**Aalto University
School of Electrical
Engineering**

**Department of Communications
and Networking (Comnet)**

# Sustainable IoT

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Department of Communications and Networking

The Department of Communications and Networking (Comnet), is the largest unit in Finland in its research area.

World-class research in shaping the internet technology is conducted here. At the forefront are topics related to energy-efficient ICT.
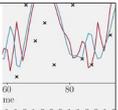
Mobile Communications and Networking

Network Security and Trust
Professor Raimo Kantola

Internet technologies
Professor Jukka Manner

Performance Analysis
Dr. Samuli Aalto
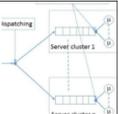
Cybersecurity
Professor Jarno Limnéll

Mobile Nerwork Softwarization & Service Customization
Professor Tarik Taleb

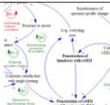## Wireless Communication, Information and Communications Theory

Information Theory
Professor Patric Östergård

Communications Theory
Professor Olav Tirkkonen
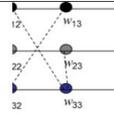
Communications Engineering
Professor Riku Jäntti, Head of Department

Wireless & Mobile Communications
Professor Jyri Hämäläinen, Dean

https://www.aalto.fi/en/department-of-communications-and-networking

Wearable Computing & Ambient Intelligence

Mobile Cloud Computing
Professor Yu Xiao

Ambient Intelligence
Professor Stephan Sigg

Communications Ecosystem

Network Economics
Professor Heikki Hämmäinen

Human Computer Interaction
Professor Antti Oulasvirta

Sustainable IoT

- Internet of things IoT / everything IoE has an important role in addressing societal challenges both in industrialized and developing countries.

IoT challenges

While being useful for addressing the societal challenges, IoT also brings new problems

- Increased e-waste and hazardous problem waste
- Privacy risk

There are also economical and operation challenges related to

- Device cost
- Battery life-time of the devices and the cost associated with changing batteries

E-Waste and disposable IoT devices

- The United Nations found that people generated 44.7 million metric tons of e-waste globally in 2016, and expects that to grow to 52.2 million metric tons by 2021.

- Semiconductors are being added to products that previously had none - making them e-waste when they reach the end of their life cycle. Adding intelligence in the devices also shorten their lifetime turning products that might last 15 years into ones that must be replaced every five years which makes the problem worse.

- There is also alarming number of small connected devices such as trackers, jewelry, or wearables that are designed to fail once the battery dies.
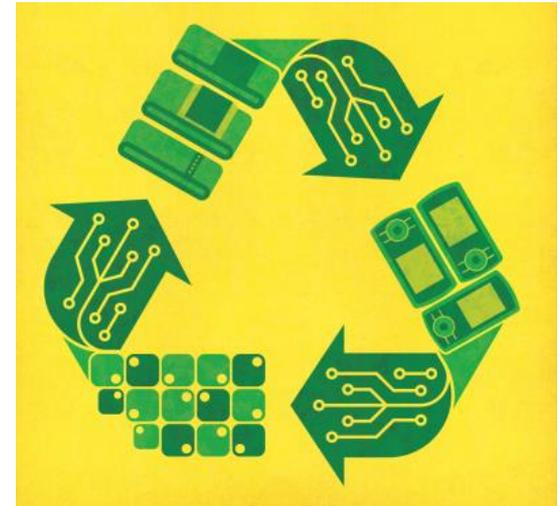
S. Higginbotham, "The internet of trash [Internet of Everything]," in *IEEE Spectrum*, vol. 55, no. 6, pp. 17-17, June 2018, doi: 10.1109/MSPEC.2018.8362218.

Example of a product that is designed to fail as the battery runs out: The smart basketball.

Privacy and Security

- The various IoT sensor systems collect unnecessary detailed information on our daily lives putting our privacy at risk

- The security of IoT systems is a 'nightmare'. Development of quantum computing is likely to make the situation even worse.

- Even if the devices can be trusted and the communication is secure, malicious party can still obtain information infringing our privacy merely by observing the traffic among the numerous IoT devices.

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Operation time

Operation time is very situational. In harsh conditions it is still a problem.

Example:
Battery life of
a NB-IoT modem

Battery life – PA efficiency impact

- 45.820 model
- Battery capacity: 5Wh

Mode	Power Consumption @ 23dBm with PA efficiency		
	40%	45%	50%
transmitting current drawn	589mW	533mW	489mW
receiving current drawn	90mW	90mW	90mW
idle current	2.4mW	2.4mW	2.4mW
power save current	15µW	15µW	15µW

	Battery life (years)								
PA efficiency	40%			45%			50%		
Packet size, reporting interval	MCL 144 dB	MCL 154 dB	MCL 164 dB	MCL 144 dB	MCL 154 dB	MCL 164 dB	MCL 144 dB	MCL 154 dB	MCL 164 dB
50 bytes, 2 hours	18,9	10,1	2,3	19,2	10,5	2,4	19,4	10,9	2,6
200 bytes, 2 hours	17,4	5,1	1,1	17,7	5,5	1,2	18,0	5,8	1,3
50 bytes, 1 day	35,1	30,9	16,5	35,2	31,2	17,2	35,2	31,5	17,8
200 bytes, 1 day	34,6	24,8	10,2	34,7	25,5	10,9	34,8	26,1	11,5

10 year battery life met for all scenarios with daily transaction

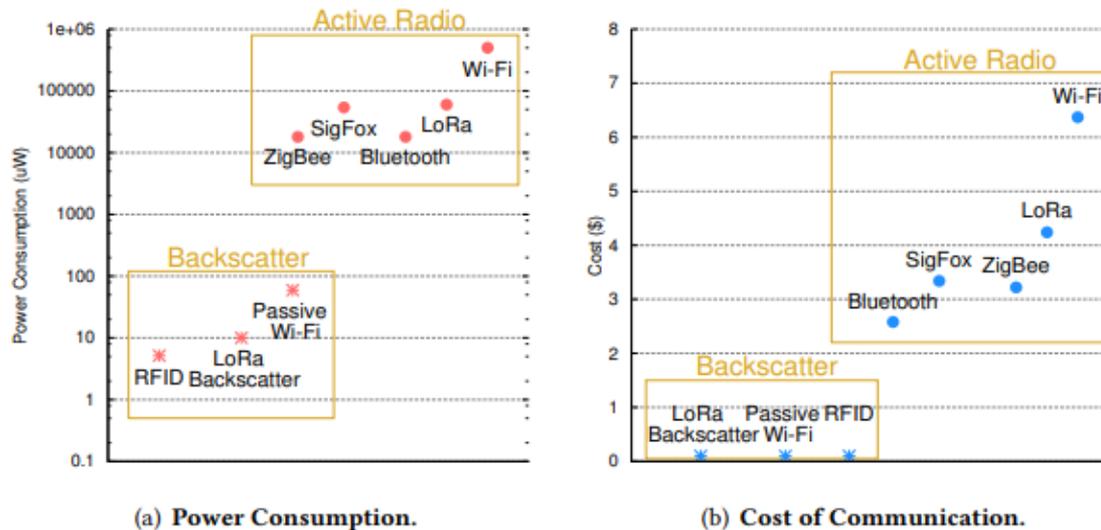51   © Nokia 2016   **NOKIA**

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Power consumption and cost

The more complicated the radio modem is the more costly it is and the more it consumes power.

(a) **Power Consumption.**

(b) **Cost of Communication.**

We compare power consumption and cost of different communication technologies including backscatter and radio techniques.

Talla, V., Hessar, M., Kellogg, B., Najafi, A., Smith, J.R. and Gollakota, S., 2017. Lora backscatter: Enabling the vision of ubiquitous connectivity. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *1*(3), pp.1-24.

How to address these challenges?

E-waste

- Use additive manufacturing methods to minimize material waste
- Use biodegradable substrates and organic components

Device power consumption and cost

- Move as many functions from the device to the infrastructure side as possible.
- Use narrowband and low-carrier frequency technology that has higher manufacturing tolerances

Security and privacy

- Use covert communications to hide the traffic from malicious third parties.