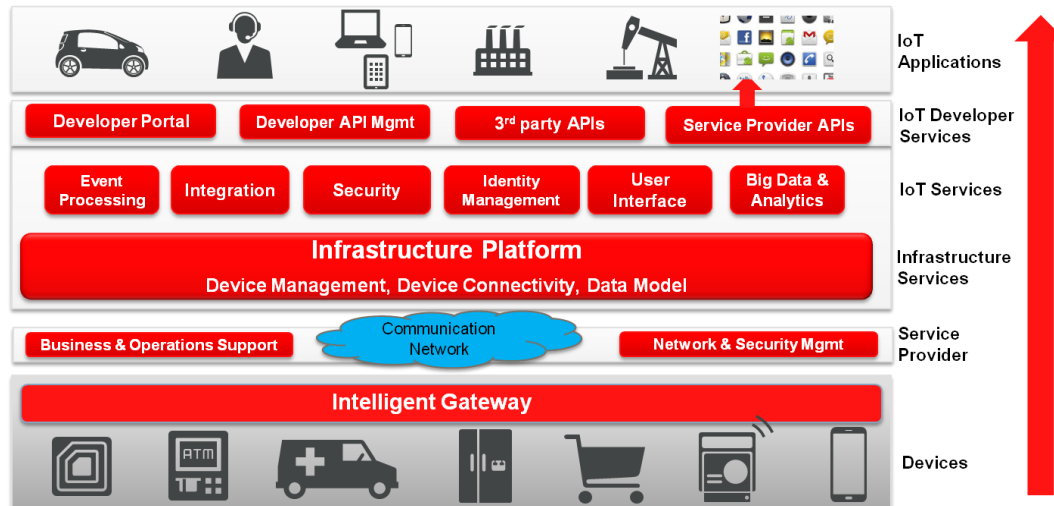


Figure 1: IoT Architectural Framework

- The device layer, at the bottom, is the main source of data. This layer is where sensing/edge devices gather data and transmit them at regular intervals. These devices, in turn, may interact with an intelligent gateway which enables initial data aggregation, filtering, correlation etc.
- This data is then funneled through a communication service provider network (CSP). CSPs are investing heavily in IoT and Machine-to-Machine (M2M) platforms in order to both scale their IT systems to cope with the growth in connections and move up the value chain beyond connectivity into application enablement platforms and M2M and IoT solutions.
- The IoT infrastructure layer acts as the glue between the physical world of sensors/gateways and virtual enterprise infrastructure. Similar to traditional enterprise infrastructure, this layer provides much needed scalability and reliability as millions of devices start communicating with enterprise applications.
- The IoT services layer is completely independent from the underlying devices, communication protocols and connectivity semantics. This layer includes a core set of services to build IoT applications (i.e. composite applications) across a range of industry sectors. The IoT services layer helps the enterprise to:
 - Analyze data in real-time (event processing)
 - Act on M2M data and events (integration services)
 - Provide historical, real-time and predictive analytics (analytics services)
 - Visualize operational and analytical data through mobile/desktop (UI services)
 - Manage data security and identity of devices/apps (security and identity management Service)

- The IoT developer services layer enables developers to build applications using IoT services, development kits, software tools and services. This layer helps expose the platform to a range of applications and use-cases.

The role of middleware is to provide the infrastructure and IoT services which in turn help drive innovation, enable new revenue streams, and improve operational efficiencies. Let's take a look at a remote service monitoring example to review the role of middleware and all its associated components as described earlier.

Critical machinery, once deployed in the field, is expected to work with minimal failures while delivering high performance and reliability. In typical remote monitoring and industrial automation scenarios—although many physical objects from machinery to equipment may already be “smart and connected”—they are typically operated in a standalone fashion and not integrated into existing business processes.

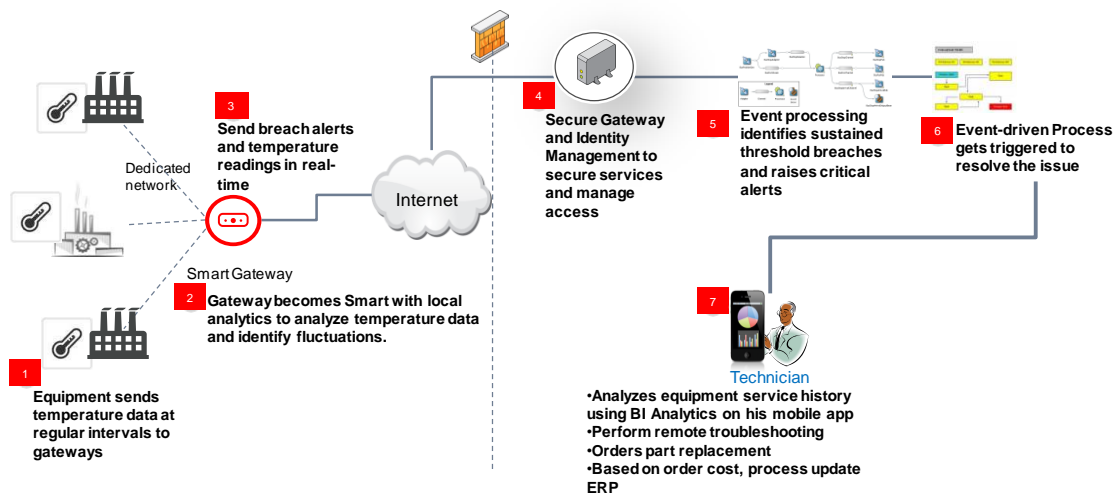


Figure 2: Remote Service Monitoring

Consider the above scenario, where temperature sensors are used to monitor the health of remotely deployed equipment. The incoming data associated with optimal operating temperatures for equipment is analyzed in real-time to detect equipment malfunction/failure. The data coming from these temperature sensors is analyzed locally in a smart gateway, which triggers any local alerts based on operational inconsistencies. The smart gateway aggregates the raw temperature data, filters it, and sends it to the back-end for further analysis. The data is relayed to the back-end via a secure gateway that secures it while also providing authentication and authorization capabilities. Such events, in reality, could run into thousands or millions every second. Event processing engine at the backend helps filter out unnecessary noise. It could look for consistent threshold breach alerts from an individual machine or aggregate alert data originating from multiple gateways to identify if it's a failure across broader set of machines. A business process triggered by the event handler automates a sequence of actions to remedy the situation. Should the alert require action, the appropriate technician is contacted to resolve the issue. The technician analyzes the service history, operating conditions, and other data using business intelligence (BI) and analytics and remotely troubleshoots the equipment, all using a mobile device. The technician also uses his mobile device to order parts that require replacement. The steps are detailed in Figure 2: Remote Service Monitoring. In summary, remote servicing can help improve

uptime, reduce costs through fewer field service visits, and increase service contract sales with new managed service offerings.

When dealing with large number of devices, scalability and reliability is of paramount importance. Middleware provides the enablement platform for building, deploying and managing scalable IoT applications.

The role of middleware in IoT can be summarized into three key value propositions:

- **Real-time Analysis**

IoT solutions often deal with large amounts of data, alerts, and information in different formats from a vast array of devices, sensors and other machines. For all this data to be useful, businesses need the ability to analyze and act on the results – and that means they need capabilities to discover, store and analyze this deluge of data. More importantly, businesses need the ability to do it all fast and in a way that communicates critical business information to key stakeholders, which is not an easy task given the sheer amount of data they are dealing with.

- **Integration**

The world of IoT without a business process is like a closet filled with wires. Embedding intelligence by way of real-time data gathering from gateways and devices and consuming them through business processes helps businesses achieve not just cost savings and efficiency but also helps them generate more revenue patterns. Businesses need to overcome several business and service challenges to be able to realize smooth orchestration and manageability of disparate systems.

- **Security and Monitoring**

Security is often a major inhibitor to adoption. IoT solutions should incorporate access control and data authentication while maintaining the privacy of the users (or devices). Systems are also required to be resilient to attacks while providing a high degree of reliability.

Users should be able to interact with the IoT environment by connecting any mobile device (tablet or phone) to monitor and control the devices and/or applications connecting to the network. Real-time monitoring enables users to convert data into knowledge, which is critical in fast decision making.

The following section details how Oracle Fusion Middleware can help businesses achieve these value propositions.

Building an IoT Platform with Oracle Fusion Middleware

The following section describes how the Oracle Fusion Middleware stack provides a scalable infrastructure to help businesses analyze, manage, monitor and secure its IoT solutions.

Real-time Analysis

Event processing is integral part of an Internet of Things platform. As massive amounts of data streams from sensing devices, it's important to derive an understanding of what data is important and what's not. Businesses typically look to the traditional systems of record and business intelligence and big data technologies to derive that understanding and enable decision-making. There are some practical limitations working with big data, which does not necessarily mean infinite storage. Although storage is cheap, it helps to have clean data, with context and less redundancy. Also, existing systems do not necessarily have real-time processing capabilities. For example, Hadoop is useful for storage and large scale processing of datasets, but it is batch-oriented and suffers from inherent latency. Big data allows the luxury of time in processing for actionable insight, but this data loses its operational value in a short time frame.

Oracle Event Processing delivers on real-time analysis of high-velocity data. It is a complete solution for building IoT applications to filter, correlate and process events in real time so that downstream applications are driven by true, real-time intelligence. Oracle Event Processing filters out noise (such as data ticks without any change in values) and helps identify critical conditions before this data is actually relayed to the back-end. Built on industry standards including SQL, Java, and OSGI, it provides an open architecture for processing complex events.

- **Complex Event Stream Processing.** Oracle Event Processing processes data streams arriving (and departing) across many disparate event sources or event sinks. It has the ability to process 1M events per second from such streams. These streams can range from electronic sensing devices such as temperature sensors to immediate data element changes in an RDBMS or in-memory grid. Oracle Event Processing also provides a comprehensive array of analytic functions and capabilities for filtering, aggregation, correlation, and pattern matching. Some examples of events include:
 - Correlated Events: *'blowOutTire' and 'driverLeftSeat' will result in a 'accident' event*
 - Causal events: *Event 'manufacturing process halted' will result in event 'delayed shipment'.*
- **Standards-Based Continuous Query Language (CQL)** – Oracle Event Processing's design environment and runtime execution supports standards-based, continuous query execution for IoT applications needing answers in microseconds to discern patterns and trends that would otherwise go unnoticed. Oracle Continuous Query Language (Oracle CQL) is a query language based on SQL with added constructs that support streaming data. From the example as described in Figure 2: Remote Service Monitoring, a sample CQL query to detect temperature alerts from remote machines occurring at least 5 times per minute and classify them as a “sustained temperature alert” would look like this

Continuously calculate the sustained temperature alerts from remote machines occurring at least 5 times every minute

```
SELECT SUM (alert) as c, sensorID, "sustained" as alerttype  
FROM AlertsInputChannel [range 60 minutes]  
GROUP BY sensorID  
HAVING SUM(alert)>5
```

- **Scalability with Oracle Coherence and Oracle Exalogic** – Event processing applications make frequent updates to application state where roundtrips to the database would negatively impact performance. Oracle Event Processing is integrated with Oracle Coherence to handle the storage of data in-memory thereby allowing much greater performance is achievable without a reduction in availability. It has the ability to provide both very high throughput and low latency on a single Oracle Exalogic compute node (upto 1 million events per second), commonly expected in IoT applications.

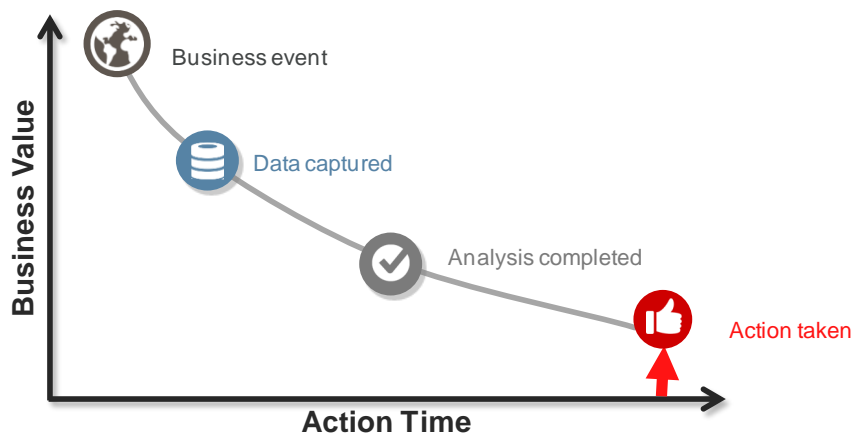


Figure 3: Business value vs. Action Time

As data travels from sensing devices to gateways and eventually to back-end enterprise infrastructure, latency occurs at every step of data capture and analysis. With time, this cascades into a reduced business value as illustrated in Figure 3. To maximize the value of data, it is important to decrease the time to react by moving data analysis as close to the source as possible.

Oracle Event Processing for Java Embedded is a smaller footprint version of Oracle Event Processing tailored for deployment on gateways. It takes timely action while the data is being generated and before it even enters the backend. While Oracle Event Processing Server edition performs complex downstream operations combining and correlating multiple streams of data putting it in a larger context (Customer information from CRM, etc.), Oracle Event Processing for Java Embedded is more suited for upstream operations to perform basic filtering and aggregation, (local decisions eliminate noise/false positive, optimize bandwidth, etc.).

- ✓ Oracle Event Processing is pre-integrated with Oracle Coherence to provide high throughput for storing data and data aggregation and real-time event querying capabilities
- ✓ Oracle Event Processing Embedded takes timely action while the data is being generated and before it even enters the backend.
- ✓ Oracle Event Processing on Oracle Exalogic delivers extreme throughput (upto 1M events per second) and latency performance.

Referring to the example in Figure 2: Remote Service Monitoring, the smart gateway with Oracle Event Processing for Java Embedded can filter temperature data from several sensors and analyze multiple streams of data to detect any alerts. Only the filtered data is sent to the back-end systems thus preventing

sensor data from clogging up the communication and storage infrastructure. A sample CQL query to detect alerts and filter data looks like this –

CQL query to detect temperature alerts and filter data looks like this

```
SELECT sensorID, status, temperature from heatInputChannel[now]  
Where temperature < temp_low or temperature > temp_high
```

Oracle Event Processing for Java Embedded has the ability to handle millions of events per second with microseconds of processing latencies. This is achieved through a complete layered solution, not only with a design focus on high performance event processing use cases, but also a tight integration with the industry-leading embedded Java application platform. Oracle Event Processing for Java Embedded is available for ARM and x86 devices with low memory footprint. Such devices include home automation gateways, smart meter aggregators, healthcare hubs, industrial gateways etc.

Oracle Event Processing and Oracle Event Processing for Java Embedded can be extended to a wide range of industries and IoT use-cases. For example, consider remote diagnostics of data centers for the proactive maintenance of power protection infrastructures. Oracle Event Processing and Oracle Event Processing for Java Embedded can perform comprehensive data collection in order to provide early warning of alarm or out-of-tolerance conditions. Oracle Event Processing for Java Embedded installed in the gateway appliance, helps filter and analyze real time usage, and detect fault and problem event patterns across thousands of distributed data centers, enabling dynamic diagnostic and automatic correction interception. Events of significance are sent from the gateway to the backend systems for a more detailed analysis. The enterprise grade Oracle Event Processing identifies major issues occurring in the data center and performs more complex analyses. For instance, sustained high resistance levels of batteries, when correlated with historical information over the last several months could warrant a replacement much before the preventive maintenance cycle. It analyzes correlates and aggregates these events identifying consistent issues and takes appropriate actions by triggering a downstream business process.

Integration

The sensors (or things) communicate with the back-end technology in order to initiate a sequence of actions. Consider the following situations where information gathered from sensors or devices is aggregated in order to initiate a sequence of corrective actions.

- In large cities with limited parking supply, information gathered from parking meters can trigger a business process which enables dynamic pricing of parking meters.
- In large scale manufacturing and industrial applications, the current condition and wear and tear of machines operating on the floor can drive predictive maintenance resulting in reduced risks and maintenance costs. The work can be routed to qualified technicians where the knowledge required and skills needed are dynamically matched against resources available.

Processes essentially “listen” for event patterns & issues as they arise (parking supply, part replacement). Powered with this insight, systems can trigger alerts or invoke corrective processes immediately before routine issues snowball into disasters.

Oracle Business Process Management Suite and Oracle SOA Suite provide a strong and reliable service orchestration platform for simplified management. Oracle SOA Suite enables flexible application integration by mediating, routing and managing interactions between applications in the enterprise and in cloud. Oracle BPM Suite drives modeling and orchestration of macro business process. Together, they provide the foundation to integrate processes across devices, enterprise applications and people.

- Users can visually define how best to act on insights captured from streaming data delivered by sensing devices or gateways. Using BPEL and BPMN industry standards, users can model process that capture optimal paths, alternative paths, exception flows, process conversations, and handling of business events.
- Processes can be invoked directly on receipt of events from devices or after the events have been pre-processed by event processing engines such as Oracle Event Processing (described earlier)
- Users can also modify the process and test to ensure they are behaving in the desired way and only then deploy them in a production environment. Rules can be added to the process models as process conditions, decision tables or as system steps that may call any other enterprise policy systems.
- Processes can be integrated with business intelligence infrastructure to further optimize core processes and operations. SOA processes can invoke Oracle Business Intelligence to gather contextual information. In IoT use-cases, this is essential when sensor data or events lack enough context to determine how the data should be processed. Combining real-time sensor information with historical and prescriptive analytics can make the processes intelligent and responses much more human centric.
- SOA and BPM processes acting on sensor-related data and events are tightly integrated with Oracle Business Activity Monitoring, which provides dashboards that allow administrators to make decisions based on real-time streaming information coming either directly from sensing devices/gateways or events arriving from Oracle Event Processing engine.

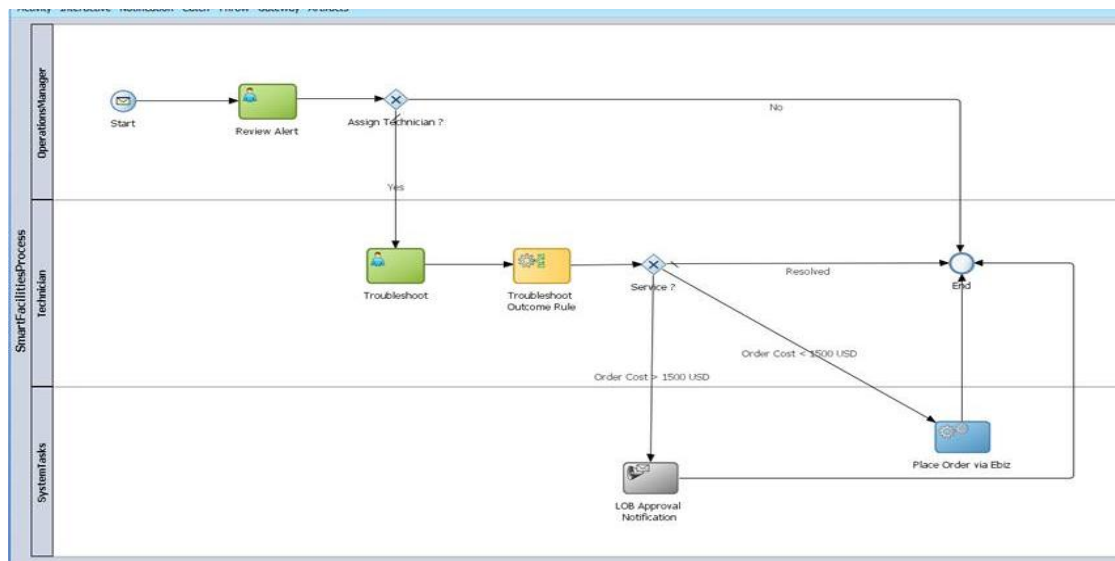


Figure 4: IoT BPM Process

To understand how the integration described above plays out in an Internet of Things context, consider a remote sensor network deployed in the field for remote monitoring of machines. The temperature data gathered from these sensors is processed at real-time by event processing engine to ensure that the machines are functioning as required. If specific pattern is detected in temperature increase, Oracle Event Processing can trigger a business event to perform predictive maintenance. The event in such a case can be for the operations manager to review the alert, raise a ticket or send a

- ✓ Oracle BPM provides the ability to integrate processes that involve devices, applications and human intervention.
- ✓ Oracle SOA on Oracle Exalogic provides the ability to scale applications delivering faster response time.
- ✓ Pre-integration with Oracle BAM and Oracle BI to act on the data.

message alert to a qualified technician highlighting the location and nature of the problem (as indicated in Figure 4: IoT BPM Process). The assigned technician can then take appropriate action to troubleshoot the problem either by repairing or replacing the parts (with appropriate LOB approvals). BPM is key

to coordinating value-added responses to events received from IoT, and connecting human participants to handle some of these responses. Oracle BPM thus provides the ability to integrate processes that involve devices, applications and human intervention.

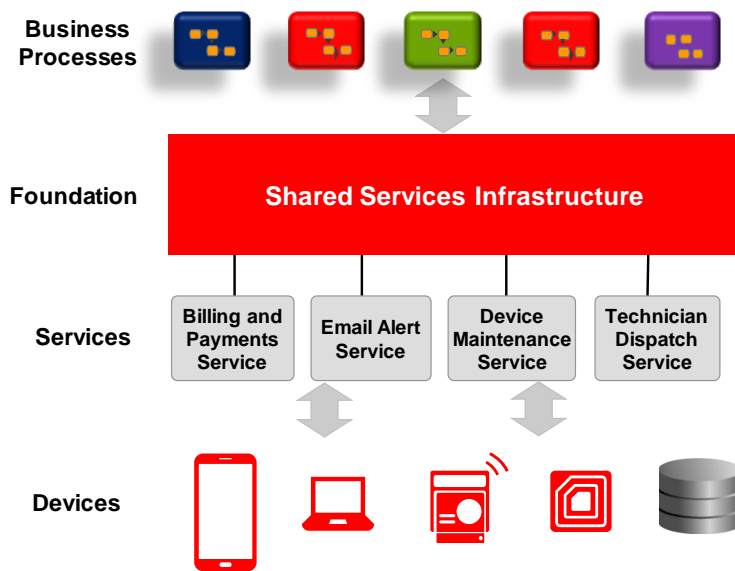


Figure 5: SOA: Shared Services

Process involves interaction with underlying enterprise applications to initiate order part replacement or trigger a usage service for billing and payments. These applications could be on-premise or on the cloud. This type of architecture potentially has many business and technical services overlapping across business processes. (Ref Figure 5: SOA: Shared Services). Oracle SOA Suite enables reuse of existing assets including legacy services. With this foundation, it becomes convenient to achieve new value by leveraging the loosely coupled architecture and the flexibility that it offers across a range of services in IoT scenarios.

In the Internet of Things use cases, there is less value in looking at individual events or occurrences while the real value and intelligence lies in the ability to correlate and make sense of the various patterns of occurrences. Elevating “services infrastructure” into a “shared services infrastructure” to support spikes in loads, improving high service availability, introducing agility, and simplifying manageability are key to enterprises. Shared service infrastructure (Figure 5: SOA: Shared Services) allows reuse of service and is managed by SOA governance and Oracle Service Bus (described in following section). Oracle SOA Suite on Oracle Exalogic provides IoT applications the ability to scale, delivering faster response time, and delivers 15X more throughput gains, 2X faster response time, and 2X improvement in SOA file processing for large payloads.

Typically, the devices should be decoupled with the applications. Loose coupling is achieved through abstracting and resolving the differences between two or more systems in order to facilitate a seamless integration. Virtualization helps achieve this decoupling across highly scalable environments. In essence, the service bus acts as an intermediary layer between the devices and the backend applications to help reduce the gap resulting from different protocol stacks and data models.

Oracle Service Bus integrates new devices and device services and enables true plug and play supporting a wide variety of applications and services. In an IoT world where devices and its associated services can potentially grow very fast, Oracle Service Bus helps consolidate and reduce the number of point to point connections. Oracle Service Bus supports many different transports: Oracle HTTP/REST, HTTP/SOAP, WS-I and JMS. Oracle Service Bus is designed to connect, mediate, and manage interactions between device communication/event processing modules and business services instances across an expanding service network.

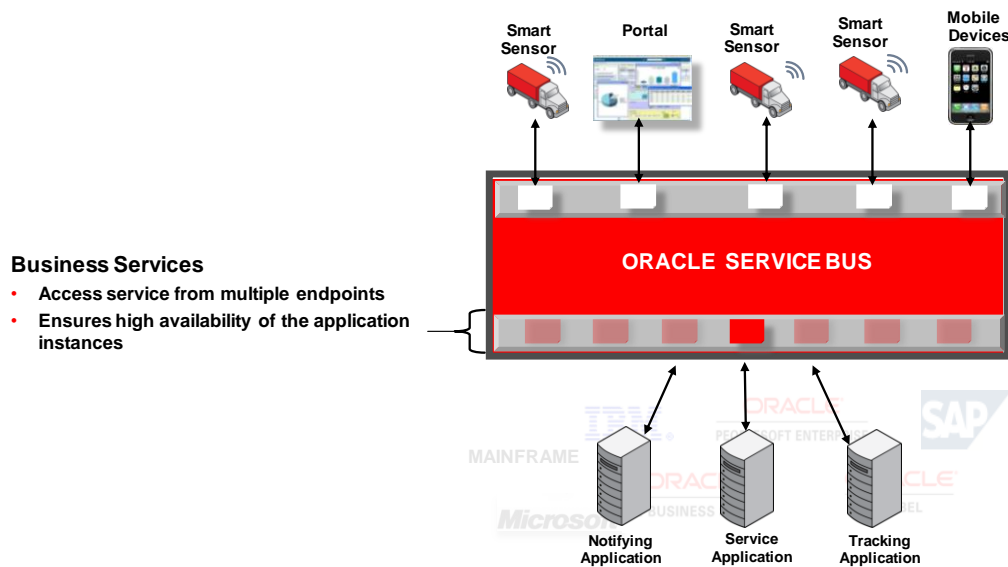


Figure 6: Oracle Service Bus: Service Handling

Consider the example in Figure 2: Remote Service Monitoring, where a thermostat constantly monitors the temperature of industrial equipment and relays the data back to the back end. This communication takes place over REST (JSON over HTTP). This data will typically be filtered, correlated etc by the Oracle Event Processing (described in the previous section) and forwarded to the back end systems. Oracle Service Bus virtualizes the REST services exposed by Oracle Event Processing. At the same time, Oracle Service Bus can gather all the operational statistics of exposed IoT services, monitor service level agreements (SLAs) and then initiate actions such as invoke the right application instance in order to initiate action based on the gathered statistics. For example, if a GPS sensor embedded in a truck were to indicate that it is running late, an SLA could invoke an alerting framework sending an email alert or a message notifying the status of the vehicle to the management center which could then track the movement of the truck and initiate appropriate action. (See Figure 6: Oracle Service Bus: Service Handling)

Oracle Service Bus

- ✓ Consolidates and reduces the number of point to point connections and provides a layer of abstraction to virtualize the services
- ✓ Supports HTTP/REST, HTTP/SOAP, WS-I and JMS

The world of IoT entails a number of real-world devices connected to each other in a web-like structure. These devices offer their functionality via SOAP-based web services or RESTful APIs, enabling

other components to interact with them dynamically. Thus, unlike traditional enterprise services and applications, which are mainly virtual entities, the new IoT composite applications enable enterprise applications to interact with devices which provide their functionalities as web-services. Such devices when integrated with enterprise applications like ERP, CRM, and BPMS etc enable new revenue streams and create a rich experience for the customer. Oracle's BPM and SOA technology enables this integration bringing the IoT world into the enterprise world creating interesting business opportunities and delivering unique competitive advantages. Oracle Service Bus enables loose coupling between the device layer and the enterprise services (through virtualization) while providing guaranteed reliability and scalability of enterprise services.

Secure and Monitor

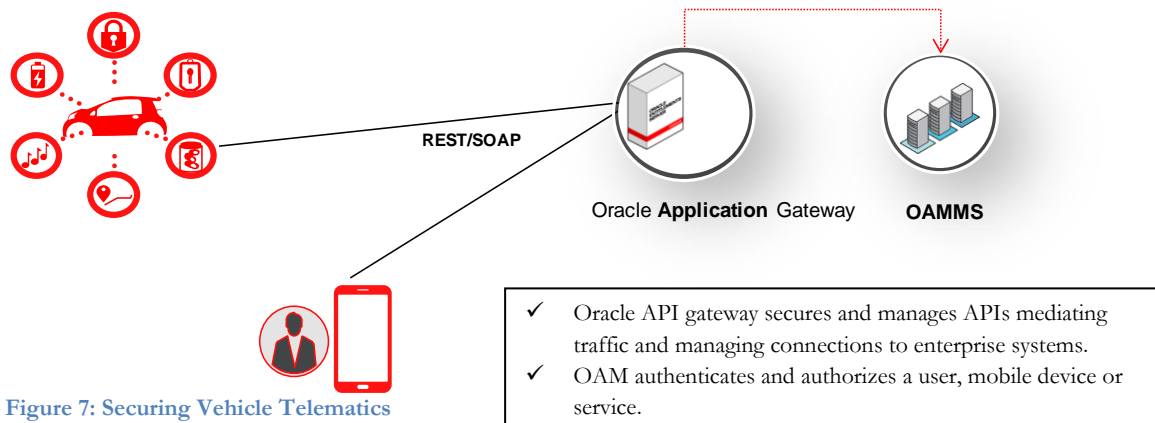
The intertwining of the physical world with the virtual world is bound to generate complex privacy, authentication and authorization issues with several constraints such as interoperability, scalability and usability requirements. This necessitates dealing with the identities of not just users and services, but also devices. Privacy risks will arise as the objects within IoT collect and aggregate fragments of data that relate to their service. Multiple points of data can potentially divulge personal information such as location, time etc. Furthermore, rogue devices, when not properly authenticated, may access services or start sending data to disrupt traffic and possibly even bring down the network. Given the potential volumes of traffic IoT is poised to generate from industrial applications such as transport and power to personal devices and home networks, businesses need to prepare for the accompanying risk and security. Security considerations are necessary to ensure that the edge devices, gateway, services and the operator of the services are authorized to be able to communicate with each other.

Oracle Identity and Access Management Suite is a suite of products that provides authentication, authorization and identity management to address some of these challenges. And while it was originally created for traditional desktop and Web applications, Oracle Identity and Access Management Suite has been extended to support everything from wireless sensors to mobile phones to traditional identity use cases.

One of the key benefits of using Oracle Identity and Access Management for managing the security of IoT is that the same infrastructure that is used to manage traditional applications and identities can be reused for IoT applications.

- The Oracle API Gateway is basically a lightweight interface between the Oracle Access Manager and client services. It provides a centralized way to control security and management policies for information assets exposed via internet APIs, to applications and developers.
- Oracle Access Manager provides the services to authenticate and authorize a user, mobile device or service. Oracle Access Manager automatically collects, propagates, and leverages identity and device context for personalization and authorization across web, web services, and application tiers.
- Oracle Directory Server is a small footprint, standards-based solution that provides storage, proxy synchronization and virtualization capabilities.
- Oracle Mobile and Social Access Service leverages multiple components of Oracle's identity and access management, including Oracle Access Manager, Oracle API Gateway and Oracle Directory Services. Oracle Mobile and Social Access Service provides the following features
 - User Management and Passwords (and other credentials)
 - Device Fingerprinting and Registration
 - Device Security
 - Transaction Security
 - Services Security

To put all the above features of the Oracle Identity and Access Management Suite into context in an IoT scenario, consider the following Telematics example.



A trend with (most) car companies these days is the ability to perform remote diagnostics, record vehicle maintenance history and provide social check-ins to log into the applications and access these services through a mobile phone or a tablet. A car-user decides to remotely start his car and turn on his air-conditioning so it warms up before he enters. He logs into the car application on his smart phone and launches the car application and hits the “Start Car” button. The application authenticates the user-credentials by making a call to the Oracle Access Manager. Upon authorizing the user, Oracle Access Manager returns an access token back to the application. The application then sends the access token plus the car identification (typically the Vehicle Identification Number or VIN) so that the telematics service can verify this user can perform operations on this specific car. The relationship of the user and the VIN is established at the time the car was delivered to the car owner. The web services are processed through the Oracle API Gateway which provides security to the client services by verifying tokens, prompting for credentials and preventing DoS (Denial of Service) attacks by blocking unauthorized operations. The application then sends the token plus the command (like “StartCar”) to an application running on the gateway in the car. This application, which controls various microcontrollers in the car, then issues a command to “StartCar” and turns the air-conditioning ON.

Furthermore, sensors in cars help collect diagnostic information about engine and transmission performance, anti-lock brake conditions, air-bag systems etc. This information is aggregated, filtered and analyzed in a local gateway in the car. The gateway running Oracle Event Processing embedded on the Java Embedded platform, checks for any inconsistencies and triggers an alert should there be any problem. These alerts are sent via the Oracle API gateway, which secures the data, monitors the real-time alerts, usage statistics and provides various transformations and routing capabilities. The Telematics application running in the back-end verifies that the alerts are coming from a known source and takes appropriate action, like sending an SMS alert or an email notification. Oracle Access Manager manages the authentication and authorization of these services.

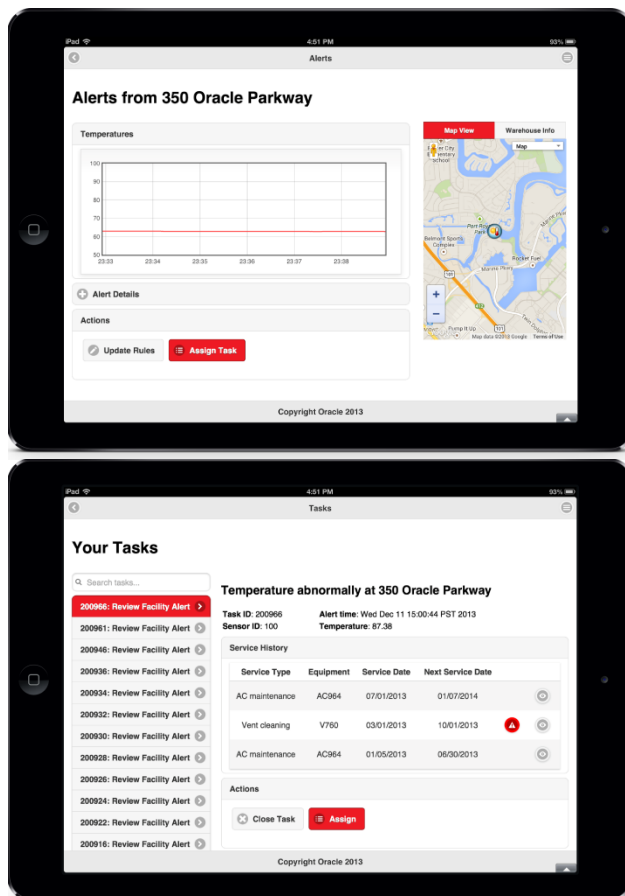
Mobile devices help visualize and control various processes and provide self service capabilities to IoT users. Consider the following IoT use-cases.

- Sensors installed inside equipment help monitor if any parts have exceeded their designed thresholds and send reports to owners and manufacturers if they have. This information is made available on tablets or smartphones for managers and technicians to automatically schedule service maintenance ahead of equipment malfunctions.

- With the use of installed sensors, mobile apps, and real-time web applications, cities are able to optimize parking space availability in order to enable citizens quickly find an open spot for their cars.

With the emerging network of devices that are able to communicate directly over the web such as the popular Fitbit wristbands to smoke detectors and home energy systems that can be adjusted via a phone app or web browser, the ability of devices to collect, store and share personal data is only going to increase. Mobile devices are effectively the “eyes and ears” of the applications connecting to the network

Oracle’s ADF Mobile is a client development platform that enables development of applications that run on mobile devices. An Oracle ADF Mobile based application can be developed such that it can work well on either a tablet or a phone. When the application is launched, the appropriate form factor will load. Tablet views are often fewer in number but more complex, whereas phone views are often greater in number but generally simpler due to screen size constraints. Defining both sets of views within the same application promotes reuse for business logic, data access, web service integration and so on which the Oracle ADF Mobile provides.



Oracle ADF Mobile

- ✓ Helps build mobile apps to visualize sensor information and control gateways/actuators remotely
- ✓ Platform and device agnostic
- ✓ Integrates with IAM solution to ensure authorized and authenticated access to data & insights from devices

Figure 8: Screenshots of an Oracle ADF mobile application on a tablet.

Oracle ADF mobile applications enable monitoring and control of devices in real-time. One can change the functionality of the devices, add new features or provision new services by simply uploading a new version of the code. For example, in an IoT framework, sensors that are currently

monitoring only light level information can be enabled with additional capabilities such as temperature sensing by simply uploading a new version of the code. (given that the device supports this additional feature). These functionalities can be selected/unselected by simply checking them using an Oracle ADF mobile application running on a mobile device.

Access and security are also important aspects of IoT. ADF mobile integrates with the Oracle IAM solution to provide authentication such as single sign-on, access control and other encryption features for web applications. This ensures only authorized and authenticated resources access streaming data & insights from edge devices. ADF mobile also enables application reusability and portability. The applications that are developed using ADF mobile have several features to support various functionalities that can be easily packaged and re-used across platforms such as the iOS or Android across mobile phones or tablets. Based on a hybrid mobile architecture, ADF Mobile supports access to native device services, enables offline applications and protects enterprise investments from future technology shifts.

Adoption Patterns

Remote Service Management - Life Technologies



Historically, vendors tend to design products with complete end use in mind. The Internet of Things adds an interesting dynamic to remote monitoring in that it allows these products to be monitored, upgraded, maintained and serviced in ways not possible before.

Challenge

Life Technologies, a biotechnology company based in the US, provides products and services to customers in the fields of scientific research, genetic analysis and applied sciences. The company has a presence in approximately 160 countries, and holds more than 3,100 patents and exclusive licenses. Life Technologies possessed many legacy systems that created integration challenges for its customer to get a complete view of all their purchased instruments. The key challenge for Life Technologies was to be able to proactively monitor the medical instruments sold to customers and alert them should the instruments need any attention, such as repairs, services and maintenance. Life Technologies was also seeking to allow customers visibility to their instruments status, contracts and groups within their organization. Furthermore, it was necessary for customers to have a self-service mechanism for requesting instrument services and sales quotations and also be able to view any current promotions and sales.

Solution

Oracle's SOA Suite and Oracle Webcenter based solution to design Life technologies' My Life Service portal is the first of its kind in the biotechnology instrument services industry to help proactively monitor and manage remote equipment. Life technologies' Internet of Things solution combines Axeda's device management technology along with Oracle's middleware technology to remotely manage its medical instruments. Axeda platform manages and tracks activities across different devices to detect problems before they cause downtime. Early detection of part repair or replacement requirements ensures immediate resolution. This device information integrated with Oracle SOA Suite via REST interfaces. SOA Suite services interact with Axeda's webservices to query instrument data and synchronize the information into service portal applications. Instead of waiting for customers to call when there's a problem, technicians are automatically notified when potential problems arise, enabling manufacturers and third party service providers to proactively schedule maintenance and maximize asset readiness.

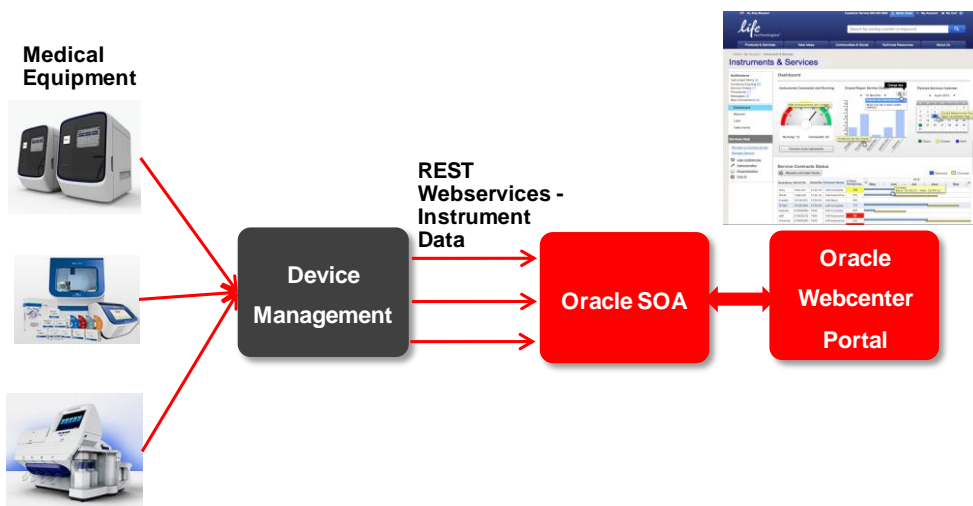


Figure 9: Life technologies' remote monitoring solution to track activities and troubleshoot issues

Content or asset data that gets fetched through these services is displayed to the end user on the Oracle WebCenter-based “MyLife Service portal” in real-time. This helps the users to not just visualize the data but also proactively maintain and manage the assets.

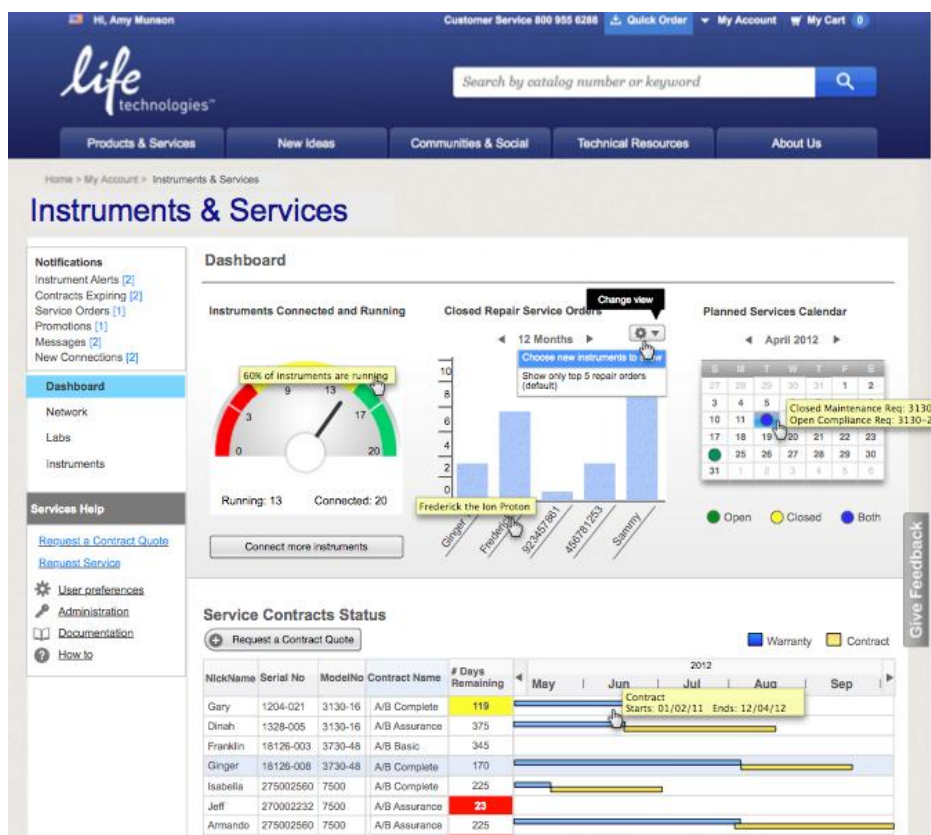


Figure 10: Life technologies' dashboard to track activities and troubleshoot issues

MyLife service portal helps Life technologies pro-actively maintain instruments used by its customers. My Life service portal essentially delegates administration to different customers who have purchased products from Life Technologies. For Life Technologies' customers, the portal manages all of the users associated with their company or organization and their labs where the instruments were deployed. The lab administrators of these companies manage specific lab instruments, view relevant service information and request any upcoming maintenance.

Oracle WebCenter enables use of a single account to access all available web resources. Some of the packaged and custom systems of this solution are as follows:

- My Labs enables customers to easily group instruments for ease of location and management of instruments
- My Instruments allows customers to leverage cloud based real-time monitoring to proactively service and repair instruments before there is a critical issue
- My Network enables social collaboration using WebCenter Discussions and WebCenter Activities to collaborate and share information with other lab members.
- Request Quote or Service Call enables customers to quickly schedule desired services without having to place a call to the customer service representative and saves Life Tech significant costs.

Business Impact

Proactive maintenance and monitoring is expected to save significant costs in general service request processing by avoiding the need for customer service representatives to take phone calls even for basic requests. This is expected to result in millions of dollars of savings in support costs. In addition, the portal is expected to generate millions in new revenues for providing access to cloud based proactive monitoring, promotions, up-sells of related products, renewals for services and maintenance contracts, along with significantly improving customer satisfaction by allowing customers to create their own social networks. *"One of the biggest goals for Life Technologies (now ThermoFisher) is customer first. We must have all the tools and processes in place to gain end customer satisfaction. MyLife service portal is a first of its kind biotechnology solution we built using middleware technology where we leveraged SOA Suite capabilities extensively to strengthen our brand. This solution allowed us to analyze customer data to gain more insight to drive and make profitable decisions while also increasing our overall market share"* says Sreedhar Reddy, Senior Manager IT, Shared Services Group, ERP and Middleware.

Smart City and Traffic Management – SF Park



Cities are getting smarter by using physical devices to connect to a virtual world over an information network.

Challenge

San Francisco Municipal Transport Association (SFMTA) could not build more roads in San Francisco, as the city simply did not have any more space. It had to find ways to enable San Francisco's public transportation system to operate faster with increased reliability and accommodate the anticipated future trip growth. As the city's parking supply is a valuable and a limited public asset, SFMTA had to manage parking effectively through intelligent parking management approaches. The goals for the SFPark project included improving parking convenience by making it easier to park and pay, thereby improving traffic flow for improving Muni (San Francisco city public transportation system) and enabling demand responsive pricing to reduce circling and double parking. Oracle Service Bus and Oracle Business Intelligence Enterprise Edition-based solution helped meet these goals.

Solution

SFPark includes use of innovative and leading edge technology, including parking sensors, new and improved meters, garage data occupancy sensors and roadway sensors for analyzing traffic flow and measuring the impact of smart parking policies on traffic, etc.

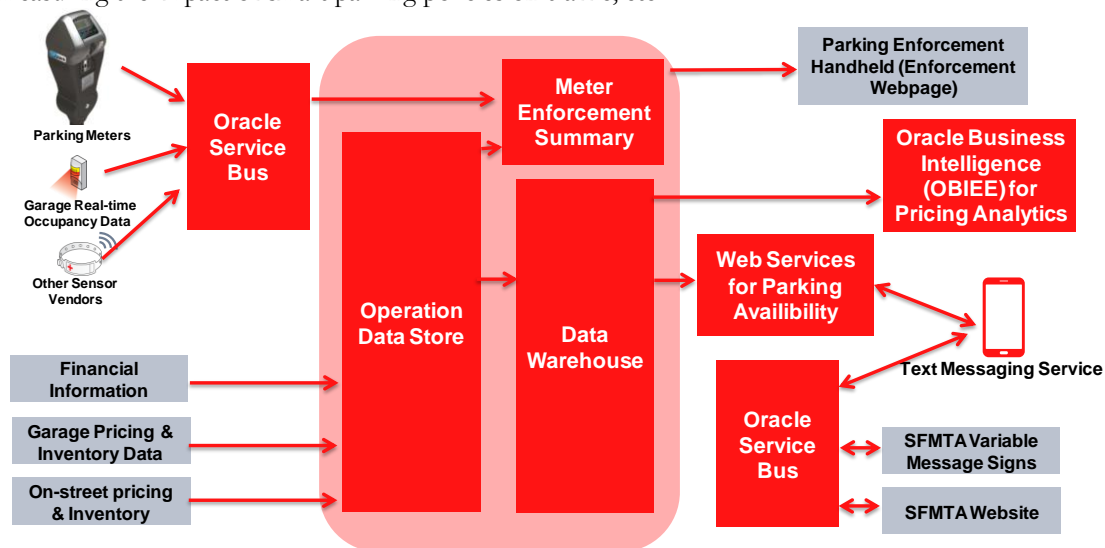


Figure 11: SFPark Architecture

A SOA-based approach enables standards based implementation using loosely coupled services and interfaces. The solution leverages Oracle Service Bus mediate data flow between the parking meters and backend infrastructure. Oracle Service Bus provides the backbone for communication of messages such as real-time occupancy of publicly available parking spots, pricing information from vendors etc. Oracle Service Bus performs message transformation, and error handling for HTTP/JMS/FTP/Email

type messages via SOAP, XML, Text, Binary etc. Web services helps relay information to multiple external systems (SFMTA Website, SFMTA Message Signs, Text Messaging Service etc). The operational data store communicates with Oracle Service Bus to collect this data in real time. Oracle Data Integrator loads the batch data and transforms data into data warehouse star schema. The data analysis is handled by Oracle Business Intelligence Enterprise Edition to help review the vast amount of real time data that is being collected from various sources. The Oracle Business Intelligence Enterprise Edition solution improves efficiency and accuracy to initiate demand responsive pricing changes and meter operational schedule updates for improved Muni operations and reduced congestion. This results in improved city transportation and better experience for all using city roads and transportation services.

The scalability and performance including fault tolerance afforded by the Oracle solution helps the project function 24x7 with minimal support requirements.

Business Impact

SF*park* rolled out this new parking management system at 7,000 of San Francisco's 28,800 metered spaces and 12,250 spaces in 15 of 20 City-owned parking garages, reducing traffic by helping drivers find parking. Meters that accept credit and debit cards helped reduce frustration and parking citations. Furthermore, demand responsive pricing helped encourage drivers park in underused areas and garages, reducing demand in overused areas.

The return on investment for the SF*Park* project was not just monetary. The project provides for improved Muni operations and reduced congestion thereby increasing citizen satisfaction with city transportation and improved air quality and better experience for all using the city roads and transportation services.

Telco - NTT Communications



Challenge

NTT Communications is the long-distance/international communications and ICT solution provider in NTT Group (NTT Communications will be referred to as “NTT Com” hence forth unless otherwise specified). As the market mainstream has been changed from the fixed line-based voice communication to the data communication via mobile/wireless devices, NTT Com must be vigilant in focusing on their network QoS because the internet-based services of NTT Com’s customers such as mobile carriers and other global companies are heavily dependent on NTT Com’s network QoS. In light of such demands, NTT Com must be responsible for monitoring real-time network traffic and predicting failure detection of its networks.

The traditional approach of network traffic analysis was analyzing the logs from each network device (which was not in real time and required a huge human workload), or by way of using the dedicated monitoring option of the network devices (which was expensive, not scalable, and not extensible). One other option was to build its own monitoring system by hand, but it was too difficult to handle the performance requirements of 84M packets per minute using traditional application architecture.

Solution

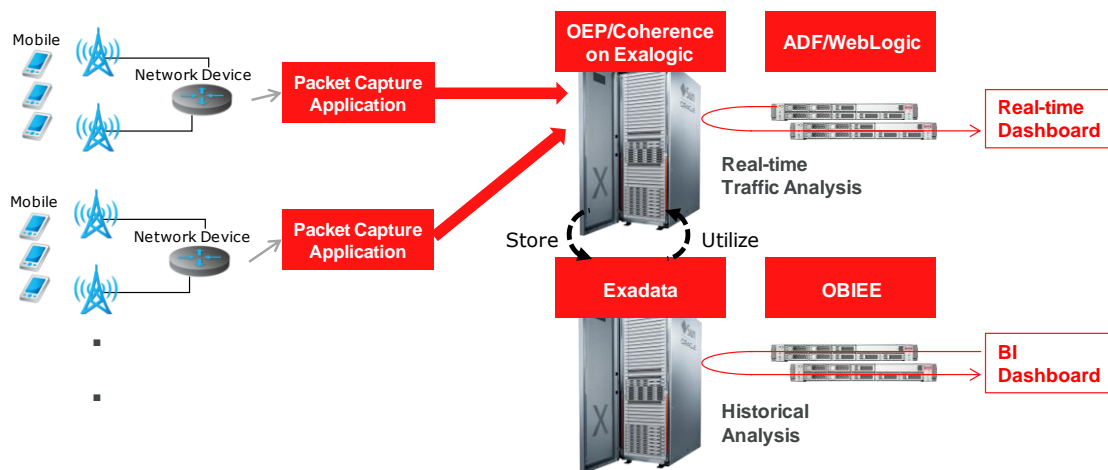


Figure 12: NTT Com's Real-Time Traffic Monitoring Solution

The proposed solution (Figure 12: NTT Com's Real-Time Traffic Monitoring Solution) leverages Oracle's in-memory datagrid, Oracle Coherence, and Oracle Event Processing technology. The network packets are captured in real time and sent to Oracle Coherence to ensure reliable receiving, and then sent to Oracle Event Processing for aggregation and pattern matching. Continuous Query Language (CQL) in Oracle Event Processing is used to aggregate continuous data and identify the packet error rate, lost rate, etc, in real time. Oracle Event Processing also triggers an action if a suspicious traffic pattern is identified. For example, by intercepting the packets from several network points and comparing multiple packets within a small time window, Oracle Event Processing can detect the problem—such as “L2 switching loop”—and can find the device that may possibly be the root cause. This was impossible to achieve earlier based on the network logs-based analysis.

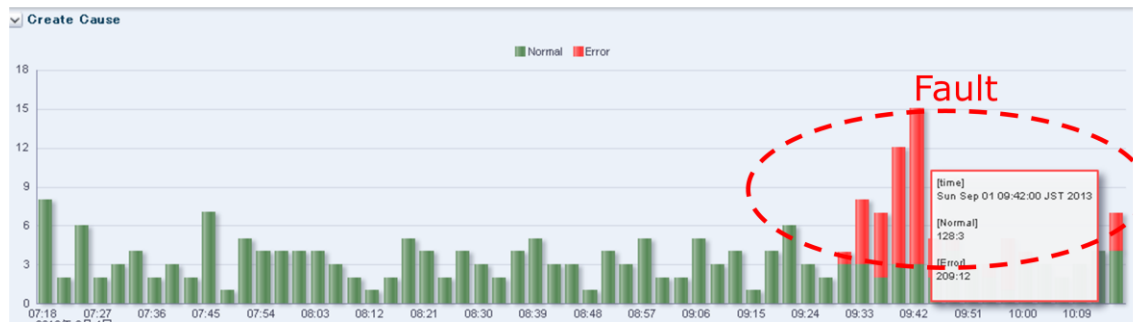


Figure 13: Network Log Activity

The aggregated results are sent to the Oracle Coherence cache again for the subsequent real-time monitoring application built using Oracle's Application Development Framework. The captured packet statistics and the aggregation results are further stored in Oracle Exadata asynchronously for historical analysis (using Oracle Business Intelligence Enterprise Edition).

This solution is being enhanced even further to enable improved intelligence in predicting larger issues in the network before they occur.

Business Impact

About 1000 dedicated operators were being tasked to monitor the mobile networks in real time, resulting in high operational costs. The Oracle Coherence and Oracle Event Processing-based real-time traffic monitoring solution could help reduce their operational workload considerably, especially regarding issues caused by the network trouble. The network operators are now able to monitor consumption patterns of each customer in real time and then the user experience and QoS are made better.

The proposed solution helped expand the breadth of data analysis and deliver great predictability and visibility which in turn led to higher quality and improved customer experience. The ability to process highly dynamic data efficiently provided NTT Com with a broader insight into customers in order to offer differentiated services that were not possible before.

Summary

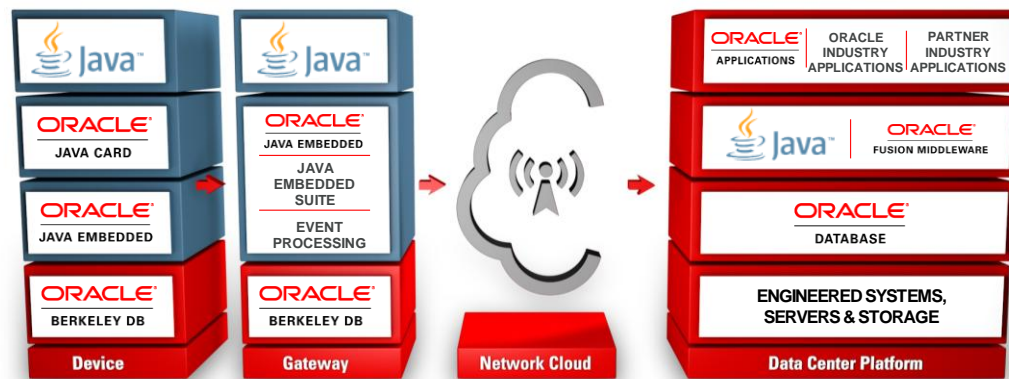


Figure 14: Oracle Internet of Things Platform

Oracle has a complete portfolio of best-in-class technologies at every level, engineered to work together from device to gateway to the data center. From the devices and gateways using the proven Java platform, and back in the data center itself leveraging Oracle's middleware, analytics, database and engineered systems, Oracle has the product and technologies to make Internet of Things successful for you.

Oracle Fusion Middleware offers a scalable platform to acquire, analyze, manage, visualize and secure data from connected devices to help you:

- **Uncover Business Opportunities.** You can analyze high velocity data and manage large data volumes to be able to make fast decisions and take immediate action.
- **Optimize Business Processes.** You can integrate the machine and sensor data with core enterprise systems. Virtualization of enterprise IoT services and orchestration of business processes helps you enable new revenue streams, and improve operational efficiencies.
- **Improve Customer Experience.** You can leverage from the insights to improve your customer service, offer newer products or streamline existing processes, all in a secure environment.



Internet of Things: Role of Oracle Fusion
Middleware, April, 2014

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Hardware and Software, Engineered to Work Together