fora

Newsletter

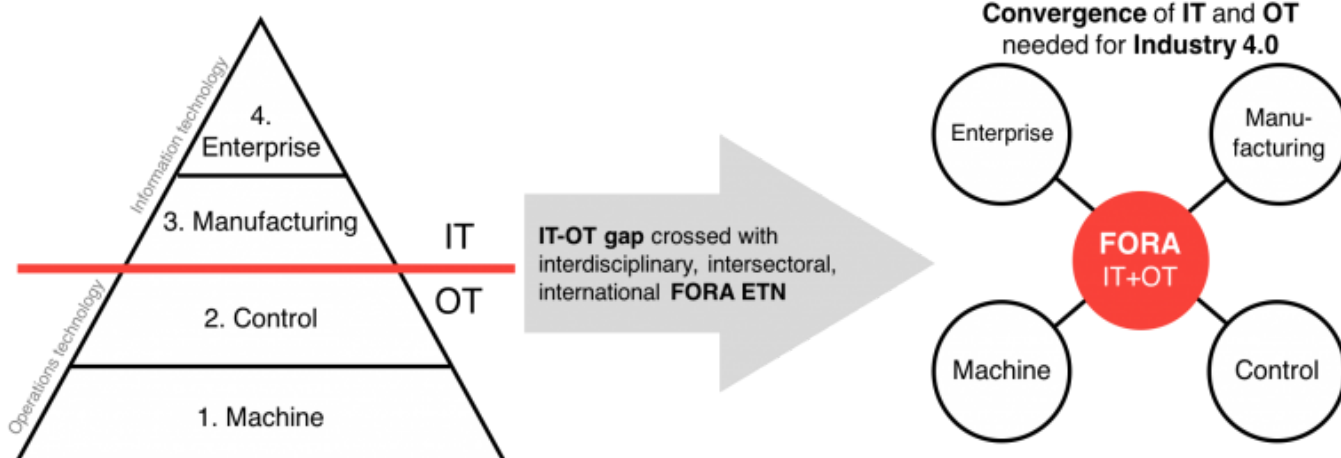## Summer 2019 | Issue 1
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Convergence of IT and OT needed for Industry 4.0

IT-OT gap crossed with interdisciplinary, intersectoral, international FORA ETN

FORA—Fog Computing for Robotics & Industrial Automation

FORA is a four years European Training Network (ETN) project, with the aim of training interdisciplinary scientists, 15 Early-Stage Researchers (ESRs), that understand both the IT and OT domains, understand the needs of the industry, including SMEs, and that can have an impact at European-level.

The FORA training program follows the Principles for Innovative Doctoral Training and other relevant policies, with a clear focus on excellence, gathering a multi-disciplinary team of 4 academic and 3 industrial participants (academic: Vienna University of Technology (TUWien), Technical University of Kaiserslautern (TUKL), Mälardalen University (MDH), Technical University of Denmark (DTU), and industrial beneficiaries: TTTech Computertechnik AG (TTT), SYSGO AG (SYSGO) and ABB AB (ABB)) to support the PhD education of 15 ESRs.

Upcoming

D6.2 D15 Exploitation plan
Status: calling for inputs
Available on: Sept. 30, 2019

D1.2 D5 Fog Infrastructure reference architecture document
Available on: March 31, 2020

Autumn meeting on requirements and reference architecture
Date & Venue: TBD

Deliverables

D1.1 D4. Fog Computing: state of the art and research challenges
Link: **fora-etn.eu/deliverables**

The FORA participants have identified the key skills and competences required to further strengthen industrial automation, and more specifically Fog Computing, and have designed the FORA training program to meet these requirements, while enhancing geographical and intersectoral mobility and promoting entrepreneurship and innovation.

FORA provides scientific (through research and science-based training) and transferable skills training based on a strong collaboration between academic and industrial partners. The ESRs will be trained scientifically by:

- Conducting cutting-edge research on their project, collaborating with other ESRs. We will expose ESRs to multiple disciplines, and develop an active strategy to enable interdisciplinary research, integrating the contributions of the various disciplines.

- Being seconded to academic and/or industrial partners abroad for at least half a year.

- Being educated on highly relevant scientific topics in the FORA training schools, complemented by local courses from their university, but also by traveling abroad to workshops and conferences to present their work.

The FORA kick-off meeting took place during Oct. 19-29, 2017, at TTTech's premises in Vienna, Austria. We had 19 participants, with representatives from each beneficiary. The main focus of the meeting was on the recruitment plan, training schools and secondments.

D1.4 D18 Fog Computing Platform: requirements and initial designs
Link: **fora-etn.eu/deliverables**

Activities

FORA IoT Summer School
2019, June 17-21, Copenhagen

FORA Project Meeting
2019, June 3-4, Copenhagen

FORA Training Day
2018, December 11, Copenhagen

FORA Training School (TS1)
2018, June 4th-8th, Vienna

Kick-off meeting
2017, October 19-29, Vienna

Secondments

Reza Barzegaran
TU Wien Feb.- April, 2019

Vasileios Karagiannis
Tech. University of Kaiserslautern, May - August, 2019

Václav Struhár
TTTech, Sep. - Nov., 2019

Nitin Desai
TTTech, Sep. - Nov., 2019

Publications

19 papers have been published so far, **14** are **open access**
Link: fora-etn.eu/publications

All ESRs have been successfully recruited and enrolled in a doctoral program, where they will receive training for a period of 36 months, and finally earn a PhD degree, based on a personal training program according to their Career Development Plan (CDP). List of the recruited ESRs is available at fora-etn.eu/people.

FORA Training School 1

We organized the FORA Training School 1 during June 4th-8th at TUWIEN, Vienna, Austria.

The main objective of TS1 (consisting of Scientific Courses, SC1-3, and Transferable skills Course, TC1) was to introduce the basics of Fog Computing and Industry 4.0 very early on, i.e., 3 months after the majority of the ESRs have started. TS1 also covers resource management topics (SC3). To help plan their research, ESRs also received training on research methodology and scientific publishing.

The second day was organized at the Vienna Pilot Factory, where the ESRs could see demonstrations of Industry 4.0 applications in a Smart Factory environment. The ESRs have participated in a demo of an Edge Computing device from TTTech Computertechnik AG (with a hypervisor called PikeOS from SYSGO AG), during a visit to TTTech's Research Labs.

We had 20 lecturers providing the training, about a third from outside FORA, leaders in their respective fields. We had 44 participants, with 10 participants from outside of FORA. Based on what we have learned in TS1, the future training events will be fully open, and run in a Summer School format.

News from ESRs

Cosmin Avasalcai, March 2019

In March 2019, Cosmin Florin Avasalcai attended Future of Information and Communication Conference (FICC) in San Francisco to present his paper "Latency-Aware Distributed Resource Provisioning for Deploying IoT Applications at the Edge of the Network". His paper motivates the need for decentralized resource management techniques in Fog Computing and discusses its research challenges.

In July 2019, Cosmin attended IEEE World Congress on Services in Milan, where he presented his paper "Decentralized Resource Auctioning for Latency-Sensitive Edge Computing" at the colocated IEEE Edge Conference.

His paper presents a seamless technique to deploy IoT applications at the edge of the network, such that all application requirements are met.

Jan Ruh, April 2019

In April 2019, Jan Ruh attended CPS-IoT Week in Montreal to present his paper "The Need for Deterministic Virtualization in IIoT" at the colocated workshop on Fog Computing and IoT. His paper motivates the need for real-time capable hypervisors in industrial automation and provides requirements for deterministic virtualization.

More information about TS1 including the presentation materials is available online at fora-etn.eu/activities/fora-training-school-ts1

FORA's Interim Check Meeting

The FORA's interim check meeting took place on Dec. 12, 2018 at Park Inn By Radisson hotel, Copenhagen. In conjunction with this meeting, we had a training day on Dec.11 to define the main concepts of the Fog Computing platform and plan its development and use. We had 32 participants, with representatives from each beneficiary.

More information about the meeting and the training day are available online at fora-etn.eu/activities/fora-training-day-interim-check

Jia Qian, June 2019

At the end of June 2019, Jia Qian attended EDGECOM 2019 in Paris, presented the paper "Distributed Active Learning Strategies on Edge Computing".

The core idea of the paper is to present a possible solution tailored for Fog Platform, which intelligently decomposed the computation task between Fog Node and edge Devices. Doing so, the user privacy concern and the unbearable latency can be addressed.

Reza Barzegaran, June 2019

Reza has participated in the CPS Summer School, which was held in KTH for four days from June 10.

A software package for CPS simulation was introduced in the summer school. Another one was introduced for analyzing the reliability of the system and finding the failure points in a system. The talks were mostly focused on Industrial applications.

A week after the summer school, Reza participated in FORA summer school. In a section, an FPGA kit was given to each of the participants, and they tried to program it. There was also an interesting section about standards.

In July 2019, Reza's paper titled "Using JitterTime to Analyze Transient Performance in Adaptive and Reconfigurable Control Systems" was accepted in ETFA 2019.

FORA Project Meeting

The FORA Project Meeting took place on June 3-4 2019, at Park Inn By Radisson hotel, Copenhagen. The meeting had the following purposes:

- Defining the FORA reference platform architecture
- Facilitate the research collaboration
- Define Use Cases and benchmarks for Fog Computing
- Support the development of demonstrators around Fog Use Cases for industrial applications

More information about the meeting is available online at fora-etn.eu/activities/fora-project-meeting-june-2019

FORA IoT Summer School: Edge & Fog Computing

The FORA IoT Summer School, in collaboration with DTU, Nordic IoT Hub, and the Georgia Institute of Technology, took place on June 17-21, 2019 at Technical University of Denmark, Copenhagen.

The FORA IoT Summer School was a week-long intensive introduction to all aspects of IoT systems. Rich sensor systems and distributed computation allow computing systems to measure and interact with the physical world.

Patrick Denzler, June 2019

Daniel Ramsauer successfully defended his Master thesis with the title " OPC UA / DDS Gateway" on the 5th of June.

The main goal was the development of a prototype based on the OMG Group published specification for the connection of the two middlewares. In addition, three scenarios for connecting OPC UA clients through the global DDS data space were generated to evaluate the gateway features and deficiencies.

The work was supervised by Prof. Dr. W. Kastner and Patrick Denzler of the TU Wien and contributed to the research ongoing in the work package two in the FORA network.

Zeinab Bakhshi, July 2019

Zeinab Bakhshi presented her paper titled "The preliminary road-map for dependability requirements in Fog computing" in RTN workshop in ECRTS conference on 9th of July 2019.

This work was based on a literature review to find the open challenges and gaps between the current research and the dependability requirements of fog platform.

These emerging IoT systems will necessarily stretch from edge and fog computing devices that connect to cloud servers. Challenges at all levels of abstraction—devices, software, networks, architectures, and applications—must be faced to deliver on the potential of IoT systems technology.

Topics range across the design stack and network: low power VLSI edge devices, signal processing and control, security, algorithms, applications.

This summer school is a successor to two traditions: the DTU summer session on embedded computing and Georgia Tech summer schools on IoT and CPS.

More information about the Summer School is available online at fora-etn.eu/activities/nordic-iot-summer-school-2019-edge-and-fog-computing

Publications

- Avasalcai C., Dustdar S. (2020) Latency-Aware Distributed Resource Provisioning for Deploying IoT Applications at the Edge of the Network. In: Ara K., Bhatia R. (eds) Advances in Information and Communication. FICC 2019. Lecture Notes in Networks and Systems, vol 69. Springer, Cham. (link)
- Radu Dobrin and Nitin Desai and Sasikumar Punnekkat. 2019. On Fault-tolerant Scheduling of Time Sensitive Networks. 4th International Workshop on Security and Dependability of Critical Embedded Real-Time Systems. (link)
- Nitin Desai and Sasikumar Punnekkat. 2019. Safety of Fog-based Industrial

Koen Pieter Tange, July 2019

Koen Pieter Tange presented some preliminary findings of his systematic survey paper on security requirements for the Industrial Internet of Things at the CPS-IoT week earlier this year in Montreal, Canada.

These findings were mainly about how IIoT security research has progressed in the past 6 years, and which countries are most active in this area.

Since then, he has further analyzed the papers that were found and has produced a finished version of the survey. This version discusses a variety of security topics that were addressed in the papers, and distills them into a set of categorized security requirements relating to authentication, access control, maintainability, resilience, data security and data sharing, security monitoring, network security, and models and methodologies.

The full version of the survey has been submitted to a journal and will hopefully be published later this year.

**Introducing real-time fog computing in an industrial setting**

The current research aim of Salman (ABB) and Vaclav (MDH) is to introduce a strict real-time behavior in the fog computing layer in an industrial setting (robot control).

Automation Systems. Workshop on Fog Computing and the IoT 2019 (link)

- Mohammadreza Barzegaran, Anton Cervin, and Paul Pop. 2019. Towards quality-of-control-aware scheduling of industrial applications on fog computing platforms. In *Proceedings of the Workshop on Fog Computing and the IoT* (IoT-Fog '19). ACM, New York, NY, USA, 1-5. (link)
- Koen Tange, Michele De Donno, Xenofon Fafoutis, and Nicola Dragoni. 2019. Towards a systematic survey of industrial IoT security requirements: research methods and quantitative analysis. In Proceedings of the Workshop on Fog Computing and the IoT (IoT-Fog '19). ACM, New York, NY, USA, 56-63. (link)
- Eleftherios Kyriakakis, Jens Sparsø, and Martin Schoeberl. 2019. Implementing time-triggered communication over a standard ethernet switch. In Proceedings of the Workshop on Fog Computing and the IoT (IoT-Fog '19). ACM, New York, NY, USA, 21-25. (link)
- Eleftherios Kyriakakis, Jens Sparsø, and Martin Schoeberl. 2018. Hardware Assisted Clock Synchronization with the IEEE 1588-2008 Precision Time Protocol. In Proceedings of the 26th International Conference on Real-Time Networks and Systems (RTNS '18). ACM, New York, NY, USA, 51-60. (link)
- Jan Ruh and Wilfried Steiner. 2019. The need for deterministic virtualization in the industrial internet of things. In Proceedings of the Workshop on Fog Computing and the IoT (IoT-Fog '19). ACM, New York, NY, USA, 26-30. (link)
- T. Hiessl, V. Karagiannis, C. Hochreiner, S. Schulte and M. Nardelli. 2019. Optimal Placement of Stream Processing Operators in the Fog. *IEEE 3rd International Conference on Fog and Edge Computing (ICFEC)*, Larnaca, Cyprus, 2019, pp. 1-10. (link)
- V. Karagiannis, S. Schulte, J. Leitao and N. Preguica. 2019. Enabling Fog Computing using Self-Organizing Compute Nodes. *IEEE 3rd International Conference on Fog and Edge Computing (ICFEC)*, Larnaca, 2019 (link)
- Vasileios Karagiannis, Alexandre Venito, Rodrigo Coelho, Michael Borkowski, and Gerhard Fohler. 2019. Edge computing with peer to peer interactions: use cases and impact. In Proceedings of the Workshop on Fog Computing and the IoT (IoT-Fog '19). ACM, New York, NY, USA, 46-50. (link)
- Vasileios Karagiannis. 2019. Compute node communication in the fog: survey and research challenges. In *Proceedings of the Workshop on Fog Computing and the IoT* (IoT-Fog '19). ACM, New York, NY, USA, 36-40. (link)
- O. Skarlat, V. Karagiannis, T. Rausch, K. Bachmann and S. Schulte. 2018. A Framework for Optimization, Service Placement, and Runtime Operation in the Fog. IEEE/ACM 11th International Conference on Utility and Cloud Computing (UCC), Zurich, 2018, pp. 164-173.(link)
- V. Struhár, A. V. Papadopoulos and M. Behnam. 2018. Work-in-Progress: Fog Computing for Adaptive Human-Robot Collaboration. 2018 International Conference on Embedded Software (EMSOFT), Turin, 2018, pp. 1-2. (link)
- Cosmin Avasalcai and Schahram Dustdar. 2018. Latency-aware decentralized resource management for IoT applications. In *Proceedings of the 8th International Conference on the Internet of Things* (IOT '18). ACM, New York, NY, USA, Article 30, 4 pages. (link)
- T. Rausch, C. Avasalcai and S. Dustdar. 2018. Portable Energy-Aware Cluster-Based Edge Computers. *IEEE/ACM Symposium on Edge Computing (SEC)*, Seattle, WA, 2018, pp. 260-272.(link)
- M. Schoeberl and R. U. Pedersen. 2018. tpIP: A Time-Predictable TCP/IP Stack for Cyber-Physical Systems. *IEEE 21st International Symposium on Real-Time Distributed Computing (ISORC)*, Singapore, 2018, pp. 75-82. doi: 10.1109/ISORC.2018.00018
- Ismail, A., Truong, H.L. and Kastner, W., 2019. Manufacturing process data analysis pipelines: a requirements analysis and survey. *Journal of Big Data*, 6(1), p.1. (link)
- P. Pop, M. L. Raagaard, M. Gutierrez and W. Steiner. 2018. Enabling Fog Computing for Industrial Automation Through Time-Sensitive Networking (TSN). In IEEE Communications Standards Magazine, vol. 2, no. 2, pp. 55-61, JUNE 2018. doi: 10.1109/MCOMSTD.2018.1700057.

Introducing real-time fog computing in an industrial setting (cont.)

This research will enable the consolidation of the robot control functions in the fog computing layer and allows an easy extension of the industrial system (new robots, sensors, applications) and overcomes limitations of the current state of the practices (e.g., limited computation capacity of controllers, integration and synchronization with other systems etc).

Investigating task- and network-level synchronization
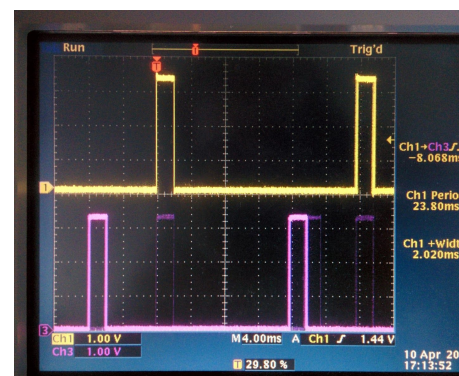
The figure shows two poorly synchronized distributed tasks producing PWM signals. PWM signals are a widely used mechanism that allows controlling servos and motors as well as various IO devices. In a distributed system with multiple actuators, task-level and network-level time synchronization can become a critical requirement as it can lead to malfunctioning operation of a cyber-physical system.