UNIVERSITÀ
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DI PADOVA

Towards a Hyperconnected World Opportunities and Challenges

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UNIVERSITÀ DEGLI STUDI DI PADOVA

General Info regarding **BMCS students**

- **Course Web Page:**
  http://hit.unipd.it/towards-hyper-connected-world-opportunities-and-challenges
- **Course requirements**: None
- **Examination modality:** None
- **Course material, enrollment and last minute notifications**
  Made available by the teacher on Moodle for BMCS classes

Aim

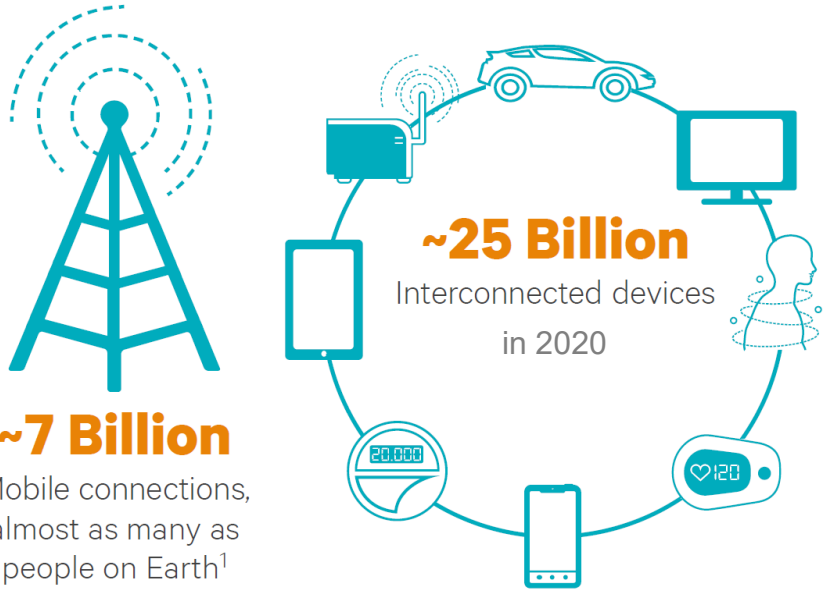
The exponential growth of **connected devices**, **big data** and **edge/cloud computing** is creating an hyper-connected world, fostering **innovative** use cases, **opportunities** and **challenges** in our society and daily lives. The successful advent of this hyper-connected scenario depends on the capability to integrate technologies such as Internet of Things, Mobile-to-Mobile communication, connected vehicles/drones, cloud computing, edge computing, data gathering/dissemination and social networks.

This course discusses **various case studies** in this field in order to understand its (interdisciplinary) research potentiality.

A Mobile World

The mobile experience is expanding everywhere

Billions of Mobile Connections



~7 Billion

Mobile connections, almost as many as people on Earth[1]

~25 Billion

Interconnected devices in 2020

Billions of Mobile Experiences

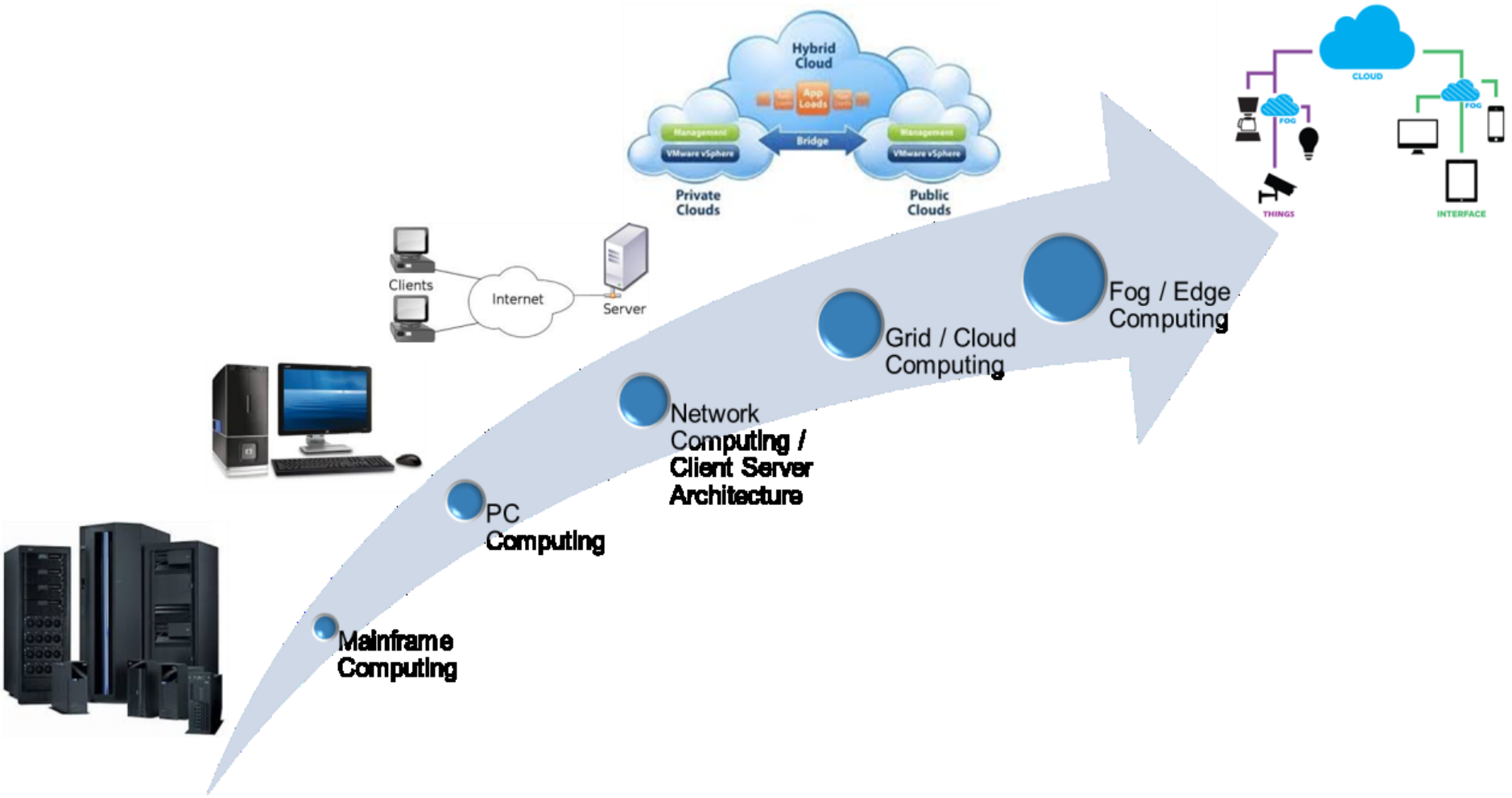
>100 Billion

App downloads completed in 2013[3]

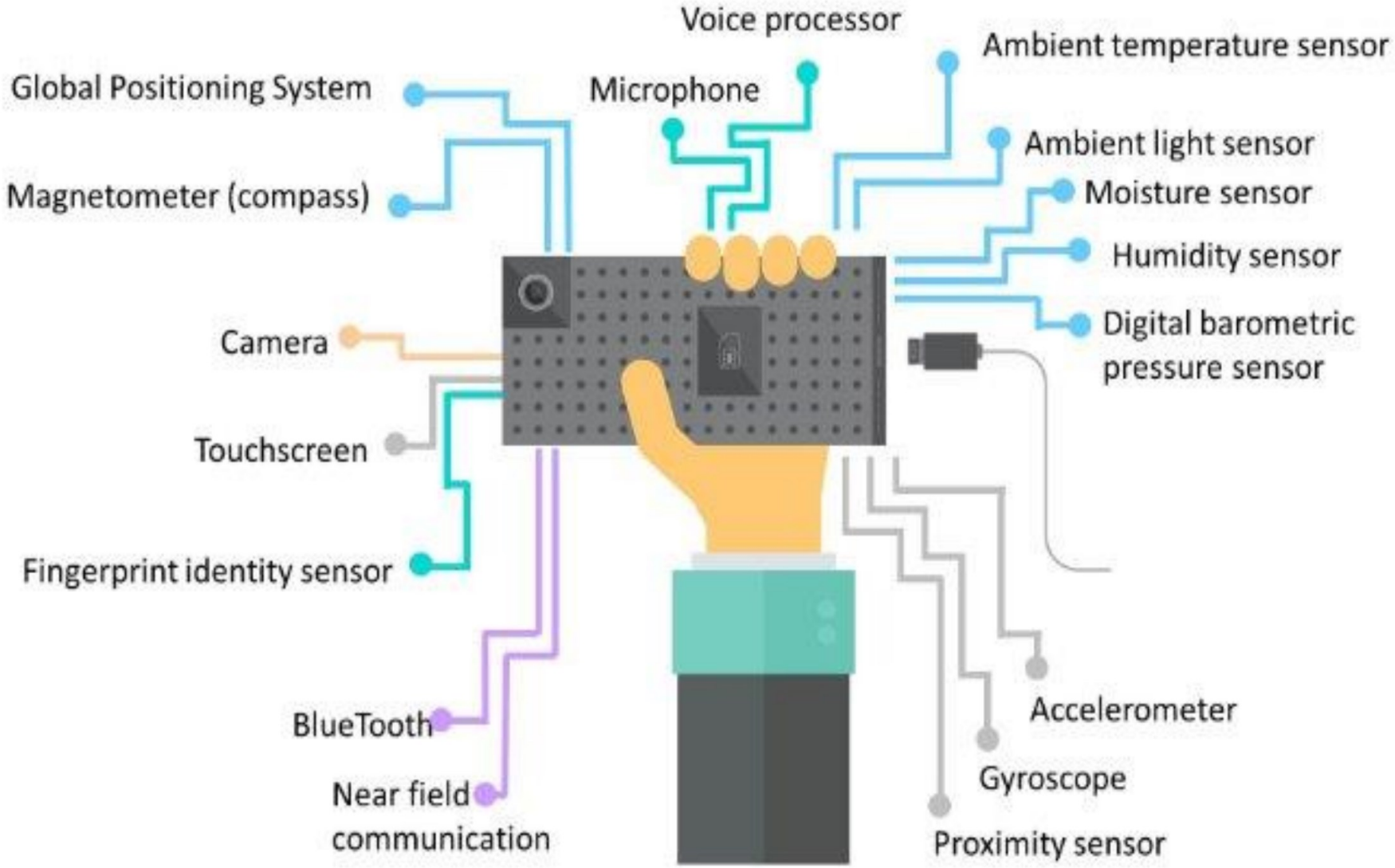
~270 Billion

App downloads expected in 2017[3]

A brief History of Computing

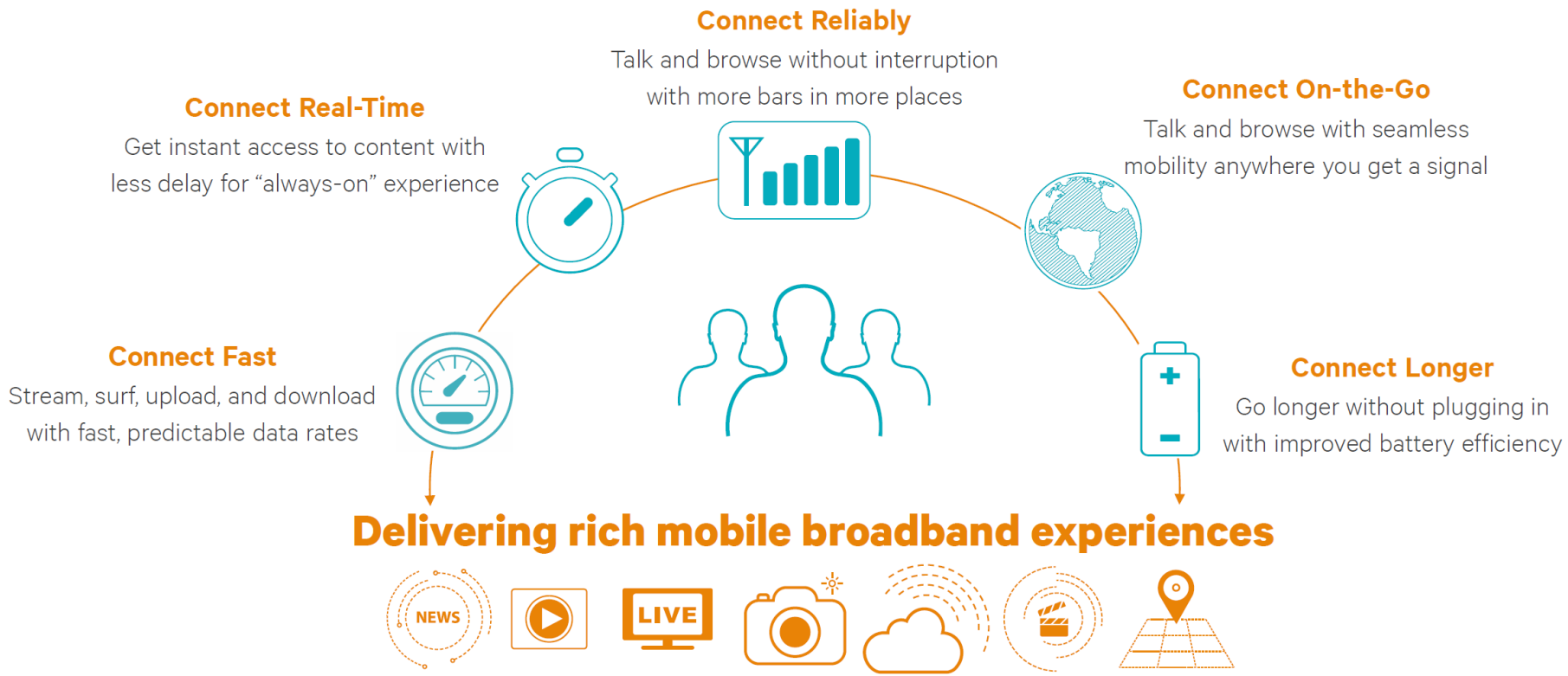


The Smartphone as a Computing Platform



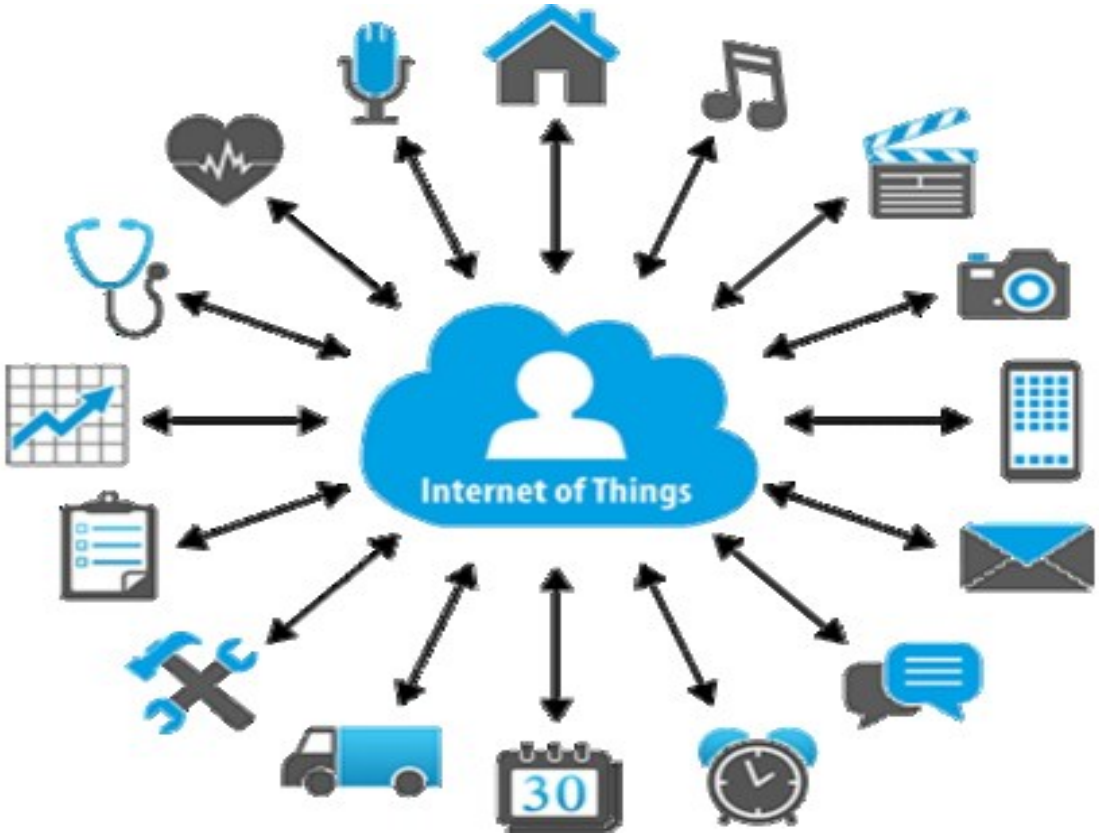
A Mobile World

Connectivity is the foundation of a great mobile experience



Internet of Things (IoT)

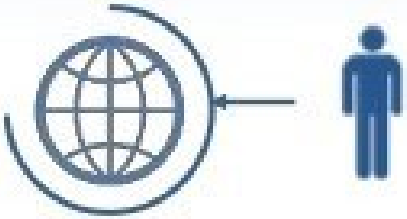
A technology able to connect everyday things embedded with electronics, software and sensors to the Internet enabling them to collect [elaborate] and exchange data



From IoP to IoT

Internet of People

Internet of People, 2010



People connected to internet

World population – 6.8B
Connected Devices – 12.5B (1.83x)

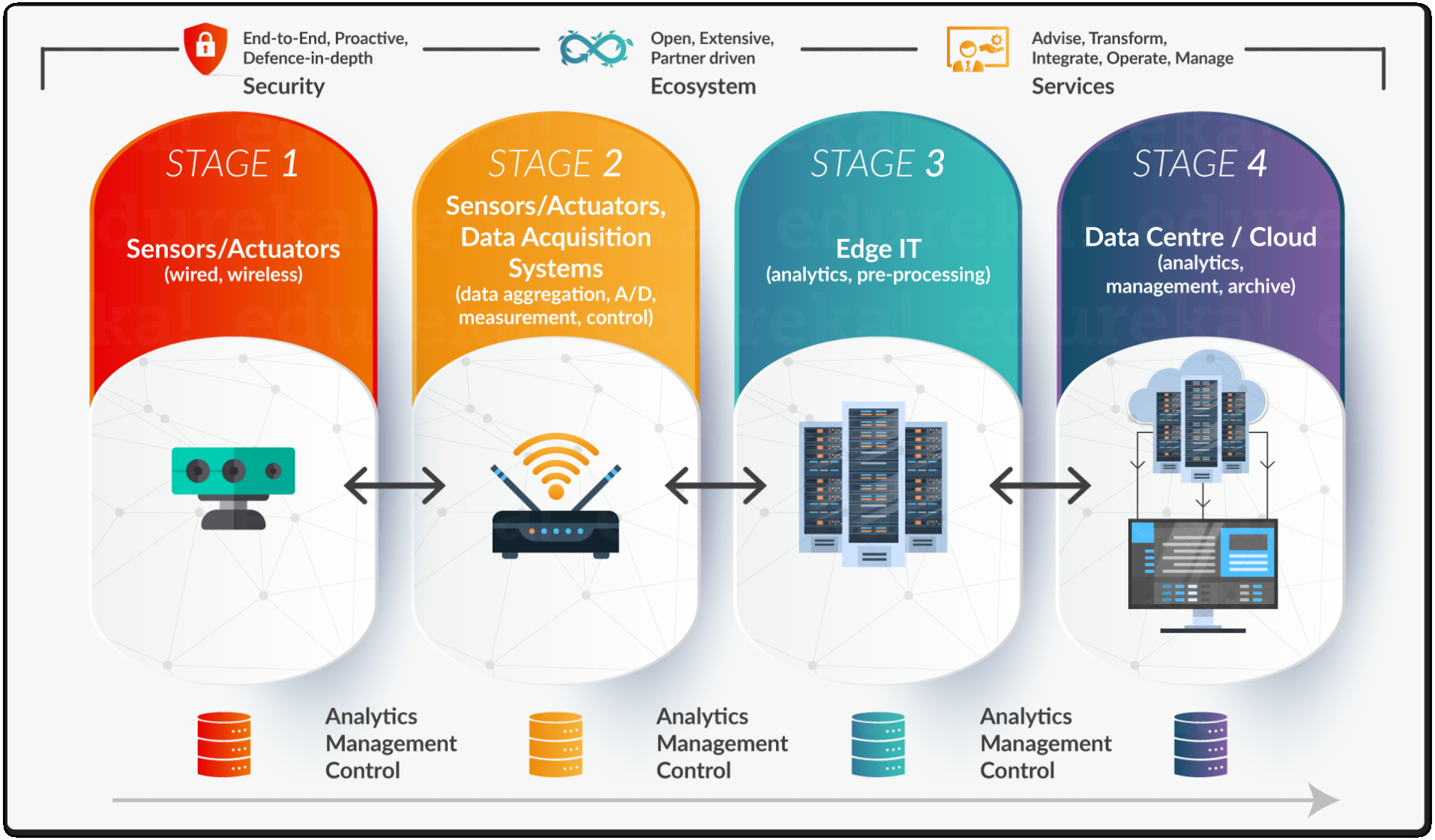
Internet of Things

Internet of **Things,** 2020

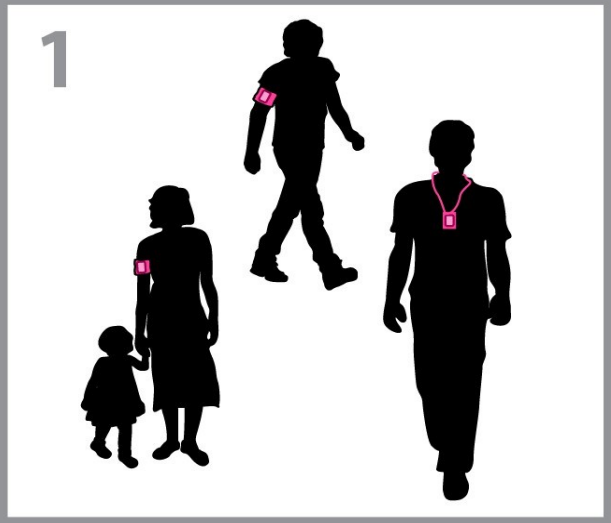
People connected to internet + Things connected to internet
+ Things connected to things

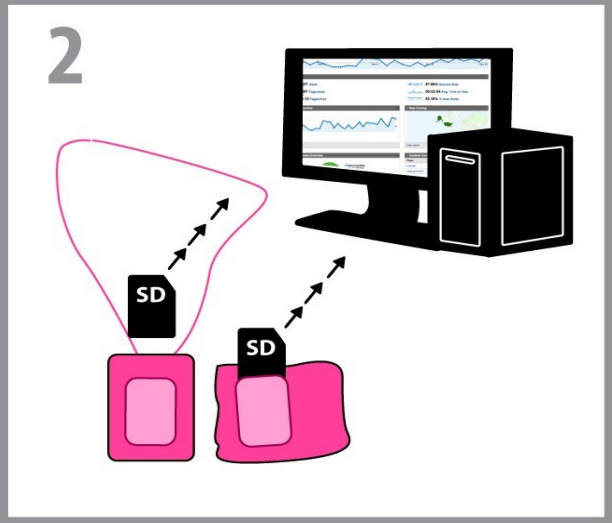
World population – 7.6B
Connected Things – 212B (27.89x)

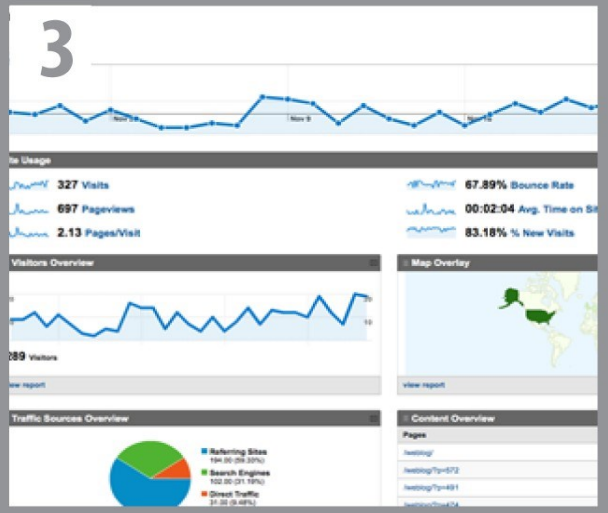
Core Stages of an IoT Architecture



Sharing and Reusing – “Free or Paid”

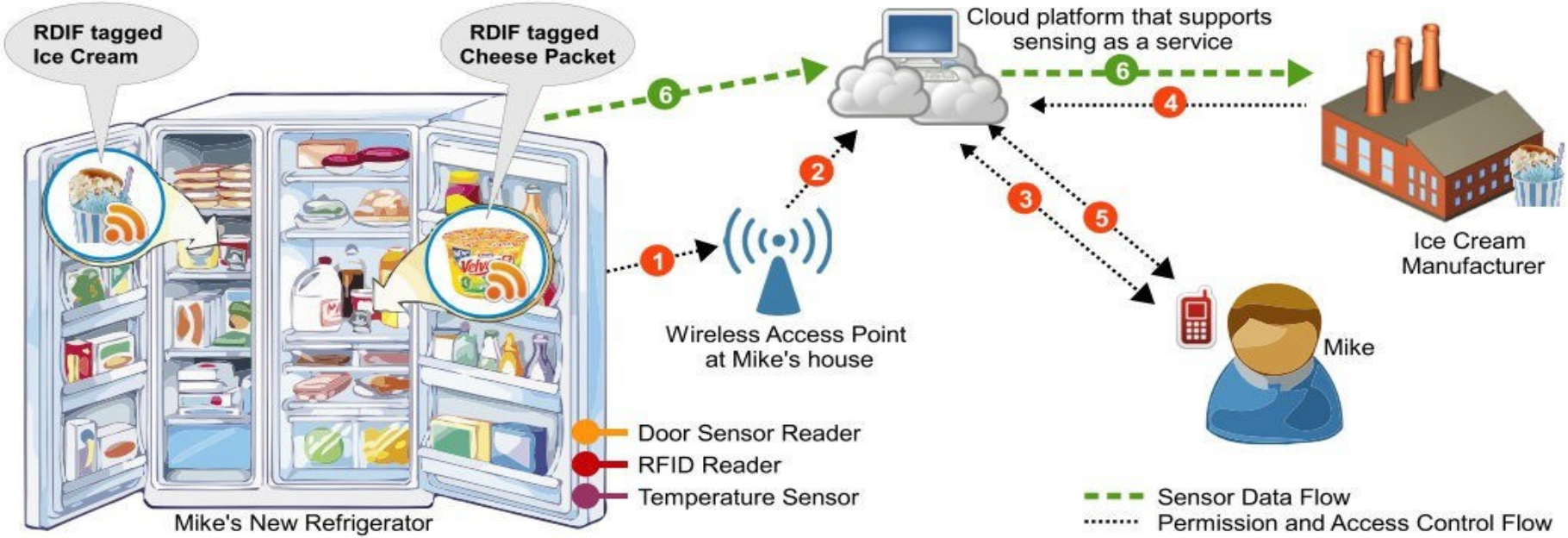






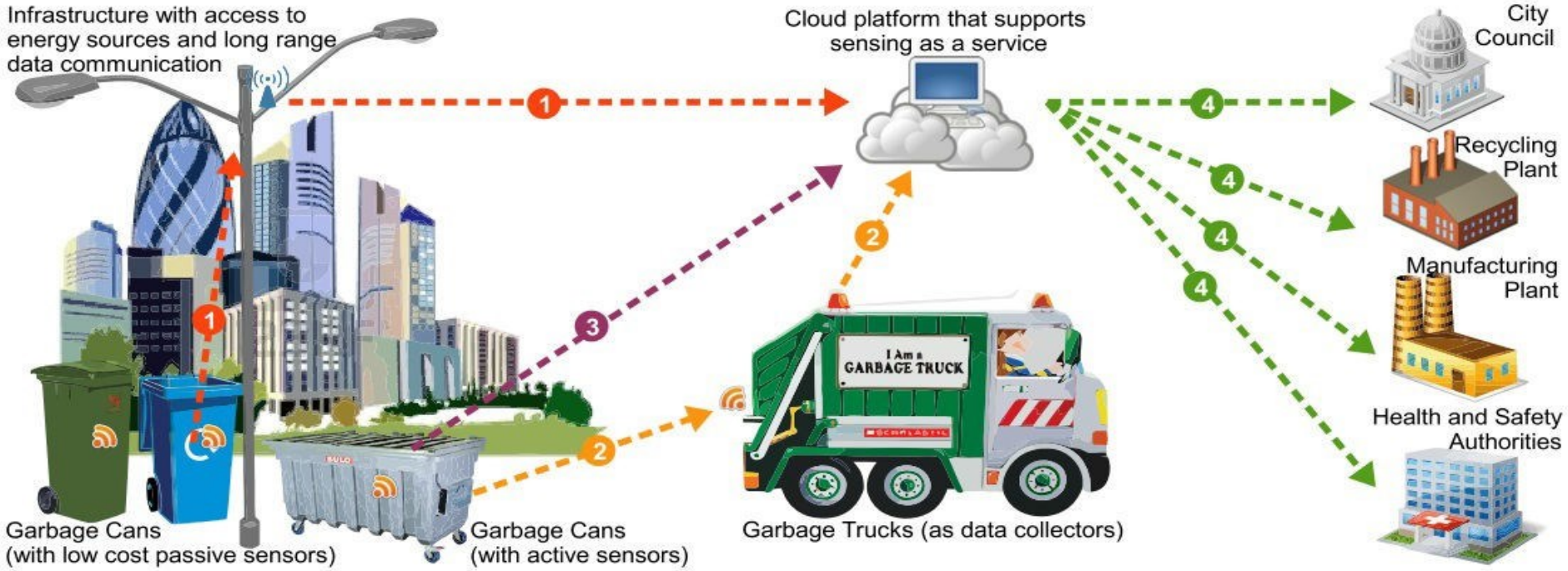
COLLECT SHARE LEARN

Smart Home Scenario – Interactions in Sensing-as-a-Service Model



[Source: "Sensing as a Service Model for Smart Cities Supported by Internet of Things", Charith Perera et. al., Transactions on Emerging Telecommunications Technology, 2014]

Efficient Waste Management Supported by the Sensing-as-a-Service



[Source: "Sensing as a Service Model for Smart Cities Supported by Internet of Things", Charith Perera et. al., Transactions on Emerging Telecommunications Technology, 2014]

IOT Application Scenario - Shopping

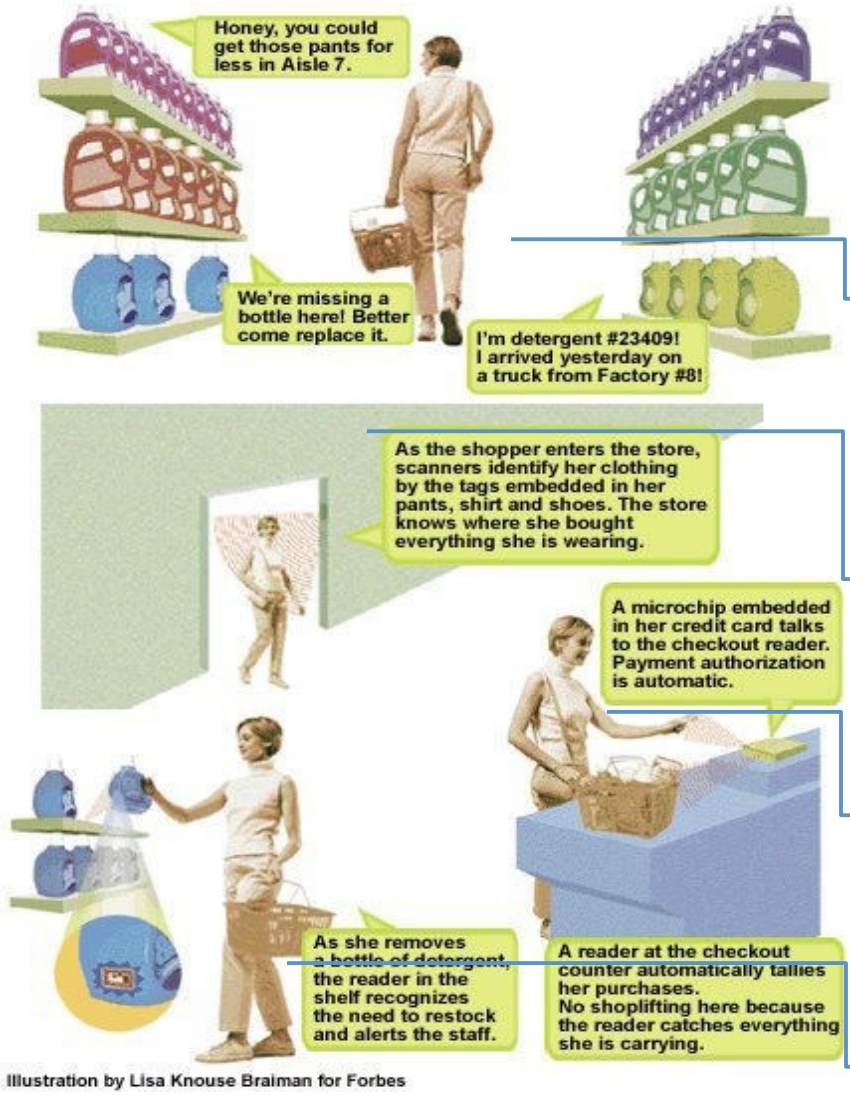


Illustration by Lisa Knouse Braiman for Forbes

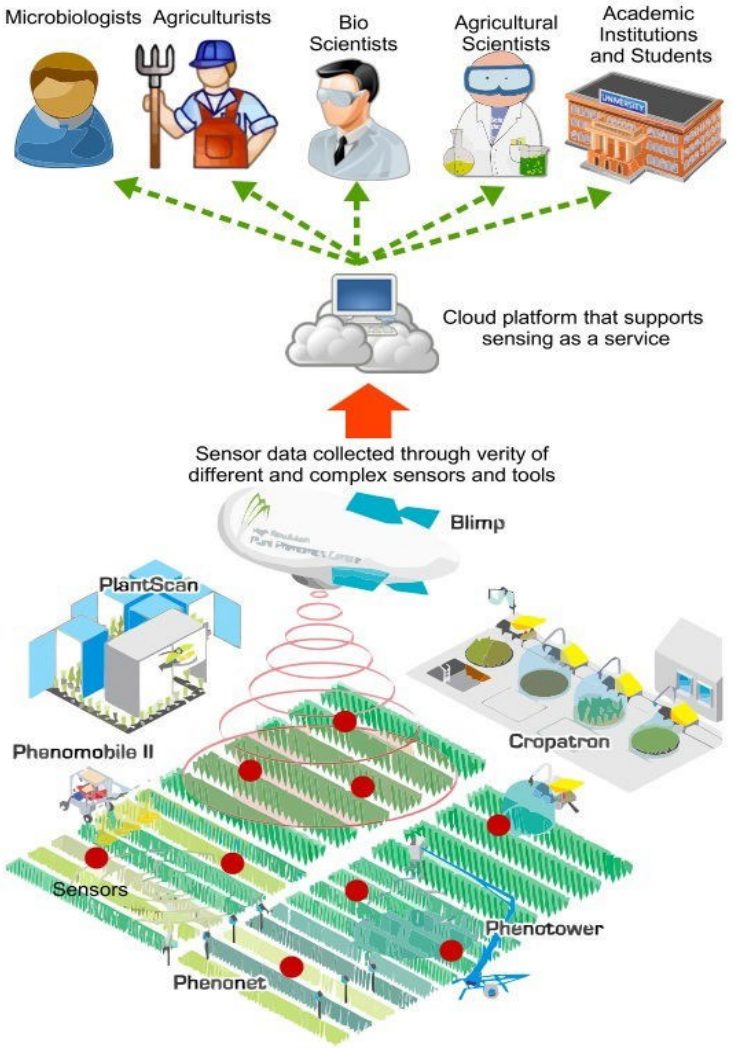
(2) When shopping in the market, the goods will introduce themselves.

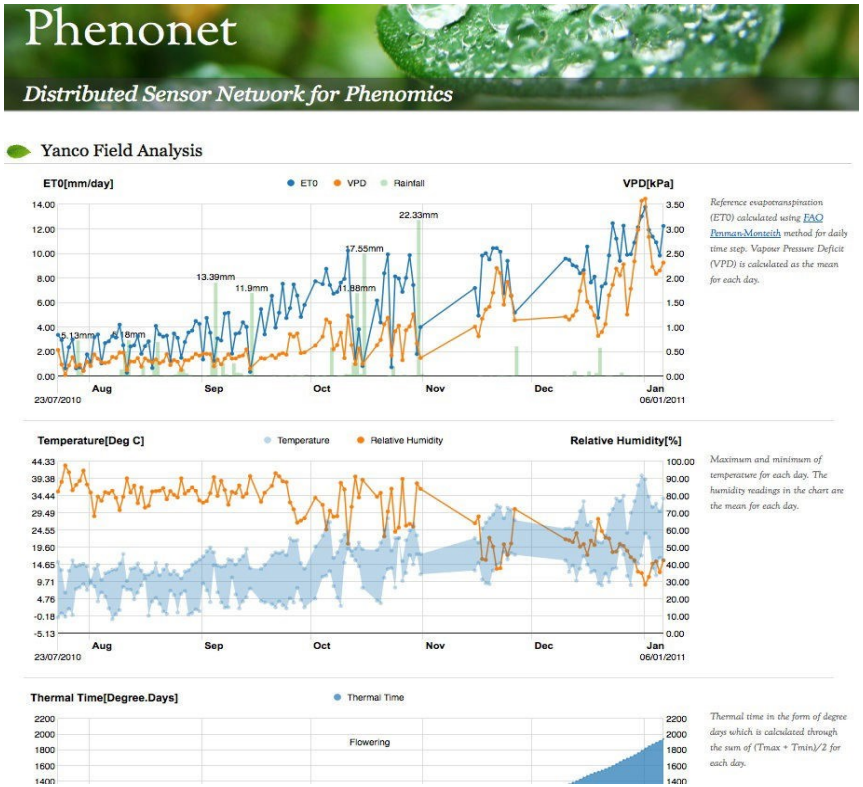
(1) When entering the doors, scanners will identify the tags on her clothing.

(4) When paying for the goods, the microchip of the credit card will communicate with checkout reader.

(3) When moving the goods, the reader will tell the staff to put a new one.

Collaborative Research Supported by Sensing-as-a-Service Model





The sensing-as-a-service model allows researchers to share resources across borders and understand phenomenon which are not available in their own countries.

The Social IoT (Internet of Everything)

https://youtu.be/i5AuzQXBsG4

17 May 2018 | 19:00 GMT

The Internet of Trash: IoT Has a Looming E-Waste Problem

A lack of forethought will leave us with a mountain of obsolete devices and no way to dispose of them

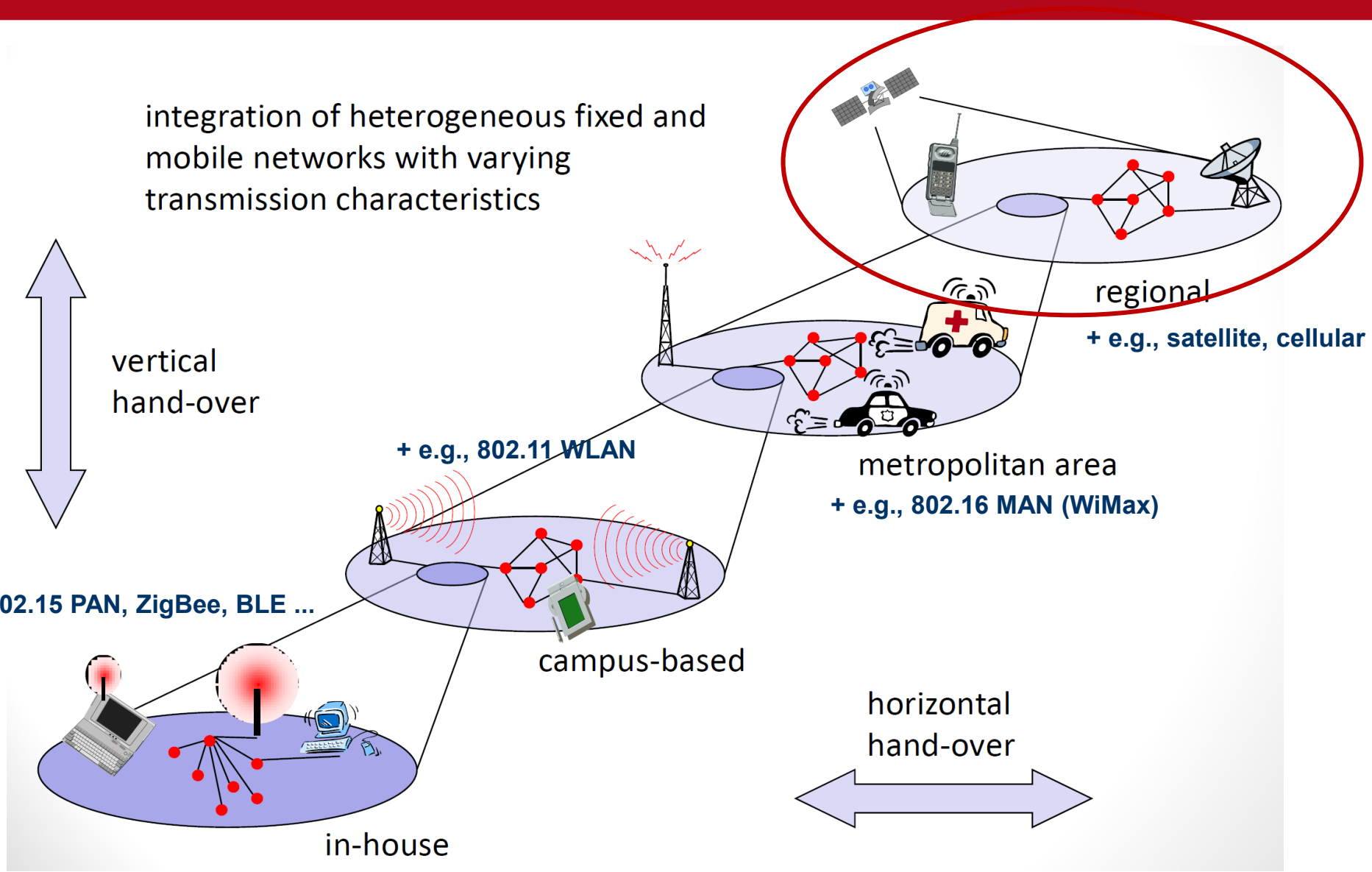
By **Stacey Higginbotham**

Food for Thought

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.

We're adding semiconductors to products that previously had none, and we're also shortening the life of devices as we add more computing, turning products that might last 15 years into ones that must be replaced every five years.

An Overlay of Networks



On-going research: Nano-Satellites

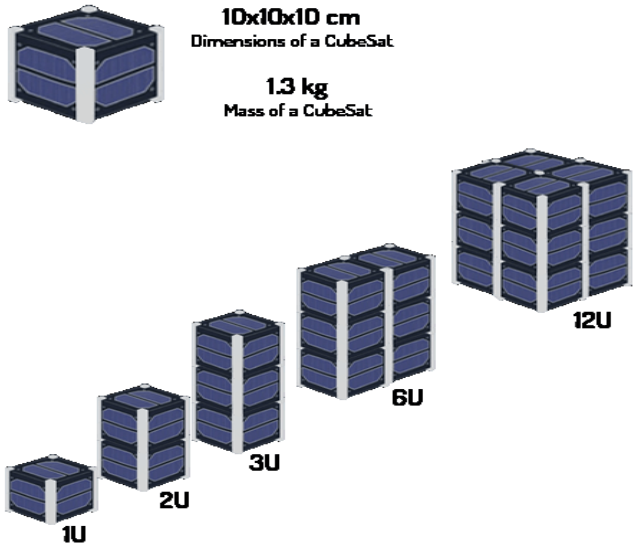


Figure: CubeSat taxonomy

Thousands of CubeSat launched so far

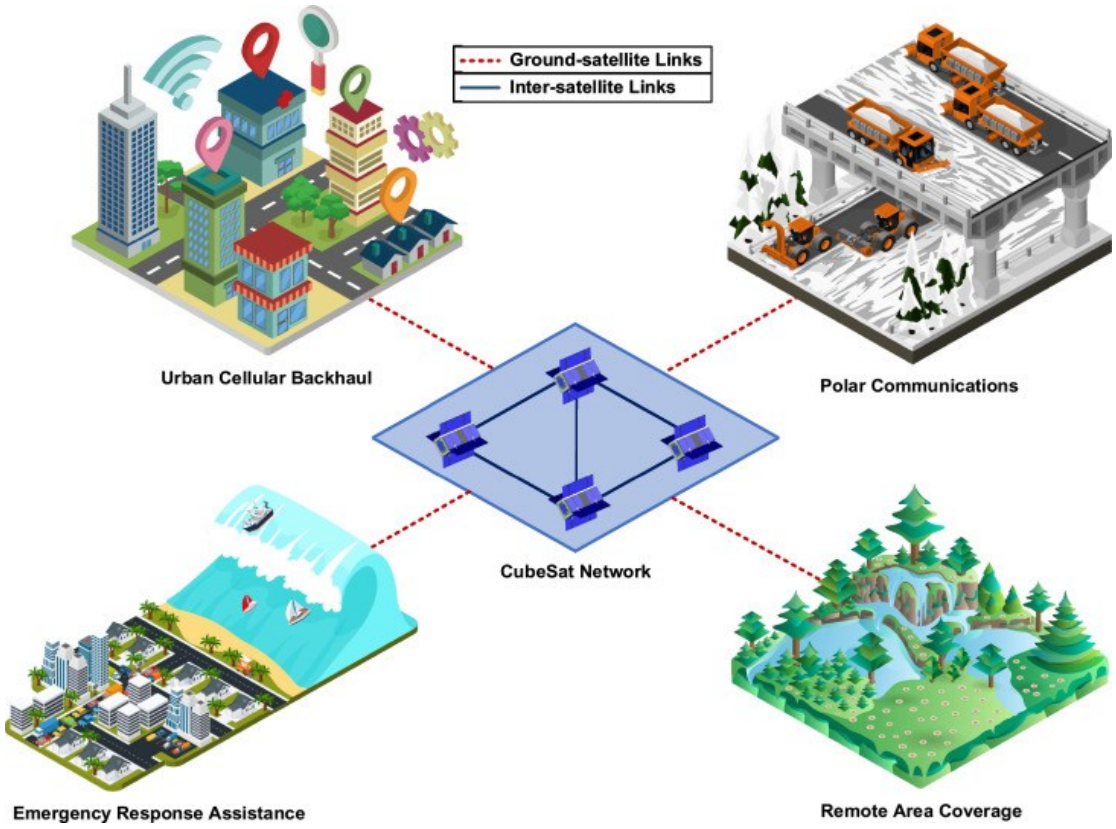


Figure: In-space backhaul scenarios.

Internet of Space Things (IoST)

https://youtu.be/4G2d3ek7PTQ

Evolution from 1G to 5G

1G

Analog

voice capability, limited coverage and mobility

2 kbps

AMPS

2G

Digital

better voice, improved coverage, text messaging

64 kbps

GSM, CDMA

3G

Mobile Data

basic Internet, multimedia, smaller phones

2 Mbps

HSPA, EVDO

4G

Mobile Broadband

high-speed data, smartphones

1 Gbps

LTE, LTE-A

5G

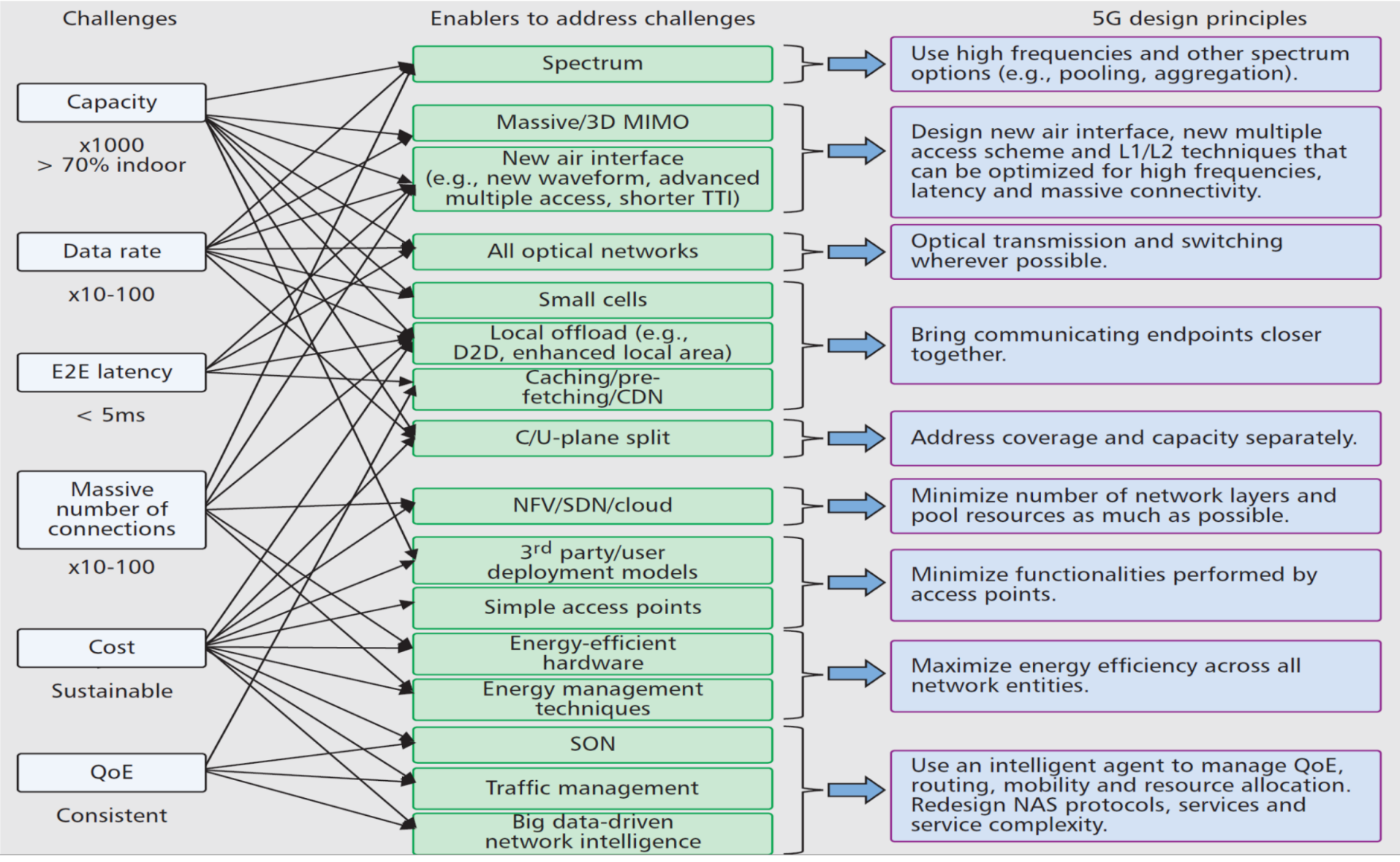
Extreme Speed, Connectivity & Reliability

a platform for future innovation

10+ Gbps

5G service & use cases – Nov 2017 – 5G America White Paper

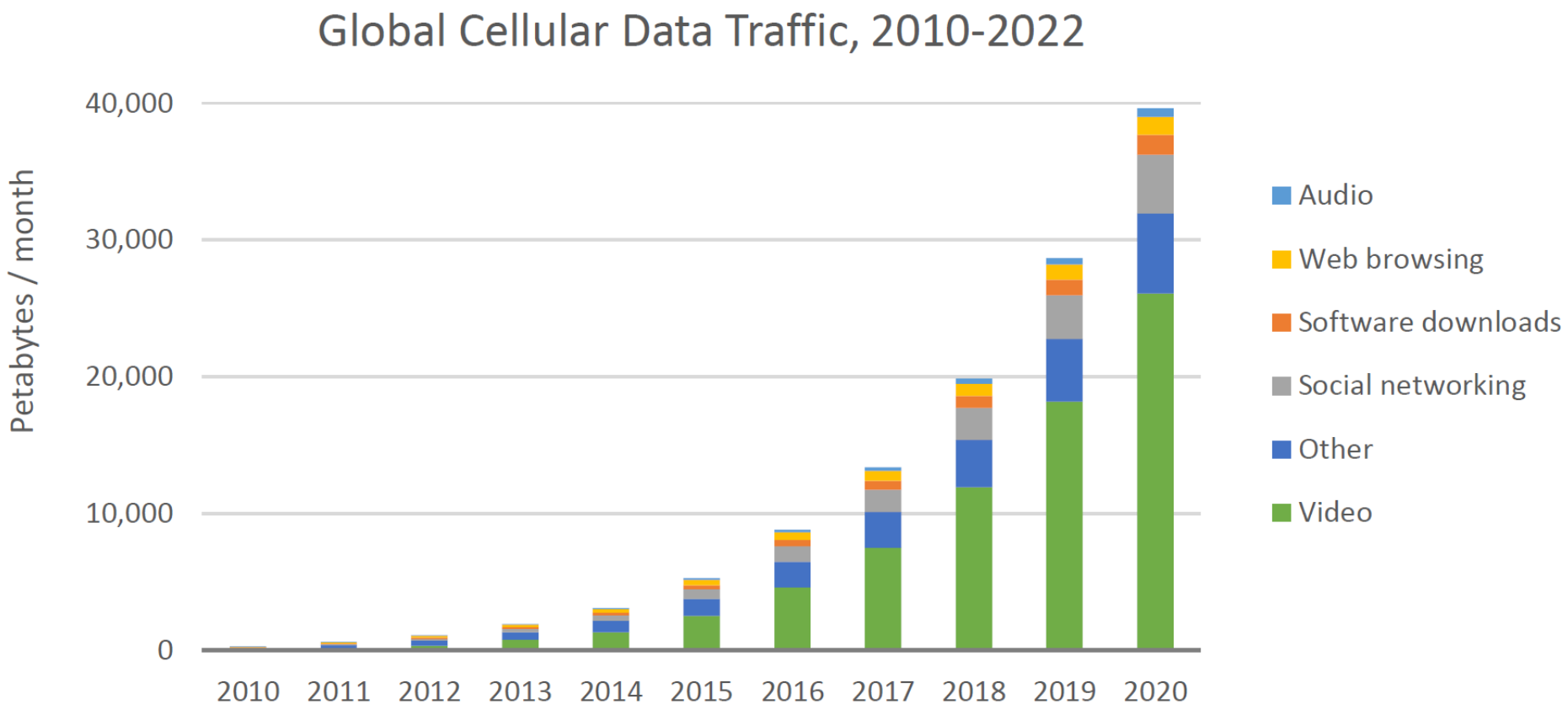
5G Challenges & Enablers



Everything you need to know about 5G (accordingly to IEEE)

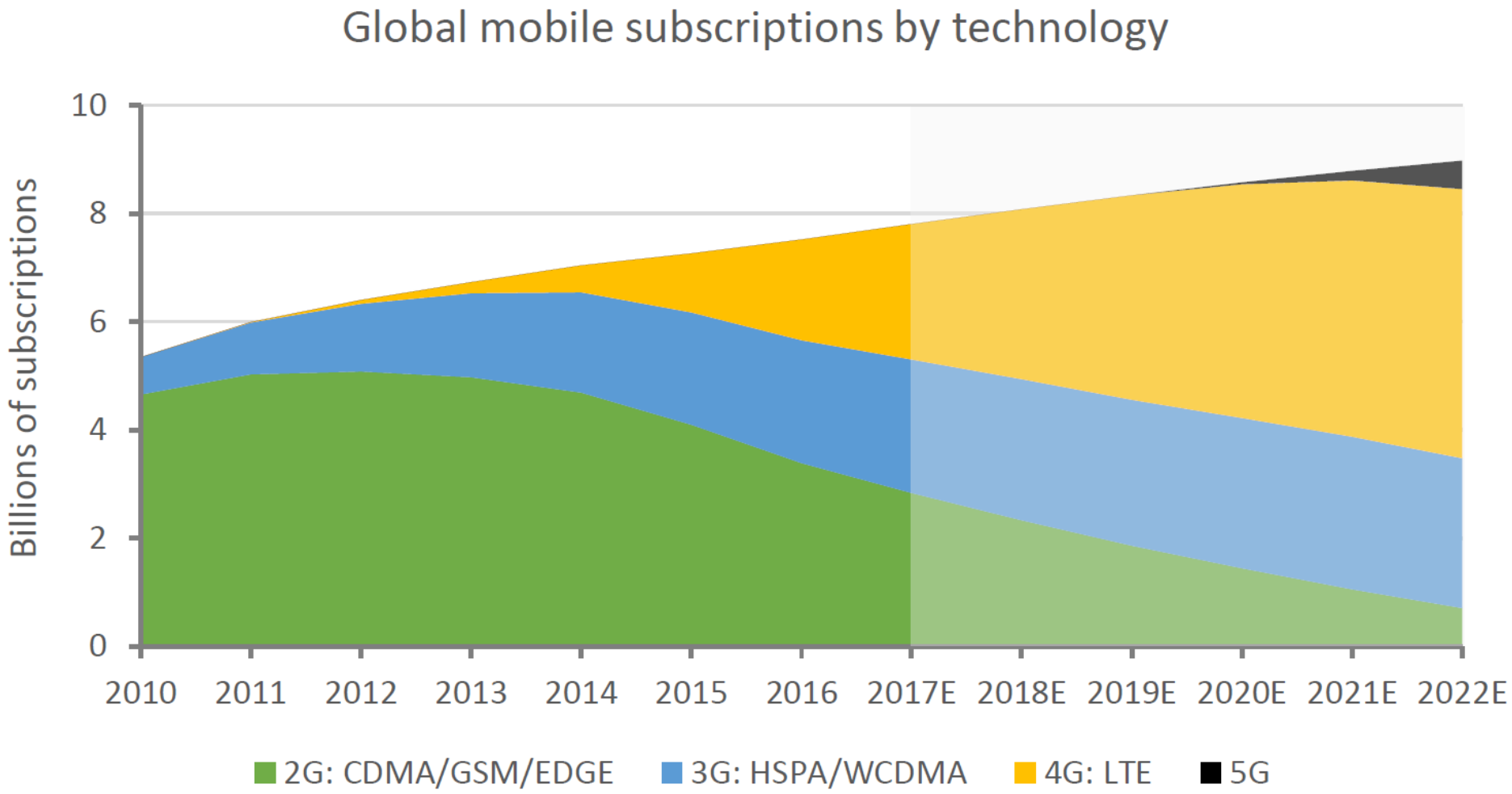
https://www.youtube.com/watch?v=GEx_d0SjvS0

Cellular Data Traffic



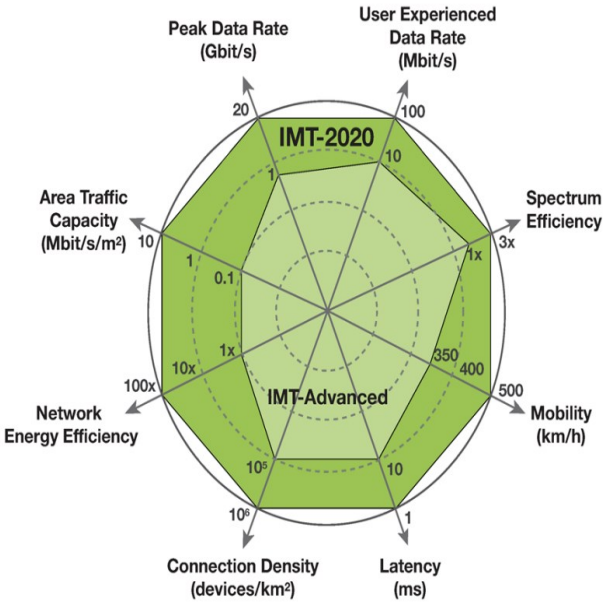
Ericsson Mobility Report

Mobile Subscriptions by Generation



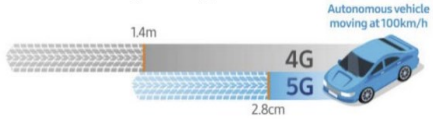
Ericsson Mobility Report

5G Use Cases & Requirements



[ITU-R document 5D/TEMP/625]

	Performance	Applications
eMBB Enhanced Mobile Broadband	• Peak Rate: 20Gbps (4G : 1Gbps) • UX Rate : 100~1000Mbps	• High definition (HD) videos • Virtual reality (VR) • Augmented reality (AR)
URLLC Ultra Reliable & Low Latency Communications	• Latency: 1ms (4G : 10ms)	• Remote robot control • Connected autonomous vehicles • Interactive gaming
mMTC Massive Machine-Type Communications	• Connection : 10^6 devices/km^2 ($4G : 10^5$ devices/km^2)	• Smart city • Smart agriculture



5G service & use cases – Nov 2017 – 5G America White Paper

5G Use Cases

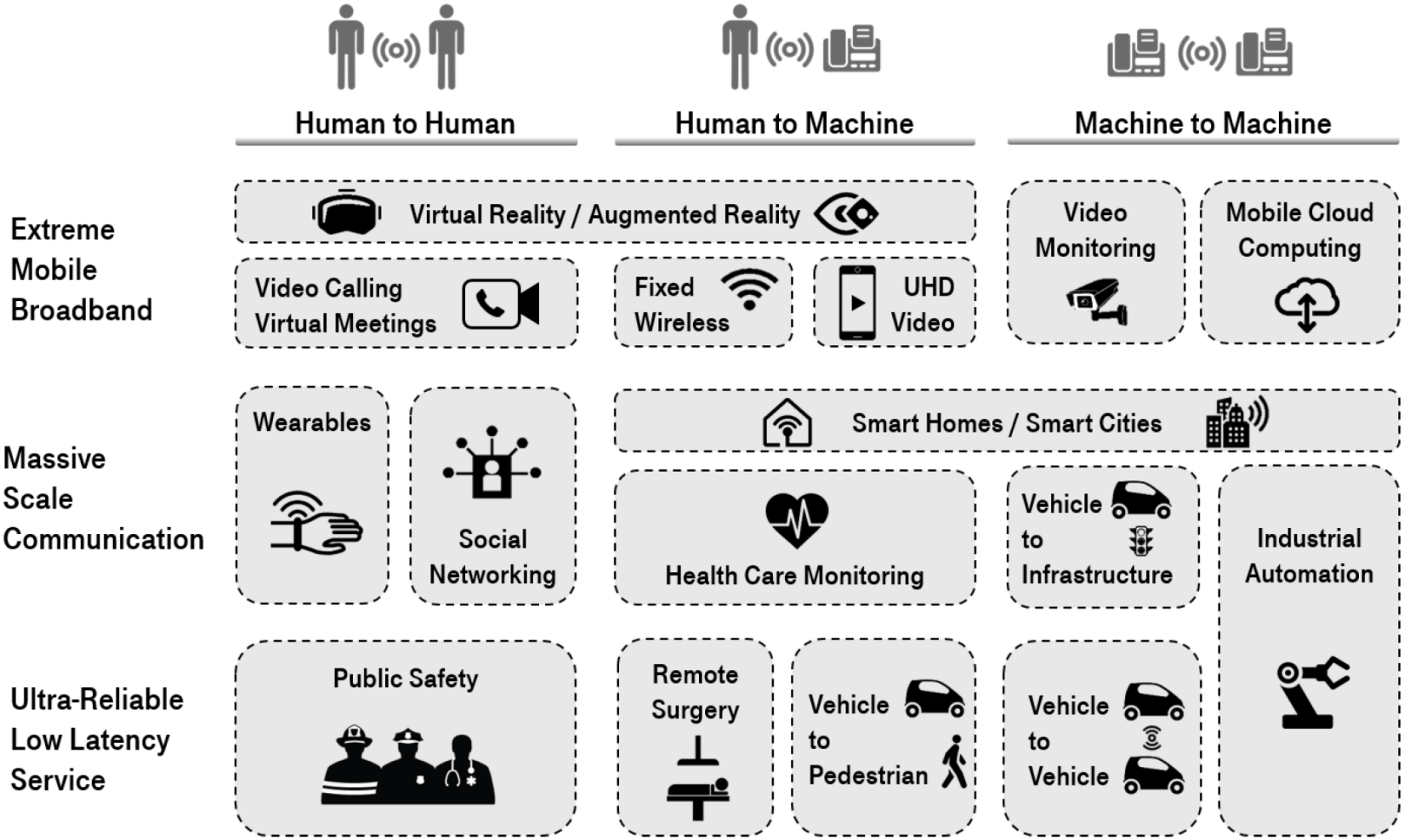


Figure 6. Some 5G Use Cases Grouped by the Type of Interaction and the Range of Performance Requirements.

5G service & use cases – Nov 2017 – 5G America White Paper

Use Case: 5G car connectivity V2V, V2X

https://www.youtube.com/watch?v=6Eho04iCMxw

Use Case: Robot Surgery, Tactile Internet

https://www.youtube.com/watch?v=L4nGXopLK8w

Use Case: The 4th Industrial Revolution (Industry 4.0)

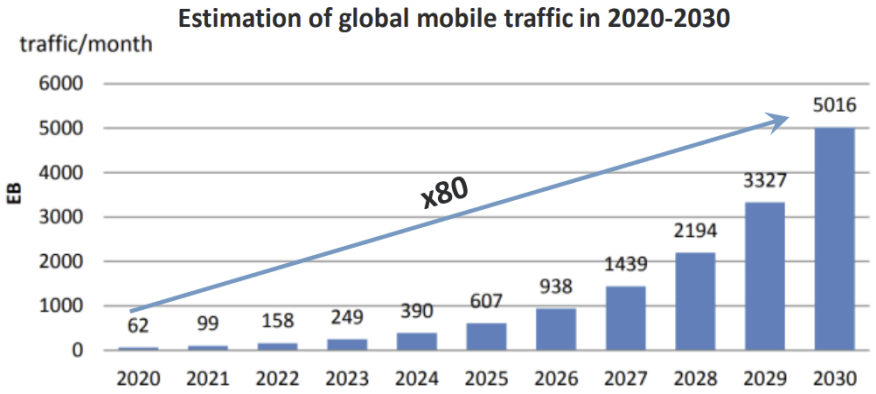
https://www.youtube.com/watch?v=bMaDhf0LKAY

Use Case: Automation of Everything

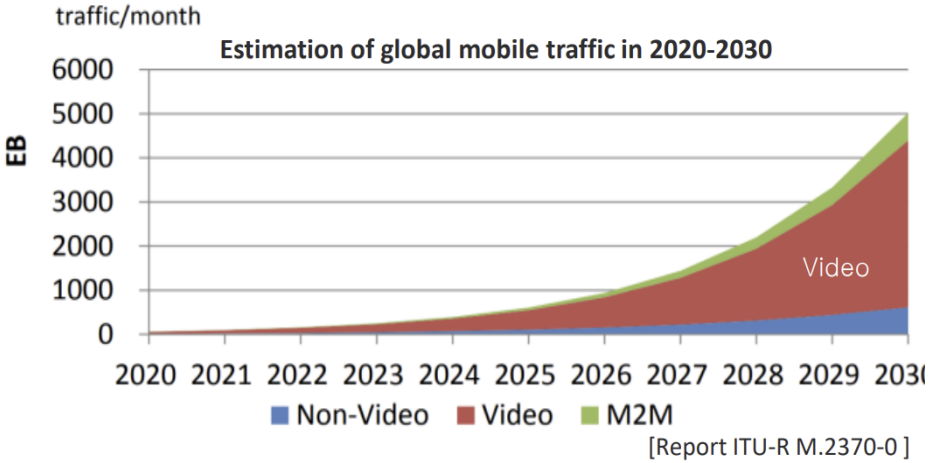
https://www.youtube.com/watch?v=nNIRV8Xr19A

Towards 6G: A Driver

x 80 Increase of Mobile Traffic



75% of Mobile Traffic: Video



[Report ITU-R M.2370-0]

Super-high-definition Video

64 K Digital Cinema
~ 256Gbps

61440×34560

1080i and 1080p
HDTV uncompressed:
10 bit@1920x1080@24fps
= 127MB/sec ~ 1Gbps

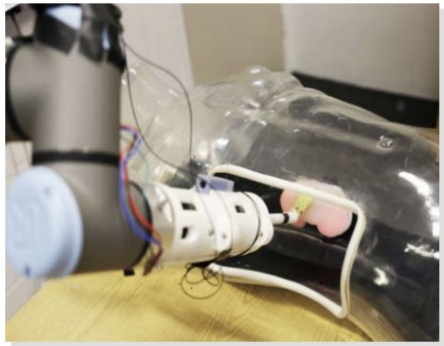
Super-immersive Multimedia

Towards 6G: A Driver

Zero Perceived Latency

Internet of Skill

3D scanning & transmission: 100 Tera-pixel/m^2 [Technical Gazette]



Everything Connected at 2030

[CISCO]

Super-Precision Positioning

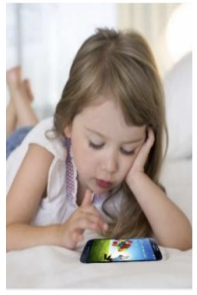
Commercial UAV

Ground robotics navigation

Lane-level navigation

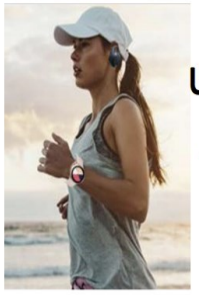
Industrial navigation and tracking

Heavy machine navigation



2010

Various Devices



2020

Ubiquitous Devices

2030

Digital Inclusion: Killer App for 6G

Wireless solutions are critical to sustainable development

Sustainability targets set by UN for 2030