InterOSS-IoT Workshop – Papers and abstracts

November 7th, 2016

Session 1: Semantic interoperability	
#1 Title:	Semantic Interoperability as Key to IoT Platform Federation
Authors:	Michael Jacoby, Aleksandar Antonic, Karl Kreiner, Roman Lapacz and Jasmin Pielorz
Author keywords:	Semantic Interoperability, Internet of Things, IoT Platform Federation, Semantic Mapping, symbIoTe, SPARQL Query Re-Writing
Abstract:	Semantic interoperability is the key technology to enable evolution of the Internet of Things (IoT) from its current state of independent vertical IoT silos to interconnected IoT platform federations. This paper analyzes the possible solution space on how to achieve semantic interoperability and presents five possible approaches in detail together with a discussion on implementation issues. It presents the H2020 symbIoTe project as an example on how semantic interoperability can be achieved using semantic mapping and SPARQL query re-writing. We conclude that the found approaches together with the proposed technologies have the potential to act as corner stone technologies for achieving semantic interoperability.
#2 Title:	Overcoming the heterogeneity in the Internet of Things for Smart Cities
Paper authors:	Aqeel Kazmi, Zeeshan Jan, Martin Serrano and Achille Zappa
Author keywords:	Internet of Things (IoT), Interoperability, Smart Cities, Linked Data, Data Model
Abstract:	In the past few years, the viability of the Internet of Things (IoT) technology has been demonstrated, leading to increased possibilities for novel human-centric services in the smart cities. This development has resulted in numerous approaches being proposed for harnessing IoT for smart city applications. Having received a significant attention by the research community and industry, IoT adaptation has gained momentum. IoT-enabled applications are being rapidly developed in a number of domains such as energy management, waste management, traffic control, mobility, healthcare, ambient assisted living, etc. On the other hand, this high-speed development and adaptation has resulted in the emergence of heterogeneous IoT architectures, standards, middlewares, and applications. This heterogeneity is hindrance in the realization of a much anticipated IoT global eco-system. Hence, the heterogeneity (from hardware level to application level) is a critical issue that needs high-priority and must be resolved as early as possible. In this article, we present and discuss the modelling of heterogeneous IoT data streams in order to overcome the challenge of heterogeneity. The data model is used within the VITAL project which is an open source IoT system of systems. The main objective of the VITAL platform is to enable rapid development of cross-platform and cross-context IoT based applications for smart cities.
#3 Title:	Exposing Internet of Things Devices on REST and Linked Data Interfaces
Paper authors:	Tobias Käfer, Sebastian Richard Bader, Lars Heling, Raphael Manke and Andreas Harth
Author keywords:	Internet of Things, Linked Data, REST
Abstract:	Web technologies are widely used open standards to interconnect devices on virtually any platform. The W3C's Web of Things effort wants to bring web technologies to the Internet of Things

to address interoperability challenges on the Internet of Things.

In this paper, we report on four independently developed implementations whose aim was to expose Internet of Things devices via web technologies, more concretely REST and Linked Data interfaces.

While they were all developed with the same goal in mind, and with technologies that promote uniformity on the interfaces, the implementations still exhibit different schemas and architectures with different communication patterns.

Session 2: Interoperabile architectures and platforms	
#1 Title:	An Architecture for Interoperable IoT Ecosystems
Paper authors:	Stefan Schmid, Arne Bröring, Denis Kramer, Sebastian Käbisch, Achille Zappa, Martin Lorenz, Yong Wang, Andreas Rausch and Luca Gioppo
Author keywords:	Internet of Things Architecture, Interoperability, Marketplace
Abstract:	The Internet of Things (IoT) is maturing and more and more IoT platforms that give access to things are emerging. However, the real potential of the IoT lies in growing IoT cross-domain ecosystems on top of these platforms that will deliver new, unanticipated value added applications and services. We identified two crucial aspects that are important to grow an IoT ecosystem: (i) interoperability to enable cross-platform and even cross-domain application developments on top of IoT platforms as well as (ii) marketplaces to share and monetize IoT resources. Having these two crucial pillars of an IoT ecosystem in mind, we present in this article the BIG IoT architecture as the foundation to establish IoT ecosystems. The architecture fulfills essential requirements that have been assessed among industry and research organizations as part of the BIG IoT project. We demonstrate a first proof-of-concept implementation in the context of an exemplary smart cities scenario.
#2 Title:	A Sensor Observation Service extension for Internet of Things
Paper:	Argyris Samourkasidis and Ioannis N. Athanasiadis
Author keywords:	Sensor Observation Service Disruption-tolerant communication Internet of Things, Pagination
Abstract:	This work contributes towards extending OGC Sensor Observation Service to become ready for Internet of Things, i.e. can be employed by devices with limited capabilities or opportunistic internet connection. We present an extension based on progressive data transmission, which by-design facilitates selective data harvesting and disruption-tolerant communication. The extension economizes resources, while respects the SOS specification requirement that the client should have no a-priori knowledge of the server capabilities. Empirical experiments in two case studies demonstrate that the extension adds little overhead and may lead to significant performance improvements in certain cases, as for irregular timeseries. Also, the proposed extension is not invasive and backwards compatible with legacy clients.
#3 Title:	Requirement-based Deployment of Applications in Calvin
Paper authors:	Ola Angelsmark and Per Persson
Author	Calvin, IoT, peer-to-peer, platform, applications, requirements, deployment

keywords:	
Abstract:	In order for IoT application developers to deliver on the promise of IoT, new tools and methodologies that address the challenges associated with the development of highly distributed systems running on a non-reliable and heterogeneous hardware platform are required. Some of the main characteristics of cloud computing that has been a driving force for its success, are resource pooling, elasticity and the capacity for combining unrelated services. We believe that a similar approach is needed for IoT as well. In this paper, we show how Calvin, an open source peer-to-peer platform for distributed applications, tackles many of the problems inherent in IoT. By only loosely associating the functionality of a device with a semantics, and having implementations based on conventions rather than pre-defined terminology, it is possible to let a system of Calvin runtimes autonomously handle deployment decisions, and respond to changing requirements. We will discuss how to develop and deploy dynamic and adaptive IoT-applications based on capabilities and requirements, and how to resolve requirements by automatically combining information from multiple sources based on encapsulated domain knowledge.

Session 3: Business models and security	
#1 Title:	Business Models for Interoperable IoT Ecosystems
Paper authors:	Werner Schladofsky, Jelena Mitic, Alfred Paul Megner, Claudia Simonato, Luca Gioppo, Dimitris Leonardos and Arne Bröring
Author keywords:	Internet of Things, Ecosystems, Business Models, Interoperability
Abstract:	The Internet of Things (IoT) is growing and more and more devices, so-called "things", are being connected every day. IoT platforms provide access to those "things" and make them available for services and applications. Today, a broad range of such IoT platforms exist with differing functional foci, target domains, and interfaces. However, to fully exploit the economic impact of the IoT, it is essential to enable applications to interoperate with the various IoT platforms. The BIG IoT project aims at enabling this interoperability and supporting the creation of vibrant IoT ecosystems, which facilitate the development of cross-platform and cross-domain applications. While the value of interoperability for the overall economy is well understood and cannot be underestimated, some stakeholders may still need to find their business value in interoperable IoT ecosystems. Thus, this paper identifies the different stakeholders of such ecosystems, and analyzes how these stakeholders can enhance their existing business models when taking part in an interoperable IoT ecosystem.
#2 Title:	On the Road to Secure and Privacy-preserving IoT Ecosystems
Paper authors:	Juan Hernández-Serrano, Jose L. Muñoz, Arne Bröring, Oscar Esparza, Lars Mikkelsen, Wolfgang Schwarzott, Olga León and Jan Zibuschka
Author keywords:	Internet of Things (IoT), security, privacy
Abstract:	The Internet of Things (IoT) is on the rise. Today, various IoT platforms are already available, giving access to myriads of things. Initiatives such as BIG IoT are bringing those IoT platforms together in order to form ecosystems. Such IoT ecosystems facilitate cross-platform and cross-domain application developments and establish centralized marketplaces to allow resource monetization. This combination of multi-platform

	applications, heterogeneity of the IoT, as well as enabling marketing and accounting of resources results in crucial challenges for security and privacy. Hence, this article analyses the requirements for security in IoT ecosystems and outlines solutions followed in the BIG IoT project to tackle those challenges. Concrete analysis of an IoT use case covering aspects such as public, private transportation, and smart parking is also presented.
#3 Title:	Attribute-Based Access Control scheme in federated IoT platforms
Paper authors:	Savio Sciancalepore, Michal Pilc, Svenja Schröder, Giuseppe Bianchi, Gennaro Boggia, Marek Pawlowski, Giuseppe Piro, Marcin Plociennik and Hannes Weisgrab
Author keywords:	Internet of Things, symbIoTe, Security Mechanisms, Attribute-Based Access Control, Interoperability Framework, Macaroons, JSON Web Token
Abstract:	The Internet of Things (IoT) paradigm rapidly changed how people think about and experience the Internet. During the inevitable evolution of the Internet landscape, in fact, IoT introduced the possibility to connect electronic things from everyday life to the Internet, while making them ubiquitously available. Now, the new research trend is following the development of advanced services, based on a trusted federation among heterogeneous IoT platforms. In this context, however, a new set of security problems (including authentication and authorization) emerges. The aim of this contribution is to describe the main facets of the preliminary security architecture envisaged in the context of the symbIoTe project, recently lunched by European Commission under the Horizon 2020 EU program. At the time of this writing, the developed solution already offers distributed and decoupled mechanisms for the provisioning of authentication and authorization services in complex scenarios embracing many, heterogeneous, and federated IoT platforms. Specifically, they leverage Attribute Based Access Control and token-based authorization techniques. Thus, the work will provide a step-by-step description of security functionalities in three different target scenarios and will suggest, at the end, some promising technical implementations that can be taken into account in the hereafter of the symbIoTe project.

Session 4: Platform performance and applications	
#1 Title:	Ingestion and Storage Performance of IoT Platforms: Study of OpenIoT
Paper authors:	Alexey Medvedev, Alireza Hassani, Arkady Zaslavsky, Prem Prakash Jayaraman, Maria Indrawan-Santiago, Pari Delir Haghighi and Sea Ling
Author keywords:	Internet of Things (IoT), Data Management, storage, ingestion, evaluation
Abstract:	Internet of Things is a very active research area with great commer-cialisation potential. The number of IoT platforms is already exceeding 300 and still growing. However, performance evaluation and benchmarking of IoT plat-forms have not reached the maturity stage yet. This paper analyses and compares a number of popular IoT platforms from data ingestion and storage capabilities perspectives. Popular open source IoT platform OpenIoT has been selected for the case study and evaluated through extensive experimentation. The results of the experiments and the lessons learnt are presented and discussed. While having a great research promise and pioneering contribution to semantic interoperability of IoT silos, the OpenIoT platform needs more development effort to be ready for any substantial deployment in commercial IoT applications.
#2 Title:	Apps for Environments: Running Interoperable Apps in Smart Environments with the

	meSchup IoT Platform
Paper author:	Thomas Kubitza
Author keywords:	Internet of Things, Smart Environments, Middleware, Smart Space Apps
Abstract:	With Apps a popular concept was introduced allowing end-users to easily extend their devices such as smartphones or computers with specific functionality. Two million Apps have ever since found their way into each of the popular App stores Google Play and Apple Store. We believe that the App-concept is not only well applicable to single devices but also to complete environments equipped with smart networked things. In the moment when Apps can be easily downloaded and executed in home, office and industry environments a wide new applications space will be opened up. In this work we introduce the concept of Smart Space Apps that can be downloaded from a cloud-based App store into a smart environment where they dynamically utilize the capabilities of available smart things to optimally achieve the purpose they were installed for. We introduce a unified schema for the access of sensor and actuators of heterogeneous devices from within Smart Space Apps and describe the middleware and runtime that implements this approach. We explain how Apps are packaged into an exchangeable format and published within a cloud-based App store. Multiple application use cases are shown and challenges of this novel approach are discussed.
#3 Title:	Using semantics and open standards for personal real-time big data processing: Experience from a case study in Remote Patient Monitoring
Paper authors:	Nenad Stojanovic and Aleksandar Stojadinovic
Author keywords:	wearables, semantics, big data, remote patient monitoring
Abstract:	Due to the expansion of IoT and especially wearable sensors, remote personal monitoring based on the huge amount of real-time personal data streams has become a huge trend in the healthcare and wellbeing domains. However, current solutions cover only a small part of the (huge) application potential, in some cases even going below the expectation of early adopters. One of the main reasons is the lack of the proper technological foundations for dealing with real-time big data produced in these scenarios. Shortly, solutions are missing better (semantic) understanding of sensed data (enabling interoperability) and more efficient real-time processing (enabling situational awareness). In this paper we present our approach for building advanced remote monitoring systems based on semantic- and complex event processing technologies, focusing primarily on the experience from an eHealth case study in monitoring cardiac patients. We discuss in details the challenges of getting semantics "down" to the mobile phones and "up" to the real-time big data processing. We conclude that semantics is very useful for building advanced mobile applications, but the pure semantic models and techniques have to be combined with open standards and mainstream big data technologies (e.g. hybrid storage) in order to be applicable for large case studies and for commercialization.
#4 Title:	Semantic Interoperability at Big-Data Scale for the Industrial Internet of Things with the open62541 OPC UA Implementation
Paper author:	Julius Pfrommer
Author keywords:	OPC UA, Open Source, Object-Orientation, Semantic Information Modeling

keywords:	
Abstract:	The OPC Unified Architecture (OPC UA) is a protocol for Ethernet-based communication in industrial settings. At its core, OPC UA defines a set of services for interaction with a server-side information model that combines object-orientation with semantic technologies. So-called Companion Specifications use the OPC~UA meta-model to define domain-specific modelling concepts for semantic interoperability. open62541 is an open source implementation of the OPC UA standard. In this work, we describe the core concepts of OPC UA, how they reflect in the overall architecture chosen for open62541 and the measures taken to scale OPC UA to Big-Data operations.