
Contributions to the 6th Workshop on Very Large Internet of Things (VLIoT 2022)

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ABSTRACT

The concept of the Internet of Things, where small things become available in the Internet and get connected with each other for the purpose of advanced applications, raises many new open challenges to research. This even increases when considering large-scale Internet-of-Things (IoT) configurations, which is the focus of our Very Large Internet of Things (VLIoT) workshop. We recognize that the IoT research community is very active and the industry continuously develops novel IoT applications for daily live. Hence we received many high-quality submissions, from which we accepted 7 to be introduced in this editorial.

TYPE OF PAPER AND KEYWORDS

Short communication: *Internet of Things, Very Large Internet of Things, VLIoT@VLDB 2022, IoT visions*

1 INTRODUCTION

The COVID-19 pandemic [2] still affects daily lives, but risks seem to be predictable nowadays, such that most COVID-19 confinements have been released in most countries. Hence there is a back to nearly normal live and work, such that the number of research contributions is again increasing besides those directly dealing with the COVID-19 pandemic. As a matter of fact, although we got submissions where COVID-19 plays a major role, the accepted paper's topics don't deal with COVID-19 any more, but contain other Internet of Things (IoT) contributions.

The IoT is not only about small devices, but also the interplay between them and the user with the goal

of higher-level applications [8]. Research questions may arise to optimize the communication regarding message number and sizes [10], the processing to speed up performance [9], and minimize latency for optimal user experiences and power consumption to increase battery lifetime. High availability is often achieved by intelligent replication of data and processing. Masses of data are generated by the IoT devices, which are often processed and aggregated by streaming engines the components of which are placed along the topology of the IoT devices. Intelligent utilization of the heterogeneity of the IoT environment is another key for the success of IoT systems. There is a strong need of all IoT systems and applications to be designed for security and privacy [7]. Hence, research in the area of IoT tackles these areas in combination with other areas like databases, security and cryptography, machine learning, Semantic Web, networks, operating systems, smart home and cities applications, distributed systems,

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compression, blockchains and many more.

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, Connected Automated Vehicles, and others.

This year's edition of the VLIoT workshop features two keynote speaks from high-level researchers about large-scale, heterogeneity-aware and trustworthy federated learning by Yiran Chen and hologram-type communication by Ian F. Akyildiz.

2 VLIoT CALL: TYPES OF PAPERS

This sixth 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 2022 solicited papers in the following, non-exclusive, 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 SUMMARY OF THE ACCEPTED PAPERS

In total, seven papers [4, 12, 11, 5, 1, 3, 6] from 15 submissions were accepted for presentation at the workshop.

The authors of [4] develop and present a simulation framework to offer MQTT-based on publish/subscribe architecture that can also support the LoRaWAN communication standard. One of the widely used publish/subscribe protocols that are widely used in publish/subscribe architectures of IoT environments is MQTT, where a broker acts among publishers and subscribers to relay data on certain topics. MQTT's large-scale and quick deployment for IoT environments with a widely used wireless MAC layer protocol such as LoRaWAN has not been thoroughly tested. Hence the authors utilize NS-3's LoRaWAN library and integrate it with a broker that connects to other types of publishers/subscribers to enable unicast capability from the broker to LoRaWAN end-devices while supporting multiple topics at the broker. The authors assess and analyze the performance at scale for several scenarios under this IoT architecture.

The authors of [12] propose an end-to-end patient monitoring application that includes a data processing system running at the edge of IoT deployments avoiding latency bottlenecks and security risks of state-of-the-art cloud-based solutions, an easy-to-use UI displaying the available vital parameters, and the integration of machine learning for the prediction of the patients' health state. The authors describe their real-world patient monitoring scenario for hemodynamic and pulmonary decompensations, which are dynamic and life-threatening deteriorations of lung and cardiovascular functions. Furthermore, the authors envision the infrastructure of an IoT ecosystem for a multi-hospital scenario that enables geo-distributed medical participants to contribute data to the application in a secure, private, and timely manner.

The authors of [11] propose a 3D Histogram based Categorical Anomaly Detection (HCAD) solution to monitor categorical sensor data (rather than numerical readings) in IoT. HCAD is based on a histogram model with the three dimensions categorical value, event duration and frequency for profiling normal working states of IoT devices. HCAD automatically determines the range of normal data and anomaly threshold requiring very limited parameter setting being applicable to a wide variety of different IoT devices. The authors test the proposed solution integrated it into an online monitoring system on real IoT datasets such as telemetry data from satellite sensors, air quality data from chemical sensors, and transportation data from traffic sensors. In extensive experiments, HCAD achieves higher detecting accuracy and efficiency than state-of-the-art methods.

The authors of [5] present the ORBiDANSe project which is building a bridge between two technologies. Generally datacube deployments are aiming at large scale, data center environments accommodating Big Data and massive parallel processing capabilities for achieving decent performance. A downscaling experiment has been proposed in this work. A datacube engine, rasdaman, has been ported to a cubesat, ESA OPS -SAT, and is operational in space. Effectively, the satellite thereby becomes a datacube service offering the standards-based query capabilities of the OGC Web Coverage Processing (WCPS) geo datacube analytics language. This contribution will pave the way for on-board ad-hoc processing and filtering on Big EO Data in substantially shorter time.

The authors of [1] propose an implementation on the Web of Things (WoT) discovery and name it as WoTHive to address the syntactic and semantic functionalities specified in the discovery described by WoT. This work initiate the benefits the Semantic Web technologies bring to discovery in WoT. WoTHive is tested on different experiments and reports that

the implementation is technically sound for CRUD operations and that its semantic discovery outperforms the syntactic one implemented. As a future scope, the experimentation will be extended to add queries that rely on the federation and show how the overall WoT discovery can benefit from this mechanism that only exists for semantic discovery.

The authors of [3] introduce IoT Hub as a Service (HaaS), which is a data-oriented framework to enable communication interoperability between the ecosystem's entities in order encounter today's fragmented nature of IoT due to the enormous number of different IoT things, the format of reported information, communication standards, and the technologies and frameworks for developing IoT applications. The framework's main concept are *Cards*, which are programmable objects representing things' information, reported data items, and developers' applications. The framework maintains indexes of cards' meta-data supporting interoperability, data management, and application development. With the framework's functionalities, users can create virtual smart spaces (VSS) to define cards' accessibility and visibility. By supporting four types of Cards - participating IoT things, data items, VSS, and applications - the framework dynamically creates, updates, and links the cards throughout the life-cycle of the different entities, and facilitates the development of synchronous and asynchronous applications.

The authors of [6] deal with Industry 4.0 scenarios and in particular with smart manufacturing lines consisting of multiple connected machines. Due to machine to machine communication over a network between the machines, a huge amount of data is generated during manufacturing. This emerging data flow is an inherent and essential part of today's industry for the purpose of improving processes and thus, product quality, by analyzing the collected manufacturing data. However, a high level of data quality is a precondition to adequately make use of the collected data and good analysis results. Hence, the authors address the important issue of inconsistent data in smart manufacturing and present an approach to automatically generate SPARQL queries for validation of manufacturing data in Industry 4.0 scenarios.

5 SUMMARY AND CONCLUSIONS

The IoT domain offers many chances for interesting research and as result of it interesting applications for daily life improving the living conditions and conveniences of its users. We recognize that there is a shift in IoT research going away from very special limited topics and more and more researchers try to offer

complete systems providing solutions for large scale IoT configurations as well as IoT applications in specialized areas like those of the medical domain. However, still many visions need to be realized having space for many years of research.

We wish you interesting hours when studying the contributions of this year's Very Large Internet of Things (VLIoT) workshop.

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A WORKSHOP ORGANIZATION

Chairs

- Sven Groppe, Universität Lübeck, Germany
- Sanju Tiwari, Universidad Autonoma de Tamaulipas, Mexico
- Shui Yu, University of Technology Sydney, Australia

Program Committee

We have currently recruited 25 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 as shown also by the map below. While most PC members are from academia, we have 3 experts also from industry (12%). 6 of the PC members and chairs are women (24%).

- Omar Boucelma, Aix-Marseille University, France
- Mirian Halfeld Ferrari, Université d'Orléans, France
- 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
- Ahmed Khaled, Northeastern Illinois University, USA
- Abdelmajid Khelil, Landshut University of Applied Sciences, Germany
- Jan Lindström, MariaDB Corporation, Finland
- Riccardo Martoglia, University di Modena and Reggio Emilia, Italy
- San Murugesan, Western Sydney University, Australia
- Luis Muñoz, University of Cantabria, Spain
- Anne H. Ngu, Texas State University, USA
- Elaheh Pourabbas, National Research Council of Italy, Italy
- Igor Leão dos Santos, Centro Federal de Educação Tecnológica Celso Suckow da Fonseca (CEFET-RJ), Brazil
- Sana Sellami, Aix-Marseille University, France
- Mu-Chun Su, National Central University, Taiwan
- Reza Tourani, Saint Louis University, USA
- Marco Vieira, University of Coimbra, Portugal
- Yingwei Wang, University of Prince Edward Island,

Canada

- Demetris Zeinalipour, University of Cyprus, Cyprus
- Steffen Zeuch, DFKI, Germany

AUTHOR (AND CO-CHAIR) BIOGRAPHIES



Sven Groppe 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 and two research projects on FPGA acceleration of relational and Semantic Web databases, and is a member of the Hardware Accelerator Research Program by Intel. He is currently the project leader of German Research Foundation projects on GPU accelerated database indices and on Semantic Internet of Things. Furthermore, he is leading a project about quantum computer accelerated database optimizations and he is project partner in a project about COVID-19 high-quality knowledge graphs, visualizations and analysis of the pandemic with 2 french partners. He is also the chair of the Semantic Big Data (SBD) workshop series (so far 2016 to 2020) and Big Data in Emergent Distributed Environments (BiDEDE) in 2021 and 2022, both are affiliated with the ACM SIGMOD conference, and of the Very Large Internet of Things (VLIoT) workshop in conjunction with the VLDB conference (so far 2017 to 2022). He is the general chair of the International Semantic Intelligence Conferences in 2021 and 2022, and of the International Healthcare Informatics Conference (IHIC 2022). His research interests include databases, Semantic Web, query and rule processing and optimization, Cloud Computing, acceleration via GPUs, FPGAs and quantum computers, peer-to-peer (P2P) networks, Internet of Things, data visualization and visual query languages.



Sanju Tiwari is a Senior Researcher at Universidad Autonoma de Tamaulipas (70 years old University), Mexico. She is DAAD Post-Doc-Net AI Fellow for 2021 and visited different German Universities (Leibniz University Hannover, Leipzig University, Leipzig, University of Lübeck and Leuphana University Lüneburg) in June 2022 under this DAAD fellowship. She also appointed as Ph.D. Co-Supervisor at Rai University, Gujarat, India. She has worked as a Post-Doctoral Researcher in Ontology Engineering Group, Universidad Politecnica De Madrid, Spain. Prior to this, she worked as a Research Associate for a sponsored research project “Intelligent Real-time Situation Awareness and Decision Support System for Indian Defence” funded by DRDO, New Delhi, India. Her current research interests include, Ontology Engineering, Knowledge Graphs, Linked Data Generation and Publication, Question/Answering. She has to-date published more than 50 research papers and 3 Scopus indexed Books. She has edited an Elsevier and ISTE book based on Semantic Web in IoT. Currently she is editing two books on Personal Knowledge Graphs and Semantic AI in Knowledge Graphs with IETE and Taylor & Francis. She is working as a General Chair (KGSWC 2020-22, EGETC-2022), and Program Chair, Workshop Chair, Publicity Chair, Steering Committee and PC Member in different renowned International Conferences (SEMANTiCS 2019-22, ESWC2021-22, CIKM2020-22, AICCSA-2021, JOWO-2021, BiDEDE-2022@ACM SIGMOD, VLIoT@VLDB-2022, SIMBIG2022). She is working as a Guest Editor for SCI/Scopus journals (MTAP Springer, TEL Emerald, IJWIS Emerald). She is the speaker of IEEE/IETE N2Women and Women’s Empowerment and NiWIIT (Nigerian Women In Information Technology).



Shui Yu is Professor of the School of Computer Science in the Faculty of Engineering and Information Technology at UTS, and is a leading researcher of cybersecurity, privacy and the networking and communication aspects of Big Data. In 2013, he initiated a new field, networking for big data, in the networking and communication domain. Shui was the leading editor of *Networking for Big Data*, published in 2015, which supplied an unprecedented look at cutting-edge research on the networking and communication aspects of Big Data. Many of his research outputs have been adopted by industry, for example, the auto scale strategy of Amazon Cloud against distributed denial-of-service attacks. As the corporate world has increasingly adopted new technologies to analyze and store vast amounts of data in a bid to generate valuable insights and unlock strategic value, Shui has concentrated on the privacy and security concerns associated with big data. Among other issues, he has researched security issues associated with smart grids, which present opportunities to help solve the problems of carbon emissions and the energy crisis. He has also investigated creating anonymous transactions on Blockchain to deal with threats to users’ privacy. His anonymous communication work for web browsing privacy has been cited by more than 200 US patents. He has published two monographs and edited two books, and produced more than 400 technical papers, published in top journals such as IEEE TPDS, TC, TIFS, TMC, TKDE, TETC, ToN, and INFOCOM. His h-index is 54. Shui serves his research communities in various roles, including serving on the editorial boards of IEEE Communications Surveys and Tutorials, IEEE Communications Magazine and the IEEE Internet of Things Journal, among others. He has been a member of organizing committees for many international conferences, such as the publication chair for IEEE Globecom 2015, IEEE INFOCOM 2016 and 2017, TPC chair for IEEE Big Data Service 2015, and general chair for ACSW 2017. Shui was also a final voting member for a number of NSF China programs in 2017; he is a Senior Member of IEEE; a member of AAAS and ACM; Vice Chair of Technical Committee on Big Data of IEEE Communication Society; and a Distinguished Lecturer of IEEE Communication Society.