What makes the OSGi standard so attractive for the Internet of Things? The dynamic modular architecture with its integrated life-cycle mechanism, the reusability of software components, a device abstraction layer as well as a wide range of communication interfaces.

The broad applicability of the dynamic modular architecture allows not only product and business solutions - in the cloud as well as standalone - to scale considerably, but different technologies can also be integrated via the end-to-end structure of the OSGi standard. An expandable OSGi IoT demo shows both the range of applications and the possibilities of IoT based OSGi. A first variant has already been publicly launched in conjunction with the EclipseCon Europe on the latest OSGi Community Event.

The OSGi Alliance has had specifications for more than a decade covering a modular and dynamic software architecture. This specified software architecture has already been used in various industries which adapted them to fit their own requirements. Accordingly, the specifications cover various markets, including the enterprise market, but also smart home, telematics and mobile devices.

In times of increasing industrial integration and associated requirements for end-to-end solutions, the relevance of the OSGi specifications - from the standardized modular runtime environment, multiple communication and transportation protocol interfaces to a device abstraction layer, and a development environment for PaaS and SaaS cloud applications - will dramatically increase.

Not only is the OSGi ecosystem growing steadily, but also a large number of OSGi-based product solutions. To take account of this development, the OSGi IoT demo was initiated. This was first presented at the OSGi Community Event in Ludwigsburg in October 2014 and is also used at the hackathon and code demo camps. The following article examines the OSGi
IoT demo, their applicability and expansion and provides an outlook for the coming years.

**IoT as a promising market**

Companies such as Cisco reckon that in the industrial IoT sector there will be over 50 billion Internet-enabled devices by 2020 and, depending on your definition, significantly more in the following years. In addition, analysts such as the International Data Corporation (IDC) have already noted strong growth in 2014 and saw in their investigation of the IoT ecosystem - this included smart and embedded systems, networked services, infrastructure, targeted IoT platforms, applications, security, analysis and professional services - a transformation ahead for the verticals exploding the worldwide market for IoT solutions from today's 1.9 billion US dollars to 7.1 billion US dollars in 2020.

So it is no wonder that IoT is on everyone's lips. However, there remain some tasks on the way to provide a real Internet of things. IoT spans various industries each with different stakeholders and each with their own challenges: proprietary solutions, countless devices and machinery, hardware and software with incompatible requirements in applications, communication protocols and storage.

- Who owns the equipment?
- Which units belong to the customer, the business and the provider?
- Who will have authorized access to all these different devices?

There are also questions about technology platforms and potential applications that are to be found in different industries and on countless devices. Which security aspects need to be considered at what level in the IoT market in order to provide guarantees to the customer? Are there one or more bridging technologies that can be used as an integration platform for IoT-market?

Standardized software platforms in embedded systems must play an increasingly important role, as the complexity of the software increases unabated and the gap of the life cycle between hardware and software is increasing. In addition, the platform features (processors, operating systems, etc.) change - for cost reasons - repeatedly in embedded systems. This is often associated with additional development and st, since software components cannot usually be reused and thus a large part of the software must be re-implemented.

Here, the OSGi Alliance enters with its standards (OSGi). The OSGi Alliance is a global industry consortium that serves a growing ecosystem. The members of the OSGi Alliance come from different industrial markets - from Smart Home and adjacent markets over telematics to Enterprise and...
Cloud. The common standardized modular architecture is extended with every new specification, meeting specific industrial requirements, and used by members and relevant suppliers in their business solutions. As part of the OSGi IoT demo an approach is demonstrated showing that many of the aforementioned problems can be solved.

**The technical implementation of the OSGi IoT Demo**

The OSGi IoT demo is set up so that - in line with its own modular and dynamic architecture - it can be expanded at any time. The OSGi Community Event in 2014 in Ludwigsburg, where the OSGi core demo was first displayed, three companies joined together with another industry consortium:

1. **Paremus**, OSGi Strategic partners who with their expertise in the enterprise space have already realized OSGi solutions for many large businesses, particularly in the financial sector. They drive many of the Alliance specifications and here provide the IoT Demo with their OSGi PaaS Product *Service Fabric*.

2. **ProSyst**, OSGi strategic Partner with more than fifteen years of experience in various industrial markets is able to realize IOT projects. In the IoT demo the OSGi based gateway Framework *mBS Smart Home* is used together with the device and software management of *mPRM*. Furthermore, ProSyst open source OSGi framework is integrated as an optional framework in the demo and enables seamless remote maintenance of all terminals via a back-end platform.

3. **BitReactive**, a member of the OSGi Alliance and an expert at the level of graphical software development with the focus on Java and OSGi solutions, brings a demo of its Eclipse-based development environment *Blocks SDK* together with a prototype simulation of a wind turbine with distributed data acquisition.

4. **SD Card Association**, the Association of SD card manufacturers, supplied SD cards to the participants of the demonstration.

The OSGi Community Event presented an introduction and presentation of the IoT demo and its architecture, after which a hackathon with interested developers was held. As part of the hackathon developers developed more applications using the provided SDKs and the demo environment, after which they were loaded into the OSGi-based cloud. Using the OSGi-based administration platform these applications were then made available for use.
The architecture and structure of OSGi IoT Demo

As IoT Edge platform the Raspberry Pi B (+) was used because it is widespread in the environment and it's low cost prototyping allows a BYOD approach (Bring Your Own Device) for demos and hackathons. With the latest version of the Raspberry Pi operating system Raspian the latest version of Oracle's Java 8 JRE is used as a Java execution environment. On this base level different open source (Apache Felix, Eclipse Equinox) and commercial (MBS SH) frameworks have been set up to showcase the simultaneous running of different OSGi implementations and the broad applicability of the demo architecture (Fig. 1).

To showcase IoT in full from Edge to Core, the Service Fabric was used with its in-built discovery mechanism. It allows Raspberry Pis remote access to various services which are provided by the PaaS. This includes the mPRM, which connects to the Raspberry Pis via the embedded OSGi frameworks, then maps their device structure to the backend. mPRM covers the entire software management, enabling authorization by other services wishing to access the devices. Using the software repository of the mPRM a Wind turbine Simulator bundle is delivered to each Raspberry Pi as it connects so that the simulated wind farm spread across the individual devices. To process the data and visualize it, the Service Fabric loads an instance of the MQTT server mosquitto, which is made available via its own discovery process to the wind turbine simulators. A monitoring system developed by BitReactive displays the current wind farm with the individual energy information.
Setup and Hackathon

After the developers have loaded their own applications, now OSGi-based, the Raspberry Pis on the Service Fabric are connected to mPRM and have become part of the wind turbine demonstration in the virtual wind farms, they now can develop other IoT applications using the BitReactive Block SDK. For example, a Z-Wave multi-sensor, which is integrated via an attached Z-Wave GPIO board on a Raspberry Pi and via software interface (e.g. the HDM connection of the mBS SH) could be used (Fig. 2).

![Diagram of IoT setup and Hackathon](image)

**Fig. 2: Setup at the end of the Hackathon**

Via the Block SDK developers can use predefined graphical blocks. These are linked together logically and can be used as building blocks for larger functional systems. For this purpose BitReactive already has a large collection of open-source blocks for the development of IoT applications. An application is created as an OSGi Bundle, then using the Application Wizard mBS SH SDK from ProSyst it is bundled as an Application Deployment with any resources necessary and stored in the mPRM software repository. At this point interested developers can download this new application for testing on their own Raspberry Pis and combine it with other applications if necessary. Winner of the Hackathon was Tobiasz Dworak, System & Software Architect, Research & Engineering Center Poland.
Summary:

The OSGi IoT Demo not only shows the first applications of an end-to-end IoT solution based on standardized OSGi architecture, but also opens up the option to dynamically integrate its own product solutions and to expand through additional applications and functionalities. In the coming years more OSGi specifications in the field of IoT will arise and be displayed in the OSGi IoT Demo. In order to present the added value of its own public product solutions the OSGi IoT demo will be expanded continuously in consultation with the OSGi Alliance. First inquiries on participation in and extension to the demo are already well advanced and these will be featured on the next OSGi Community Event in Ludwigsburg from the 3rd-5th to November 2015. If you are interested in participating please contact us at info@osgi.org.