REVIEW MAGAZINE 2018-2019

The Nordic Hub on Industrial Internet of Things

HI2OT

Page 12
Access to EU research funding

Page 36
PhD student at AALTO flies with drones

Page 17
Where do our students go?

Page 30
DTU helps SME grow their business

Page 32
The Hub creates a roadmap for Industrial IoT

Nordic Hub IIoT

Contents

1

The development of HI2OT 4
Participating universities 6
The Industrial Internet of Things 7
Implementation of HI2OT 8
Yearly Hub meetings 9
HI2OT aims at video conferencing all major events 10
HI2OT's Distinguished Lecturer Programme 11
Access to EU research funding 12

2

The HI2OT students 14
Students crossing boarders 17
Michele De Donno, DTU, visited the Shanghai Institute of Fog Computing Technology 18
Mohammadreza Barzegaran, DTU, joined Summer School at KTH 20
Jan Sranota, NTNU, joined Summer Schools at KTH and DTU 21
Florian Müller, TU Chemnitz, joined the Summer School in Lund 22
Pavel Anistratov, Linköping University, joined the Summer School in Lund 23
Oussama Bekkouche, AALTO, flies with drones 24
Didem Gürdür Broo completed her PhD at KTH and is now moving to the University of Cambridge 26
Graduate courses – focus on new developments 27

3

Collaboration with industry 28
The Nordic high-tech region 28
Hub students help SMEs grow their business 30
HI2OT workshop in Montreal 31
Creating a Roadmap for Industrial IoT 32
AXIS Communications profited from work by a HI2OT student 33
5G will help advance IoT technologies 34

4

The people behind 36
Aalto – Enterprise Systems 36
KTH – Innovative Centre for Embedded Systems 36
Lund University – Department of Computer Science 37
Lund University – Department of Electrical and Information Technology 37
Lund University – Automatic Control 38
NTNU – Production Systems Group 38
DTU – Compute 39
DTU – Photonics 39

Welcome!

The Nordic IoT Review magazine is a science and technology magazine that is published by the Nordic University Hub on Industrial Internet of Things (HI2OT), showing the progress made during the last two years (2018-2019). Featured in the magazine are news stories relating to recent advances in science and technology originating from the HI2OT. Generally, the Hub has two focuses, namely a doctoral school on Industrial IoT and a related research cooperation between the five Nordic universities involved in the Hub.

There are currently 44 PhD students associated with the Hub, taking advantage of jointly organised summer schools, specific IoT lectures and a mobility programme encouraging students to take advantage of visiting one another.

The research cooperation takes place by joint representation in EU brokerage events, facilitating knowledge exchange and provision of access to IoT infrastructures as well as driving technology roadmapping related to Industrial IoT.

Many of the articles in this magazine intentionally focus on our PhD students' experience from being involved in the Hub.

We gratefully acknowledge the long-term commitment from NordForsk for the provision of funding, facilitating the development of a world-leading Nordic research environment.

I hope you will enjoy reading the selected articles.

Ivan Ring Nielsen
Director, HI2oT

NordForsk

This project has received funding from NordForsk's Nordic University Hubs programme under grant agreement no. 86220

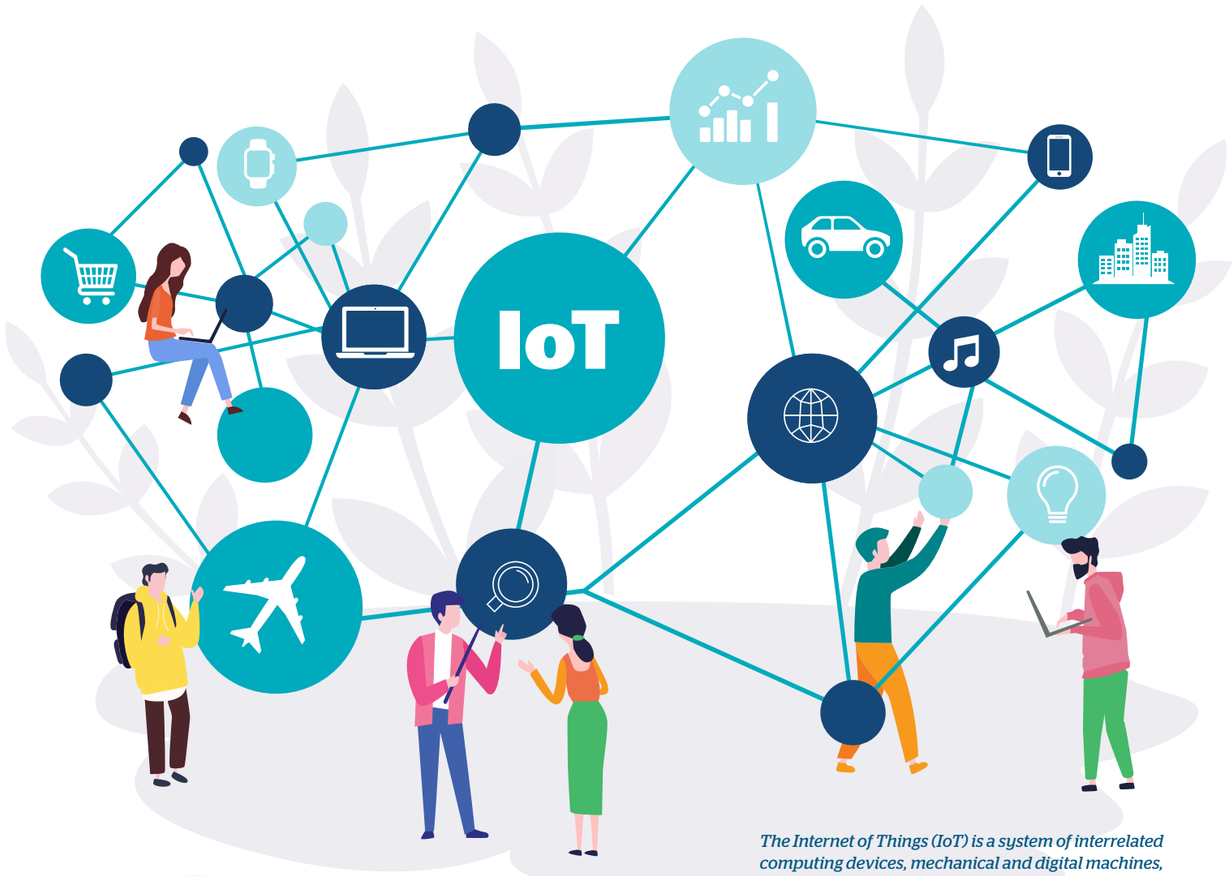
The development of HI2OT

In 2017, Professor Paul Pop from DTU took the initiative to bring together the major Nordic universities active in research and education in the growing field of Internet of Things. To narrow down the scope of the initiative it was decided to focus on the Industrial Internet of Things (IIoT).

Also in 2017, NordForsk issued a call aimed at strengthening international competitiveness and facilitating the development of world-leading Nordic research environments. The initiative encouraged Nordic universities to cooperate across borders as a tool for achieving their own strategic objectives, and thereby build long-term institutional capacity. To stimulate the cooperation, Nordforsk made additional funding available to Nordic university consortia.

The initiative was named Nordic University Hubs aimed at advancing the strategic priorities of Nordic higher education institutions through increased cooperation. The call attracted 63 applications from which NordForsk decided to fund six Hubs:

HI2OT: Nordic University Hub on Industrial Internet of Things
NordPlant – A Climate and Plant Phenomics Hub for Sustainable Agriculture and Forest Production in Future Nordic Climates
Nordic POP (Patient Oriented Products)
Nordic Consortium for CO2 Conversion (NCCO2)
Reimagining Norden in an Evolving World (ReNEW)
Nordic Sound and Music Computing Network



The Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

Compared to EU's funding programmes the Hubs were unique in the way that the funding was available for a total period of six years. HI2OT covers the period 2018-2023.

The aim of the Hubs are also structural, meaning that the institutions involved should try to exploit each other's equipment and educational resources. Therefore, it will take time to fully take on board such capacity building.

The overall aim of HI2OT is to promote Nordic collaboration in Industrial IoT, which will increase the capacity of the participating organisations by creating a critical mass to facilitate the development of a world-leading Nordic research environment in Industrial IoT.

The Hub has these specific objectives:

1. Develop a virtual Hub that connects the local professional networks of participating partners, facilitating knowledge exchange and pooling of infrastructure. The Hub will provide access to each other's professional networks and costly infrastructure (e.g. Smart Factory labs), organise events for experience exchange (e.g. annual conference) and for transfer of knowledge to the industry (research visits and "industry days"), and for perform mapping activities (e.g. identifying IIoT Nordic competences).

2. Create a platform from which the partners can more effectively project themselves at EU and global level. The platform will organise: joint participation in EU brokerage events and EU information meetings; joint participation in EU roadmapping activities; industry/academia matchmaking, e.g. jointly targeting SME instruments such as EuroStars; outreach and communication events. HI2OT will organise an International IIoT Conference.

3. Establish an integrated approach to IIoT research and training, bringing together world-class expertise in multiple disciplines. This will be achieved through researcher mobility to promote research collaboration, a Summer School in IIoT, advanced courses dedicated to PhD and MSc students, industrial training courses in IIoT, and the development of an Industrial IoT curriculum to be taught in the Nordic countries' universities.

Participating universities

Nordic Hub IIoT

Lund University

Lund, Sweden

DTU

DTU – Copenhagen, Denmark

NTNU

NTNU Trondheim, Norway

KTH Vetenskap och Konst

KTH Stockholm, Sweden

A!

Aalto University

Aalto Helsinki, Finland

The Industrial Internet of Things

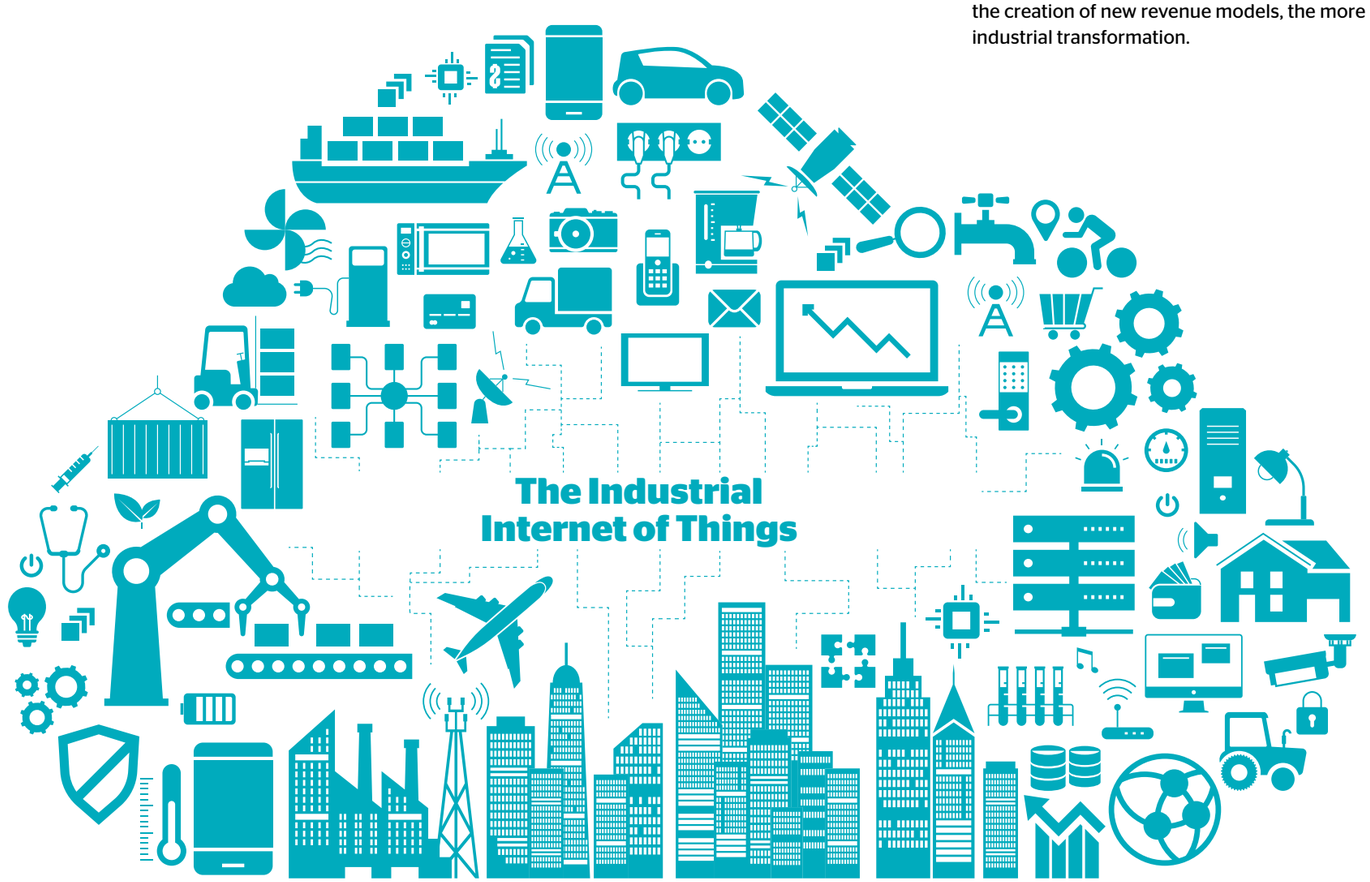
The Industrial Internet of Things (IIoT) refers to interconnected sensors, instruments, and other devices networked together with computers' industrial applications, including manufacturing and energy management.

This connectivity allows for data collection, exchange, and analysis, potentially facilitating improvements in productivity and efficiency as well as other economic benefits.

The IIoT is an evolution of a distributed control system (DCS) that allows for a higher degree of automation by using cloud computing to refine and optimize the process controls.

The Industrial Internet of Things originally described IoT (Internet of Things) as it is used across several industries such as manufacturing (Industry 4.0), logistics, oil and gas, transportation, energy/utilities, mining and metals, aviation and other industrial sectors and use cases which are typical to these industries.

Just like the Internet of Things in general, the Industrial IoT covers many use cases, industries and applications. Initially focusing on the optimization of operational efficiency and rationalization/automation/ maintenance, with an important role for the convergence of IT and OT, the Industrial Internet of Things opens plenty of opportunities in automation, optimization, intelligent manufacturing and smart industry, asset management, industrial control, moving towards an on demand service model, new ways of servicing customers and the creation of new revenue models, the more mature goal of industrial transformation.



Implementation of HI2OT

To implement HI2OT actions a number of Working Groups (WG) have been established.

WG Proposals
The aim of this WG is to share information on actual calls for proposals where HI2OT members could apply for funding. A Google site has been set up to show brokerage events available throughout Europe. This activity helps the partners to e.g. jointly promote participation in IoT related projects.

WG Conferences
There are quite a number of conferences related to industrial IoT where students can submit their technical papers. However, the focus of this WG is to identify conferences and events where the Hub could project itself. The Hub has presented or organised sessions related to:

- High-Tech Summit in Copenhagen with two Hub sessions: (1) Fog Computing and the IoT and (2) IoT technologies and Security (Cloud to Edge).
- IoT Workshop during the Nordic Test Forum (NTF).
- Nordic IIoT Hub workshop during the CPS Week in Montreal (page 31).
- A public presentation at Folkeuniversitetet in Copenhagen on the subject "Internet of Things – Things' internet".

WG Training
The aim of the Training WG is to establish new graduate courses for our PhD students. Often these courses are offered by means of summer schools where international speakers are invited to give very high class lectures. The development of new graduate courses are, however, also promoted in this WG. The partners agree on a way of sharing the costly development of the courses and subsequently to offer the courses to all Hib students through e.g. the Zoom system.

Currently five such graduate courses have been provided:

- The Summer School on Cyber Physical Systems
- Nordic IoT Summer School: Edge and Fog Computing
- Nordic IoT Summer School: Robot motion generation and control at Lund University
- Hands-on training on Time-Sensitive Networking and Edge Computing.
- IoT course on Cloud Computing, Distributed Computing and Resource Management.

WG Dissemination
Most of the daily HI2OT promotion is done by www.nordic-iot.org

To keep all students and partners informed about the events a newsletter is published 2-4 times per year.

A number of promotional flyers are used for the promotion of the specific Hub events.

Four posters elaborating on the graduate school aspects of the cooperation have been made available.

To support the partners' presence in conferences and meetings a roll-up poster has been produced and distributed to each partner:

Drinking mugs with the Nordic IoT logo have also found their way to the partner sites.

WG Testbeds and Equipment
Together, the partners have a huge amount of IoT related equipment - from autonomous vehicles driving around on campuses to specific equipment for manufacturing sensors and boards. A complete list of available IoT equipment, including access info and user manuals, is available on the project web.

Yearly Hub meetings

The first Yearly Hub meeting was held on 14-15 August 2018, in Helsingborg, Sweden.

The themes for the technical tracks were benchmarks, use cases and demonstrators. At the time of the meeting 28 PhD students were involved in the Hub. In order to address more specific Hub needs parallel Working Group meeting were organised.

The meeting was opened by Rector Annika Olsson, Campus Helsingborg. Following the opening a number of presentations addressed the current status of the Hub activities. The participants were given a presentation about IoT in Helsingborg with focus on today's and future projects followed by how to collaborate on Smart City Use Cases.

The second day was divided into group work addressing the first year planning of training activities, proposal writing, conference participation, recruitment, dissemination and large testbeds/equipment.

The second Yearly Hub meeting was held on 25-26 April 2019 in Espoo, Finland
The meeting was set up at the lovely Otaniemi campus at Aalto University. It was attended by 37 Hub members. Compared to the first year's event there was a stronger focus on involving the students in the programme.

Parallel sessions were used to address issues specifically related to the management of the Hub and at the same time the PhD students could focus on progress and collaboration opportunities related to their thesis work. This was done by two poster sessions on Fog/Edge computing, chaired by Michele De Donno, DTU and Cloud computing, chaired by Jussi Hanhirova, Aalto. Each session attracted roughly ten students presenting and discussing their findings. The poster sessions were also used to identify bilateral student-to-student cooperation, which have materialised by means of a number of mobilities.

The Hub partners gathered at the first Yearly meeting in Helsingborg.

The technical programme also included four invited presentations:

- Industrial IoT setups by Jari Juhanko, AIIC
- Industry/academic cooperation by Yrjö Neuvo, Aalto University, FI
- Machine Intelligence Provisioning and Distribution by Edgar Ramos, Ericsson Research
- Brief info on FP9 – HORIZON Europe (new instruments, new topics, budgets, etc.)
- Pekka Rantala, Business Finland, FI

HI2OT aims at video conferencing all major events

At the beginning of HI2OT it was decided to go for the Zoom video conferencing system provided by Zoom Inc. The system is now available at all partner sites and offers a unique way of sharing, especially highly sought-after lectures only offered by a single Hub partner.

All partners have acquired the Logitech video camera that is very fast, simple to connect and well suited for meetings and classroom lectures. It is a modern learning tool that helps universities and schools to improve student outcomes with secure video communication services for hybrid classrooms, office hours, administrative meetings, and more. It expands traditional classrooms with video communications to meet the needs of today's students, including video breakout rooms, multi-sharing, polling, and group chats. A Hub student can request the Zoom access for any lectures provided by the eight partners.

The first event that was entirely Zoomed to all the Hub partners was the Robot motion generation and control Summer School that took place in Lund in August 2019 (see p22-23).

Student testimonial:
I used Zoom for a distance learning session with a professor from the Summer School in Lund. I remained in the Aalto office while attending a real-time class in Lund. It was fantastic. I could hear the lecturer perfectly. He alternated from showing his slide presentation to the view of the test set-up seamlessly and the video quality was flawless.

The Logitech video camera utilised by all Hub partners for streaming joint events.

HI2OT's Distinguished Lecturer Programme

The Distinguished Lecturer Programme (DLP) provides a service to support the students and faculties with high qualified distinguished lecturers specialised in various aspects of IoT technologies and to deliver technical seminars and workshops. The DLP can be arranged in response to a request from one or more HI2OT partners.

A list of renowned distinguished speakers is drafted with the associated topic. Whenever possible the speeches will be made available to all Hub students by means of the Zoom service.

The first such event transmitted to all students was a presentation by Dr. George Oikonomou, Senior Lecturer in IoT Networking at the University of Bristol, UK. The presentation was "The Contiki-NG open source operating system for low-power, severely constrained wireless embedded devices: Introduction and hands-on crash-course for beginners."

Other Distinguished lectures include:

- Optimisation challenge – The TSN scheduling problem Dr. Silviu S. Craciunas, TTTech Computertechnik AG (AT)
- IoT and edge intelligence Prof. Marilyn Wolf, Georgia Research Alliance, USA
- Designing Ultra-Low Power Medical Wearables for the Internet of Things Era Associate Prof. David Atienza, EPFL (CH)

The Hub Distinguished Lecturer programme is co-ordinated by Associate Professor Xenofon Fafoutis, DTU-Compute.

Access to EU research funding

HI2OT eagerly participates in the numerous brokerage events organised throughout Europe. By sharing their resources the partners can afford participation in more events.

Most of the major EU calls use brokerage or matchmaking events where potential partners come together and find the perfect match for their organisation, activities and plans.

In H2020, several such brokerage events are taking place both on individual topics but also events covering a specific region of EU member states. Since IoT by nature is multi-disciplinary and has several application domains there will be nearly 100 such events annually throughout Europe. None of the Hub partners can afford to participate in all these events. For this reason, the workload is shared between the Hub partners.

To support the presence during the events a number of joint flyers and posters have been produced highlighting the qualifications of the HI2OT partners and their project/topical interests for the calls concerned.

Brokerage events where the Hub has been present include:

- Horizon 2020 Transport Info day 7 October 2019, Brussels (Belgium).
- H2020 Brokerage event, 7 November 2018, Lisbon
- IoT Solutions World Congress 2018, Barcelona, 16-17 October, 2018
- EFECS 2019 – European Forum for Electronic Components and Systems, 19-21 November, Helsinki

Joint EU proposal with LTH and DTU
Based on the Hub relationships established between DTU and LTH a proposal was developed for the EU programme Eurostars.

In the project an IoT-enabled real time production planning solution will be developed that can handle uncertainties, aiming at reducing down-time, increasing output, reducing the risk of non-delivery and increasing the profits for the manufacturing end users. These are areas where both DTU and LTH have their key competence.

Apart from the two Hub partners it included two SMEs, namely Octavic PTS and Glaze ApS. They are already present in several European markets, e.g. pharmaceutical, automotive, machinery and medical. The proposal was submitted in September, hopefully with a positive evaluation in 2020.

Joint PhD student with NTNU and DTU
In October 2019 a Nordic Five Tech Alliance PhD student was hired to work on his thesis jointly between DTU and NTNU.

Nordic Five Tech is a strategic alliance of the five leading technical universities in Denmark, Finland, Norway and Sweden. The alliance was established in November 2006 with the goal of utilising the shared and complementary strengths and creating synergies within education, research and innovation.

The student will work on Autonomous Vehicle System Platforms for Safety-Critical Applications with a shared presence in Lyngby and Trondheim.

Joint ITN proposal
At the end of 2019 the Hub partners decided to submit an Innovative Training Networks (ITN) proposal to EU.

The ITN programme, also known as part of the Marie Skłodowska-Curie Actions, supports competitively selected joint research training and/or doctoral programmes, implemented by partnerships of universities, research institutions, research infrastructures, businesses, SMEs, and other socio-economic actors from different countries across Europe.

They aim to train a new generation of creative, entrepreneurial and innovative early-stage researchers, able to face current and future challenges and to convert knowledge and ideas into products and services for economic and social benefit.

European Training Networks help researchers gain experience of different working environments while developing transferable skills. If granted it will provide the partners with up to 15 PhD scholarships.

The HI2OT students

Currently, 44 PhD students are affiliated to the Hub coming from five Nordic universities. The students are divided into four groups covering various aspects of the industrial IoT applications:

Networking

The Networks Technologies and Service Platforms act as the glue between the applications of the future and the underlying Network infrastructure, equipment and Technologies. This requires heavy collaboration with the Telecom industry and equipment providers.

1. Next generation SDN/NFV-based Management of Service
2. 5G-based steering of Unmanned Aerial Vehicles
3. Mobile Network enabled UAVs for the delivery of IoT services
4. Communication in Real-Time Multicore Systems
5. Energy conservation in 5G networks using DRX
6. Latency Critical Networking
7. Future Scenarios and Value Network Configurations for Industrial 5G
8. Design, optimisation and control of self-driving networked systems
9. Optimisation and control of networked systems for autonomous vehicle applications
10. Ultra-reliable and low-latency networked systems aimed for time-critical services in an Industry 4.0 environment
11. Ultra-reliable IoT network for mission-critical applications
12. 5G network slicing strategies for a smart factory
13. Towards Mitigating the Impact of UAVs on Cellular Communications

Fog/Edge Computing

Fog computing refers to extending computing to the edge of the network. Edge brings processing close to the data source, and it does not need to be sent to a remote cloud or other centralised systems for processing. This can improve the speed and performance of data transport, as well as devices and applications on the edge. Fog computing is a standard that defines how edge computing should work, and it facilitates the operation of compute, storage and networking services between end devices and cloud computing data centres.

1. Resource Management in Fog Computing for Industrial Applications
2. Feedback Control in Cyber-Physical Systems
3. Security for embedded real-time systems
4. Edge computing
5. Autonomous learning camera systems in resource constrained environments
6. Reliable Architecture for Future Smart Communities
7. Security in Fog Computing
8. Open source Fog Node: hardware support for virtualisation
9. Smart Manufacturing
10. Information security for operational safety in Industry 4.0 based production
11. Fog Computing Security
12. Configuration of Autonomous Vehicle System Platforms for Safety-Critical Applications
13. Fog computing for IoT

Cloud Computing

With the explosion of data, devices and interactions, cloud architecture on its own can't handle the influx of information. While the cloud gives us access to compute, storage and even connectivity that we can access easily and cost-effectively, these centralised resources can create delays and performance issues for devices and data that are far from a centralised public cloud or data centre source.

1. Intersection of cloud computing, telecom, and control theory
2. Control-based resource management in the distributed cloud
3. Mission critical cloud
4. Event-Based Cloud Control
5. 5G Mobile Networks Optimisation using Cloud-RAN architecture
6. Event-Based Control and State Estimation
7. Towards a service-oriented framework supporting MBSE tool-chain development
8. State estimation and motion planning of non-linear systems
9. Autonomous Systems and Software
10. Digital twins

Data Analytics & Machine Learning

Data collected from systems—ranging from field sensors to commercial vendor data services—often are incomplete and require specialised software to be usable. Deep learning algorithms are required that teach machines to automate complex tasks for multiple industries. This group is applying and developing advanced methodologies and techniques in the predictive analytics realm, such as data mining, image and video classification, and predictive forecasting systems.

1. Distributed real-time operational data analytics
2. Data Analytics for Cyber-physical Systems: Current Situation and Strategies for Action
3. Machine Learning for Autonomous Data Centres
4. Distributed machine learning at the edge
5. Efficient user generated information management
6. Optimisation of future mobile communication systems using Deep Learning
7. Neoro-adaptive Digital Learning
8. Virtual reality for IoT

Students crossing borders

The HI2OT students take advantage of visiting one another to gain access to expensive or rare IoT equipment or to pursue e.g. joint publications.

During the yearly meeting in 2019 at Aalto, two poster sessions were organised within Fog/Edge computing and Cloud computing. Most of our students active in these areas presented their work with a focus on progress and collaboration opportunities related to their thesis work. In particular, the students were encouraged to pursue mobility schemes between the various research groups.

These mobilities are now starting to take off, e.g.:

- LTH-Aut visited DTU-Compute to work on a joint paper
- DTU-Photonics visited NTNU to see their IoT deployment looking for some potential collaboration in the future
- Aalto to visit DTU to contribute to a session on Large IoT structures organised during the High Tech Summit
- DTU-Photonics visited LTH to share research knowledge
- DTU-Photonics visited LTH for a month to continue their work on LP-WAN modeling
- LTH to visit DTU-Compute/Photonics to work on a SSIoT collaboration project
- DTU-Compute visited Shanghai University to explore cooperation possibilities
- Aalto students visited DTU with presentations of their thesis findings

Also, longer term non-Nordic mobilities are taking place, such as:

- DTU staff as a research fellow at U C Berkeley, USA for 3 months
- A professor from Illinois, USA visited LTH for 3 months (and gave two talks to our PhD students)
- A PhD student from DTU visited University of Auckland, New Zealand for a period of 2 months
- A PhD student from LTH visited U C Berkeley, USA for 6 months
- A PhD student from Genova, Italy visited DTU-Compute for 12 months

Michele De Donno, DTU, visited Shanghai Institute of Fog Computing Technology

Michele De Donno, DTU, works on security aspects within fog computing and IoT. Recently he visited the newly established Shanghai Institute of Fog Computing Technology (SHIFT) where our own developed AntibloTic anti-malware aimed at Fog computing was presented.

Fog computing is the system architecture that makes use of so-called edge devices, i.e. the entry point into enterprise networks, to carry out a substantial amount of computation in behalf of IoT devices. His project addresses the security issues arising from having every "thing" connected to the Internet, making computing more pervasive like never before. From the security perspective, the increasing adoption of IoT devices in all aspects of our society has exposed businesses and consumers to several threats such as Distributed Denial of Service (DDoS) attacks.

In order to discuss his findings, he visited one of the newly established research centres in China, the Shanghai Institute of Fog Computing Technology (SHIFT), in March 2019. The institute is a joint lab between Shanghai Tech University and Shanghai Institute of Microsystem and Information Technology.

During his visit, he gained good insight into which technologies and approaches they are adopting in the scope of Fog Computing. He visited professor Dr. Yang Yang, who is a full professor at Shanghai Tech University and the Co-Director of SHIFT.

As part of the visit, Michele presented his new advancements on how to tackle the IoT security problems using "AntibIoTic". AntibIoTic is an anti-malware that relies upon Fog computing to secure IoT devices and to overcome the major security issues of the IoT by including Fog computing into the system. His presentation was attended by the key staff of SHIFT, among others four professors and two PhD students.

Dr. Yang Yang and the other professors in the audience acknowledged the presentation and provided an overview of the approaches taken at SHIFT related to Fog Computing and cyber-security. The interest at SHIFT includes: task scheduling and resource allocation in Fog Computing, use of machine learning for task offloading in Fog networks, Blockchain-based Fog resource management and sharing, energy efficiency for task offloading, robots rescue services based on Blockchain and Fog Computing.

Michele was also given a guided tour of the research labs where he had a close look at the inspiring number and variety of available Fog devices and also the chance to attend the exciting demo of a robot rescue service based on Blockchain and Fog Computing.

Michele currently has one year left before graduating at DTU. During the remaining year, he plans to visit Lund to join their international research environments, both industrial and academic.

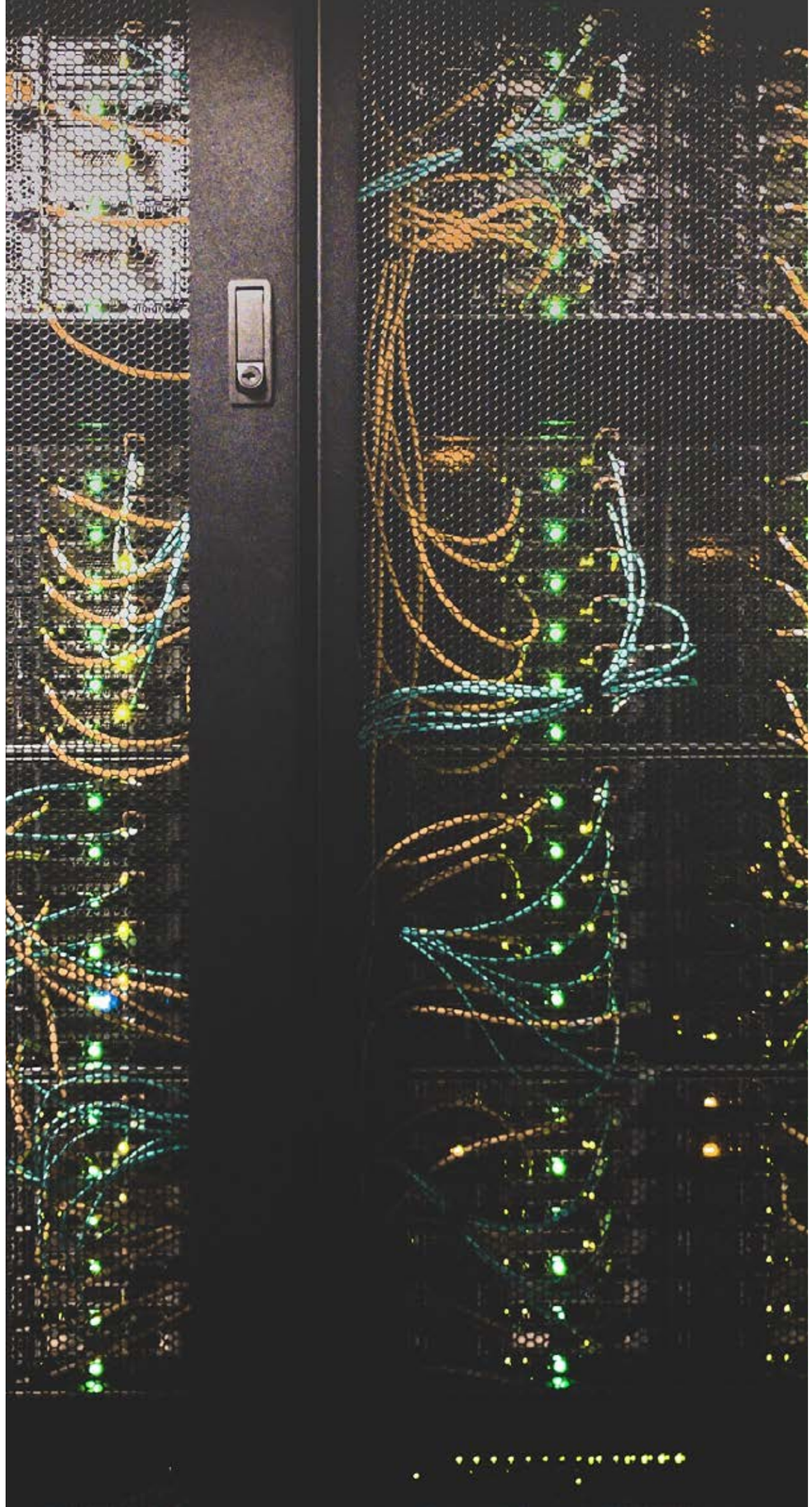
Mohammadreza Barzegaran, DTU, joined Summer School at KTH

Mohammadreza Barzegaran, DTU, is studying for his PhD on Resource Management in Fog Computing for Industrial Applications. In June 2019, he attended the Summer School organised by KTH, Stockholm, on Trustworthy Highly Autonomous Cyber Physical Systems (CPS):

“The five days covered the latest CPS insights and knowledge and addressed topics as various as computer science, control engineering, data science and computer engineering. The most prominent leaders in the field gathered to make this week one of its kind leaving the attendees with a deep understanding of the complexity of Autonomous CPS solutions and how different areas intertwine with each other.

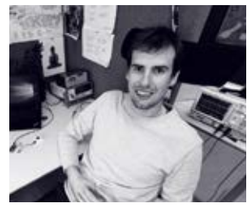
I met around 30 PhD students, some of them from the FORA project, a European Training Network. Several speakers were invited from industry and presented industrial applications.

The summer school had an area for both speakers and participants. I met people from e.g. Computer Science, Control Engineering, Data Science, Computer Engineering. All of them are working on the same topic, i.e. CPS and their work can impact the others. Several talks were really interesting for me: the Acumen software for modelling CPS, the Mercedes Benz S-500 self-driving system, and the security talk from Toyota Security.”



Jan Sranota, NTNU, joined Summer Schools at KTH and DTU

Jan Sranota is studying for his PhD at the Department of Mechanical and Industrial Engineering, NTNU. In June 2019, he participated in the KTH Summer School on Trustworthy Highly Autonomous Cyber Physical Systems (CPS) and also the DTU Summer School on Edge and Fog computing. From DTU, he acquired knowledge on the optimisation of power consumption, which he could apply to his work in Trondheim:



“I especially appreciated Associate Prof. David Atienza’s lecture on Designing Ultra-Low Power Medical Wearables for the Internet of Things Era. Optimising the power consumption of microcontrollers is very relevant to my research. Often small HW/SW adjustments in sensing and data processing lead to significant reduction of power use, which in turn can prolong the lifetime of the constrained device by years.

So far, I have published two papers related to my thesis on Information security for operational safety in Industry 4.0 based production. The papers address the implementation of various standards for RailCheck.

Another great session was the hands-on training on FPGA, specifically MAX1000, led by lecturers from Arrow. In a half-day the participants created their own processor on unified hardware and wrote the HelloWorld.c app.”

Florian Müller, TU Chemnitz, joined the Summer school in Lund

Florian Müller is a control technology engineer and finished his PhD in 2018. He now works at the Chemnitz University of Technology as a post-doctoral in the field of bipedal robots.

In August 2019, he went to Lund together with colleagues to attend the Summer School on Robotics with topics in motion planning and control for underactuated mechanical systems. He enjoyed every single day of the five days:

“

On the first day, my supervisor Prof. Ulrike Thomas from the Chemnitz University of Technology and head of the Robotics and Human Machine Interaction Lab started the first lecture on the topic of trajectory planning. The day ended with some practical Matlab examples for trying out ourselves in the computer laboratory.

On the second day, the main speaker Prof. Anton Shiriaev (NTNU) started his four-day ongoing lecture on underactuated systems. I obtained a lot of new input for my current research. Of course, this is not a trivial topic, but Anton gave a lot of practical examples with many computations on the blackboard. His employee finished the work-shop by presenting the butterfly robotic. If you haven’t heard about it, watch the video “Nonprehensile manipulation” (manipulation without grasping) on YouTube.

The social activities around the workshop were well organised. On the first day we had a nice little BBQ on the rooftop of the university building. This is where the coffee breaks also took place. It was interesting to find out that scientists of many different nationalities attend this summer school. We benefitted from a lot of productive exchange on interdisciplinary research topics. This exchange was continued on Wednesday at a restaurant in Lund’s beautiful city centre. The next day, we went out for another dinner but this time we went together to Malmö.

”

Pavel Anistratov, Linköping University, joined the Summer School in Lund

Pavel Anistratov studies motion planning for passenger cars. He participated in the Summer School on Topics in Motion Planning and Control for Underactuated Mechanical Systems in August 2019 at Lund University.

“

During the five days, I got to meet other PhD students and researchers who are involved in the topic of motion planning and control. It was also interesting to find out that some of the PhD students had recently joined the WASP. It is the same research programme that is supporting my PhD research on time-critical motion planning for passenger cars at the Division of Vehicle Systems (LiU).

The summer school started with an introductory lecture to motion planning done by Prof. Ulrike Thomas and a practice session (including programming in Matlab) carried out by her colleague Sascha Kaden. I found it very useful to be reminded about the foundation concepts and to be given small problems to solve as a way of warming up for the summer school after the holiday period.

In the following days, lectures were held by Prof. Anton Shiraev with focus on planning, control, and path following for nonlinear systems and non-prehensile manipulation. As an example of the latter, the butterfly robot was shown to us by the colleagues of Prof. Shiraev.

The lectures were rich with the theoretical background of the underlying processes and many illustrative examples. The presented material gave me a new perspective on how motion planning is connected with consecutive control and path following and examples of the systems where it is challenging to distinguish clearly between them. I can see that this observation will be useful in my research.

”

Oussama Bekkouche, AALTO, flies with drones

Part of Oussama Bekkouche's PhD programme at Aalto University is to play with drones. He is looking at how the 5G mobile network can support mission-critical applications by decreasing the end-to-end latency and the unreliability of communication.

Unmanned Aerial Vehicles (UAVs), commonly known as a drone, are aircraft without a human pilot on board and a type of unmanned vehicle. UAVs are a component of an unmanned aircraft system (UAS); which include a UAV, a ground-based controller, and a system of communications between the two. The flight of UAVs may operate with various degrees of autonomy: either under remote control by a human operator or autonomously by onboard computers.

Compared to crewed aircraft, UAVs were originally used for missions too "dull, dirty or dangerous" for humans. While they originated mostly in military applications, their use is rapidly expanding to commercial, scientific, recreational, agricultural, and other applications, such as policing and surveillance, product deliveries, aerial photography, smuggling, and drone racing. Civilian UAVs now vastly outnumber military UAVs, with estimates of several millions sold.

Given the continuously increasing use of Un-manned Aerial Vehicles (UAVs) in different domains, their management in the uncontrolled airspace has become a necessity. This has given rise to new systems called UAVs Traffic Management (UTM) systems. Nevertheless, currently, there is a lack of communication infrastructures that can support the requirements of UTM systems. Luckily, the envisioned 5G mobile network has introduced the concept of Multi-access Edge Computing (MEC) in its architecture to support mission-critical applications by decreasing the end-to-end latency and the unreliability of communication.

Oussama Bekkouche's PhD project aims at highlighting and deeply exploring how the new paradigms introduced by the 5th Generation of mobile communications (5G) (e.g., MEC, network slicing, etc.) can be harnessed to solve the set of problems that face the integration of Unmanned Aerial Vehicles (UAVs) in the future ecosystem, this include the need for an Ultra-reliable and Low-latency Communications (URLLC) for an efficient Beyond Visual Line-of-sight (BVLOS) control, security issues, lack of centralised intelligence and the high mobility of UAVs.

The intended doctoral study will devise an efficient solution for controlling and managing UAVs by exploiting the envisioned flexible system design of the 5G mobile networks. This will mainly be achieved by the introduction of new Virtual Application Functions (VAFs) and/or Virtual Network Functions (VNFs) in the different segments of the network (i.e., core, transport and edge networks) to create a customised network instances (i.e., slices) that best respond to the challenges posed by the mission-critical nature of UAVs.

Didem Gürdür Broo completed her PhD at KTH and is now moving to the University of Cambridge

One of the first HI2OT students to graduate is Didem Gürdür Broo.
In 2019 she finished her PhD in Mechatronics at KTH.

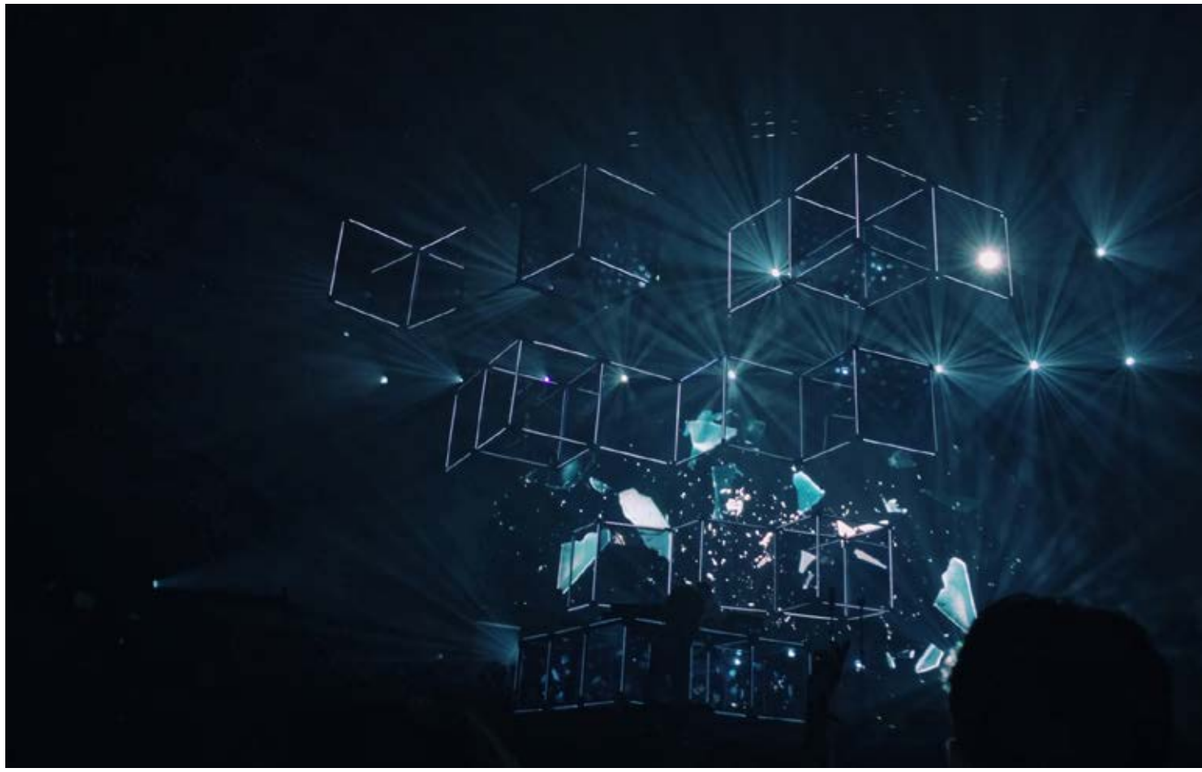
Didem cares about the future of the world and nature. She is a computer scientist with a PhD in Mechatronics, which gives an idea about how much she loves to talk about the future and emerging technologies. She is a data person, always finding a way to talk about the importance of data, the effect of it on decision making and, at some point, you can expect her to talk about art, visualisations and visual analytics. Didem is a person who does not hesitate to talk about inequalities and to point out her ethical concerns. She dreams of a better world and actively works on improving inequalities regardless of their nature. She is an analytical thinker with a passion for design thinking, a researcher with a future perspective, an engineer who likes problems more than solutions and a teacher who likes to play during lectures. She is a good reader, certified future strategist, divemaster, photographer and drone pilot.

Currently, she is a postdoctoral researcher at the same department where she teaches research methodology and advanced mechatronics project courses, in addition to supervising students on mechatronics and robotics thesis projects. Didem is now moving to Cambridge for a research associate position at University of Cambridge.

During her PhD, Didem was part of HI2OT and collaborated with universities and companies all around the Nordic countries while conducting research on data and visual analytics for cyber-physical systems. Didem received a Bachelor's degree as a computer engineer as the top student of her class with an exceptional track record, awarded with the best graduation project. She has been awarded with the best conference paper from different scientific conferences. She has also actively volunteered in different human rights organisations to increase awareness of LGBT rights, gender equality, refugee rights and animal rights. She has been interviewed by several blogs, magazines, newspapers and appeared on television programmes to discuss women in technology and engineering, to motivate girls to choose STEM disciplines and to increase awareness of sustainability and equality related issues.

Didem has a multidisciplinary background from arts, computer science and mechatronics. She strongly advocates the importance of cross disciplinary, collaborative research. She has developed a multidisciplinary network in Europe and the Nordic countries and worked with industrial partners. She has been granted as IEEE Senior Member due to her significant performance and excellence over the last five years. She is a member of European AI Alliance and contributes to the discussions of all aspects of artificial intelligence development and its impact on the society.

Her position at University of Cambridge will be a milestone in her career and an opportunity to become an independent research leader in the domain of sustainable, ethical, human-centred cyber-physical systems.



Graduate courses – focus is on new developments

As part of HI2OT we carried out a survey on PhD course topics (available and desired courses). Among other things the questions address what course topics the students felt were missing among their local PhD courses and that they would want the Hub to offer.

The survey was carried out by professor Karl-Erik Arzen from Lund University. The input was used to draft the programme for the two summer schools offered in 2019. Examples of available PhD courses:

- The Hub: Nordic IoT Summer School: Edge and Fog Computing – 2.5 ECTS
- The Hub: The Summer School on Cyber Physical Systems – KTH 2-4 ECTS
- Industrial Robots and Automatic Handling Systems – NTNU 7,5 ECTS
- Research in Artificial Intelligence – KTH 15 ECTS
- Telecommunication Networks of the Future – DTU 5 ECTS
- PhD Course in Design of Mobile Backhaul Networks – DTU 5 ECTS
- Graduate Course in Machine Learning - KTH 6 ECTS
- PhD Seminar in Computer and Information Science – NTNU 7,5 ECTS
- Computer Systems Architecture – KTH 10 ECTS
- FORA/Hub Training School (Societal Challenges and Industry 4.0, Fog Computing and Networking, Resource Management and Middleware in the Fog)
- Network technologies and application development for Internet of Things – DTU 5 ECTS
- IoT prototyping. Proof of Concept for your Telecom IoT Project
- The Hub: Robot motion generation and control Summer School, August 5-9, 2019, Lund University

New courses will be developed with a view to the results of the HI2OT survey.

Collaboration with industry

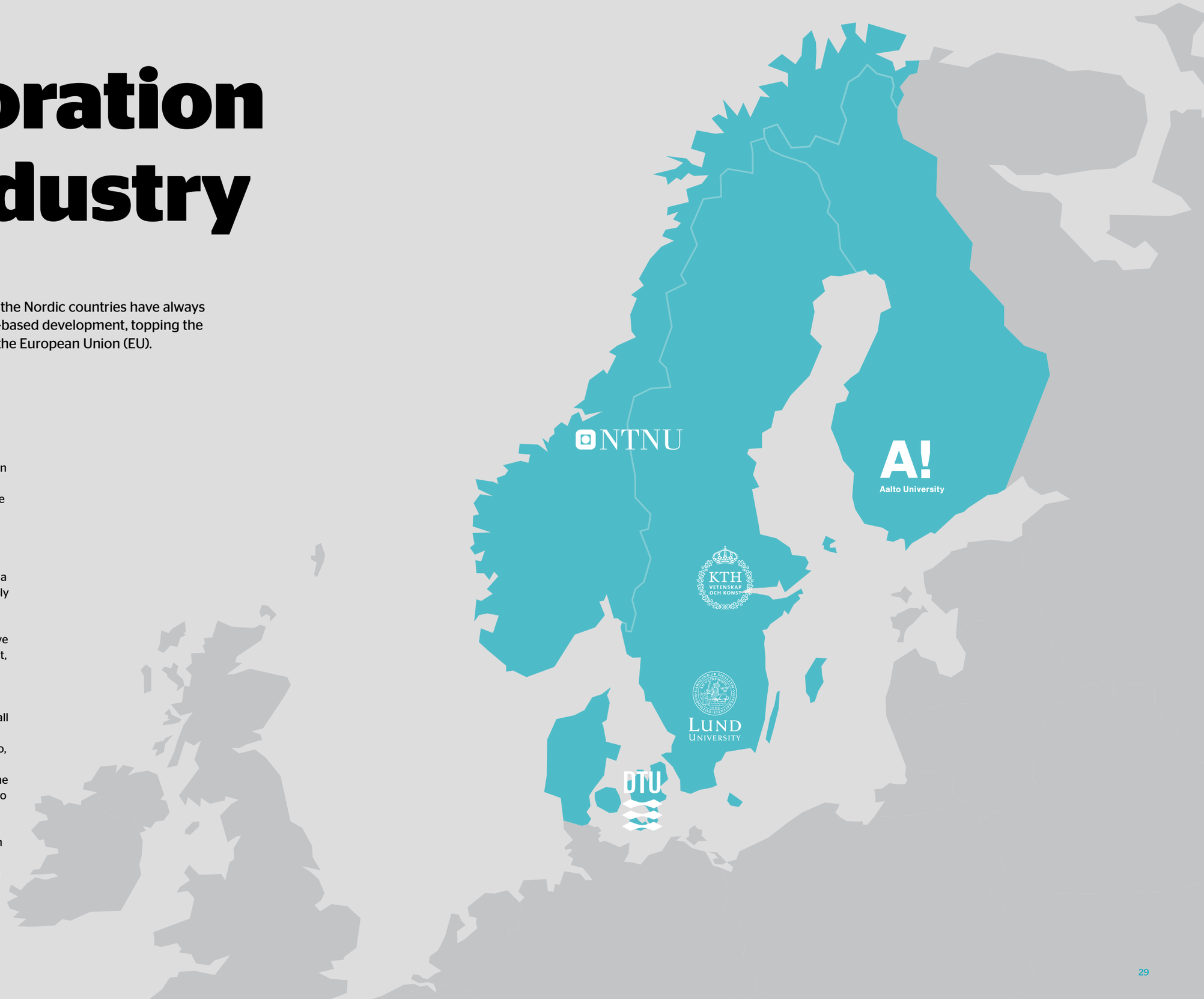
The Nordic high-tech region
With a long tradition of supporting innovation, the Nordic countries have always been pacesetters when it comes to innovation-based development, topping the rankings of the most innovative economies in the European Union (EU).

According to the Regional Innovation Score-board (European Commission, 2017), Stockholm is the most innovative region in the EU, followed by the capital region of Denmark. With the relatively early adoption of the green growth agenda, the Nordic countries have become frontrunners in green economy transformation, having obtained a significant competitive advantage in green solutions.

The EU 2020 target aims at 40% of 30–34 year olds with a tertiary level qualification. The Nordic average is currently 49% (Eurostat, 2017).

The Nordic countries are generally performing well above the EU average when it comes to economic development, despite the significant and ongoing impact of the economic crisis. From a macro-regional perspective, the Nordics constitute a very coherent region. In terms of innovation, the Nordic countries also rank highly and in all Nordic regions, the share of employment in knowledge-intensive sectors is well above the EU28 average. Even so, the Nordics still make up the most innovative region in Europe and almost all regions, with the exception of some areas of Finland, exhibit a stable pattern when it comes to R&D expenditure.

The Nordic Region also remains an attractive destination for foreign investment, accounting for 7% of Europe's total Foreign Direct Investment (FDI) inflows, in a Region having 4% of the European population.



Hub students help SME growing their business

Staff members and PhD students from the DTU-Photonics department are supporting LEKON, a small company's implementation of IoT for asset tracking.

DTU supports a company's development of devices that can assist in localising tools and other assets that require certification and/or a track record. The LEDOC system developed by LEKON A/S has been on the market for more than ten years.

Ledoc is an online system that creates an overview of a company's entire quality management system. These are tangible business benefits that play an important part in building a sustainable business performance. The ISO 9001 standard provides specific requirements for a quality management system that enhances the ability to consistently deliver products and services that meet customer - as well as statutory and regulatory requirements.

By utilising IoT they can add more intelligence to the system. The students are currently investigating what kind of network(s) they should use for the tracking system, e.g. Sigfox, LoRa, Narrow band IoT, RFID, GPS, etc. A full implementation of the module from LEKON will be on the market within the next year.

HI2OT workshop in Montreal

A Workshop on Fog Computing and the IoT was organised in April 2019 by HI2OT during the CPS-IoT Week in Montreal, Canada, which attracted nearly one thousand participants.

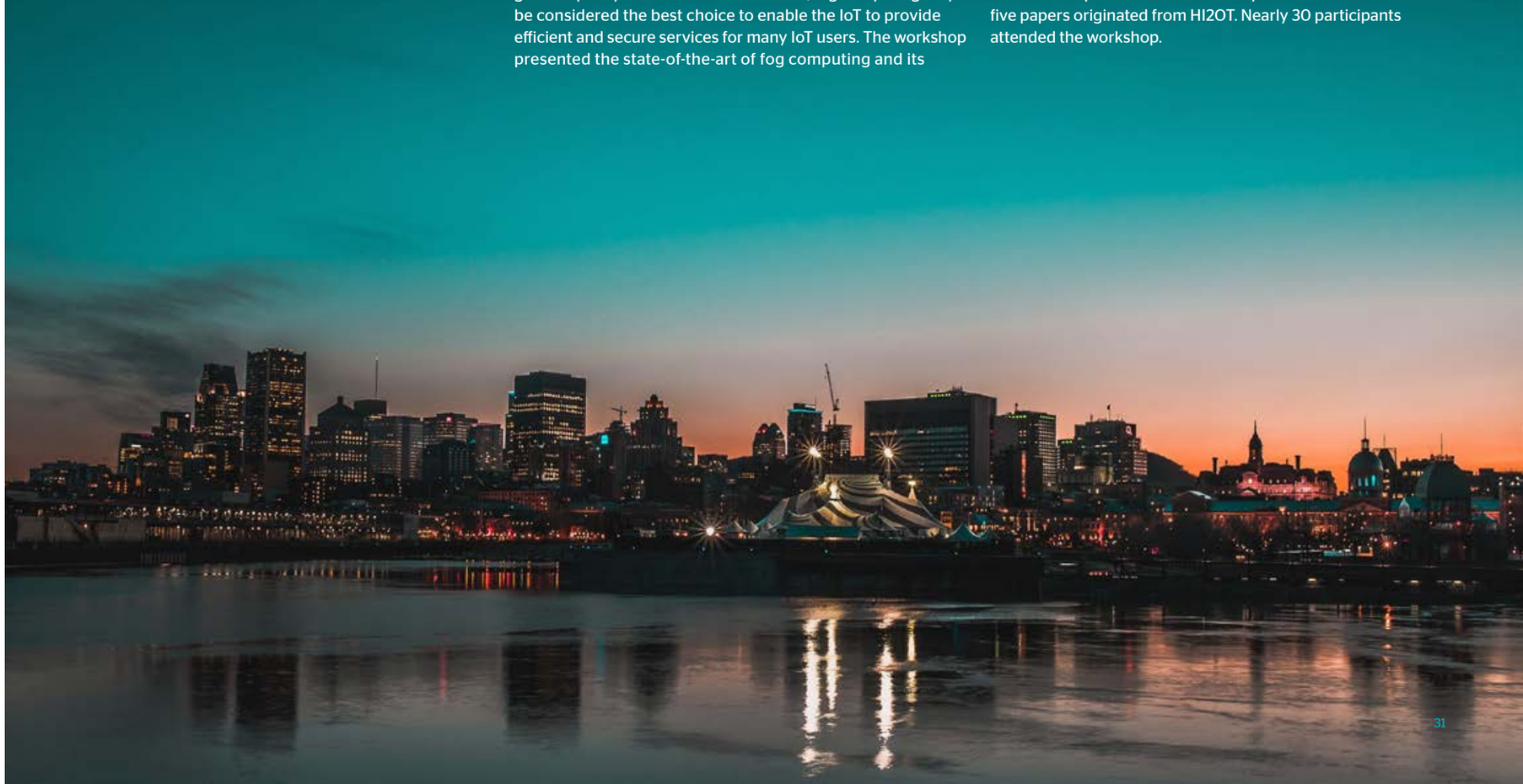
Montreal is known for its leadership and innovation in fields ranging from aeronautics, information technology, and medicine.

With the rapid growth of Internet of Things (IoT) applications, the classic centralised cloud computing paradigm faces several challenges such as high latency, low capacity and network failure.

To address these challenges, fog computing brings the cloud closer to IoT devices. The fog provides IoT data processing and storage locally at IoT devices instead of sending them to the cloud. The fog provides services with faster response and greater quality than the cloud. Therefore, fog computing may be considered the best choice to enable the IoT to provide efficient and secure services for many IoT users. The workshop presented the state-of-the-art of fog computing and its integration with the IoT by highlighting the benefits and implementation challenges.

The workshop, called Fog Computing and the IoT, was organised by our recognised professors Paul Pop, DTU, and Karl-Erik Årzén, Lund University. A keynote speech was given by Dr. Johan Eker working both at Lund University and Ericsson Research. Currently, Johan is looking into control of large scale computer system-based machine learning and control theory. The work is being carried out in collaboration with Ericsson, who are providing access to real data and real cloud deployments and data centres.

Our workshop included 14 technical presentations of which five papers originated from HI2OT. Nearly 30 participants attended the workshop.



Creating a Roadmap for Industrial IoT

In November 2019, the Hub organised an IoT roadmapping workshop in Stockholm. The theme and purpose of the workshop was to give talks and overviews of existing roadmaps in order to come up with a synthesis based on the views of our staff and the invited people. The new IIoT roadmap will be published in the spring of 2020.

The workshop was kicked off with introductory speeches by Paul Pop and Martin Törngren. The keynote speaker of the workshop was Dr. Haydn Thompson, who gave an overview of existing roadmaps with a focus on IIoT roadmaps on AI and Edge/Fog computing. Haydn Thompson has over 30 years' experience working in a mixture of senior industrial research and development roles in flight control systems, space programmes and signal processing applications for leading companies. For nearly 20 years he was the Programme Manager of the Rolls-Royce Control and Systems University Technology Centre. Currently he is Managing Director and Owner of THHINK Wireless Technologies Ltd who is involved in an EU Support Action named CPSoS – Towards a European Roadmap on Research and Innovation in Engineering and Management of Cyber-Physical Systems of Systems. It will establish the state-of-the-art and future research challenges in the area of Cyber Physical Systems of Systems. Cyber-physical systems of systems are large complex physical systems that interact with and are controlled by a considerable number of distributed and networked computing elements and human users. Examples are rail systems, electric grids, smart buildings, and large production facilities.

His presentation was followed by short pitches provided by the Hub seniors attending the workshop, each pitch then collected in a poster that was made generally available during the workshop. With their various backgrounds they were able to complement the overall picture of where IIoT is moving in the next decade. The new IIoT roadmap will be published in the autumn of 2020.

AXIS Communications profited from work by a HI2OT student

Alexandre Martins works with AXIS Communications AB in Lund. AXIS Communications, founded in Sweden in 1984, created the world's first network camera in 1996.

The company challenges conventions and innovates solutions for the security, audio, Voice over IP and building automation markets. The aim is to optimise security and business performance while making sure that their solutions are as simple and user-friendly as possible – from installation to operation.

Alexandre's PhD project looks at autonomous learning camera systems in resource constrained environments. In IoT scenarios there are many potential benefits of extracting control and decision algorithms from individual agents or plants and placing them in the cloud. Such benefits include increased available computational power, decreased cost through the economies of scale, better system resilience, and better performance due to absolute awareness between competing agents in the same area.

The project will deliver a framework to maximise system resources allocation among the different agents (camera, servers, or other IoT devices) while introducing flexibility, scalability and resilience. Each device will be able to inter-act with other neighbours and allocate available resources where it is the most needed and efficient to have.

Alexandre's thesis work is supported by the WASP Foundation.

The WASP programme

Wallenberg AI, Autonomous Systems and Software Programme (WASP) is Sweden's largest individual research programme ever, a major national initiative for strategically motivated basic research, education and faculty recruitment.

The programme addresses research on artificial intelligence and autonomous systems acting in collaboration with humans, adapting to their environment through sensors, information and knowledge, and forming intelligent systems-of-systems. Software is the main enabler in these systems, and is an integrated research theme of the programme.

The vision of WASP is excellent research and competence in artificial intelligence, autonomous systems and software for the benefit of Swedish industry.

5G will help advance IoT technologies

A substantial challenge for IoT technologies is disconnected systems. Now 5G, the fifth generation of mobile communication networks, is on the way with the ability to transmit data faster and support more connections. And 5G can process data quickly, which has been a challenge for IoT solutions using 4G/LTE networks. The result has been long lag times from sending to receiving data. By using 5G, more devices can transmit more data at the same time without overcrowding the network.

The 5G connection will allow everyone to realise the power of IoT technology. As of now, the potential of IoT is vast, but with 5G technology, the potential connectedness will come to fruition. “Smart” devices will be able to transmit data quickly even from thousands of miles away using sensors. The implications are endless on an individual, business, and municipal scale.

The “smart” city can become a reality with both local businesses and residents reaping the rewards. The 5G connection will reach the “unreachable” places such as remote, far away areas or deep underground tunnels. With sensors then placed in these regions, people can be alerted to emergencies such as fires or floods, and workers in these locations can remain safely connected.

For businesses investing in IoT technology or creating IoT-based platforms, 5G will make many of the desired specifications possible. With better connectivity, reduced latency, and a faster connection, more people can transmit more data.

Given that, businesses and developers can expand IoT technologies continuously without the worry of disconnected systems which has thus far held back IoT innovation. 5G will aid the expansion of IoT solutions, which will benefit everyone.

Autonomous bus service at the Otaniemi campus
From June 27, 2019, an autonomous bus service was moving around the Otaniemi campus with people in it. This self-driving bus functions under all-weather conditions, such as heavy rain, fog, and snow.

The bus demonstrates its powerful potential to be a safer and easier means of transportation linking together the campus and the Metro station.

It started its early pilot programme in the Aalto campus in Otaniemi on June 27, 2019. The programme is a collaboration between Sensible 4, Nokia and the City of Espoo. The pilot was making use of Nokia’s latest 5G technology.

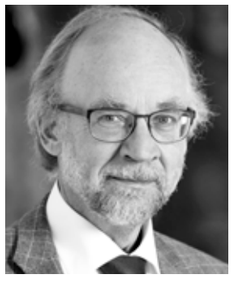
The first video call over 5G in Sweden was conducted between Telia’s CEO Johan Dennelind and Prince Daniel. Also included is Jan Gulliksen, Vice-Rector for Digitisation at KTH, and Åsa Jamal, Communications Manager at Telia.

Sweden’s first 5G network inaugurated
In December 2018, Sweden’s first 5G network opened at KTH’s campus. The 5G network gives us great opportunities to test and demonstrate our world-leading research and innovation in sustainable transport solutions. “We will, for example, use the new network in our research projects on control towers for self-driving cars,” says Anna Pernestål, KTH.

Trondheim to become Norway’s biggest 5G city
In March 2019 Telenor announced that Trondheim will become the first major city in Norway to receive 5G. Starting this summer, the construction of a number of 5G base stations will commence. “Early experimentation with 5G is important for Norwegian innovation power and competitiveness. At Telenor, we want to stay in front of development within 5G, IoT and AI. Once we have expanded 5G technology into Trondheim, it’s not only mobile technology that is ‘coming home’: we can see it becoming among the leading high-tech municipalities in Scandinavia,” says Sigve Brekke, President and CEO of Telenor.

The people behind

Aalto - Enterprise Systems
The research of the Enterprise Systems (ES) group at Aalto University focuses on digital transformation of industry and especially its implications for enterprise architecture, service and business platforms, ICT and data governance, and digital strategising. ES is a research group at the Department of Computer Science, AALTO, the largest computer science dept. in Finland, providing world-class research and education in modern computer science to foster future science, engineering and society. ES consists of 2 professors, 1 adjunct professor, 4 post-docs, 10 doctoral students.



Martti Mäntylä is presently professor of Information Technology with dual appointment to the Department of Computer Science in the School of Science and the Department of Mechanical Engineering in the School of Engineering. His focus area is Enterprise Systems, especially the Industrial Internet and more widely the digitisation of industry in general. My activities are focused on digitisation in industry and society in general, in particular the so-called Industrial Internet. A key activity is to lead the Digital Disruption of Industry consortium funded by the Strategic Research Council of the Academy of Finland. I am also actively engaged with the Aalto Industrial Internet Campus strategic initiative.

KTH - Innovative Centre for Embedded Systems
The KTH hub is anchored with the Innovative Centre for Embedded Systems – ICES (www.ices.kth.se). The strength of ICES lies in the industrial network of partners and in the coverage of key multidisciplinary competences of Cyber-Physical and IoT systems, encompassing both academic and industrial experts. Competences include system and architecture design, end-to end communication performance, safety and security engineering, and verification, as well as model-based engineering methodologies for the analysis, design, verification and systems management. The centre involves researchers from multiple research groups at KTH, in particular from the schools of Industrial Engineering and Management, and the Electrical Engineering and Management.

Martin Törngren has been a Professor in Embedded Control Systems at the Mechatronics division of the KTH Department of Machine Design since 2002. He has a particular interest in Cyber-Physical Systems, architectural design, system safety, model based engineering, and the co-design of control applications and embedded systems. He has been in charge of developing and leading both graduate and continued education courses, as well as the development of new/renewed master programmes. He spent time as a post doctoral at the EU-JRC, did a 10 month sabbatical 2011/12 at UC Berkeley, a 2 month sabbatical in spring 2018 at Stevens Institute of Technology (Hoboken, New Jersey) - followed by a 2 month sabbatical again at UC Berkeley in autumn 2018. In 1994, he received the SAAB-Scania award for qualified contributions in distributed control systems, and in 2004 the ITEA achievement award 2004 for contributions in the EAST-EEA project.

Lund University - Department of Computer Science
Parallel Systems is a division of the Department of Computer Science, bringing together 9 senior members, 2 post-doctoral fellows and 5 doctoral students. Their expertise covers three larger domains: embedded systems, computability and algorithms, and graphics. Within the area of embedded systems design, the group carries out research relevant for IoT systems, including scheduling, resource management, programming languages and compilation techniques, runtimes and optimisation methods for data-centric distributed application.

Flavius Gruian has been an Associate Professor of Embedded Systems in the Parallel Systems division, Department of Computer Science since 2018. He received his diploma in engineering from 'Politehnica' University of Timisora, Romania (1996), his Tech Lic. from Linköping University, Sweden (2000) and PhD from Lund University, Sweden (2002). He also spent time as a visiting student at the Seoul National University, South Korea (2001) and as a post-doctoral fellow at the University of Auckland, New Zealand (2005), where he worked with reactive languages for modelling globally asynchronous locally synchronous systems (GALS). Since 2008, he has been a senior lecturer at the Department of Computer Science, Lund University, teaching subjects such as embedded system design, operating systems, concurrent programming, and coordinating the MSc theses at the department. His research expertise covers energy and power management in resource constrained real-time systems, embedded Java architectures, instruction scheduling and code generation for custom architectures, real-time communication infrastructures and constraint programming.

Lund University - Department of Electrical and Information Technology
The Department of Electrical and Information Technology conducts high-quality research in a variety of areas in electrical engineering and computer science, ranging from pure theoretical research to applied projects in close collaboration with industry. It is at the forefront of international research in most of its areas. The Department of EIT is the major academic platform for local Swedish industry in the telecommunications area. A lot of the academic research conducted at EIT finds its way to standards and actual products produced by companies like Ericsson. EIT consists of 49 scientific staff, 6 postdocs and 57 PhDs.

Erik Larsson is Professor in computer architecture at the Department of Electrical and Information Technology at Lund University (LU).He received his M.Sc., Tech. Lic and PhD from Linköping University in 1994, 1998, 2000, respectively. He did his PhD (Oct. 2001-Dec. 2002) at the Computer Design and Test Laboratory at Nara Institute of Science and Technology, Japan, and through the Swedish Foundation for Strategic Research at NXP Semiconductors, Eindhoven, The Netherlands (Oct. 2008-May 2010). From 2002 until 2012 he was Assistant Professor at Linköping University (2002-2005) and Associate Professor (2006-2012). From 2012, held the position of Associate Professor at LU (2012-2018) and from 2018 as Professor. His current research interests include test planning for manufacturing test, test during operation (in-situ), scan-chain diagnosis, silicon debug and validation, IJTAG/SJTAG, stacked 3D chip test, fault-tolerance for MPSoCs (Multi-Processor System-on-Chip), and property checking in distributed systems (MPSOcS with Network-on-Chip (NoC)). He has more than 130 publications in these areas.

The people behind

Lund University – Automatic Control
The goal of the department is to provide students with a solid theoretical foundation combined with a good engineering ability. This is reflected in the research programme which covers both theory and applications. The research area covers Real-time and embedded control, control of computer systems, computer-control theory, networked control loops, hybrid control, network dynamics, distributed control and optimisation, and general control theory. AutCont at ULUND has 13 scientific staff, 4 postdocs and 23 PhD students.

Karl-Erik Arzen is professor at the Department of Automatic Control. My research area lies at the border between control and computer engineering. Currently my emphasis is dynamic feedback-based resource management (feedback computing) for different types of computer systems, including both embedded systems and cloud infrastructures. I am also interested in embedded control, real-time systems, cyber-physical systems, and programming languages for control applications. I am the deputy coordinator for the ELLIIT strategic research area on IT and mobile computing, a member of the programme management group for the Wallenberg Autonomous Systems Programme (WASP), and a member of the executive committee and treasurer for the IEEE TC on Real-Time Systems.

NTNU – Production Systems Group
Production Systems (PS) is a research group at the Department of Mechanical and Industrial Engineering at NTNU, the largest department for industrial production in Norway. The research group combines robotics, machine tool technology and metrology with automatic control and sensor systems. The research benefit from synergy between the manufacturing industry with its strong focus on cost effective operations, and the offshore and maritime industry with high-value products in small batches. PS consists of over 4 scientific staff, 2 postdocs and 13 PhDs.

Amund Skavhaug, born 1965, has been working with industrial, embedded and real-time computer systems since studying at NTH in the eighties. His inner motivation is “to contribute to the development of other human beings, industry and the society in general”. In the last 10 years, he has worked mainly, industrially and academically with “Remote Presence” systems, especially targeting wind energy, industrial (wireless) networks as well as health and safety systems for homes. His main focus now is the possibilities and challenges in Industry 4.0.

DTU – Compute
Embedded Systems Engineering (ESE) is a section at DTU Compute, the largest computer science department in Denmark, consisting of 12 scientific staff (prof. and assoc. prof.), 5 postdocs and 20 PhDs. ESE focuses on design of modern Industrial IoT systems: real-time systems, fault-tolerant and safety-critical systems, time-critical hardware architectures and deterministic virtualisation, Deterministic Ethernet, heterogeneous distributed multi-core architectures and execution platforms; models, methods and tools for the analysis, design and verification of such systems.

Paul Pop is a professor at DTU Compute (Department of Applied Mathematics and Computer Science). I joined DTU in 2006 as an associate professor. I received my PhD in Computer Systems from Linköping University in 2003 and my Master’s in Computer Science in 1997 from the Technical University of Timisoara, Romania.
Paul’s research is about methods for systems engineering: modelling, analysis, simulation and optimisation. Systems engineering is the treatment of engineering design as a decision making process. He has applied systems engineering methods in the design of embedded systems, which are special purpose computer systems dedicated to perform a specific function.

DTU – Photonics
DTU Fotonik is working with all aspects of current and future communication technologies. The department comprises 4 research sections: Communication Technologies, Nonlinear Optics & Biophotonics, Light Sources & Industrial Sensors and Nanophotonics, and participates. DTU Fotonik participates in the Nordic IoT hub with one section, Communication Technologies, with focus on IoT technologies and infrastructure.

Michael S. Berger received his M.Sc. EE and PhD from the Technical University of Denmark in 1998 and 2004. He is currently Associate Professor at the university within the area of switching and network node design. In his PhD thesis “Architectures of Electro-Optical Packet Switched Networks”, focus was on network and node architecture for future packet switched networks. He has been project leader for several research projects, among others the ERAN project on Intelligent 5G mobile Ethernet Radio Access Network that ended in summer 2018. He is task leader in INCOM and currently involved in a Eurostars Project on Fronthaul networks for C-RAN, and the Nordic University HUB on Industrial IoT.

Make your PhD program in one of five Nordic universities and take advantage of joint courses, labs and IoT test facilities.

www.nordic-iot.org

The Nordic University Hub on Industrial IoT
Review magazine 2018-2019
Published by the Technical University of Denmark
Department of Computer Science
December 2019

Printed by:
Rosendahls
rosendahls.dk

Layout:
We Love People
www.welovepeople.dk

NordForsk