

Java and IoT: The Intelligent Platform for the Connected Vehicle

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Java and the Internet of Things: The Connected Vehicle

A vehicle is typically the most expensive and complex consumer device that we own. We expect it to keep up with the rest of our devices that produce and consume a rapidly growing set of media and social data. We also expect vehicles to be 100 percent reliable and to keep us safe. Meeting all of these needs is a challenge for manufacturers that have a growing set of requirements themselves. For instance, manufacturers need better data from their vehicles to increase reliability, manage the complex interactions between control systems and media/communication systems, anticipate problems, and enhance customer experience and safety. And by the way, data should increase profitability for the manufacturer and strengthen customer engagement.

Apart from the technical and logistics issues, larger business issues also appear. For example, how do you effectively manage hundreds of millions of lines of code distributed across multiple in-vehicle computing devices? Additionally, the pace of change for internet and mobile-oriented technology is on the order of 6 to 12 month cycles, yet vehicles are expected to be in the market for ten years or longer.

These business challenges require a vehicle to behave like a flexible computing platform – not unlike the transformation IT went through with the web about 20 years ago. It follows that vehicle manufacturers will require similar solutions: industry standards and interfaces combined securely with a modern development platform to build, deploy and update applications.

Driving the Need for IoT Integration

As more vehicles connect to the internet, they become an important and growing segment of the Internet of Things. The term Internet of Things (IoT) is used to define a system in which the internet connects to the real world via ubiquitous sensors. The vision of IoT is to create an automated system of computers, devices, and sensors that process their own data instead of depending solely on people for input. As a result, the system as a whole can have a view of what's taking place at any location and point in time. This would lead to a world of connected systems that could greatly reduce waste, lower costs, and eliminate loss for just about any human-machine activity.

Given the daunting requirements of today's vehicles (e.g. safety, reliability, consumer connectivity and entertainment, and so on) and the rapidly emerging IoT technology wave, perhaps no other technology today is better positioned to power an in-vehicle IoT strategy than Java. Given its ability to run on a wide range of devices—from mobile and embedded systems with limited CPU and memory, to servers with immense power and capacity—Java powers a world of compute resources with ubiquitous connectivity. Java-powered devices in this ecosystem will communicate with each other, with people, and with the real world via sensors and controllers to gather knowledge, and ultimately understanding, about the environment in real-time.

The Connected Vehicle

The idea of the connected vehicle—which goes beyond cars to include trucks and fleets of vehicles—is not entirely new. The difference today is that vehicles are becoming active rather than passive members of the Internet of Things, connecting with enterprises, transport infrastructure and each other in entirely new ways. The emergence of the connected vehicle—one where the vehicle communicates with occupants, authorized service centers such as the dealer, and even other vehicles—is directly related to the expectations people have based on the interaction, immediate feedback, and richness of today's smartphones.

A connected vehicle has considerable benefits, such as its ability to communicate with the vehicle owner, the manufacturer, and the local dealership when potential maintenance issues are detected. Instead of simply flashing a dashboard warning light, for example, fault codes and other relevant information can be sent automatically. With this information, your dealer can inform you of the repair cost, ensure the parts are available beforehand, and suggest a convenient time for repair based on what it knows about your schedule. If you're not eligible for a loaner vehicle from your dealer, your insurance policy can be crosschecked automatically to arrange a rental for drop off at your convenience.

Further, additional features can be made available through new embedded applications provisioned after the vehicle is purchased, such as navigational map updates, maintenance schedule reminders and changes, and occupant entertainment options. This is important for manufacturers to attract and retain consumers who expect their "things" to help them with their complicated lives. Another example is the automatic detection of theft—of either the vehicle itself or one of its internal components—and the timely notification that theft is occurring before it's too late.

By 2024, 89 percent of new cars will have embedded connectivity, compared to just five percent in 2014 ([Analysys Mason](#)).



In addition to the benefits to the vehicle owner/operator, end-to-end connectivity offers new value to the manufacturer as well. Additional sensors and systems that monitor, capture, analyze, and report new information on the vehicle's components can generate better insight into performance, usage, and engineering. It may be determined, for instance, that certain parts are over-engineered—representing potential manufacturing cost savings—while other parts may need improvement due to unforeseen real-world scenarios. This may represent additional cost savings if the component in question is critical to safety. Additionally, real-time data gathered from other vehicles by the same manufacturer can be analyzed to predict failures *before* they occur.

In all of these cases, the key new business benefit to the manufacturer is telemetry that's available immediately. Traditionally, manufacturers don't have access to vehicle data until it shows up at the dealer for maintenance. IoT connectivity enables manufacturers to report on and react to real-time data with business intelligence and analysis. Further, manufacturers can dynamically send software updates that collect additional information about specific issues for certain models. Once the analysis is complete, they can reset the vehicle to normal data collection modes. The result is a more complete understanding of how vehicles operate over time and in what conditions.

Beyond the potential benefits of the connected vehicle, there are challenges and concerns that need to be considered. Let's explore these challenges now and discover how, once again, technology can come to the rescue.

Oracle and Telematics: The Value of Oracle's Technology

Using open systems from Oracle cuts development costs and drives new business. Oracle delivers end-to-end platforms that make it possible for vehicle manufacturers and suppliers of infotainment equipment and advanced driver assistance systems to expand their business along the value chain. Adapting the connected vehicle can deliver immediate impacts on your business: when you know your customer better and you can deliver better service, you increase the likelihood that the customer will buy the next vehicle from you.

The growth of in-vehicle software and the expansion of telecommunications in the cloud provide new possibilities to leverage database and enterprise technology, such as Oracle Event Processing, at the edge of the network. Oracle Java Embedded is ready to support multiple business cases for a broad range of industries, such as utilities, vehicle manufacturers, insurance companies, service providers, and so on. You can go to market more quickly and cost-effectively with a pre-integrated, complete solution stack based on leading products from Oracle.

Developing effective solutions, keeping costs down, and bringing them to market faster is made possible when OEMs and Tier 1 suppliers can rely on Oracle to provide:

- » *Reliable and flexible database technology*
 - » *Durability, persistence, and high availability*
 - » *Existing and future sensor technology*
 - » *Standards-based embedded SOA*
 - » *Greater vehicle-to-command-center data capability*
 - » *Insight into vehicle operations*
 - » *Updated IT standards*
-



The Challenges of IoT in Telematics

With the computing equivalent of 20 personal computers, 100 million lines of code, and processing up to 25 gigabytes of data per hour, today's vehicles have enormous potential to enhance our travel experience and safety ([McKinsey & Company](#)). But with all of this come potential challenges and concerns.

Security, Data Safety and Privacy

First and foremost is driver privacy and security. On average, 37 percent of people surveyed worldwide displayed reluctance to use vehicle connectivity features due to privacy concerns, and 54 percent were concerned their vehicle may be hacked and manipulated ([McKinsey & Company](#)).

This is the central challenge of combining control systems with communication or social systems, yet consumers demand an integrated experience. Therefore, manufacturers need to find ways to ensure data and privacy security, as well as the security of in-vehicle systems.

Digital Distractions

Some critics raise concerns about additional distractions caused by vehicle connectivity, even when these features may be targeted to passengers other than the driver. The challenge here is not only to ensure that new connectivity features aren't distracting, but that they help reduce existing driver distractions (e.g. cell phone texting and dialing, in-dash radio operation, navigation, and so on). Again, these features must be carefully integrated with control systems to ensure communication doesn't interfere with control.

Implementation Portability and Cost

Looking beyond the safety and privacy concerns of in-vehicle connectivity, manufacturers are challenged with the additional potential cost of connectivity. First, the cost of LTE cellular communications needs to be optimized to control costs. Second, many of the systems involved are embedded, traditionally requiring specialized tools and implementation skills that can be costly as well.

As models vary even within a single brand, vehicle designers and manufacturers are looking for ways to cut costs through re-use and portability. This involves complex long-term planning for future telematics hardware upgrades, to avoid re-implementing systems due to evolving hardware. Standards and advanced development techniques are needed to offset added cost and remove portability concerns.

Enterprise Integration

The value of a connected vehicle goes beyond its internal systems. It's what it connects to that truly adds value. Tapping into the value of IoT and building autonomous control into a vehicle's components, or even the vehicle as a whole, requires increased integration with outside systems and enhanced connectivity. The related challenge is to find or build a platform that offers robust connectivity options seamlessly.

Increased Value: Java and the Connected Vehicle

Oracle Java Embedded is built for the demands of the connected vehicle, with billions of devices, gateways, desktops and servers dependent on it to run the vehicle's core functions. Proven and highly leveraged technologies such as Java Embedded give vehicle manufacturers the ability to leapfrog competitors.

Whether it's used in telematics systems, aftermarket components, or other vehicle systems (see Figure 1), Java technology offers a number of key features that make it the ideal platform for vehicle connectivity. It enables headless, lights-out operation, a robust and secure application environment, and remote software provisioning and management, all built on the industry standard Java language and virtual machine already used in IT. Overall, Java Embedded addresses all of the challenges listed and more.

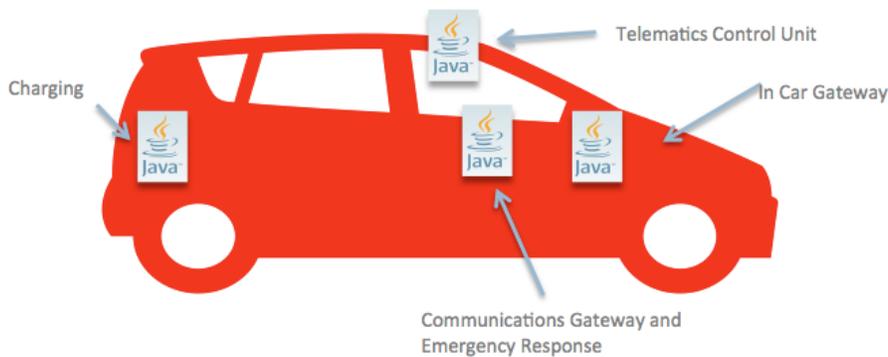


Figure 1. Oracle Java Embedded powers and connects critical in-vehicle telematics and components

Safety and Security

Java is a proven secure technology, providing a secure environment to run multiple applications, where each is isolated from the other, the operating system and other software components (see Figure 2). The security features of Java and its libraries include secure messaging, user authentication and authorization, vehicle and device identity, data encryption, PKI, code signing, and more.

Additionally, the “write once, run anywhere” mantra of Java development applies to security as well. Developing componentized Java applications according to supported security standards means you’ll be less likely to require new security measures as your hardware platform changes.

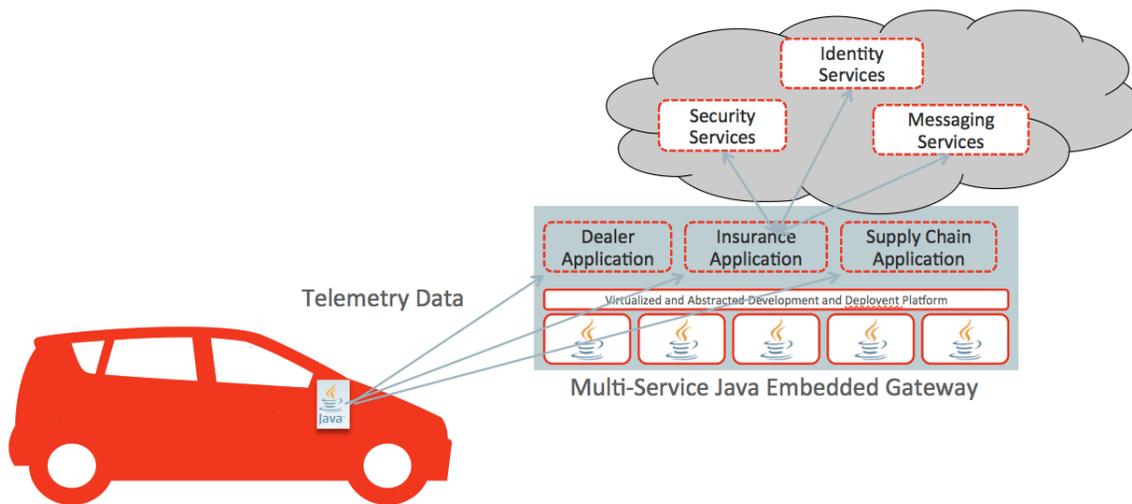


Figure 2. Oracle Java Embedded enables security and identity in telematics solutions

Total Connectivity Solution

There has been extreme growth in data being generated by the vehicle, along with the need to send more data to the vehicle, and this is only going to increase. The importance of reliable connectivity will grow along with it, and so will the risks if this data is lost. Java offers the robust communication services needed to reduce this risk.

Java's connectivity frameworks along, with wireless communication and web service APIs, allow Java Embedded applications to work seamlessly, reliably and securely with cloud-based enterprise services. This capability is crucial when deploying remote devices and infrastructure as part of an IoT value chain.

Ultimate Flexibility

To maximize the benefits of IoT, you require full flexibility in terms of where processing is performed. For example, it's generally most efficient to process data close to where it's captured. Java Embedded provides total flexibility in terms of where analytics and processing take place, allowing you to change it later without redesign. Java Embedded is ideal for intelligent telematics as it enables more processing and decision making to take place in the vehicle. In addition, new applications can be provisioned that upgrade functionality or enhance inspection of a specific problem. This allows access to vehicle data from new authorized service providers and application vendors, subject to vehicle owner approval and other access controls.

Automotive engineers are free to implement tomorrow's connected vehicle solutions today with Oracle Java Embedded technology.

Hardware Abstraction

The Java Embedded virtual machine offers an abstraction to underlying details and changes to embedded hardware, including telematics systems and after-market devices. This allows you to decouple your application from the multitude of variations of hardware and operating systems in the embedded world. With Java, you don't need to worry about cross-compiler tool chains or related embedded development complexities. You just use Java and its single set of tools to focus on business value and time to market, regardless of hardware platform.

Optimized for Embedded

Oracle Java Embedded enables intelligent devices (such as telematics components that help you operate a vehicle more efficiently) to be developed rapidly and at lower cost, easily resolving many development and application issues. This includes easy integration with enterprise and internet-based environments. Oracle is focusing on helping the market reap the benefits of the transformation to smarter devices both inside the vehicle and out.

Maximized Innovation

Java is continuously ranked as the most widely used development language in the world with over 9 million developers, and is used to develop a wide range of applications from enterprise to embedded. As in-vehicle connected systems demand new innovations and advancement, finding available talent will increasingly become a challenge. Being able to leverage Java's large pool of talent and tools will better enable this innovation, and reduce costs as you standardize your development end-to-end.

Since manufacturers already have IT staff that know Java, it provides the opportunity to have one team focused on in-vehicle software, communications gateways, and back-end data collection and analysis—all writing code in Java. No other development platform can provide this unique set of values.

Part of the Java innovation and value proposition for telematics is its ability to allow new service providers, such as the dealership or the manufacturer, to deploy an application to the vehicle. If the connected vehicle platform doesn't allow for the safe provisioning and management of third-party applications, then manufacturers risk losing future IoT revenue from after-market devices that will.

Java Reference Architecture for Telematics

Oracle has defined a reference architecture to illustrate how Java Embedded can solve many needs in a connected vehicle solution. This reference architecture (Figure 3) serves as a guideline for the multiple use cases to which Java can be applied.

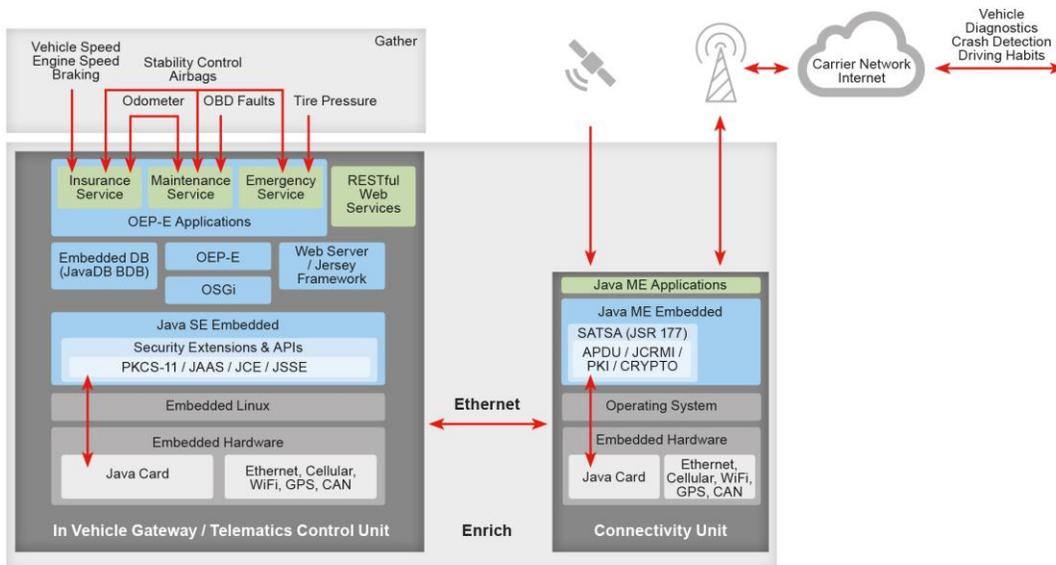


Figure 3. The Oracle Java reference architecture for telematics



The architecture covers and supports multiple applications within a single telematics unit, or distributed across multiple embedded computers and devices with high-speed reliable communications. Example use cases include:

- » Data gathering, aggregation, and reporting on vehicle performance parameters, such as vehicle speed, engine rotation speed, braking characteristics, mileage, fuel consumption, mechanical faults, tire pressure, and so on
- » Localized analytics to process this data at the point of capture for enhanced reporting, enrichment, and alerts
- » Cost-based communication routing, to ensure reliable communication starting from the least-expensive connectivity options (i.e. wifi) to others as needed. This includes the use of embedded cellular during normal operation on the road, and satellite communications for emergencies
- » Augmented vehicle operation, or assisted driving (e.g. safety features such as unintended lane change detection)

To ensure safety and security of the systems implemented and managed, Java Embedded supports automotive-grade Linux and provides the following comprehensive set of industry standard implementations:

- » Certificate-based security, Java cryptography extension with crypto-acceleration and near field communication (NFC) support
- » Java secure sockets extension (JSSE) for secure communication
- » Java authentication and authorization (JAAS) for user, device, and data identity
- » Public key cryptography standard (PKCS-11) for data encryption
- » Security and trust services (SATSA) for additional encrypted security features and communication capability

Additionally, the Oracle Java reference architecture supports integration with external systems through RESTful services, embedded SOA-based web services, and secure local storage of data. Through this architecture, Oracle and Java Embedded deliver the following telematics business benefits:

Data Management

- » The ability to filter, analyze, and correlate vehicle sensor data and take action on the large amount of data generated
 - » Real-time situational awareness, faster decisions, and immediate actions locally at the machine level and the enterprise back end
 - » Agnostic of event sources, destination or underlying communication layer
 - » Tooling and event flow monitoring

Remote Device Management

- » The ability to create a simplified and optimized network driven by remote device and application lifecycle management
 - » Application distribution and lifecycle management
 - » Real-time device monitoring
 - » Service management and diagnostics

Embedded System Diversity

- » Flexible architecture that supports applications running on a variety of devices from multiple vendors, minimizing application maintenance costs
 - » Consistent, Java-based application development environment
 - » Support for the range of devices from small embedded to enterprise-level servers
 - » Application distribution and lifecycle management

Security

- » Critical vehicle data and applications, secured on an open and integrated platform, connecting the vehicle to enterprise networks
 - » Device enrollment and management
 - » Access control, certification and compliance
 - » Fine-grained entitlements and policy management

Use Cases for Java in the Connected Vehicle

So far we've discussed the amount of data generated by modern vehicles, the challenges of connectivity, the unique value and capabilities Java offers vehicle manufacturers, and the Oracle Java Embedded reference architecture for telematics. Let's discuss some innovative connected vehicle solutions that Java can help enable today.

Semi-Autonomous and Infrastructure-Assisted Driving

Within a metropolitan area, traffic conditions can be improved when Java-enabled telematics systems inside connected vehicles can automatically alert and reroute drivers before congestion occurs. Potentially fatal driving mistakes can be prevented when automated systems cross-check the driver's actions with road conditions, vehicle speed and direction, and the positioning of other nearby vehicles.

The Digital Dashboard

Java's rich client technology enables rich digital dashboards and heads-up displays, designed specifically to visualize data (e.g. speedometer and odometer) and interact with the driver in a distraction-free environment. Allowing the driver to maintain outside communication, interact with infotainment, and operate a vehicle without compromising safety offers huge benefits for the driver, other drivers on the road, the vehicle manufacturer, and insurance companies.

Advanced Safety Features

Continuing the safety theme, a Java-enabled connected vehicle can help prevent and detect theft, report accidents, provide GPS location for emergency response, remotely unlock vehicles, and offer driver assistance in the form of gesture detection, text-to-speech services, and location services. Richer accident data can be used to make future vehicles safer and build accident avoidance systems into the vehicle itself.

Driver and Vehicle Performance Data

Data can be gathered, analyzed and encrypted by a Java Embedded-enabled gateway in the vehicle, and then communicated with authenticated and authorized third parties such as insurance companies via the vehicle manufacturer's infrastructure. These data may be used to provide safe-driver discounts, optimize lean-manufacturing processes based on real-time usage data, optimize vehicle performance (e.g. fuel consumption, recommended servicing, and so on) based on driver characteristics, and develop new features for future models.

Further use of these data include suggestions to increase economy, including alternate routes, schedules, and driving habits.

Enhanced Navigation

Real-time navigation integration with other Java-enabled systems can be used to offer new services while on long trips, such as:

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- » Suggesting gas stations with the cheapest prices en-route, along with suggested fill-up times based on calculated fuel consumption
 - » Recommending restaurants along the route according to the driver's likes, pre-set price range, and so on
 - » Send automated notifications (with audible confirmation from the driver) based on calendar and contacts integration, and route-guided arrival time, if the driver will be late

Limited only by imagination, vehicle engineers are free to implement tomorrow's connected vehicle solutions today with cost-effective applications based on Java Embedded technology.

Getting Started with Oracle

As outlined above, Oracle Java Embedded is a disruptive technology that gives vehicle manufacturers the ability to meet the challenges a modern vehicle brings, including the need for flexibility, security, modularity and updateability. Java Embedded offers vehicle manufacturers and authorized service providers the ability to standardize their end-to-end development on Java, from enterprise to embedded, leveraging internal and external pools of talent as well as available tools, software libraries, and frameworks.

Oracle Java Embedded is engineered and optimized to meet the unique challenges of designing intelligent devices that unlock the business value of the connected vehicle. An open, standards-based platform with an unequalled developer ecosystem, Oracle Java Embedded makes it faster and more affordable to get innovative, reliable, and secure telematics products to market and provide the long-term support for success.

To learn more, visit oracle.com/goto/javaembedded and oracle.com/iot.



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