Energy-efficient data collection and transmission

The IoT program focused particularly on the efficient collection and transmission of data by wireless and wired methods. As part of the program, over 150 scientific articles were published that dealt with things such as the technologies and standardization of the current 4G network and the next generation 5G network, the mobility of people and devices and additional control for IoT solutions.

When a huge number of different devices and sensors is simultaneously connected to a network and should be able to communicate with each other, global standards are needed for transfer protocols. According to the IoT program's academic coordinator, Professor Sasu Tarkoma, scientific work in the program has strongly supported standardization in the industry. Thanks to this work, the functionality of 4G networks and wireless networks and the energy-efficiency of devices connected to a network can be significantly improved.

"The program studies IoT solutions that were related to wireless protocols. The key results of the program have been wireless technologies that form a basis for future 5G network standardization."

More than 40 suggested standards for the next generation IoT and 5G network

There are many different standards, and their compatibility is being developed constantly. Researchers who participated in the program have made improvements and suggested fixes for the standards, as the aim is to create compatibility between systems. By the end of the program that started in 2012, around 40 suggestions were made.

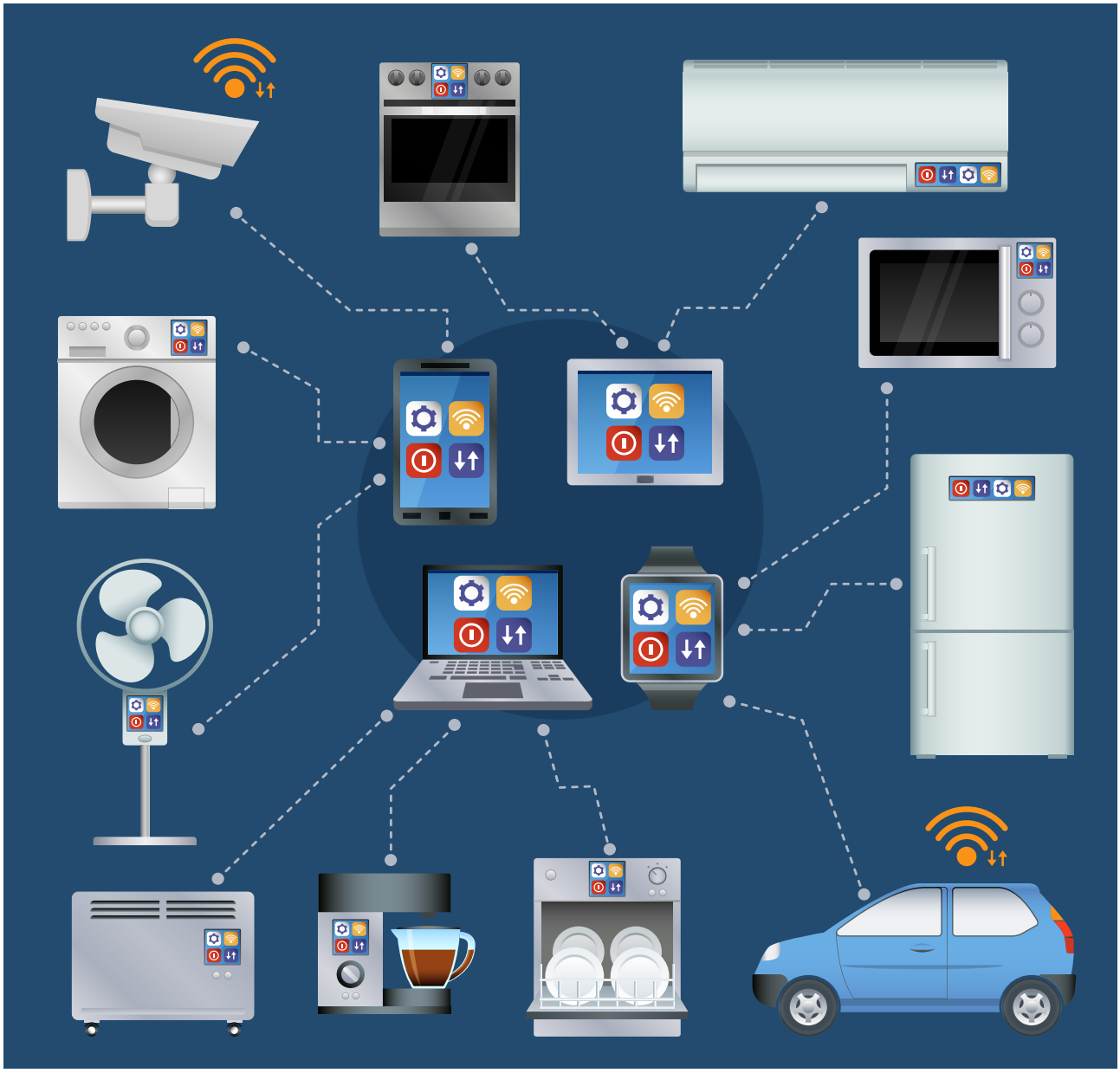
3GPP (3rd Generation Partnership Project) is an organization that defines the wireless networks of the next generations. It has also defined the LTE (Long Term Evolution) standard, which in practice is 4G. M2M (machine-to-machine) means network support for data communication between machines. Typical terminal devices with M2M connections include payment terminals, alarms and vending machines.

"3GPP, M2M and LTE/LTE-A enable data communication between machines in cell networks. This has now become part of 4G, and will become an essential part of 5G, whose standardization is now beginning. 5G has been estimated to be ready for production in 2020. The difference between M2M and traditional mobile data communication (calls, applications) is that the load is usually directed from the device to the network, is periodic and usually requires a quality assurance (Service Level Agreement) for reliability, latency and throughput."

Many companies and universities have participated in the standardization; Ericsson and the Tampere University of Technology, for example, have been active in the 3GPP and IETF network standards. The work of Renesas Mobile concentrated on the wireless IEEE standards, and the work of the University of Helsinki on network standards.

"IEEE 802.11ah is a new WiFi standard that has been developed specifically for IoT devices. Its design has taken into account the operational requirements of the IoT environment; range and energy consumption, for example, have been optimized."

"IETF Constrained Access Protocol (CoAP) is a communications protocol developed for the world of IoT that typically uses connectionless UDP (User Datagram Protocol). Its idea is to optimize the collection of data from sensors, while Homenet makes it possible to easily build a home network without interaction with the user. "



IoT Hub

IoT hub is a middleware platform that provides the necessary mechanisms to interconnect and collect data from smart objects, mobile devices and other hardware composing the IoT. During the IoT program, the University of Helsinki presented the IoT Hub concept and IoT Market architecture, which provide the necessary tools for the creation of strong and innovative ecosystems around innovative applications, services, assets and communities. The architecture suggests the bottom-up formation of IoT ecosystems. The hub includes the ownership of the data to the hub owner, and via a set of tools enables the IoT hub owner to expose only the desired content to third parties.

"The idea of the IoT Hub stemmed from a desire to take apart different technological silos. Silos should be combined and opened for the market, and third parties should get involved."

The software component developed at the University of Helsinki works on a mobile phone or access point, or in a cloud. The software enables a connection to IoT devices.

"The software abstracts devices, enables an inter-

Moprim's algorithms analyze the movement of people and vehicles and are able to tell the mode of transportation used and evaluate driving behavior.

face, uses sensors and devices and enables different applications and services that can be accessed through this software."

A home will have its own Hub, its lights and heating system will be connected to the Hub, and applications can be made for this environment. Devices made by different manufacturers will run in applications built on the IoT Hub.

"The aim is to create an open source ecosystem. Applications will be made using Javascript to make the task as straightforward as possible."

The open source solution developed in the IoT program has been used in industrial lighting applications. A prototype has been made for the Finnish lighting systems supplier Helvar, where the Hub controls the lighting system of the premises, and an application supported by it combines data collected from the premises and web services.

"For example, the lights in a conference room can be dimmed after discovering that the calendar reservation has ended and there is no one in the room. Similarly, lights can be switched on after discovering that the room is being used."

The name of the prototype code is Kahvihub (Coffee Hub). According to Tarkoma, this middleware enables the self-organized creation of IoT ecosystems, so that first small hubs are created, then large ones that are connected to build larger systems.

"This way, applications and services built on the hub will bypass the challenges related to the sharing and utilization of data that we have discovered in the current, more silo-like structures."

Algorithms that recognize movement and the mode of transportation improve the efficiency of traffic

Researchers of the University of Helsinki presented novel accelerometer-based techniques for accurate and fine-grained detection of modes of transportation on smartphones. They created an improved algorithm for estimating the gravity component of accelerometer measurements. Now researchers are able to capture key characteristics of vehicular movement patterns, and a hierarchical decomposition of the detection task. The transportation mode recognition was improved by over 20% compared to current accelerometer-based systems.

Researchers also classified human mobility patterns according to the different modes of transportation, such as Walk/Run, Bike, Train/Subway or Car/Taxi/Bus. The analysis was based on two real-life GPS datasets containing approximately 10 and 20 million GPS samples with information about the mode of transportation. Results show that human mobility can be modelled as a mix of different modes of transportation.

"Algorithms for recognizing mode of transportation and analyzing movement enable next-generation applications that support and improve mobility, such as navigation that adapts to the vehicle, driving style evaluation and optimization of fuel consumption. Current Android and iOS devices are able to recognize walking, running and driving, but are unable to differentiate between urban transportation vehicles. The developed algorithm offers precisely this new feature, and can be run either on a mobile device or as a cloud service."

According to Tarkoma, the algorithm research has quickly aroused a lot of interest in industry and the academia. This interest led to the founding of the Moprim (Motion Primitives) start-up in the winter of 2015. Moprim's application was

"Algorithms for recognizing mode of transportation and analyzing movement enable next-generation applications that support and improve mobility, such as navigation that adapts to the vehicle, driving style evaluation and optimization of fuel consumption."

introduced at the Slush event the same year. Moprim's algorithms analyze the movement of people and vehicles and are able to tell the mode of transportation used and evaluate driving behavior.

"This is a good implementation of a chain from a scientific idea and result to the founding of a commercial company that utilizes it."

The era of the Internet of Things needs new and oblique business models

Internet of Things means that businesses make increasing use of electronic information exchange and interactions. IoT makes business modeling more challenging, but also more valuable. However, the majority of current business models do not take into account the interconnected nature of companies that evolve in the same innovation ecosystem. New business models suitable for future needs were discovered by the researchers of the University of Oulu.

According to professor Petri Ahokangas, the role of the external environment in value creation has been neglected. He emphasizes a new approach, which he calls the "oblique business model". It is a model that builds on the value sharing within co-evolving IoT business ecosystems.

"As the Internet of Things continues to spread further, the implications for business model innovation are tremendous", Ahokangas says

Ahokangas states that business models are never static, and develop continuously through refinement, adaptation, revision and reformulation. In addition to value sharing, the idea of an oblique business model lies in utilizing external resources of third parties outside the company. Such business models are employed by fast-growing and service-oriented companies.

"The sharing economy relies on the idea of two-sided business opportunity where companies make the underutilized resources of third parties accessible to their customers. Therefore, the question is not only about value co-creation and co-capture, but also about value sharing."

With billions of connected devices, IoT promises to enhance decision making and data analysis to a level that has never been achieved before. Advanced transportation me-

dia are increasingly getting more and more instrumented with sensors, actuators, bar codes and other technologies. IoT can also help in assisted driving, mobile ticketing, monitoring environmental parameters and introducing augmented maps. Above all, health care is one major application sector of IoT.

The next big thing in Finland: health care

Finland has a huge aging population that needs proper care. Care for the elderly and assisted living seem to be the most prospective business opportunities for companies to explore. Since Finland will have cuts in the social sector, the health care expenses will rise and using efficient technology is an obvious way to save money. To succeed in business, companies need to be ready with proper services through a connected society in a digital way.

”The health care industry in Finland is growing fast and IoT is surely going to play a role there. The interest lies in finding out how much IoT will foster the speed of growth in this sector.”

One innovative product that claims to track the emotional health of a person and suggest activities as remedies is MoodMetric (www.moodmetric.com). It offers a wearable ring which is not only a health wearable but can also become an undetachable part of one’s daily style. It senses vital readings from the user’s skin and uses the data in interpreting emotional status. MoodMetric is using the storage and computational capacity of individual mobile devices, but the company is already developing an Internet-based infrastructure to adapt to a wide customer base.

Companies such as MyData are also good examples of an oblique business model, which will most likely collect data from multiple platforms and sources in order to ac-

“The health care industry in Finland is growing fast and IoT is surely going to play a role there. The interest lies in finding out how much IoT will foster the speed of growth in this sector.”

Many start-ups are now designing health-related solutions. Patients can allow hospitals, clinics, therapists or doctors to retrieve relevant data from their repository.

cumulate individual details. MyData is defined as personal health care data over which the individual has legal and practical control. Individual users can control the access of other parties to that data. Patients can allow only specific hospitals, clinics, therapists or doctors to retrieve relevant data from their repository. IoT interventions can easily enhance the way of personal data collection and dissemination in this scope.

”Many start-ups are now designing health-related solutions and waiting for medical acceptance for their services. Online digital services like MyData will gain more visibility and acceptance in society in the short-term future. Finding sustainable funding solutions will be one of the major operations besides innovation.”

Since product lifetime has already shortened, companies will start designing innovative services based on pricing for different services. Many new pricing models will appear for testing in this short-term period. The focus of care providing will start shifting from hospitals/clinics to other places.

Ahokangas predicts that the evolution of hospitals in Finland will be faster in the future, and especially in private hospital organizations.

”Hospitals in Finland have their own digital services, but having all of them under one comprehensive umbrella will be a challenge.”

According to Ahokangas, Finnish companies need to work on better user experience and usability of services.

”Because of its small population, Finland will need the industry to be export-oriented and operate globally.”

Fifteen vital business model components

· Partners / Actors / Suppliers / Value Network
· Value proposition/ Offering
· Customers / Customer Relationships
· Processes/ Activities/ Value chain
· Revenue
· Differentiation / Cost Leadership/ Pricing
· Resources / Assets
· Financial aspects
· Cost
· Value creation
· Competitors /Competitive environment
· Profit
· Competencies/ Capabilities
· Infrastructure/ Infrastructure management
· Technology

This list suggests that value network, value proposition and customers have been the most important themes in the discussion to define business model. It also demonstrates that financial aspects such as revenue, cost and profit are essential to the concept and cannot be overlooked while thinking about sustainability in the longer term. The components of a business model together make the overall model structure a compelling set up to conceptualize how the business in done, how revenue is generated, how profit is maximized, how sustainability is ensured and how the company/ industry is transformed. In order for a business model to perform better, all the components should be organized in a complementing way that supports the others.

Test ecosystem created in Digile's IoT-program

For the research, a case network was chosen with the support of the extended network actors of the DIGILE Internet of Things program. Researchers collected relevant qualitative data through structured interviews within the start-up scene in Finland, Finnish health tech, health care research and network service providers. All of the interviewees are in leading roles in their organizations and have deep understanding of the industry from their perspective as stakeholders. Individuals who were interviewed include the CEO of MoodMetric, the MD of Salwe, which is a health and wellness research organization coordinating pre-commercial research within industry and academia, the innovation and business architect at Ericsson Finland's new business development R&D team and the MD of the Finnish Health Tech Association (FiHTA). The interview framework was structured with a qualitative stance to understand the future business models in the IoT-enabled health care sector from the perspective of experienced campaigners in the industry in Finland.

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