Smart City, Industry 4.0, Pervasive 5G, and Mobile Edge Computing all have vast Economic potential!

- All of these are distributed IoT software eco-systems need to be **orders of magnitude more sophisticated** than anything we currently have. The Internet is defined by a hand full of simple fixed specifications - in contrast each Smart City will be a complex co-evolving software eco-system

- Such solutions must be **Economically Sustainable, Maintainable, Agile and Evolvable** over many decades

- These Economic opportunities are currently inhibited by the current **Software Complexity Crisis**
The Complexity Crisis

“76% of CIOs Say It Could Become Impossible to Manage Digital Performance, as IT Complexity Soars”
(Jan 2018 – Source: https://bit.ly/3a8ZQzz)

Operational Complexity
Increases OPEX
Decreases Agility

Anne Thomas Manes (Gartner):
SOA Symposium, Berlin, October 2010

Operational Complexity
Increases the Likelihood and Duration of Service Failures
Berkley’s ROC initiative:
http://roc.cs.berkeley.edu/papers/ROC_TR02-1175.pdf

What causes un-availability?

- Many different factors are involved
  - human behavior during maintenance dominates
A Sustainability/Longevity Crisis for IoT Solutions

“Modern-day software systems, even those that presumably function correctly, have a useful and effective shelf life orders of magnitude less than other engineering artifacts.

While an application’s lifetime typically cannot be predicted with any degree of accuracy, it is likely to be strongly inversely correlated with the rate and magnitude of change of the ecosystem in which it executes.”

DARPA BRASS initiative April 2015

OSGi Alliance: Formed in 1999 with a mission to address this fundamental problem!
Modularity

As long as the design rules (specifications) are obeyed:
- Modularity makes complexity manageable by breaking down a big tangled ball into smaller, well defined components that fit together well
- Modularity enables parallel work allows people to work on different problems all at the same time; and
- Modularity is tolerant of uncertainty because can plug in and plug out without concern of the overall structure

“Tolerant of uncertainty” means that elements of a modular design:
- May be changed
- After the fact and
- In unforeseen ways

As Long as ALL Dependencies are Managed
Specific Challenges for IoT…

Nested Hierarchy of Structures
- Smart Home is part of Smart Grid, Smart Grid is part of Smart City

Increasingly distributed Edge Centric Architectures
- No longer solely with a Cloud Hub and IoT devices as Spokes
- Sensor, Edge Devices, IoT Gateways, on site MicroCloud/Edge Compute, Fog Architectures, Clouds …

Highly fragmented Market
- 450 IoT Platforms in 2017 (Source: IoT Analytics)
- Many companies start with building their own “Micro”-ecosystems
OSGi – Addressing this Chaotic Standards Landscape

OSGi provides a coherent and risk minimizing approach to addressing an increasingly heterogeneous IT Standards landscape

- Allowing solutions based on different Functional Specifications (e.g., OneM2M and W3C/WoT) to interoperate without creating brittle / change resistant / APIs
- Via standardized protocol adapters: e.g., Zigbee, EnOcean
- Enabling solutions to embrace Future - currently unknown - Standards

OSGi provides the ideal platform to implement functional for Device Management, Device Connectivity & Software Provisioning

- Specifications for TR-069 and OMA-DM available for many years
- Specifications for Protocols: e.g., ZigBee, EnOcean

Future areas of relevance

- Domain Specific Semantics: EEBus, AGORA,…
- Protocol support for e.g., Bluetooth LE, OPC-UA,…
OSGi – Addressing IoT Requirements

Avoid Vendor Lock-in: OSGi is a mature Open Industry Standard
Economically Sustainable: OSGi is the standard for Java Modularity
OSGi avoids building Future Legacy by enabling:
  • Pluggable Maintainability; Environmental Diversity; Adaption and Evolvability
  • Ease of Integration of functional components from different suppliers / providers, based
    on different Standards

OSGi Developer Skills:
  • Can be used or re-used at the IoT Edge and the Enterprise and/or Cloud Core

OSGi Self Describing Modules enable:
  • Reusability of software components in different environmental contexts: e.g., enabling
    AI/Data processing components to be run in either the Core or the physical Edge
  • Avoids loss of structural knowledge over time (dead sea effect) as developers leave.
    Modules are Self-Describing and dependencies are automatically calculated by the OSGi
    Resolution Process
OSGi – Enabling Architectural Flexibility Cloud Hub and Spoke
OSGi – Enabling Architectural Flexibility A Federated Fog Architecture

An OSGi based Smart City/Industry 4.0 AI / FOG platform (EU Horizon 2020)

Flow of behaviors
(OSGi bundles) – local control & monitoring

Flow of Refined Data

Cloud level nodes

Edge level nodes

OSGi Edge Nodes
On-Site Gateways and/or local Clouds

Sensors & actuators
OSGi Alliance IoT Expert Group

The IoT EG was formally created in September 2015
• More than 12 OSGi member companies are contributing
• Co-Chairs: Tim Ward (Paremus) and Bruce Jackson (Thingstream)

The IoT EG areas of concern include:
• To support application developers to create IoT services
• Targeting embedded and cloud environments where they intersect with endpoint devices
• Data processing and management in IoT gateways
• Cross-industry and cross-protocol device connectivity on level of actors/sensors and IoT gateways
• Support the development and deployment of device abstraction layer and endpoint ontologies
• The virtualization of IoT services
• Connectivity to the cloud for endpoint devices and the interoperation with existing management systems and protocols
• Enable and enforce IoT end-to-end security
Call for Action: IoT is Best Done with Others

Relevance
• The value over time is shifting from hardware to software

Sustainability
• Avoid technical-debt
• Preserve existing value while enabling cost effective enhancements

Reuse
• Let’s not reinvent the wheel again and again – We already have 450+ IoT platforms
• Let’s share resources, investment and risk to ensure:
  • Interoperability in IoT Solutions
  • Software modularization from the edge to cloud
  • Evolution of distributed software right from the beginning

Many IoT technologies and standards come and go – OSGi has been addressing the IoT domain for almost 20 years.

Join us and build the next generation of IoT
As Complexity is tamed - Total Cost of Ownership is reduced

Economically sustainable IoT Solutions will be modular; these solutions will have the characteristics imbued by OSGi technology

Tell me more!
• Modularity - [https://www.osgi.org/developer/modularity/](https://www.osgi.org/developer/modularity/)
• Start to build Modular Software Systems - [https://enroute.osgi.org](https://enroute.osgi.org)