

Leibniz Institute for high performance microelectronics



Sustainable Design of Online Biosensors

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The Body of Humans

Everybody

has a heard, a chest, lungs, a liver,

arms ...



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... and everybody has a smartphone







ICT Will Enter the Body: Wearables and Implants

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VTT

online biosensors playing a crucial role.

The Medical Internet of Things (medloT)



Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions)



medIoT

Health-related IoT devices stand for ca. 19% *(red bars) of the total Internetof-things (blue).

*N. TaheriNejad et al. https://link.springer.com/ article/10.1007/s11036-022-01959-x

Sustainability of is this trend?



How sustainable is this development?





Compare to Energy Consumptions of Smartphones



CE Delft 2021

Network traffic and data storage of 546 million smartphones in Europe consumed 189 TWh in 2020.

(10-17% were due to advertising and tracking by > 1700 apps)

https://cedelft.eu/publications/carbon-footprint-of-

unwanted-data-use-by-smartphones-an-analysis-for-the-eu/

Solar power

Electricity generated by photovoltaics in Europe amounted to 170 TWh in 2020 – an rather comparable amount.

https://ourworldindata.org/energy

Large amounts of renewable energy into mobiles and IoT?



Carbon footprint of unwanted data-use by smartphones

An analysis for the EU



This report was prepared by: Meis Uijttewaal, Geert Bergsma, Thijs Scholten

Delft, CE Delft, July 2021

Wireless connectivity of Wearables: Bluetooth Low Energy







(<u>https://www.bluetooth.com/specifications/</u>) → Bluetooth Low Energy (BLE) is a *de facto* standard for wireless connectivity in smartphones, tablets and wearables. The routes go back to Nokia times and the first inventions/specifications were done in Oulu/Finland at the Centre of Wireless Communication (CWC) (<u>https://www.oulu.fi/en/university/faculties-and-units/faculty-information-</u> technology-and-electrical-engineering/cwc-networks-and-systems) Highlights:

- Dedicated RF channels: 3 channels for advertisement & 37 data transmission channels
- Range: 30 to 50 meters, 100 meter max. depending on antenna design
- Maximal Packet Size: 27 bytes
- Data Rate: 305 Kbps
- Peak power consumption: <15 mA
 - Ultra-low-power mode: $11 \,\mu$ W (sleep mode) and 0.3 mW during BLE transmission
- BLE in advertisement:

Allows transmission of secure data packages up to 256 devices to 1 receiver







Spying People on the Web

_carbolytics,

an analysis of the carbon costs of online tracking.

Authored by Fernando Cucchietti, Joana Moll, Marta Esteban, Patricio Reyes, Carlos García Calatrava.

The investigation identified more than 21 million cookies per single visit to all these websites, belonging to more than 1200 different companies, which translates to an average of 197 trillion cookies per month, resulting in 11,442 monthly metric tonnes of CO2 emissions.

https://carbolytics.org/report.html

In conflict with SDG 12: Responsible consumption and production

Number of cookies in the top 1Millon websites

Top organizations per number of cookies





GDPR on Privacy of Health Data

became effective in May 2018 and is very strict on health data:

Art. 9

"1. Processing ... of genetic data, biometric data for the purpose of uniquely identifying a natural person, data concerning health ...
shall be prohibited."
2. Exceptions



General Data Protection Regulation



You may check your own data Stored by any dataprocessing company and may order to delete them (Art. 15), use an algorithm for that via www.datarequests.org or

www.datenanfragen.de

In conflict with **SDG 16 and 17**: accountable institutions and partnership.

Brain-Computer Interfaces (BCIs)

go back to the grandfathers of bioelectronics like Peter Fromherz at about 1990

12 The Neuron-semiconductor Interface



Fig. 12.1 Cartoon of brain-computer interfacing. (a) Communication through the macroscopic optical and mechanical pathways screen-eye and finger-keyboard. (b) Hypothetical microscopic interfacing of a computer with the visual and motor cortex [1].

Figure: *The neuron-semiconductor interface*, in Willner/Katz: Bioelectronics (2005) chapter 12.

Modern Developments at various labs and companies, among them Neuralink, founded and owned by E. Musk, who "... envisions both disabled and healthy individuals swiftly getting surgical implants at local centers. These devices aim to cure a range of conditions from obesity, autism, depression and schizophrenia, to enabling web browsing and telepathy."





https://mastodon.social/@JLBe/110435697246089195

Best Practice for Software: The DRIP App

drip.

The menstrual cycle tracking app that makes period and fertility tracking more secure and more transparent.

Your data, your choice Everything you enter stays on your device

Your body is not a black box

drip is transparent in its calculations and encourages you to think for yourself. II Drillisch 穼 15:03 drip. Jun 7th 2023 8th day of your cycle 2nd cycle phase - fertile* Your next period is likely to start in 18 to 20 days. ADD DATA FOR TODAY We were not able to detect both a

 We were not able to detect both a temperature shift and cervical mucus or cervix shift.



DRIP

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Data remain locally stored on the user's device, see <u>https://drip.org</u>

Free-and-open source software https://gitlab.com/bloodyhealth/drip

Further info https://mastodon.social/@JLBe/ 110673579207395047

Conclusions



Microelectronics will increasingly become integrated into humans, with wearables representing a preliminary stage for body electronification laying the foundations for implantable devices.

- **Biosensors** are an essential part of the dawning medical Internet-of-Things med IoT and will contribute to the continuously increasing energy consumption of the ICT sector (in conflict with UN SDG 7 and 13).
- **Wireless** data transmission of devices should be designed as little energy-consuming as possible, for instance by using the Bluetooth Low Energy standard.
- **Energy consumption** of mobile devices today is mainly due to network traffic and data storage in data centres (personality profiles) of personality-spying apps like Instagram, Facebook, YouTube, TikTok, LinkedIn, WhatsApp ... (in conflict with UN SDG 12, 16, 17).
- **IT architecture** of biosensors and medIoT devices should make use of Free-and-Open-Source (FOSS) software and the principle of local data storage to prevent misuse of sensible personal data (SDG 3: Good health and wellbeing).



Thank you for your attention

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Slides of presentation available via <u>https://www.tu.berlin/en/go21248/</u> \rightarrow publications

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