Open Access

Open Journal of Internet of Things (OJIOT)
Volume 5, Issue 1, 2019
http://www.ronpub.com/ojiot
ISSN 2364-7108

Editorial of the 2019 Workshop on *Very Large Internet of Things (VLIoT)*

Markus Endler[A], Sven Groppe[B]

[A]Departamento de Informática. PUC-Rio, Rua Marquês de São Vicente 225, Rio de Janeiro, Brazil, endler@inf.puc-rio.br
[B]Institute of Information Systems (IFIS), University of Lubeck, Ratzeburger Allee 160, D-23562 Lübeck, Germany, groppe@ifis.uni-luebeck.de

Abstract

We are proud of presenting the outcome of this third edition of the "Very Large Internet of Things" (VLIoT) workshop, which was held in Los Angeles (USA) in August 2019, in conjunction with the 45th International Conference on Very Large Data Bases (VLDB). Following the success path of the two previous workshop editions - in Munich (2017) and in Rio de Janeiro (2018) - VLIoT 2019 kept its tradition to be a vivid and high-quality technical forum for researchers and practitioners working with Internet of Things to share their experiences, visions and latest findings, most of them regarding the design, implementation, deployment and management of IoT systems at very large and scale. This editorial of the special issue introduces and introduces all papers presented at the workshop.

Type of Paper and Keywords

Editorial: *Internet of Things, Very Large Internet of Things, VLIoT@VLDB 2019, workshop, open access, Open Journal of Internet of Things, OJIOT, RonPub*

1 Introduction

In a widely digitized world, the Internet of Things (IoT) plays the role of the networking and software infrastructure for most application-specific data analysis, be it an offline-statistical or an online-reactive analysis. Regarding software for IoT, most of it will be either embedded in tiny resource-constrained devices, be in the form of components/services/funcions at the middleware level, or will be application-specific mobile apps, or web-based tools. While the embedded software components usually take care of low-level and device-local functions, it is the middleware that handles the global and higher-level IoT processing. And in many cases, IoT middleware is responsible for all digital communications (among heterogeneous devices and platforms), protocol translations, action coordination, resource discovery, detection and controlling state changes of devices, probing sensor data, context awareness, and many other general tasks.

And when an IoT system is deployed at a large scale, such as in a campus-, regional-, city- or country-wide deployment, then a whole set of new challenges arise. First and foremost, it will probably be a system of systems, build so as to yield hierarchical and scalable services and protocols. Actually, concept of scalability for IoT materializes in many orthogonal dimensions,

This paper is accepted at the *International Workshop on Very Large Internet of Things (VLIoT 2019)* in conjunction with the VLDB 2019 Conference in Los Angeles, USA. The proceedings of VLIoT@VLDB 2019 are published in the Open Journal of Internet of Things (OJIOT) as special issue.

such as the geographic dimension, the network-size, the number IoT devices (smart things), the set of different types of IoT devices, set of indoor/outdoor ambients, set of clients, of application servers, of middleware services, etc. Moreover, IoT systems currently are also designed to deal with many sorts in-system data processing at different levels of the system's capillarity, at edge devices, in the fog, and in cloud-based services, all of them cooperatively transforming data into decision-ready information and knowledge. And although the specific processing logic is very much dependent on the specific needs of the analytics and the networking capabilities, many IoT systems nowadays employ data stream processing functions, turning streams of sensor/state data from the environment and IoT devices into streams of online information for the user, into notifications of non-conformity or into input to control logic that will respond actuation commands.

Fortunately, all of the papers accepted for VLIoT 2019 address some of these relevant aspects of the development, implementation, and deployment of large-scale, distributed, mobile, stream handling, heterogeneous and multi-tenant Internet of Things systems.

Since its first edition in 2017 the main goal of the VLIoT workshop has been to bring together academic researchers and industry practitioners working in the broad field of IoT and related subjects, and to allow them to present and exchange their research findings, their experience and share their vision about the future of IoT at a very large scale. Besides the above mentioned issues, this workshop also intended to discuss other related topics, such as coordination between fog-, edge-, and dew-computing in IoT, Connected Nanotechnology, Artificial Intelligence for IoT (AIoT), Internet of Vehicles, Connecetd Automated Vehicles, and others.

2 VLIoT Call: Types of Papers

This third edition of VLIoT solicited papers of different types containing contributions describing original ideas, promising new concepts, and practical experience, namely:

- Research papers: proposing new approaches, theories or techniques related to IoT, including new data structures, algorithms, whole systems, and frameworks. They should make substantial theoretical and empirical contributions to the research field.
- Experiments and analysis papers: focusing on the experimental evaluation of existing approaches including data structures and algorithms for the IoT and bring new insights through the analysis of these experiments. Results of experiments and analysis papers can be, for example, showing benefits of well known approaches in new settings and environments, opening new research problems by demonstrating unexpected behavior or phenomena, or comparing a set of traditional approaches in an experimental survey.
- Application papers: reporting practical experiences on Internet of Things applications. Application papers might describe specific application domains in the IoT such as smart homes/offices/cities, continuous health care, waste management, emergency response, intelligent response, and Industry 4.0.
- Vision papers: identifying emerging or future research issues and directions, and describing new research visions in the IoT area that may have a great impact on our society.

3 VLIoT Call: Topics of Interest

The VLIoT 2019 solicited papers in the following, non-exlcusive, list of topics:

- Semantics and Spatial and temporal reasoning for IoT
- Privacy-by-design and security-by-design in IoT
- System architectures for IoT, e.g. things-, data-,,event- and service-centric.
- IoT applications including smart homes, smart cities, healthcare, etc.
- Internet of Nano Things, Nano Computing and Communications.
- IoT programming toolkits, frameworks and evaluation test-beds
- IoT data mining and analytics
- IoT management and interoperability
- Management of distributed data streams
- Enabling technologies and standards for the IoT
- Sustainability of IoT platforms, e.g. business models for deployment and maintenance
- Societal challenges and IoT, e.g. urban planning and decision making tools
- Ownership of data in IoT scenarios
- Fog, Edge and Dew Computing for IoT
- IoT benchmarks and performance measurement
- Indexing and search in IoT environments, discovery of devices, services and data
- IoT transactions, concurrency control and recovery
- Hardware accelerators and energy savers for IoT applications and core infrastructure

4 Panel

As part of the workshop we also held a panel to which we invited four renowned and very productive researchers working in the field of Internet of Things:

- **Flavia Delicato** (Professor at the Universidade Federal do Rio de Janeiro (UFRJ), Brazil);
- **Sumi Helal** (Professor at both Lancaster University and University of Florida);
- **Cintia B. Margi** (Professor at University of São Paulo, Brazil);
- **Satyajayant Misra** (Professor at New Mexico State University).

The title of the panel was **IoT as core technology for *Smart-Everything*, Data Science and Machine Learning**, and the panelist were asked to present their visions and opinions regarding the following question:

If the IoT infrastructure is the nervous system of a Cyber-Physical System, Data Science is the knowledge construction, and Machine Learning is the brain, how can we be sure that we are collecting and processing all bits of information to build really smart, adaptive and human-friendly systems?

5 Summary of the Accepted Papers

In total, eleven papers were accepted for presentation at the workshop.

In their paper [5] Peng, Sellami and Boucelma addressed the problem of loss of some data items when doing IoT data stream processing. The authors tackle this problem by proposing a novel approach called Incremental Space-Time-based model that employs Incremental Multiple Linear Regression techniques on the data flow.

Xu and Helal [11] presented a novel optimisation approach aiming to minimize the overall energy consumption in a large scale system, that tries to minimize all data upward movements from the IoT devices up to the Edge and Cloud, and downward movements of application fragments from the cloud down to the IoT edge and the devices. The novelty of the approach resides in the combination of criteria that utilizes the dynamic characteristics and variability of both the data and applications simultaneously.

In a vision paper [6] authors Ramachandran and Krishnamachari discuss the reasons of the lack of large scale IoT deployments and the limitations of contemporary deployment models. As a solution to this problem, they present an approach involving multiple stakeholders as a means to scale IoT applications and argue that the incentive mechanisms, privacy, and security frameworks are the critical factors that will enable or not large-scale and interdependent IoT systems's deployment.

Segura, Margi, Chorti [7] analyze the performance drop of Software-defined Wireless Sensor Networks during Denial-of-service (DoS) attacks. Although not all IoT subsystems have Software-defined network components, (DoSs) are surely a very serious and representative kind of attack to which IoT systems will be increasingly exposed. In particular, the authors consider three different DoS scenarios of increasing aggressiveness: (i) false flow requests DoS, (ii) false data flow forwarding DoS, and, (iii) false neighbor information passing DoS. Thus, this understanding is also applicable to other dynamic IoT networks.

The paper of Santos, Delicato, Pires, Alves, Oliveira and Calmon [1] advocates for data-centric resource management between the IoT edge and the cloud system. In particular, they propose a novel resource management framework for edge-cloud systems that encompasses a lightweight and data-centric virtualisation model for edge devices and a set of components responsible for resource management and provisioning of services from the virtualised edge-cloud resources.

In [9] Sotres, Lanza and Sanchez discuss the problems of working with large-scale federations of experimentation facilities for IoT in the context of Smart Cities, and describe what is the approach for this integration in the well known SmartSantander project.

The paper [4] by Misic, Misic and Chang discuss how to estimate the validity (lifetime) of data cached in Internet of Things (IoT) proxy with multicast based cache management. Results indicate that the narrow and symmetrical lifetime probability distribution requires more frequent multicasting refreshments, which increases network traffic and energy consumption in IoT devices.

In [10] Tourani, Mtibaa and Misra, also focus on Smart Cities, but propose iSmart, a scalable information-centric approach and architecture for IoT infrastructure. Using named-data networking (NDN) instead of IP protocols, it allows scalable computation and storage to be performed in a distributed way, close to the users.

In paper [2] Carvalho, Endler, and Silva propose a rule-based programming model and language for describing applications of the *Internet of Mobile Things*, where potential mobility of sensors and actuators requires to handle variable network topology and intermittent connectivity. Using examples of application programs for some IoMT scenarios, they argue that Complex Event Processing (CEP) and its rule-based languages are a natural fit for implementing reactive IoMT applications.

In a quite singular paper [3] Mauldin *et al* explore the combination of Deep Learning (Recurrent Neural Network) with ensemble techniques (Stacking and AdaBoosting) to analyze and try to identify a significant event such as a fall in a health-/patient-care use case.

And last, but not least, in article [8] Semmler, Smaragdakis and Feldmann discuss and compare some online replication strategies for distributed data stores that are particularly well suited for the way that smart object's and sensor data is typically updated and queried in IoT systems.

References

[1] I. L. ao dos Santos, F. C. Delicato, P. F. Pires, M. P. Alves, A. Oliveira, and T. S. Calmon, "Data-centric resource management in edge-cloud systems for the iot," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 29–46, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n03_Santos.html

[2] F. Carvalho, M. Endler, and F. S. e Silva, "Leveraging application development for the internet of mobile things," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 105–116, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n09_Carvalho.html

[3] T. Mauldin, A. H. Ngu, V. Metsis, M. E. Canby, and J. Tesic, "Experimentation and analysis of ensemble deep learning in iot applications," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 133–149, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n11_Mauldin.html

[4] J. Misic, V. B. Misic, and X. Chang, "Data lifetime estimation in a multicast-based coap proxy," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 150–162, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n12_Misic.html

[5] T. Peng, S. Sellami, and O. Boucelma, "Iot data imputation with incremental multiple linear regression," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 69–79, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n06_TaoPeng.html

[6] G. S. Ramachandran and B. Krishnamachari, "Towards a large scale iot through partnership, incentive, and services: A vision, architecture, and future directions," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 80–92, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n07_Ramachandran.html

[7] G. A. N. Segura, C. B. Margi, and A. Chorti, "Understanding the performance of software defined wireless sensor networks under denial of service attack," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 58–68, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n05_Segura.html

[8] N. Semmler, G. Smaragdakis, and A. Feldmann, "Online replication strategies for distributed data stores," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 47–57, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n04_Semmler.html

[9] P. Sotres, J. Lanza, J. R. Santana, and L. Sánchez, "Integrating a smart city testbed into a large-scale heterogeneous federation of future internet experimentation facilities: the smartsantander approach," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 117–132, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n10_Sotres.html

[10] R. Tourani, A. Mtibaa, and S. Misra, "Distributed data-gathering and -processing in smart cities: An information-centric approach," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 93–104, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n08_Tourani.html

[11] Y. Xu, S. Helal, C. Lee, and A. Khaled, "Energy savings in very large cloud-iot systems," *Open Journal of Internet Of Things (OJIOT)*, vol. 5, no. 1, pp. 6–28, 2019. [Online]. Available: https://www.ronpub.com/ojiot/OJIOT_2019v5i1n02_YiYu.html

AUTHOR (AND CO-CHAIR) BIOGRAPHIES

Dr. Markus Endler is associate professor at the Pontifical Catholic University of Rio de Janeiro (PUC-Rio) and founder and head of the Laboratory for Advanced Collaboration (LAC). He obtained his doctoral degree from GMD Institute and TU Berlin (1992), and the Livre docente title (Habilitation) from the University of São Paulo (2001). So far, he has supervised 13 doctoral thesis, 29 M.Sc. dissertations, and co-authored more than 190 articles published in international journals and refereed conferences, as well as seven book chapters. His main research interests include distributed, mobile and pervasive computing, context-awareness, mobile coordination, Internet of Things and Smart Cities.

Dr. Sven Groppe is professor at the University of Lübeck. He earned his diploma degree in Informatik (Computer Science) in 2002 and his Doctor degree in 2005 from the University of Paderborn. He earned his habilitation degree in 2011 from the University of Lübeck. He worked in the European projects B2B-ECOM, MEMPHIS, ASG and TripCom. He was a member of the DAWG W3C Working Group, which developed SPARQL. He was the project leader of the DFG project LUPOSDATE, an open-source Semantic Web database, and one of the project leaders of two research projects, which research on FPGA acceleration of relational and Semantic Web databases. He is also leading a DFG project on GPU and APU acceleration of main-memory database indexes. He is also the chair of the Semantic Big Data workshop series, which is affiliated with the ACM SIGMOD conference (so far 2016 to 2019), and of the Very Large Internet of Things workshop in conjunction with the VLDB conference (so far 2017 to 2019). His research interests include databases, Semantic Web, query and rule processing and optimization, Cloud Computing, acceleration via GPUs and FPGAs, peer-to-peer (P2P) networks, Internet of Things, data visualization and visual query languages.

APPENDIX: WORKSHOP ORGANIZATION

Chairs

- Sven Groppe, Univerität Lübeck, Germany
- Markus Endler, Pontificial Catholic University of Rio de Janeiro, Brazil

Program Commmittee

We have recruited 20 PC members and chairs listed below who are experts in the topics of interest of our workshop. The current PC members and chairs are selected from 14 nations all over the world. While most PC members are from academia, we have 2 experts also from industry (10%). 5 of the PC members and chairs are women (25%).

- Lorena Etcheverry, Universidad de la República, Uruguay
- Mirian Halfeld Ferrari, Université d' Orléans, France
- Hemant Purohit, George Mason University, USA
- Jonathan Fürst, NEC Labs Europe, Heidelberg, Germany
- Abdessamad Imine, INRIA-LORIA Nancy Grand-Est, France
- Peiquan Jin, University of Science and Technology of China, China
- Verena Kantere, University of Ottawa
- Abdelmajid Khelil, Landshut University of Applied Sciences, Germany
- Jan Lindström, MariaDB Corporation, Finland
- Uden Lorna, Staffordshire University, UK
- Riccardo Martoglia, University di Modena and Reggio Emilia, Italy
- Luis Muñoz, University of Cantabria, Spain
- Elaheh Pourabbas, National Research Council of Italy, Italy
- Francisco José da Silva e Silva, Federal University of Maranhão (UFMA), Brazil
- Mu-Chun Su, National Central University, Taiwan
- Marco Vieira, University of Coimbra, Portugal
- Yingwei Wang, University of Prince Edward Island, Canada
- Demetris Zeinalipour, University of Cyprus, Cyprus