‘We aim to design intelligent sensor systems that deliver guaranteed Quality of Service’

THE PERVASIVE COMPUTING RESEARCH OF ILI CORE TEAM MEMBER **NIRVANA MERATNIA**
INTERVIEW BY MICHIEL DE BOER OF MOESASJI

“We are surrounded by data generating systems, objects, and people. My research mainly focuses on making sense of this data in presence of resource and data constrains. It is my ambition to do research that benefits society and stimulates scientific and technological advancement.” Get to know a little bit about Nirvana Meratnia, TU/e professor in the Department of Mathematics & Computer Science and connected to ILI as the Head of IRIS (Interconnected Resource-aware Intelligent Systems).

Both at University of Twente and at TU/e, the research of Nirvana has been centered around pervasive computing. Pervasive or ubiquitous computing aims at enabling distributed intelligence and making computation indispensable part of everyday objects and systems. It is closely linked with sensing and (wireless) communication to collectively create intelligent networked (embedded) sensor systems.

Nirvana: “These networked systems usually contain a large number of different devices, from little sensors and nodes that gather data, up to powerful computing devices and infrastructures that take care of analysis of that data, and everything in between. The approach of pervasive computing is to have computation done throughout the network and as close as possible to the devices that generate the data. My research is application agnostic as it focuses on the enabling technology used in a wide range of applications. I have worked in many different projects and applications such as logistics, predictive maintenance, smart cities, health & wellbeing, agriculture & animals. In my opinion pervasive computing can help deliver Quality of Service required in all these areas.”

PERVASIVE VS CENTRALIZED

The benefits of pervasive computing are widely recognized. There are various reasons to choose for pervasive over centralized computing. First is energy consumption. Data communication uses a lot of energy, a hurdle for small and resource-constrained (usually battery-powered) devices.

The second reason is privacy. Techniques that do not require data exchange and allow processing and usage of local (on-device) data are much more privacy preserving. And a third reason is latency. For time critical applications it is essential the computation is done where data is generated. Take for example driver support systems in modern cars.

THE AIM AND THE CHALLENGE

“Pervasive computing is beneficial to the performance of the system in terms of situational/context awareness and adaptation for example. A challenge in pervasive computing however, is heterogeneity. Designing a system that is able to ‘talk’ to many different types of devices/systems/users, ‘handles’ different types of data and data quality, and ‘satisfies’ different (sometimes conflicting) requirements, is complex. And it really becomes challenging - and interesting - if we bring learning capabilities to the system. In my research on pervasive computing and edge-AI, we aim to bring a comparable level of intelligence as exhibited in centralized approaches down to smaller platforms and resource constrained systems.”

SMART HOME

A good example on a small scale is the control of intelligent lighting in a Smart Home. In this home you have different rooms, users and activities/context. Each situation demands a certain setting for the perfect lighting scenario. The system must be able to recognize the context: What is

happening? Who is using the system? What are the needs and preferences of this user at that time? Nirvana: "The lighting system will contain different types of sensors that produce different kinds of data which must be processed and interpreted in isolation or collectively. Moreover, you don't want to share that data with a centralized service outside your home. The intelligence should be present safely in your home enabling your lighting control system to learn about the different users and their preferences. The learning model should also be generic, it must be able to process various input/sensor modalities and data quality, deals with lack of labeled data and should be able to function well in any Smart Home environment. Once you've got that running successfully, you can scale up to a public and semi-public spaces such as hospitals or universities."

LEARNING AUTONOMOUSLY

"We design AI and machine learning solutions that are resource- and data- efficient. Systems can usually learn well on huge volume of labeled data, the so called 'supervised learning' approach. Downside of this approach is that what data represents should be known beforehand. This knowledge is usually acquired through a labor-intensive process, during which data is tagged with known labels. This is a time-consuming and error-prone task. So, our ultimate goal - and we are moving in this direction – is to design systems that learn fully autonomously, are generic enough, and can efficiently deal with heterogeneity, uncertainty, lack of sufficient (labeled) data, resource constraints, and conflicting requirements."

CONNECTION TO ILI

"As a core team member of ILI, I take part in the discussions about the Bright Environments program, the vision, research agenda, challenges, links and connections with national and European research agendas and global network. The challenges of Bright Environments are comparable to those of pervasive computing, which are creating intelligent systems that can cope well with different demands, technologies, constraints, heterogeneity, concerns, and yet are self-learning to a level where they can operate autonomously, with minimum interactions and errors causing discomfort for users. Our common goal is to come up with approaches that deliver maximum Quality of Service."

RADIO SENSING

Linked to the ILI program 'Bright Environments', Nirvana is currently working on domain adaptation in the area of unobtrusive sensing. Nirvana: "We are researching the use of radio-signals such as WiFi CSI, millimeter wave, for sensing and context recognition. Patterns of radio signals change depending on what's happening in a certain space. If a person enters an empty room, for example, the pattern of radio waves will be slightly different. We design AI techniques that analyze these changed patterns and can sufficiently learn from them, intendent of external factors influencing the signal to accurately reason about the phenomena, events and context, allowing a new form of situational awareness. The research is challenging however, because many factors influence the data: temperature, sun/light intensity, direction of the antenna's, characteristics of the object/person, type of activity, etc."

LIMITLESS

"ILI is of course focused on lighting (solutions). We see a wide array of other sensors being used and becoming important in such settings. Moreover, there are interesting emerging areas around lighting: sustainability for instance. I believe intelligent lighting systems cannot be designed in isolation but can benefit from collaboration between various fields of science and technology. This is happening within ILI. Collaboration makes the possibilities limitless." ■