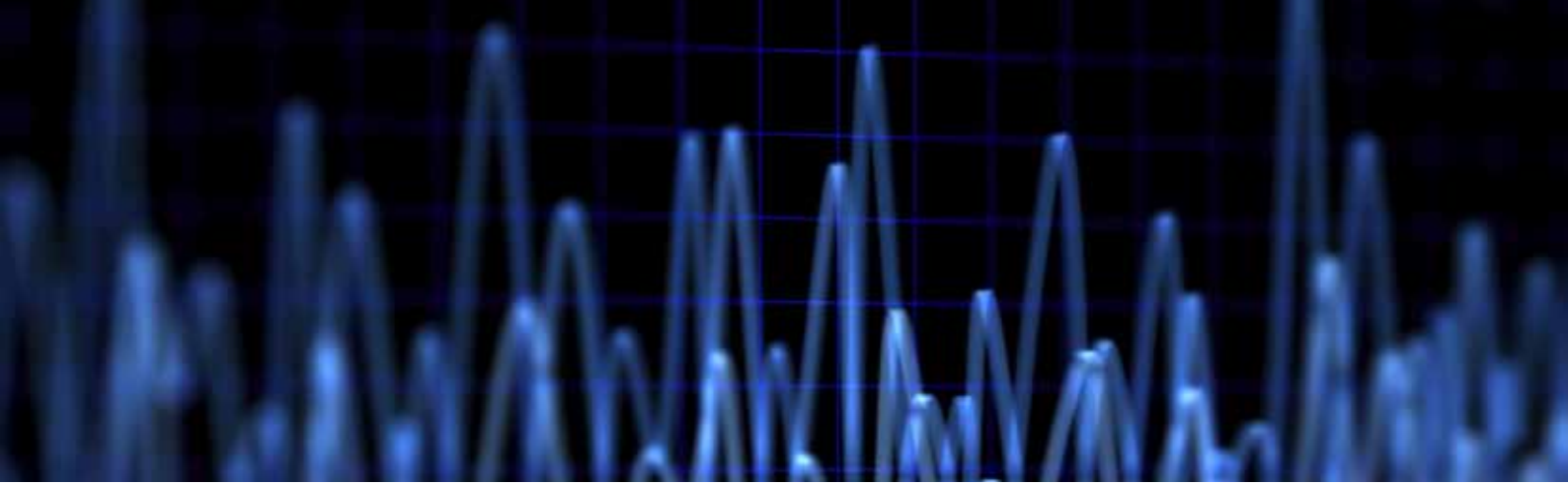


Efficient networks and radio communications via signal processing research

According to research program director Ülo Parts from Digile, the IoT program produced excellent academic publications and contributions. One good example is the signal processing research, which improved the connectivity of IoT devices. Small businesses also benefitted from the research done in the IoT program. Parts highlights two companies: Finwe and 4G Services, which participated in the IoT program.

"From the business side, I would like to highlight the developments in how smaller companies like Finwe and 4G Services have progressed in their business by utilizing the results obtained in the program."

4G Services has created a patented environmental measuring system for allowing companies to monitor and improve their environmental efficiency. The system collects data through third party sensors and mobile devices and gives recommendations for better efficiency.

Finwe has developed a 360° panorama video, which is an immersive video. It records a real world scene, where the view in every direction is recorded simultaneously and stitched together into a single video covering a full 360×180

degree view. High resolution displays, fast processors, built-in sensors, high-speed wireless communications and built-in storage form all the required elements in a compact form that can be easily coupled with a head-mounted display frame. During the Internet of Things program, finding application scenarios for panoramic photos and finding out how they can serve as an information medium was one of the research topics.

According to Parts, there was also significant input from universities when designing more efficient networks and radio communications suitable for IoT technology.

"Research papers by the groups from the Tampere University of Technology and the University of Helsinki are well recognized by the international community. In the study by the University of Helsinki, for example, the implementation of the IoT Hub was significant, as were the algorithms developed by the researchers for recognizing modes of transportation.

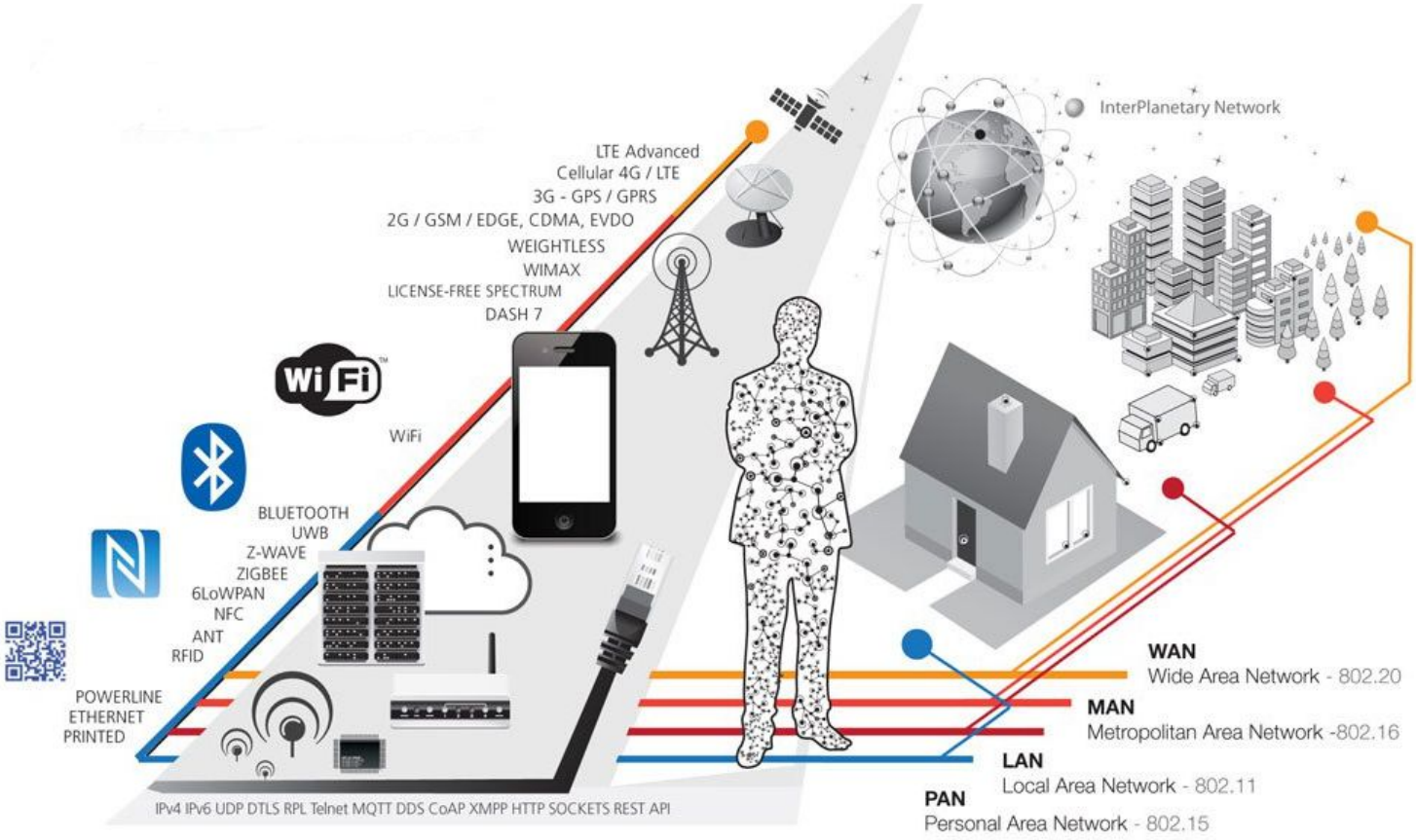
According to Parts, the signal processing and telecommunications research done by the Tampere University of Technology was significant. This work was done partly in collaboration with Intel.

Improving the radio connectivity to IoT services

Radio communications with simultaneous transmission and reception at the same radio frequency (full-duplex) carrier has recently gained considerable interest among researchers. It has the potential to significantly improve the efficiency and flexibility of radio frequency spectrum usage, and can also enable simultaneous spectrum sensing while transmitting. The researchers of the Tampere University of Technology have developed, presented and demonstrated novel state-of-the-art solutions for self-interference cancellation, at both RF/analog stages as well as digital baseband, in lower-cost small form-factor devices with full-duplex capability. This work has been carried out by the Tampere University of Technology in collaboration with the Aalto University and Intel Labs, US.

LTE-assisted WiFi

LTE (Long Term Evolution), or 4G technology, increases data transfer speeds and shortens lags when radio communication to and from a terminal device is implemented in two different ways. Wireless sensors that report on temperature, power consumption or freight transport are increasingly



The IoT world in which we live is full of not only devices and sensors, but also different standards and data transfer protocols. Monitoring all this is challenging and requires good information security. Image: VTT.

used. In the IoT program, the battery life of these devices communicating with each other was significantly improved.

LTE-assisted WiFi Direct augments network capacity and enhances user performance without increased infrastructure cost. The use of WiFi Direct offloads the costly cellular bands and improves reuse, since WiFi has a shorter range than LTE. Because WiFi has a much larger bandwidth than LTE, it also boosts user data rates. LTE assistance automates WiFi Direct device discovery as well as connection establishment. It expands the number of potential WiFi Direct connections by providing secure access to strangers. It reduces battery and channel consumption by performing device proximity detection on the user's behalf. It also provides service continuity to users by enabling a communication path via the LTE infrastructure if/when users move too far apart for successful WiFi

"It is essential to know whether the device and software are appropriate. This solution seeks to confirm that the device in untouched and that it is what it claims to be."

Direct communication. The trial made during the IoT program revealed that LTE-assisted WiFi Direct does, in fact, significantly improve network and user performance. The research was done by the Tampere University of Technology, the Brno University of Technology and Intel Labs.

IoT solutions for the security of the elderly, children and home

In the IoT program, the Technical Research Centre of Finland (VTT) in collaboration with companies and other partners developed different prototypes that improved the quality of life of both the elderly and children, as well as home information security. According to Heikki Ailisto, research professor at VTT these applications have significant commercial potential.

MPY Senior Interface: An assisted living service system for the elderly

In the IoT program, VTT researched and developed IoT services for the elderly in collaboration with MPY. The pilot system supported both general and device-dependent services. Examples of general services used in the pilot study included a video-based discussion session with a nurse using calendar-based booking, making a doctor's appointment by reserving a vacant time in the doctor's calendar, answering the video call and ordering a taxi by selecting the date and time from a calendar. The device-dependent services used in the pilot evaluation were based on devices utilizing ZigBee or Bluetooth technologies, such as a wrist alarm band, motion detector, electronic weighing device and blood pressure measurement device. The services also included contact sensors for indicating whether a door is open or closed, and a power socket metering device.

"The aim was to build IT solutions whose adoption would be as easy as possible for the elderly. Video conferencing systems allow participation in an exercise program and Internet phone calls can be made using an easy interface. Solutions supporting assisted living for the elderly were implemented in collaboration with MPY Palvelut Oy from Mikkeli."

Research done in the IoT program was utilized by MPY in its own operation, which gave birth to the MPY Senior Interface.

http://www.mpy.fi/seniori-kayttoliittyma

Children's wearable sensor vest for improving safety

VTT researchers designed a safety vest for children that tells parents the child's location and the circumstances the child is in. This portable, cloth-like solution is equipped with a wireless charging device, sensors and acceleration sensors.

According to Heikki Ailisto, the vest provides the kind of information parents and teachers might not otherwise detect.

"Acceleration sensors will detect if the child is being pushed, for example. This gives technical means for detecting bullying and intervening with it, while the temperature sensor detects if the child is left out in the cold."

Parents and teachers can monitor a child's day from a mobile phone or an Internet service. They are able to receive alerts and notifications when a child moves across a certain restricted outdoor or indoor area, for example, through gateways that have connectivity to a server or cloud. Piloting and technological implementations are based on a participatory study conducted among children, teachers and parents.

Information security at home

The number of devices connected to the Internet is exploding. There are many unmonitored devices in homes, and some of them are in inconvenient places. Some devices are also so ordinary that their operation does not cause alarm. A strangely behaving coffeemaker or refrigerator will not immediately make one think of a hacker. When devices and software are communicating with each other, it is also difficult to know whether the communication is normal. All this poses great challenges for information security.

In the IoT program, VTT researchers developed a test network with real devices connected to it. The test network was used to confirm that information security was working. The developed solution was created in accordance with international standards.

"It is essential to know whether the device and software are appropriate. This solution seeks to confirm that the device in untouched and that it is what it claims to be."

For now, the remote confirmation of IoT device integrity, or remote attestation utilizing trusted execution environment, is only available to members of the IoT program consortium.

"Acceleration sensors will detect if the child is being pushed, for example. This gives technical means for detecting bullying and intervening with it, while the temperature sensor detects if the child is left out in the cold."

Dani Korpi, Lauri Anttila, and Mikko Valkama: Reference Receiver Based Digital Self-Interference Cancellation in MIMO Full-Duplex Transceivers

http://arxiv.org/pdf/1405.2202.pdf

Dani Korpi, Lauri Anttila, and Mikko Valkama: Impact of Received Signal on Self-interference Channel Estimation and Achievable Rates in In-band Full-duplex Transceivers

http://arxiv.org/pdf/1409.1372.pdf

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