Mobile Computing

COMP5216

Week 8

Semester 2, 2020

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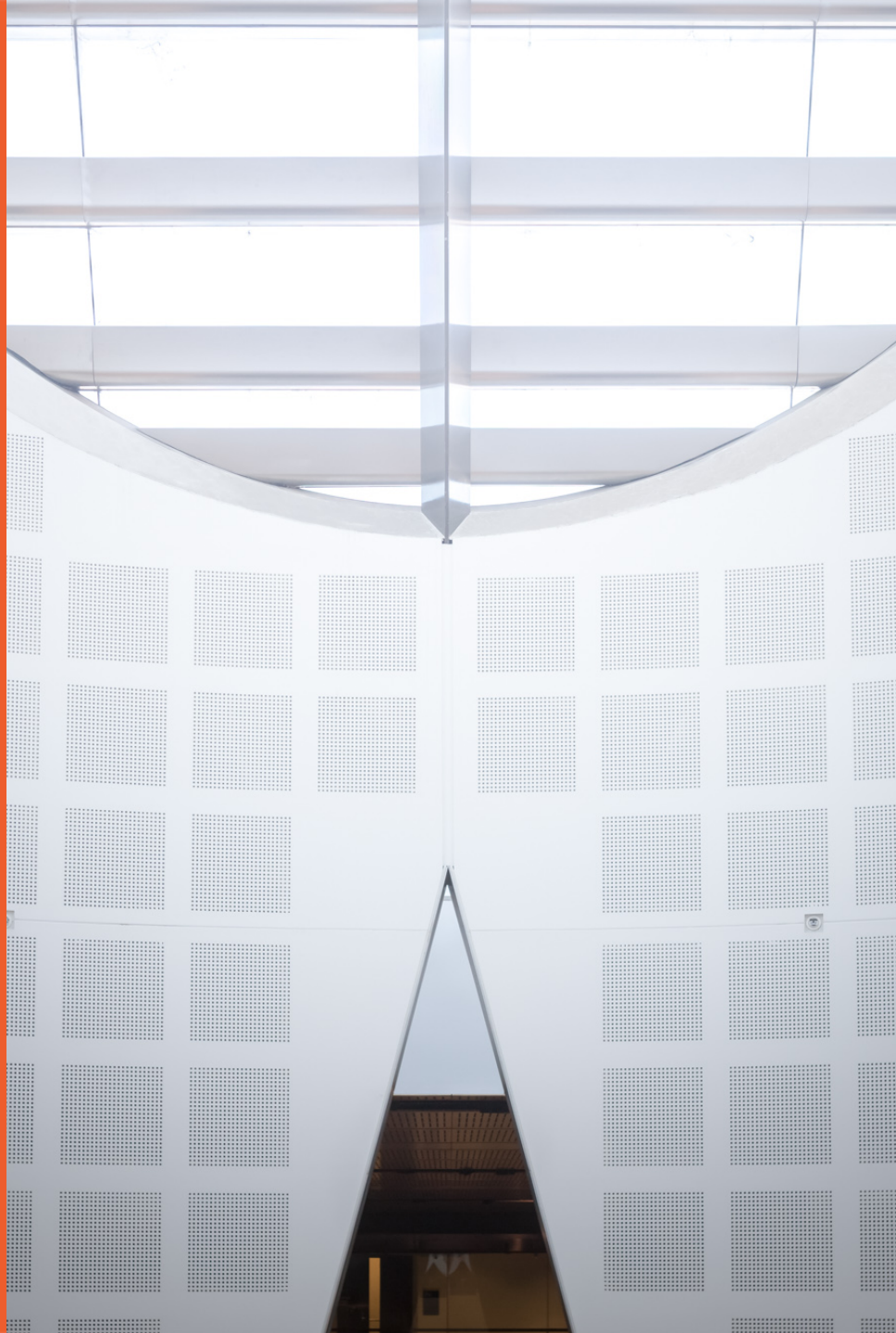
THE UNIVERSITY OF SYDNEY



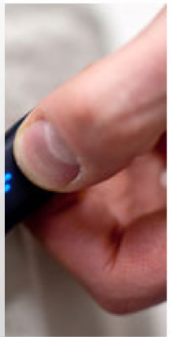
Outline

- From mobiles to Internet of Things
- Components of IoT
  - Things
  - Networks
  - Platforms
  - Apps
- Application Domains of IoT
- Challenges in IoT deployment
- Wearables
  - Connectivity, Challenges and Future
- Android Support for IoT

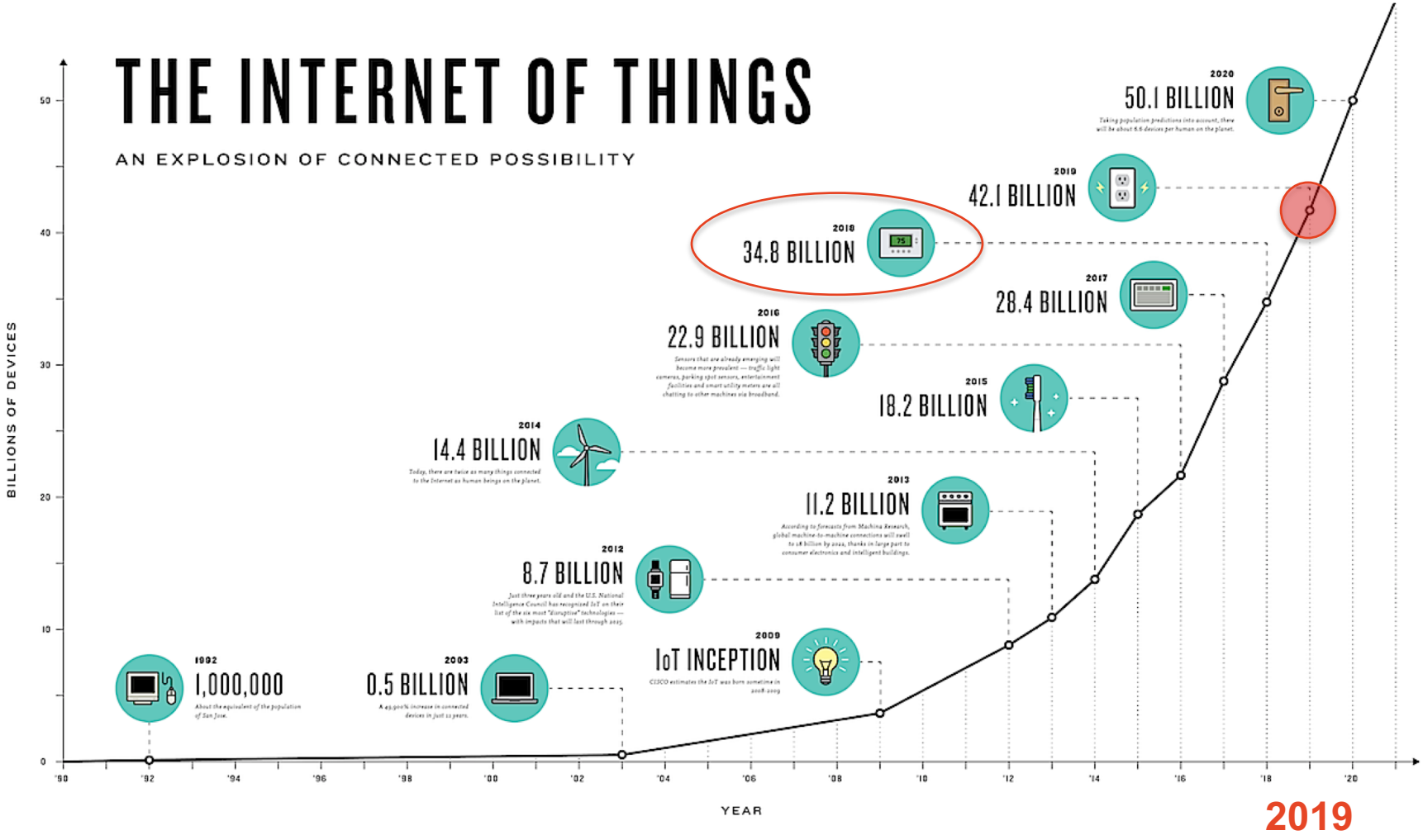
What is a mobile device ?

- Wikipedia
  - "A mobile device (or **handheld** **computer**) is a computing device small enough to hold and operate in the hand."
- Techopedia
  - "A mobile device is a handheld tablet or other device that is made for **portability**, and is therefore both compact and **lightweight**."
- Cambridge Dictionary
  - "**Any piece of** **electronic equipment** such as a mobile phone or small computer that you can use in different places."

It is not just a mobile phone…



An explosion of connected devices



Everything is inter-connected → Internet of Things

Instrumenting Environment

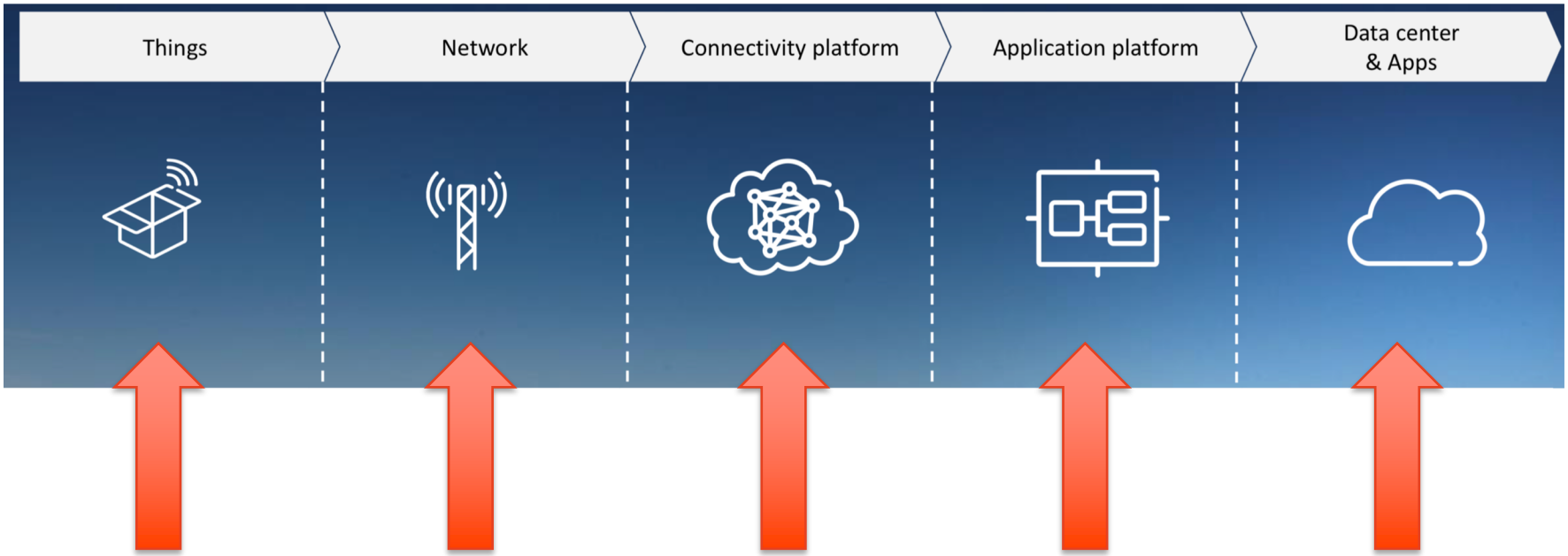
Instrumenting Human

Internet of Things

- **Wikipedia:** "Network of physical objects, devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data."

- **Gartner:** "Network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment."

IoT Architecture



"Things" that **measure** the surroundings

Connect "Things" to platforms

Managing connectivity for "Things"

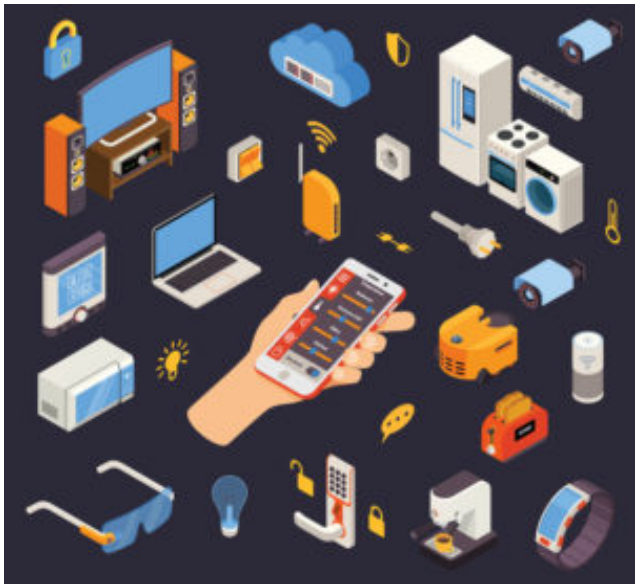
Platform for apps utilizing "Things" data

Apps utilizing "Things" data

Components of IoT

1. Things

- IoT Devices



- Device heterogeneity
  - High-end devices (laptops, smartphones, tablets)
  - Low-end devices (sensors, actuators)
  - Passive devices (barcode, QR code, RFID)

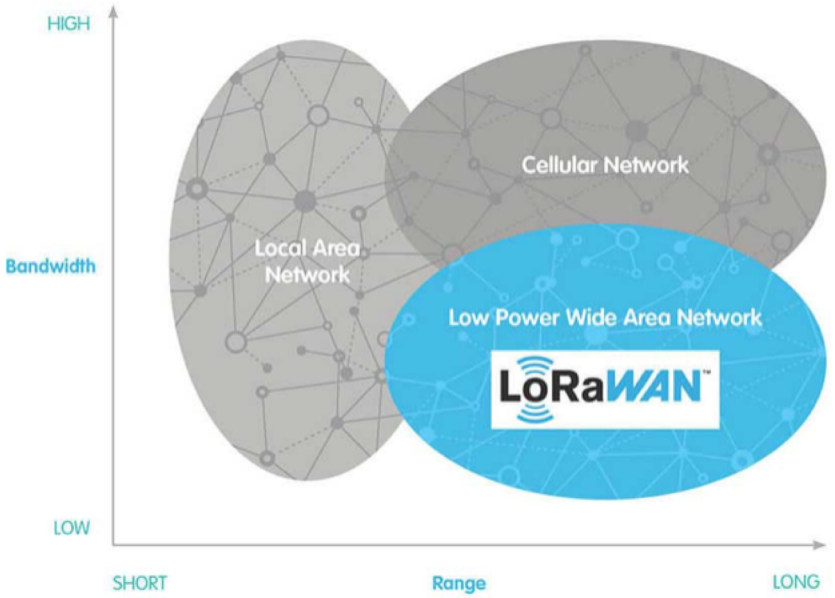
- What are the unique characteristics of IoT devices?

Components of IoT

2. Networks

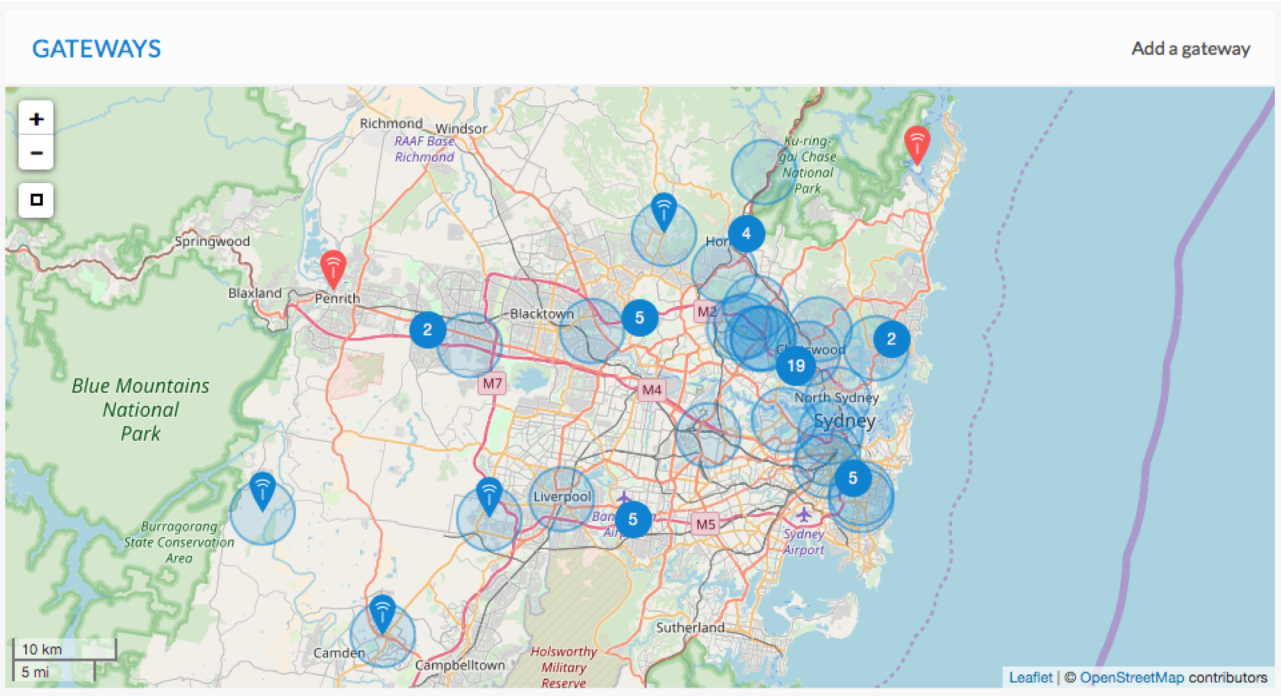
- Traditional networks – WiFi, Cellular, Ethernet
- Bluetooth, Zigbee, ANT connecting most sensors
- IoT specific networks – Narrow Band (NB) IoT, LoRa, SigFox

- **Low Power Wide Area Networks** (LPWANs)
  - Battery powered devices with a long life of several years
  - Frequency: ISM Band
    - Australia 868-915MHz
  - Current LPWAN solutions
    - **SIGFOX** - http://www.sigfox.com
    - **Ingenu** - http://www.ingenu.com
    - **LoRa** - https://www.lora-alliance.org



Components of IoT

- Many companies let you to connect your own gateway or LoRa client device for free.
  - Tutorial on building your own LoRa Gateway or devices
  - https://www.cooking-hacks.com/documentation/tutorials/extreme-range-lora-sx1272-module-shield-arduino-raspberry-pi-intel-galileo.html



https://www.thethingsnetwork.org/community/sydney/

Components of IoT

3. Platforms

- Connectivity Platforms
- Application Development Platforms

- Connectivity Platforms
  - SigFox Platforms
    - https://partners.sigfox.com/companies/platform-provider
  - Sense-T
    - http://www.sense-t.org.au
  - Open IoT
    - http://www.openiot.eu
  - FogFlow – IoT Edge computing platform
    - https://fogflow.readthedocs.io/en/latest/

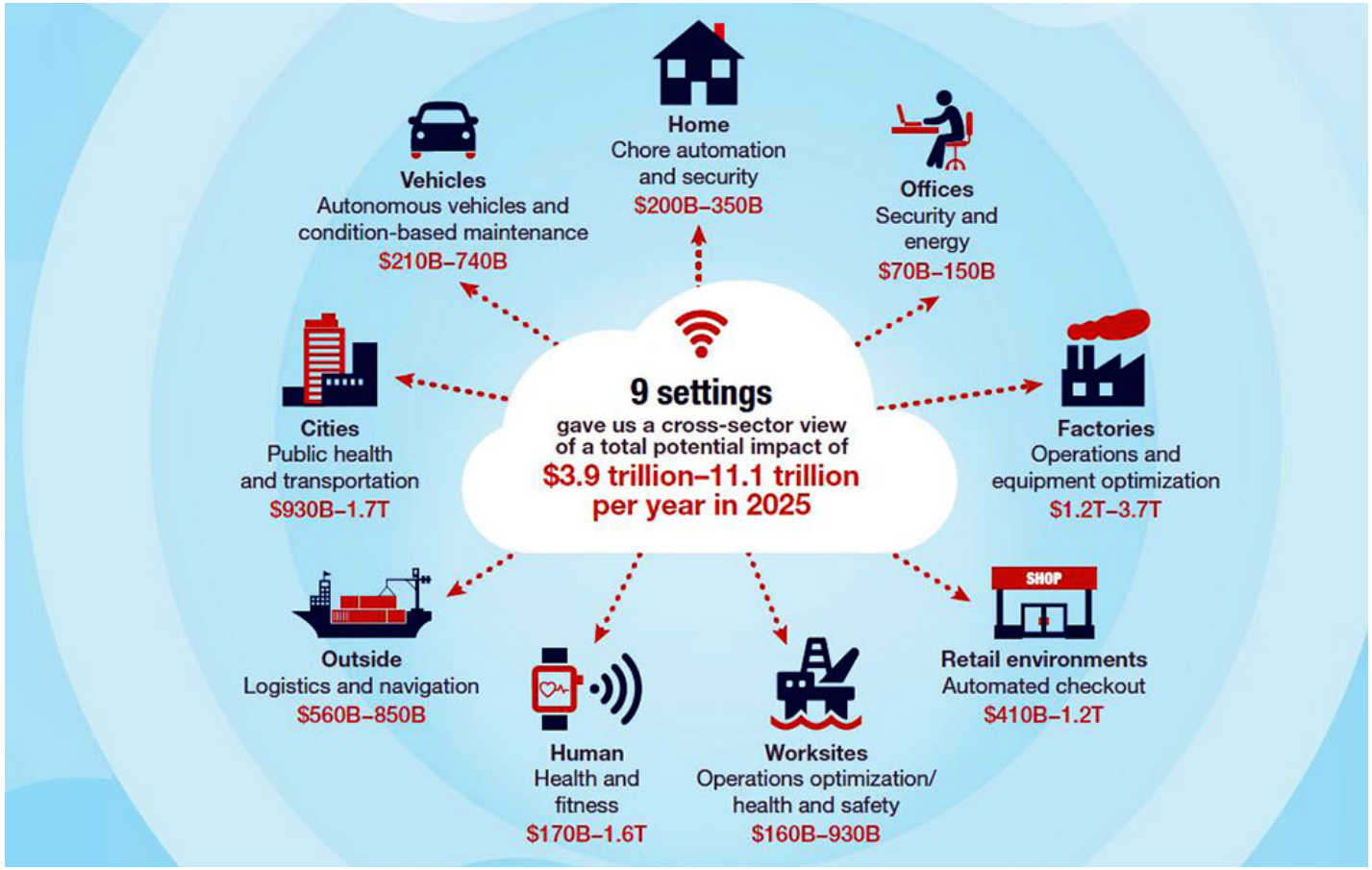
Components of IoT

- Application development platforms
  - AWS IoT
    - https://aws.amazon.com/iot/
  - Microsoft IoT
    - https://azure.microsoft.com/en-au/features/iot-accelerators/
  - Google IoT Core
    - https://cloud.google.com/iot-core/
  - IBM Watson
    - https://www.ibm.com/au-en/marketplace/internet-of-things-cloud

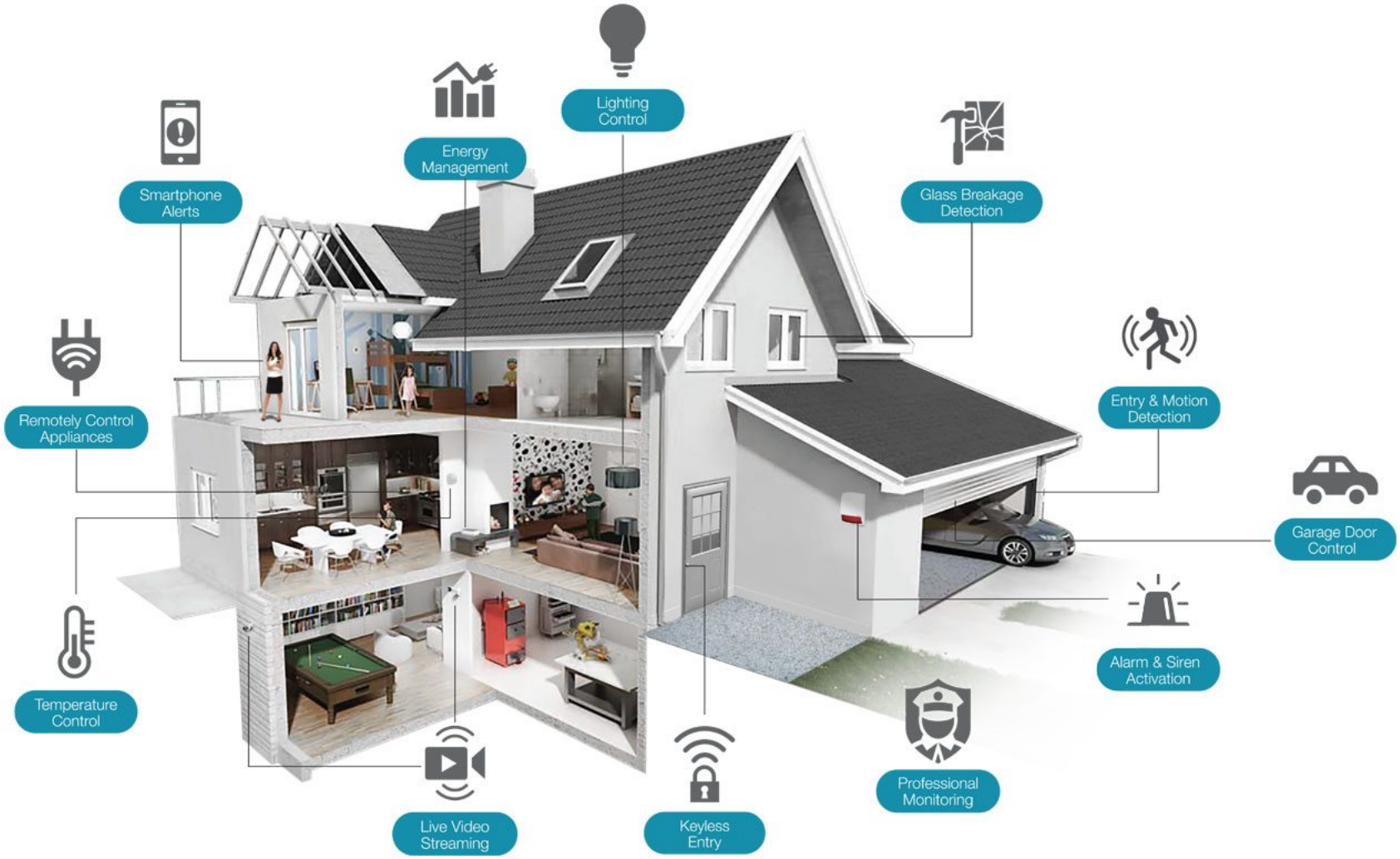
Components of IoT

4. Applications

- Transforming every sector

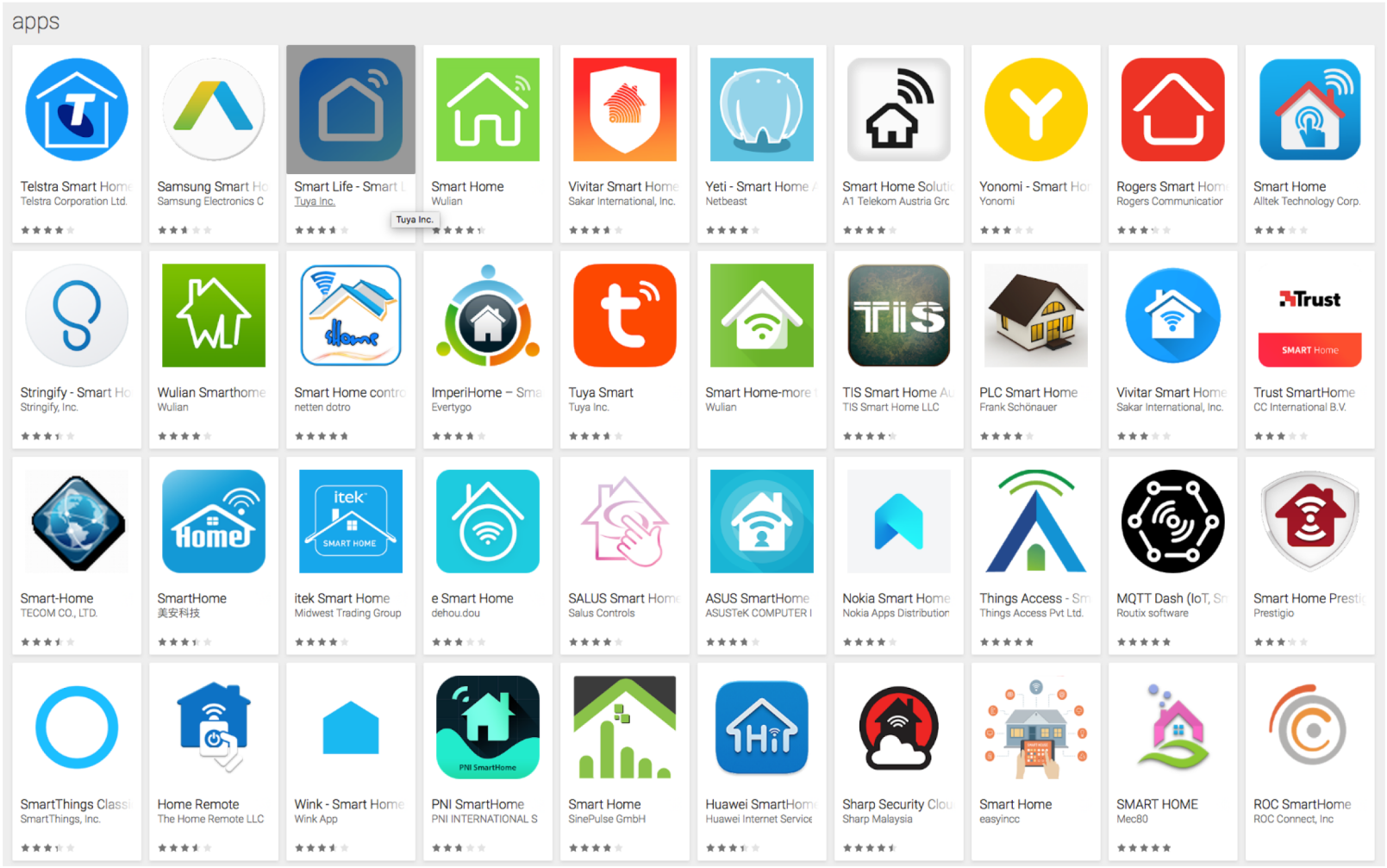


Smart Home



https://smarthomeworks.com.au/2018/03/05/smart-home-security-for-beginners/

Smart home app development



Smart home app development

- Samsung Smart Home Cloud API
  - https://developer.samsung.com/smart-home
- Amazon Alex Smart Home
  - https://developer.amazon.com/docs/smarthome/understand-the-smart-home-skill-api.html
- Google Smart Home APIs
  - https://developers.google.com/actions/smarthome/
- Apple Home Kit
  - https://developer.apple.com/homekit/

Health Care

- Different from Fitness category of apps
- Mobile Medical App Oversight
  - In the USA, **Food and Drug Administration (FDA)** approval is required for;
    - An extension of one or more medical devices which controls the device or monitors patient or analyzes medical device data
    - Transform the mobile platform into a regulated medical device by using attachments
    - Performing patient-specific analysis and providing patient-specific diagnosis, or treatment recommendations.
    - https://www.fda.gov/downloads/MedicalDevices/.../UCM263366.pdf

Health Care

- Mobile Medical App Oversight
  - In Australia, **Therapeutic Goods Administration (TGA)** approval is required for;
    - A software product is considered to be a medical device if it fits the definition of a medical device in section 41BD of the *Therapeutic Goods Act 1989*

A ***medical device*** is:
a. any instrument, apparatus, appliance, material or other article (whether used alone or in combination, and including the software necessary for its proper application) intended, by the person under whose name it is or is to be supplied, to be used for human beings for the purpose of one or more of the following:
- diagnosis, prevention, monitoring, treatment or alleviation of disease;
- diagnosis, monitoring, treatment, alleviation of or compensation for an injury or disability;
- investigation, replacement or modification of the anatomy or of a physiological process;
- control of conception;

and that does not achieve its principal intended action in or on the human body by pharmacological, immunological or metabolic means, but that may be assisted in its function by such means.

- https://www.tga.gov.au/regulation-medical-software-and-mobile-medical-apps

  - Examples:
    - Smartphone apps that calculate insulin doses based on a patient's blood glucose levels
    - X-ray image-processing software

Health Care

- Digital Glucose Fingerstick monitors
  - Accu-Chek Aviva Connect, iHealth, Beyer Contour Next One, One Touch Reveal
  - Plug into phone with adapter or Bluetooth
  - Progressive tracking
  - Alerts with GPS locator

- Smart Thermometers
  - Wired (*Kenza*) or Bluetooth (*Withings*)
  - Apps let you track symptoms
  - Define multiple users
  - $15 - $100

Health Care

Pulse Oximeter (iHealth)

Ultrasound (Phillips)

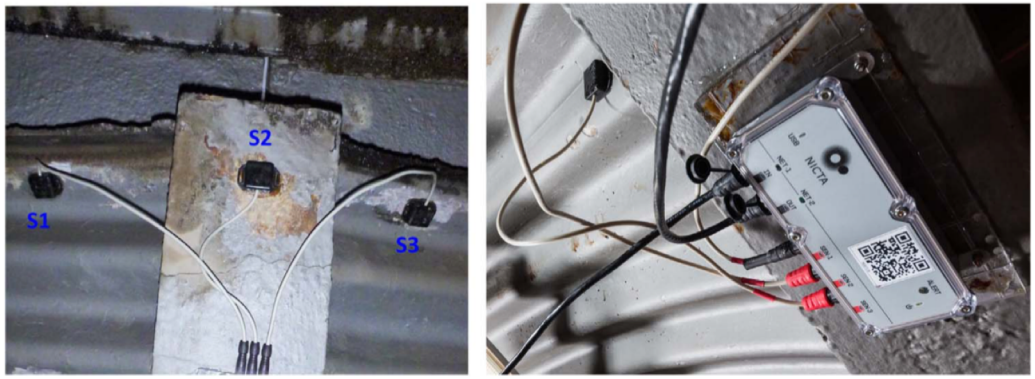
Stethoscope (Eko)

Health Care – Development Support

- Apple Health Kit
  - https://developer.apple.com/healthkit/
- Samsung Health
  - https://developer.samsung.com/health
- Google Fit
  - https://developers.google.com/fit/

Smart City

- Structural Health Monitoring
  - Deteriorating structures
  - Lessons from catastrophic bridge collapses
  - Limits in visual inspection
  - Reducing inspection cost, while
  - Providing increased public safety
  - Lifetime monitoring of future construction projects



(a) (b)

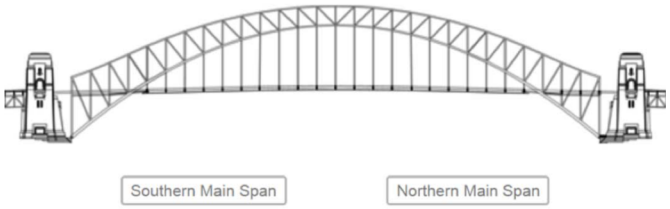
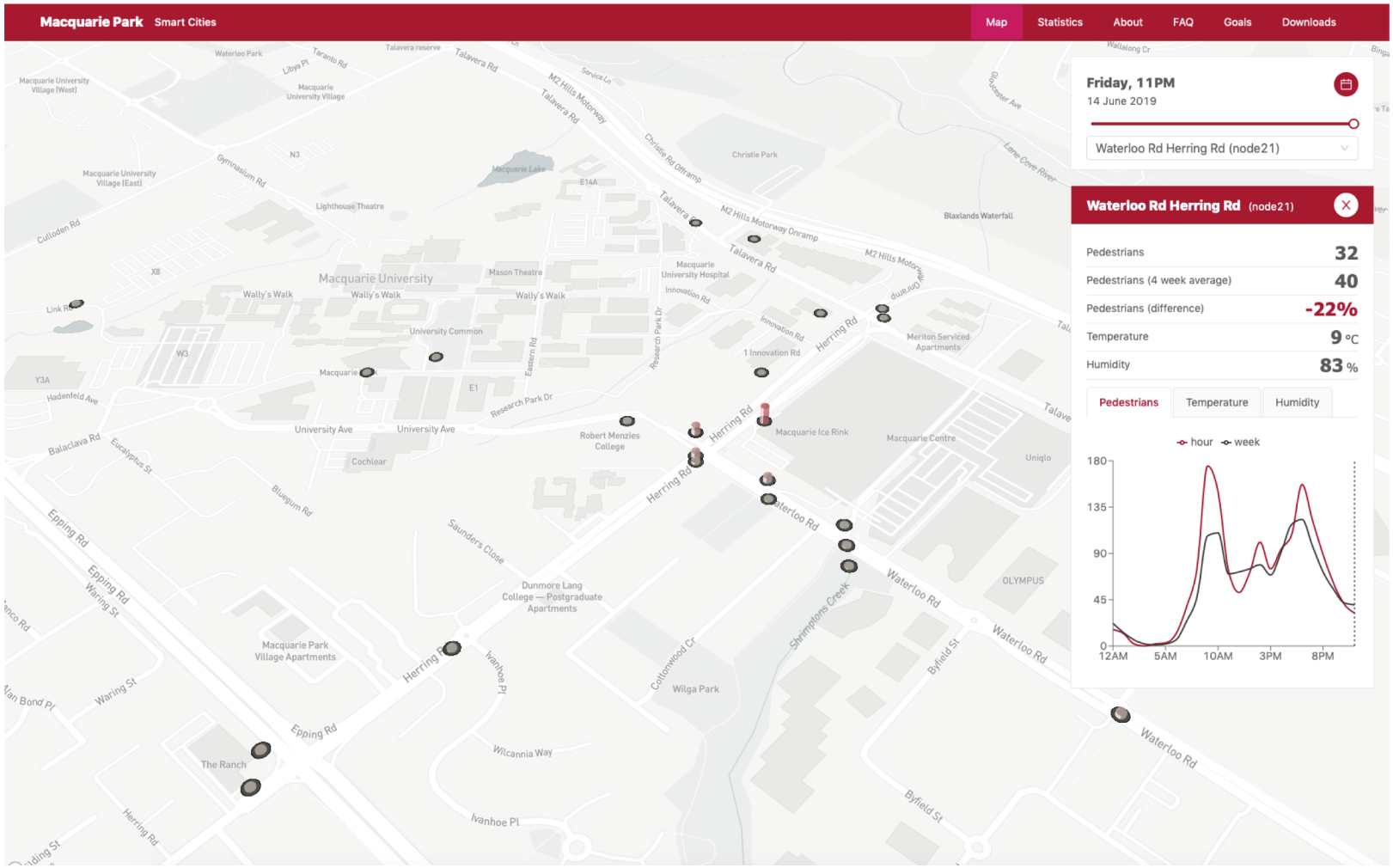


Fig. 2. Illustration of (a) the 3 tri-axial accelerometers glued underneath an individual jack arch; (b) a Data61 collection/processing node.

Alamdari, Mehrisadat Makki, Thierry Rakotoarivelo, and Nguyen Lu Dang Khoa. "A spectral-based clustering for structural health monitoring of the Sydney Harbour Bridge." *Mechanical Systems and Signal Processing* 87 (2017): 384-400.

Smart City



http://smartcity-api.science.mq.edu.au

Precision Agriculture

- Precision agriculture technologies
  - yield monitoring, mapping
  - variable rate fertilizing
  - weed mapping
  - guidance systems

Oyster bio-sensors are able to be deployed in commercial farms to provide farmers with real-time data on stock conditions.

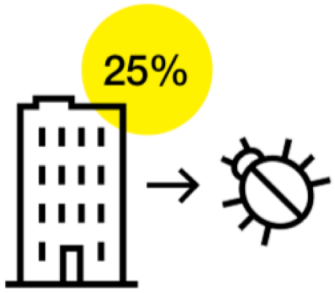
Bee with a backpack... of the sensor variety.

https://www.csiro.au/en/Research/BF/Areas/Protecting-Australias-agricultural-industries/Robot-technology

Challenges in IoT deployment

- Networking, scalability, inter-operability, energy, data filtering (too much data), user acceptance, etc.

- As mobile app developers; we should take extreme care for "Privacy and Security" of the user of the device.
- Gartner reports;



By 2020, more than 25% of identified attacks in enterprises will involve the IoT, although the IoT will account for less than 10% of IT security budgets.

The Privacy and Security Challenge

- Attack vectors;
  - DDoS Attacks
  - Botnets and malware based attacks
  - Weakening perimeters – Some devices are not ready to be directly connected to Internet
  - Data breaches

Wearable fitness trackers in the workplace: surveillance by fitbit?

By Clare Gilroy-Scott on 26 Apr 2017 in Data protection, Employment law, Occupational Health, Staff monitoring, Wellbeing

"FITNESS AND MEDICAL DEVICES ARE OFTEN FULL OF SENSITIVE INFORMATION, YET SECURITY AND PRIVACY ARE OFTEN AN AFTERTHOUGHT."

FEATURE

Security concerns rising for Internet of Things devices

Call it the Attack Vector of Things

More Devices Means More Targ

First, we had to worry about the physical securit
about mobile phones and tablet device
our home appliances, our wearables an

IoT Vulnerabilities Open Up New Possibilities To Hackers

technology risk breaching data protection law if their policies and procedures are not kept up to date. Clare Gilroy-Scott of law firm Goodman Derrick advises.

Botnets are already a major threat

- MIRAI Botnet attack
  - Massive DDoS attack
  - Targets CCTV (IP) cameras and Home Routers

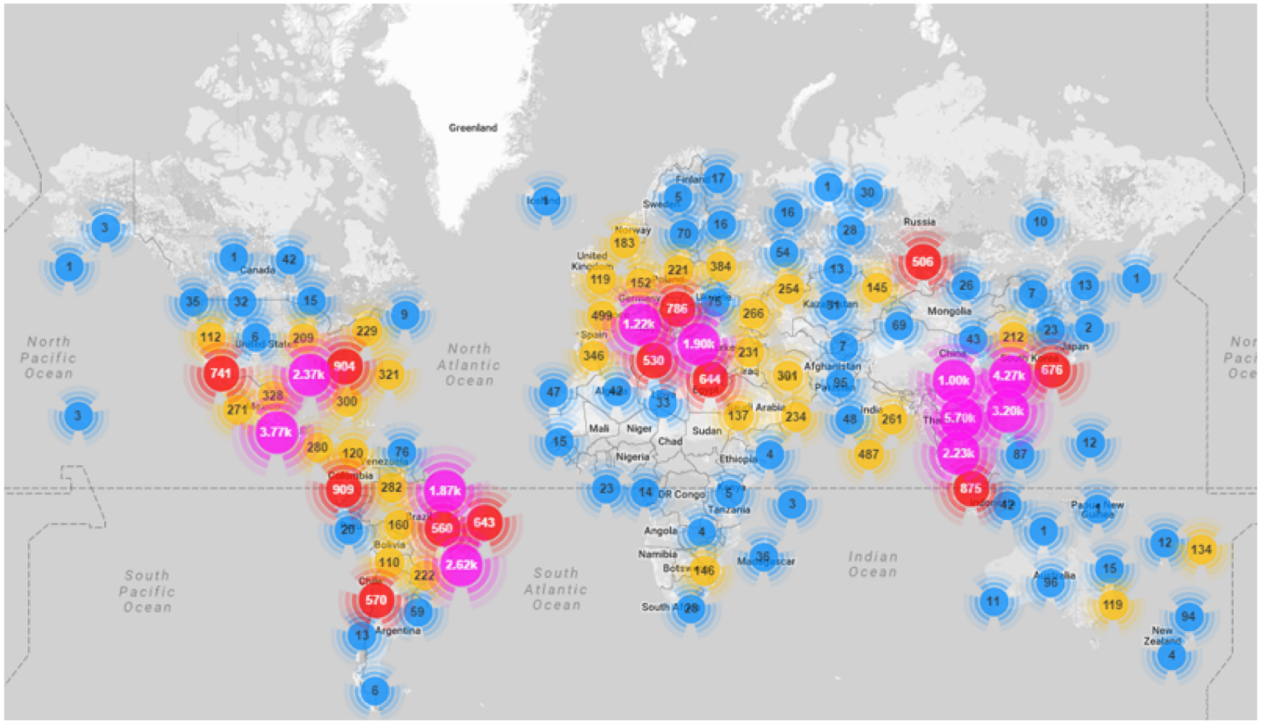


Figure 2: Geo-locations of all Mirai-infected devices uncovered so far

https://www.incapsula.com/blog/malware-analysis-mirai-ddos-botnet.html

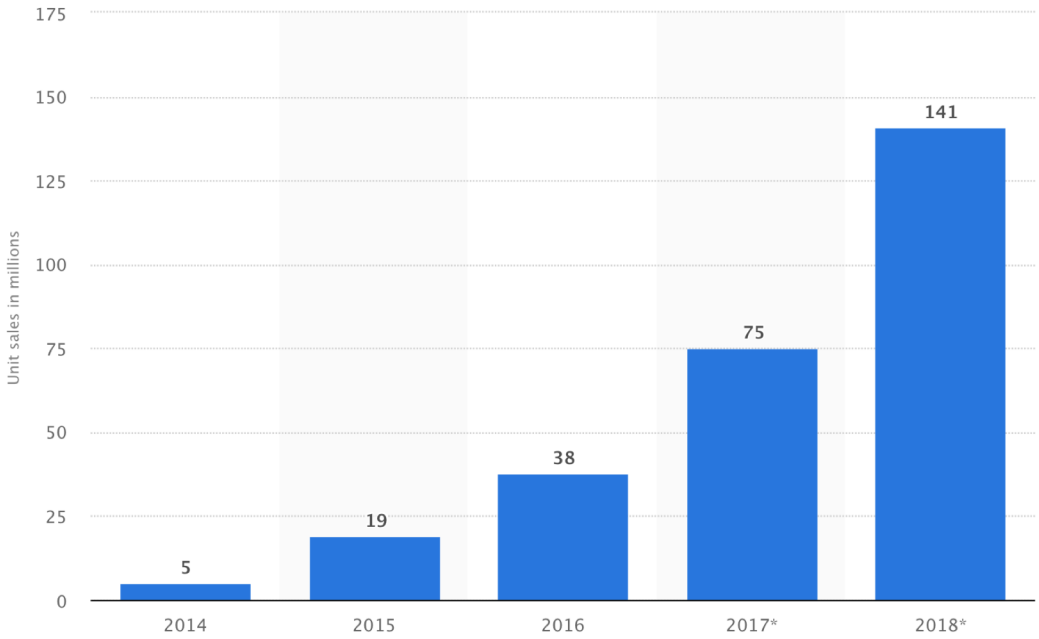
Privacy


I THINK MY NEST SMOKE ALARM IS GOING OFF. GOOGLE ADWORDS JUST PITCHED ME A FIRE EXTINGUISHER AND AN OFFER FOR TEMPORARY HOUSING.
TOM FISH BURNE
©marketoonist.com

Wearables – Instrumenting Humans

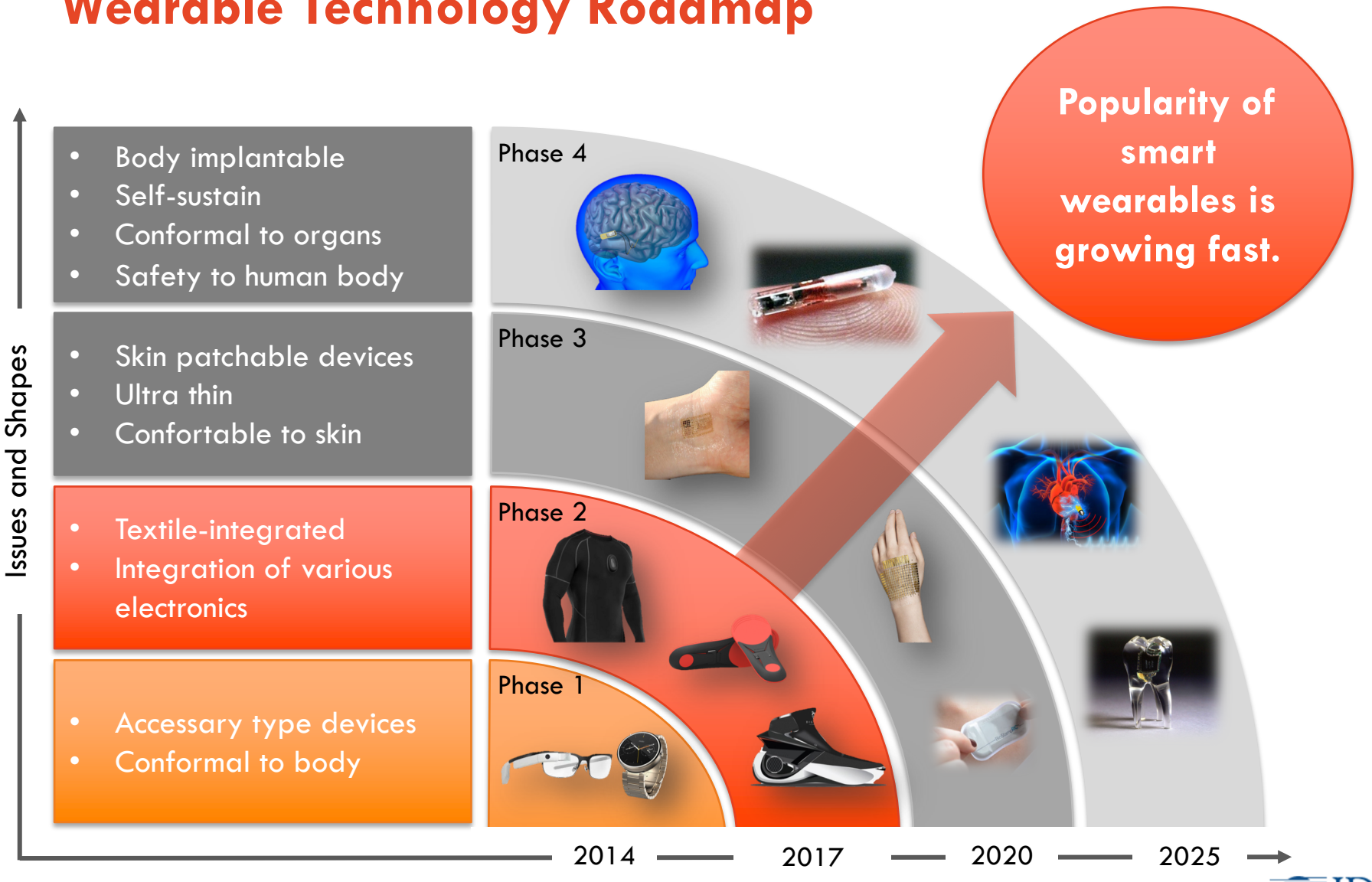
Wearables – Instrumenting Humans

- 50 million devices shipped in 2015
- 202 million devices is expected to ship in 2019
- Expected to reach a market value of $57,653 million by 2022



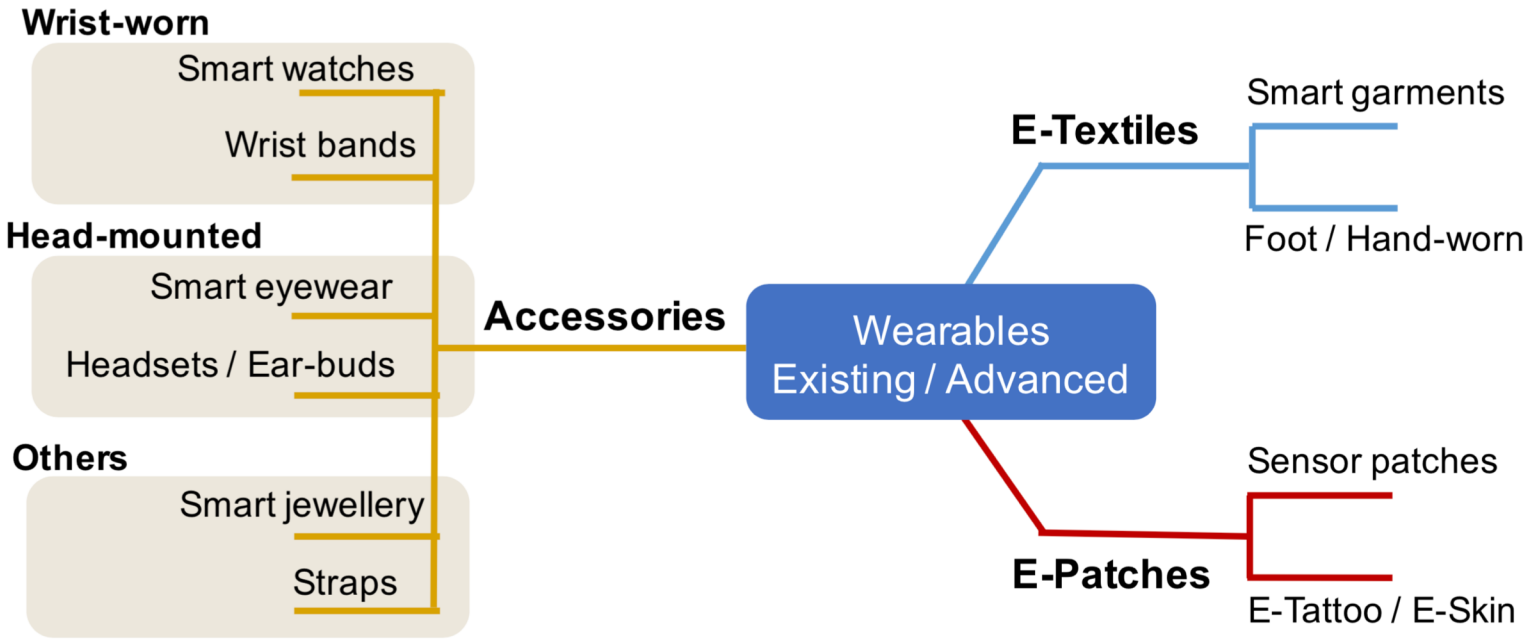
https://www.statista.com/statistics/538237/global-smartwatch-unit-sales/

Wearable Technology Roadmap



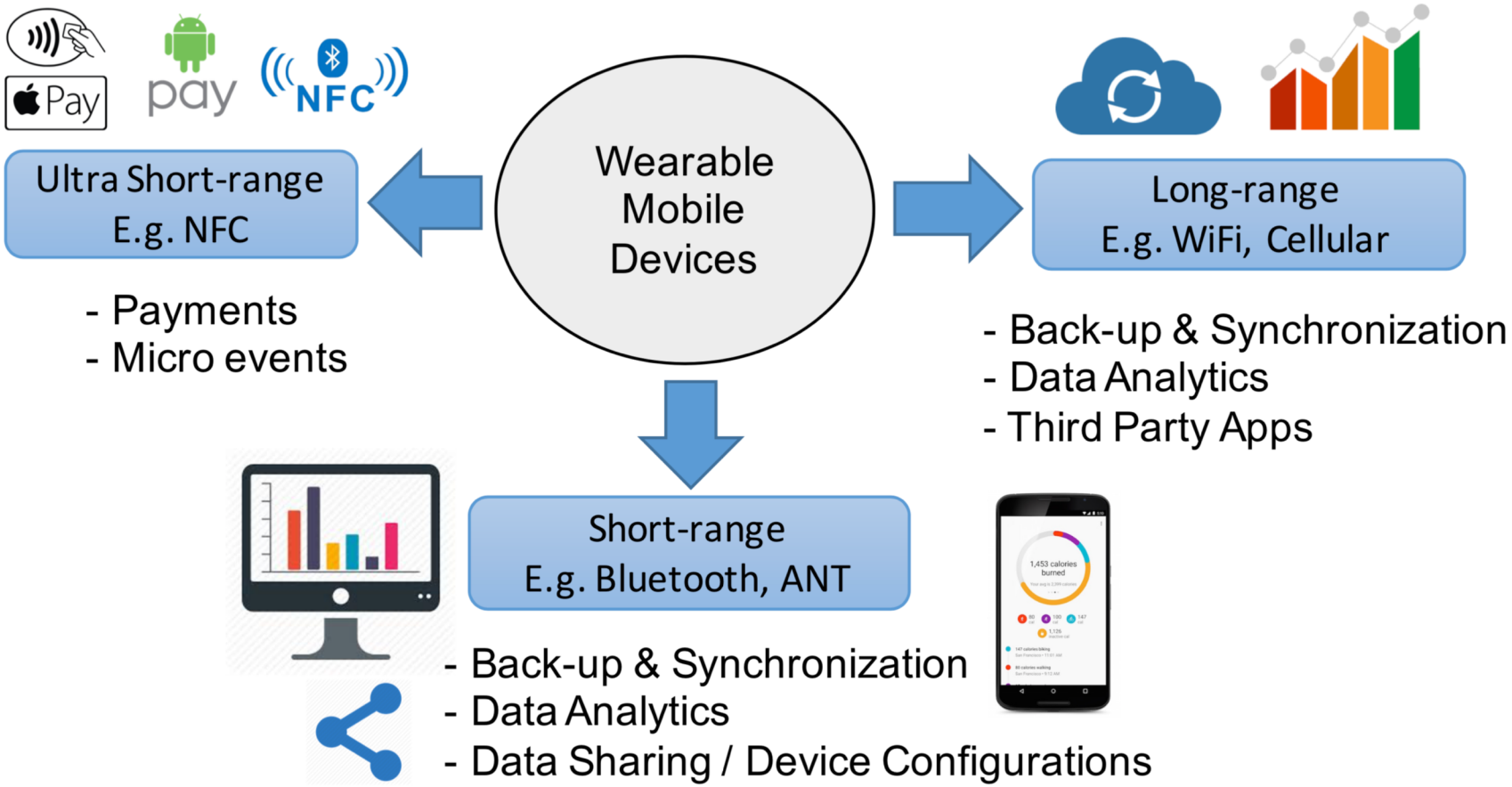
Source : International Data Corporation

Categories of Wearables

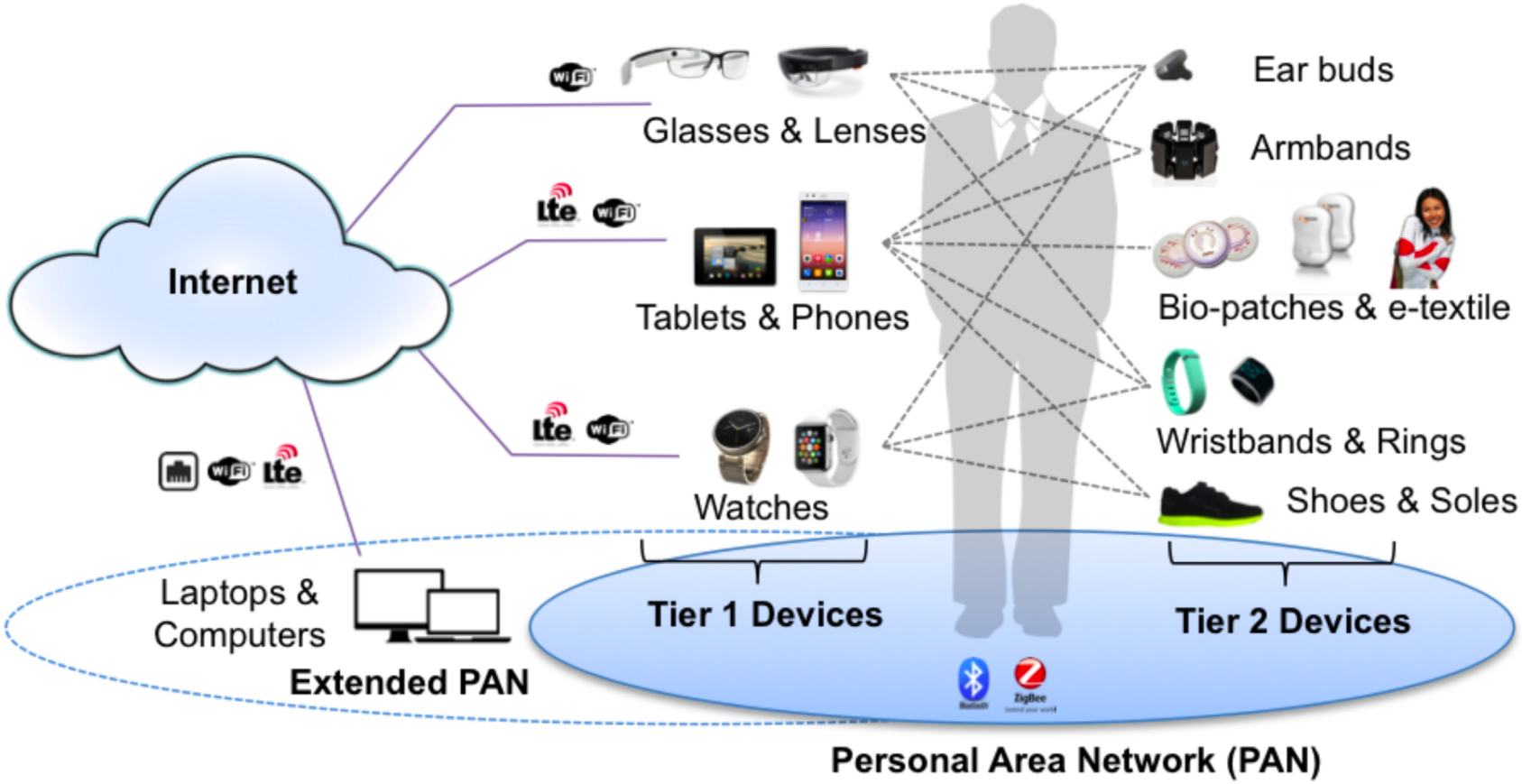


Seneviratne, S., Hu, Y., Nguyen, T., Lan, G., Khalifa, S., Thilakarathna, K., ...&Seneviratne, A. (2017). A survey of wearable devices and challenges. *IEEE Communications Surveys & Tutorials*, *19*(4), 2573-2620.

Connecting Wearables



Connecting Wearables



Eg: Mobile Vitual/Augmented/Mixed Reality

- Workforce training
  - https://www.ptc.com/en/resources/augmented-reality/infographic/ar-for-training

- Interactive retail
- Remote healthcare
- Remote learning

Eg: Mobile Vitual/Augmented/Mixed Reality

- XR for everyone
  - Zapbox – just $40
  - https://www.youtube.com/watch?v=SMyPTfuy8Ms&feature=emb_logo

Programming Challenges

- Two types of apps
  1. Smartphone apps that utilize wearables, e.g. notifications, data collection
  2. Standalone wearable apps

- **Can we program wearables similar to smartphones?**

Programming Challenges

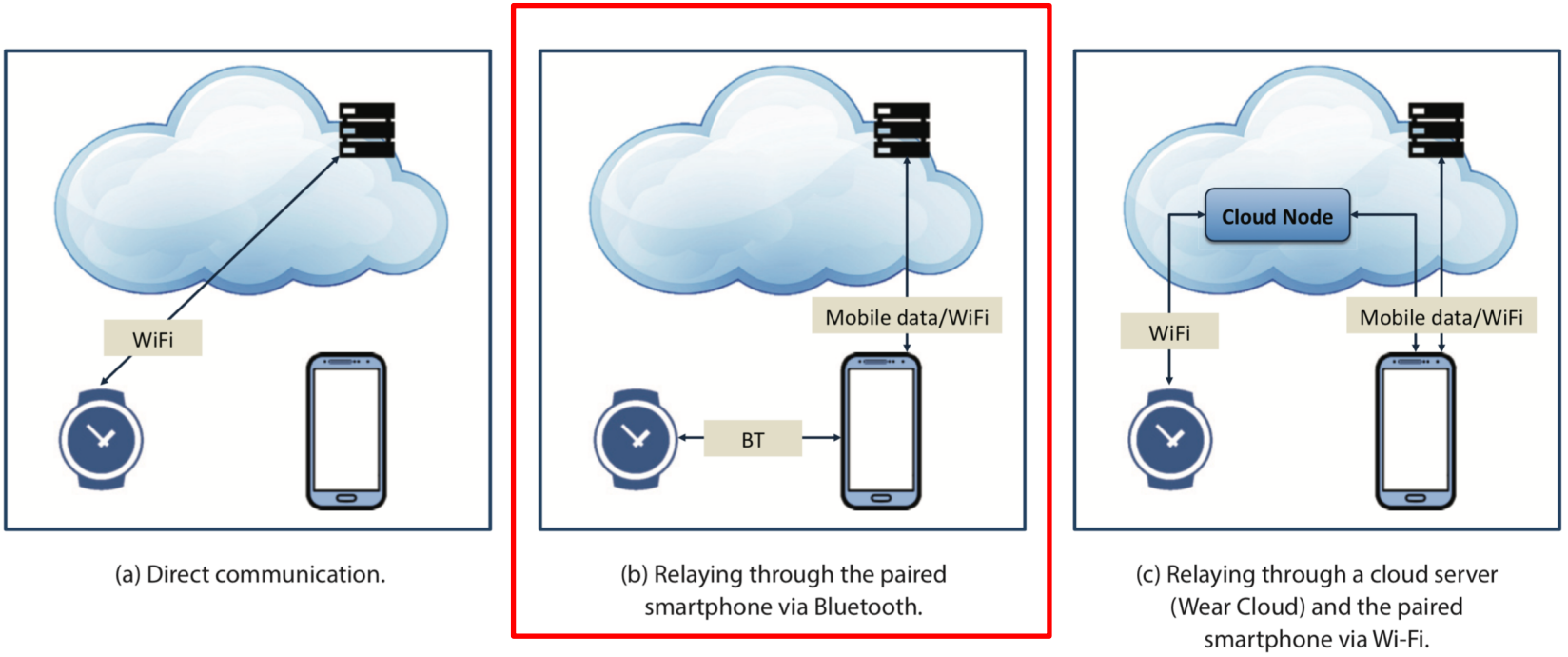
- Two types of apps
  1. Smartphone apps that utilize wearables, e.g. notifications, data collection
  2. Standalone wearable apps

- **Can we program wearables similar to smartphones?**
  - Low computing power
  - Low battery power
  - Less storage
  - Small real-estate

Device	CPU	Memory	Battery
LG G Watch R	Quad-core 1.2 GHz	512 MB	410 mAh
Google Glass	Dual-core 1 GHz	2 GB	570 mAh
Nexus 4 Phone	Quad-core 1.5 GHz	2 GB	2100 mAh

Programming Challenges

- Methods of Internet communication from wearables



(a) Direct communication.

(b) Relaying through the paired smartphone via Bluetooth.

(c) Relaying through a cloud server (Wear Cloud) and the paired smartphone via Wi-Fi.

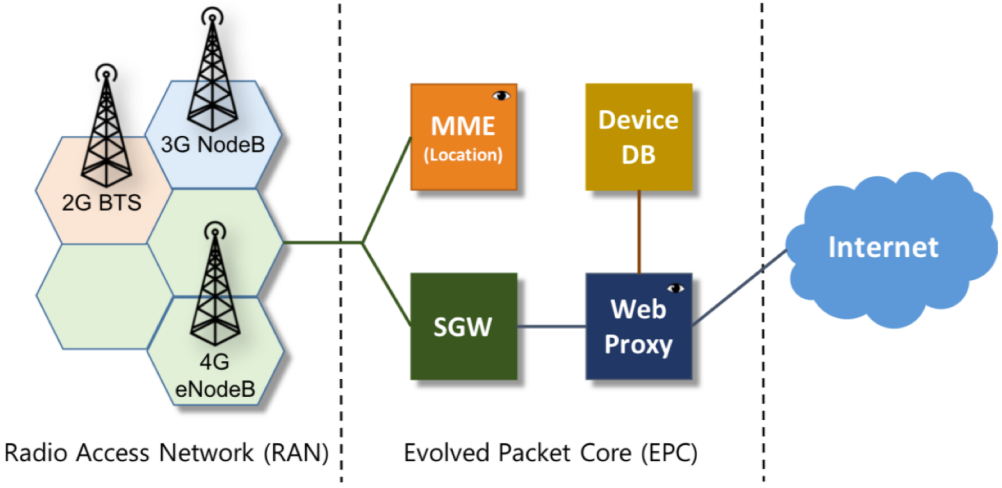
FIGURE 1. Methods of Internet communication for smartwatch apps.

H. Kolamunna, J. Chauhan, K. Thilakarathna, D. Perino, D. Makaroff and A. Seneviratne, "Are Wearables Ready for Secure and Direct Internet Communication?", **ACM GetMobile: Mobile Computing and Communications**, vol. 21, no. 3, pp. 5-10, Sep 2017.

A First Look at SIM-Enabled Wearables in the Wild

- We conducted a measurement study of capturing SIM-enabled wearable traffic at a large European ISP
  - Android and Tizen based wearables

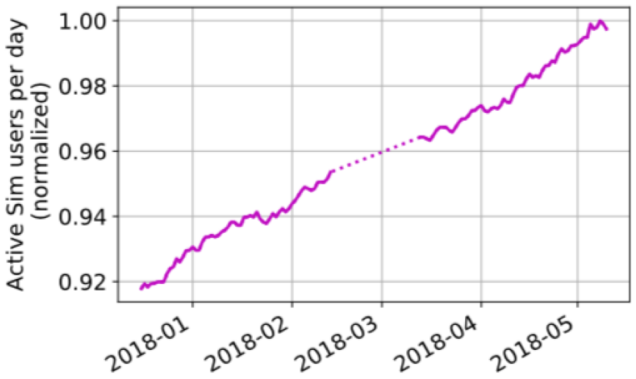
- For a period of five months - mid-December 2017 and mid-May 2018



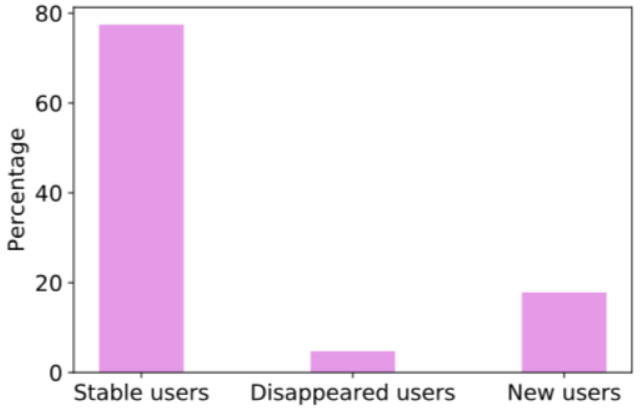
H. Kolamunna, I. Leontiadis, D. Perino, S. Seneviratne, K. Thilakarathna, A. Seneviratne. "**A First Look at Sim-Enabled Wearables in the Wild**", in *Proc. of ACM Internet Measurement Conference*, Boston, Oct. 2018.

A First Look at SIM-Enabled Wearables in the Wild

- There is increasing trend towards standalone apps



(a) SIM-enabled users.



(b) First week vs last week.

- Only 34% of such users actually generate any network transaction.
- Developers are still treating wearables as peripherals
- **We (developers) need to move on as hardware is ready !**

Efficient use of wearables

- **Common functions** are available in PAN devices.
- Non-optimal utilization leads to;
  - Waste of the limited resources.
  - Poor functionality.

Are we optimally utilizing the functions in a PAN?

Efficient use of wearables

Are we optimally utilizing the functions in a PAN?

Popular fitness tracking applications (smartphone, smartwatch)

My Fitness Companion | Cardiograph | UP | WearRun | Sleep as Android

Function Allocation

- *Random*
- *ALL*

Context Awareness

Battery level

User mobility

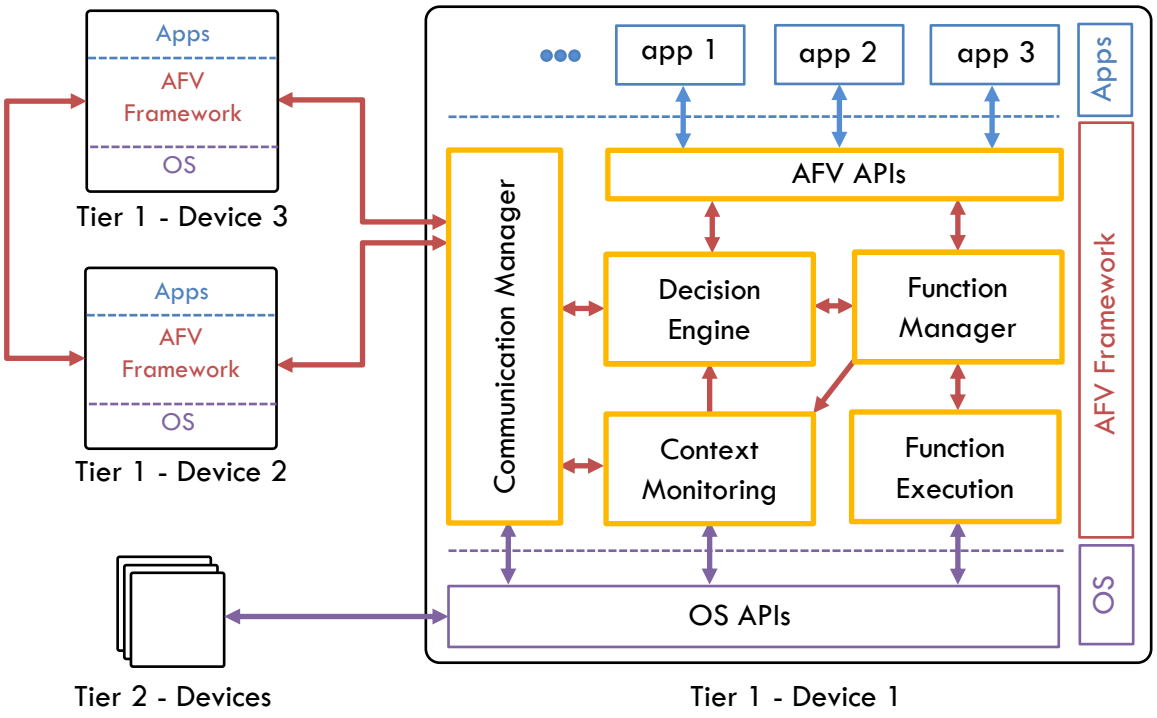
Location

Execution mode

- *No context monitoring*
- *No dynamic adaptation to context changes*

We are NOT optimally utilizing the functions in a PAN.

Application Function Virtualization



- AFV APIs
- Function Manager
  - Knowledge about PAN
  - Manages the requests
- Context Monitoring
- Decision Engine
  - Functions Allocation Problem (FAP)
- Communication Manager
  - Manages all AFV communication in the PAN
- Function Execution

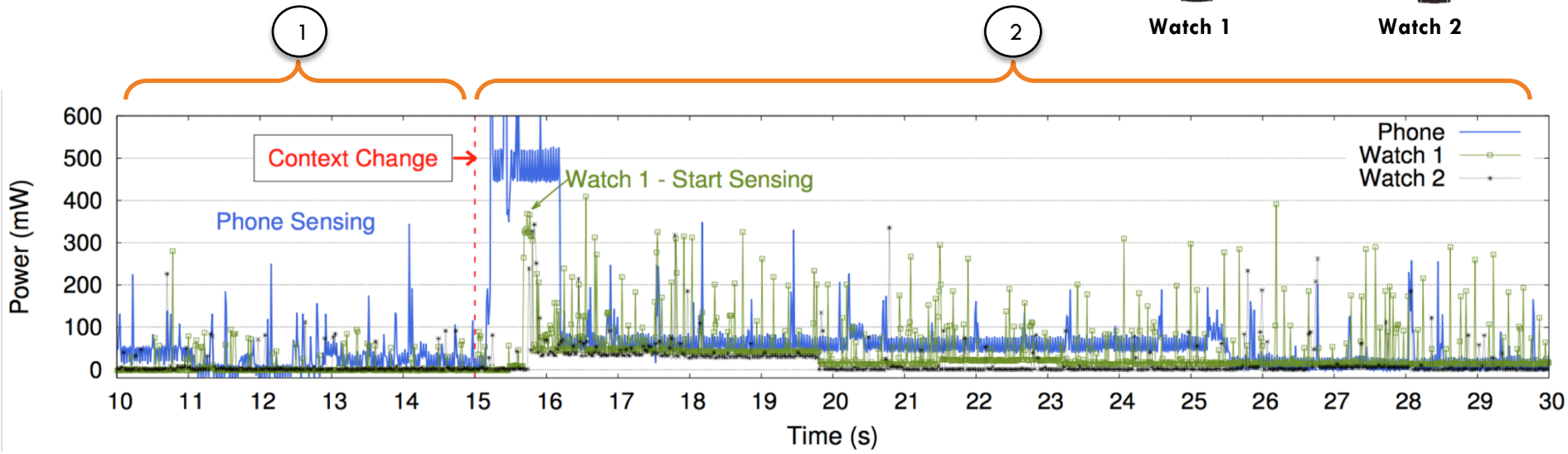
H. Kolamunna, K. Thilakarathna, D. Perino, D. Makaroff and A. Seneviratne, "Seamless Resource Sharing in Wearable Networks by Application Function Virtualization," in *IEEE Transactions on Mobile Computing*, vol. 18, no. 6, pp. 1393-1406, 1 June 2019, doi: 10.1109/TMC.2018.2861861.

Application Function Virtualization

System adaptation to context changes

① Before context change
- Phone is running accelerometer.
- Watch 1 and 2 are receiving data periodically.

② After context change
- Phone notifies the context change to watch 1 and 2 (~200ms).
- Watch 1 and 2 receives the notification (~600ms).
- Watch 1 starts running accelerometer and phone stops.
- Phone and watch 2 are receiving data periodically.



Android Support in Developing for IoT

- https://developer.android.com/wear/

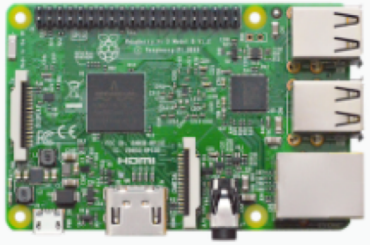
- https://developer.android.com/tv/

- https://developer.android.com/auto/

- https://developer.android.com/things/

Android Things

- Supported hardware
  - Production Platforms
  - System on Modules (SoM) are fully certified by Google
  - Secure – security updates for 3 years

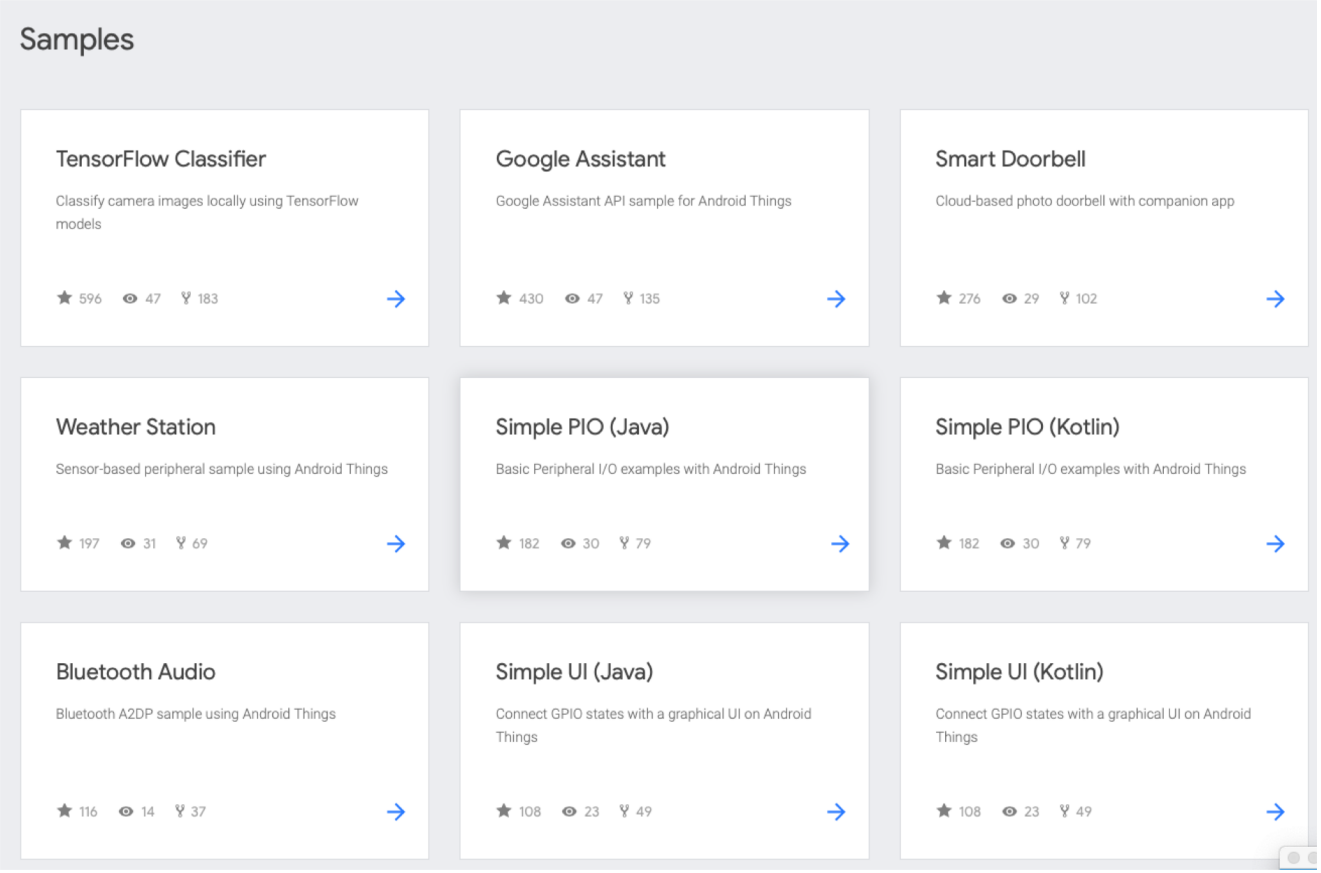
Platform	NXP Pico i.MX7D	Raspberry Pi 3 Model B
		
	Learn More Where to buy Get Started - board only Get Started - Starter Kit	Learn More Where to buy Get Started - board only Get Started - Starter Kit
CPU & Memory	• NXP i.MX7D • 1GHz dual-core ARM Cortex A7 • 512MB RAM	• Broadcom BCM2837 • 1.2GHz quad-core ARM Cortex A53 • 1GB RAM

  - https://developer.android.com/things/hardware/

Android Things

- Raspberry Pi 3 – Starter Kit
  - Raspberry Pi 3
  - Rainbow HAT
  - Power Adapter
- Tutorial
  - https://codelabs.developers.google.com/codelabs/androidthings-peripherals/#0

Android Things – Drivers, Snippets, Samples



https://androidthings.withgoogle.com/build/#!/samples/

If you would like to work in this area…

- Honours Thesis/Masters/**PhD Projects** are available
- Email me if you are interested

- Example projects:
  - Passive fingerprinting of Smart Homes
    - Can someone park outside your home and tell that you are listening to Google Home music inside the home?
  - LoRa network monitoring tool and large-scale network measurement study
  - Control AR/VR videos from Brainwaves (EEG)
    - How to bring cognitive controlling to VR gaming.
  - Privacy aware mixed reality content sharing
  - 360 video streaming on mobile devices
  - Reliable drone or UAV detection

Announcements

- Project Proposal marks are out
- If you wish to receive feedback on your proposal, please book a time slot writing down the group ID in the following spreadsheet.
- https://unisyd-my.sharepoint.com/:x:/g/personal/kanchana_thilakarathna_sydney_edu_au/EZyfEnHwCj9MgzX-x83DrB8Btfk8q5AzVwUTU3zENWPY2A?e=kb88HW

- Next week
  - Combined Industry+Guest Lecture
    - **Glenn Stephens from Microsoft on Cross-Platform App Development**