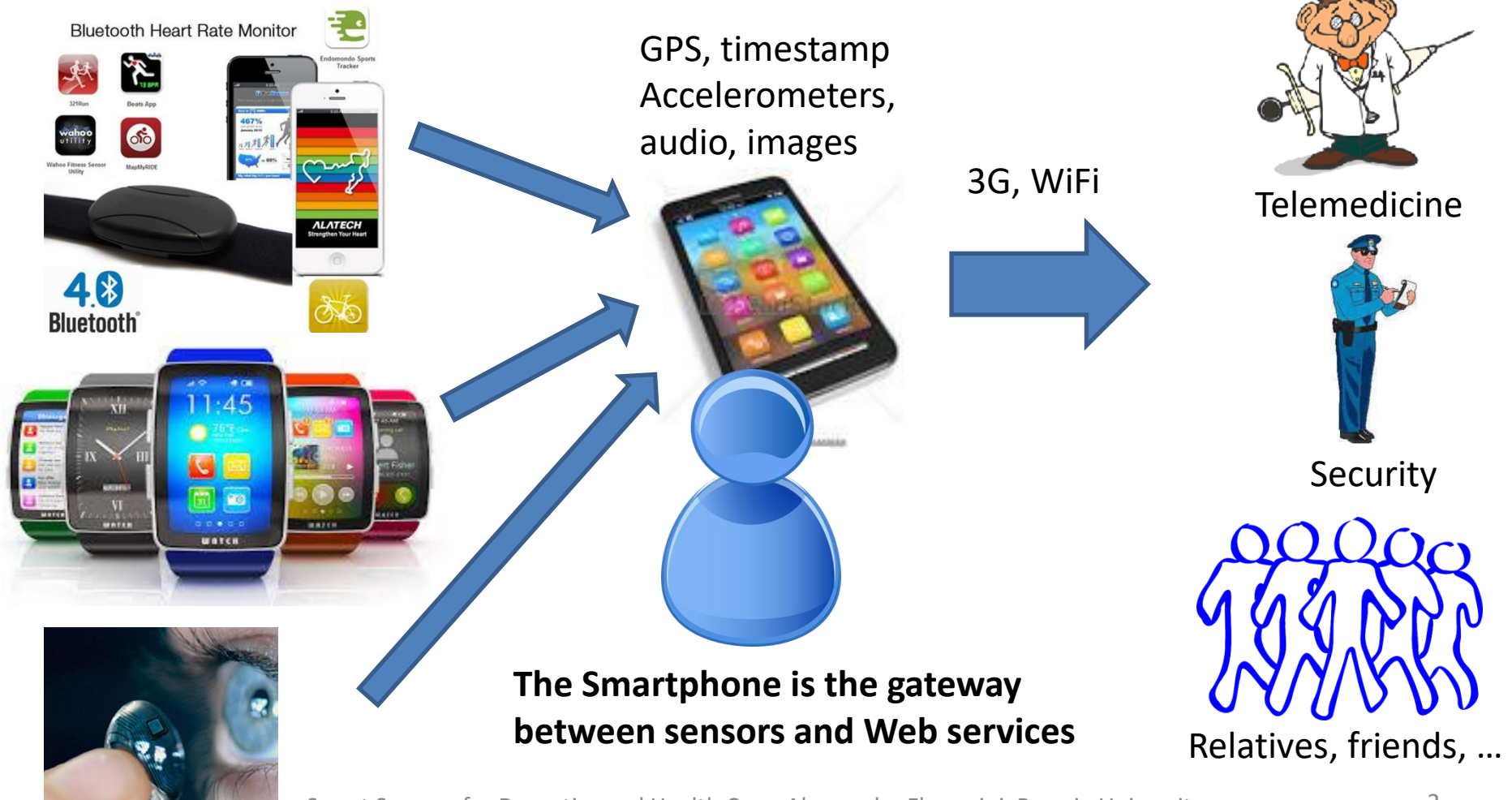# SMART SENSORS FOR DOMOTICS AND HEALTH CARE

- Wearable Smart Objects

A.A.   2018 / 2019

Alessandra Flammini
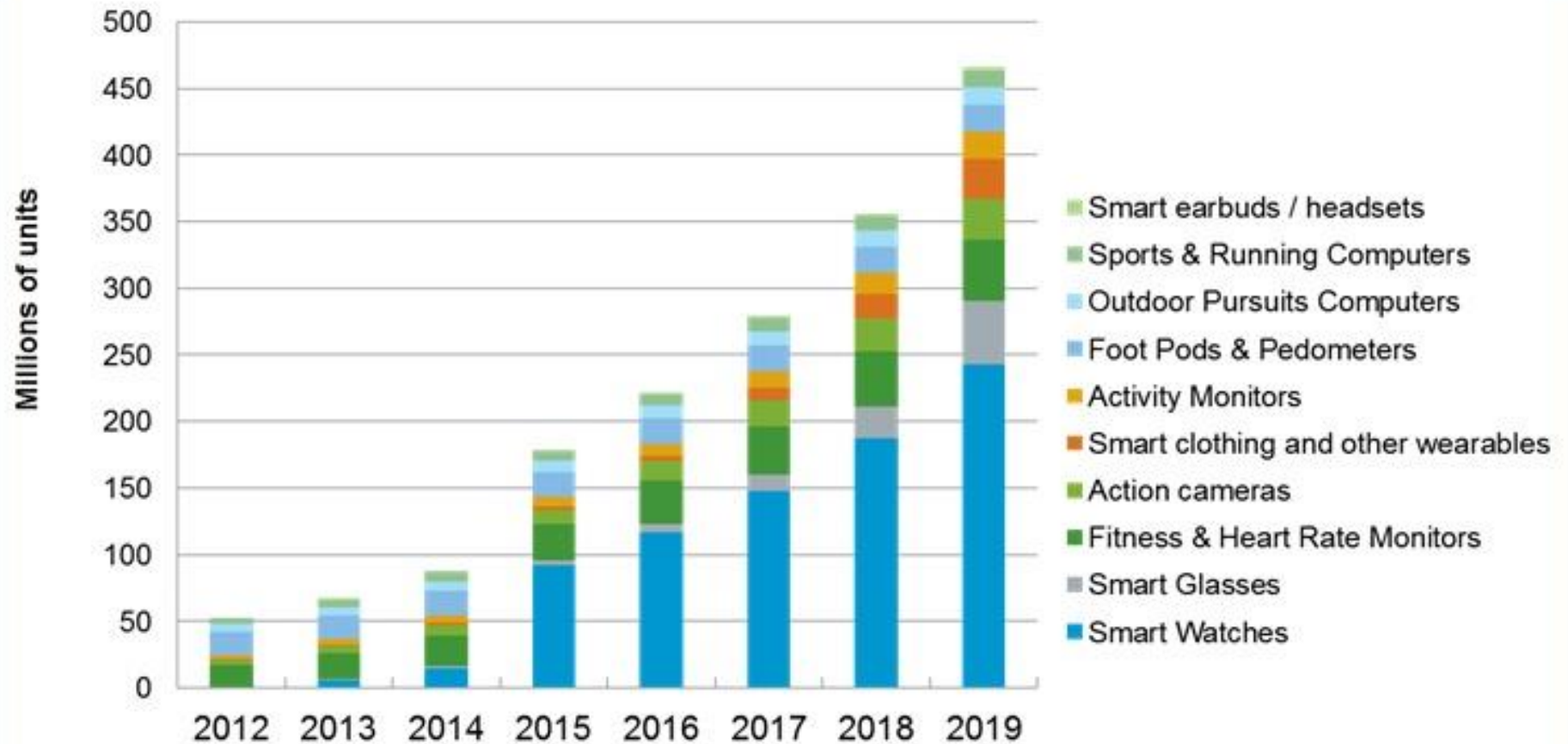
THE SMARTPHONE AS THE PERSONAL TUTOR

WEARABLE SENSORS OR THE SENSORS EMBEDDED IN THE SMARTPHONE CAN BE COMMUNICATED FOR SAFETY AND SECURITY

GPS, timestamp
Accelerometers,
audio, images

3G, WiFi

Telemedicine

Security

The Smartphone is the gateway between sensors and Web services

Relatives, friends, ...

WEARABLE SENSORS: A TREND

MEMS and sensor shipments for wearable device

Source: IHS MEMS & Sensors for wearables report - 2014   © 2014 IHS

WEARABLE DEVICE AND WEARABLE COMPUTERS

Wearable Objects

• A wearable object is:
- with sensors and/or actuators
- small and light
- battery powered
- easily wearable and removable (implantable objects are medical devices!)
- wireless connected (typ. to a Smartphone –BT- or to Internet –WiFi, GSM-)

• Wearable device means a non-programmable wearable object that must be managed by a computer (it cannot manage other peripherals)
- smart textile, exoskeleton
- cardio belt
- pedometer
- bracelet

• Wearable computers means a programmable wearable object that include computing and managing functions
- smart watch
- smart glasses
- smart lens

BRACELET, CARDIO BELT AND SMART SWATCH

- A bracelet (wearable device):   **ALL have battery problems!!!**
  - has an accelerometer
  - supposes that arm movements are a good indication of the body movements
  - need a Smartphone or a gateway to communicate (BT, low-power proprietary communication system), for computing and human interface

- A cardio belt (wearable device):
  - has two or more electrodes (textile)
  - furnishes a single lead ECG (ElectroCardioGram)
  - could have sensors (accelerometers) for posture and movement recognition
  - could have sensors for breath frequency measurement
  - need a Smartphone or a gateway to communicate (BT, low-power proprietary communication system) and for human interface

- A smartwatch (wearable computer):
  - has an Operative System and support BT and/or WiFi
  - can manage other devices (bracelet cardio belt,…)
  - have accelerometers and could have other sensors (camera, thermometer,..)
  - could have a PPG (PhotoPletismoGrafic) sensor for heart rate (poor)

VIRTUAL REALITY AND AUGMENTED REALITY

• **Virtual reality** is a computer-simulated reality with
sensory experiences (sight, hearing, touch, smell)
- – education and training
- – games (from pinball to complex headset)
- – exposure therapy (phobia)

• **Augmented reality** means a living view of reality with real-time added
information (video, audio,…)
- – Sports (soccer, arbiter plus computer vision and ball recognition)
- – Military (real-time information about the place and potential dangers)
- – games (Wii, real-time movement recognition by Kinect)
- – education (interactive whiteboard)
- – Smart Glasses

SMART GLASSES (e.g. Google glasses)

Smart Glasses
• Glasses with augmented reality
- optical head-mounted display
- internet connection (or Bluetooth to a connected Smartphone)
- "hands free" functions of smartphone
- simple Input interface (touchpad or buttons, voice, eye tracking, camera for gesture recognition, sensors, touchscreen of the Smartphone)
- could include sensors (PPG, GPS, ligth,...)
- could include activity tracker (accelerometers and computing)
- could include a camera (tag recognition –easy- object recognition –difficult-)
- could have an Operative System
- could be used in healthcare applications (blind, see&talk)
- have privacy concerns
- have battery limits and could be annoying

WEARABLE SMART OBJECTS: tests

Tests

1) The gateway function of the Smartphone implies… [b]:
a. Computing   b. Communications   c. Sensors   d. Human interface

2) A generic cardio belt (not a specific brand) can manage …. [d]
a. a bracelet   b. a pedometer   c. a smart watch   d. no other devices

3) A … can be programmed with one or several Apps [c]
a. bracelet   b. pedometer   c. smart watch   d. cardio belt

4) A… is a device with augmented reality [a]
a. smart glasses   b. smart watch   c. PC   d. Kaleidoscope

5) Smart Watch … [d]
a. Is a device with virtual reality   b. Allows ECG sensing (single lead only)
c. Is a valid help for the blind   d. has an Operative System

SMART SENSORS FOR DOMOTICS AND HEALTH CARE

- Internet of Things

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INTERNET OF THINGS (1999)

Things with internet connectivity,
- easy, thanks to low cost electronic devices (WiFi, BT with a Smartphone as the gateway)

Things with a database in "cloud"
- quite easy, thanks to low-cost open cloud technologies (google drive, dropbox)

Things communicating each other (M2M, machine to machine communications)
- quite difficult. Two approaches: standard protocols, Application in cloud (new)

Adding a new "thing" in a transparent way (without programming)
- Difficult, especially in a multi-vendor, multi-devices, multi-standard scenario

- • An example: Camera with Eye-Fi
- Enable WiFi connection or gateway (e.g. Smartphone)
- Photos are directly sent in cloud
- Possibility of instantaneous photo exchange between two cameras
- Suitable applications allow to publish photo in Instagram or Facebook

INTERNET OF THINGS AND SMART CITIES

New services for citizens are for digital natives

• Internet is in the streets and in public spaces

• a lot of available information… for who is able to recover it

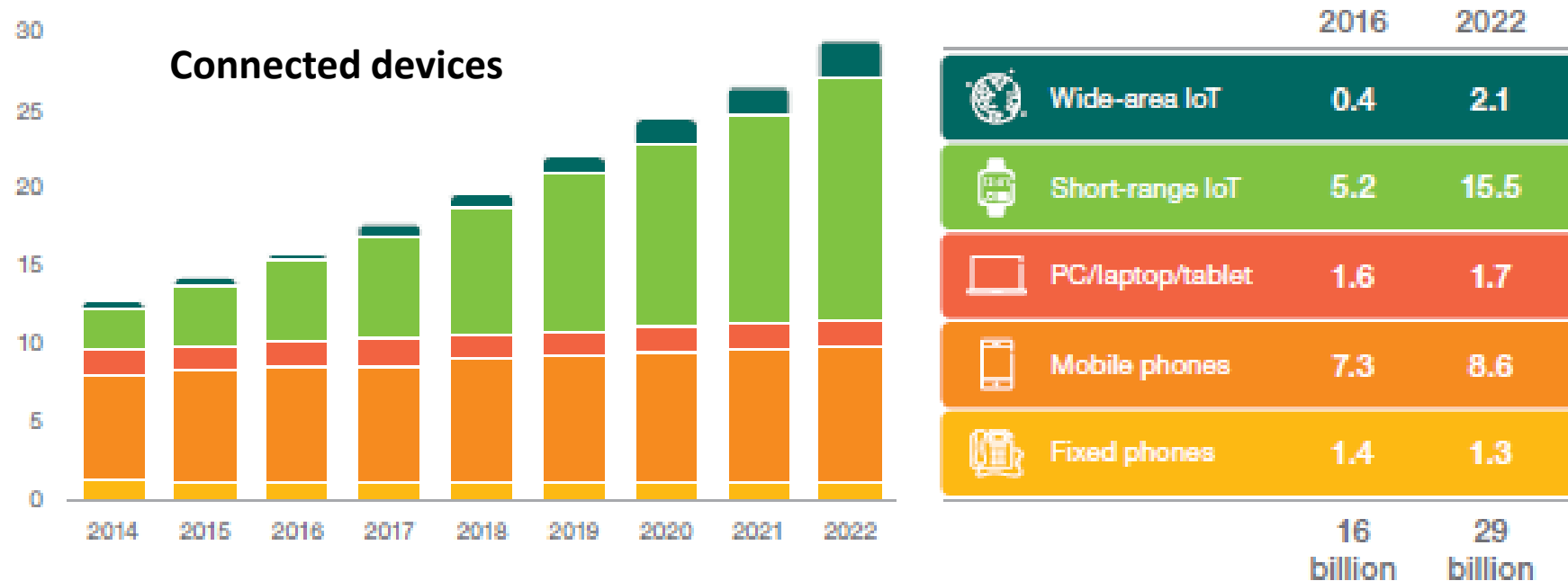• Internet technology is cost-saving (posters with respect to NFC or QR)

INTERNET OF THINGS IN THE WORLD

Data from Ericsson Mobility Report 2017

- 7,6 billions of SIM (since 1991, 2G). 7,5 billions of humans (worldometers 2017)
- 3,9 billions of smartphones (growing number), 4,4 billions of cellular phones

Data from STATISTA, the statistical portal 2017

- 2 billions of Facebook users at month in the world
- 21 millions of Facebook user at month in Italy (about 60 millions of persons)

Connected devices

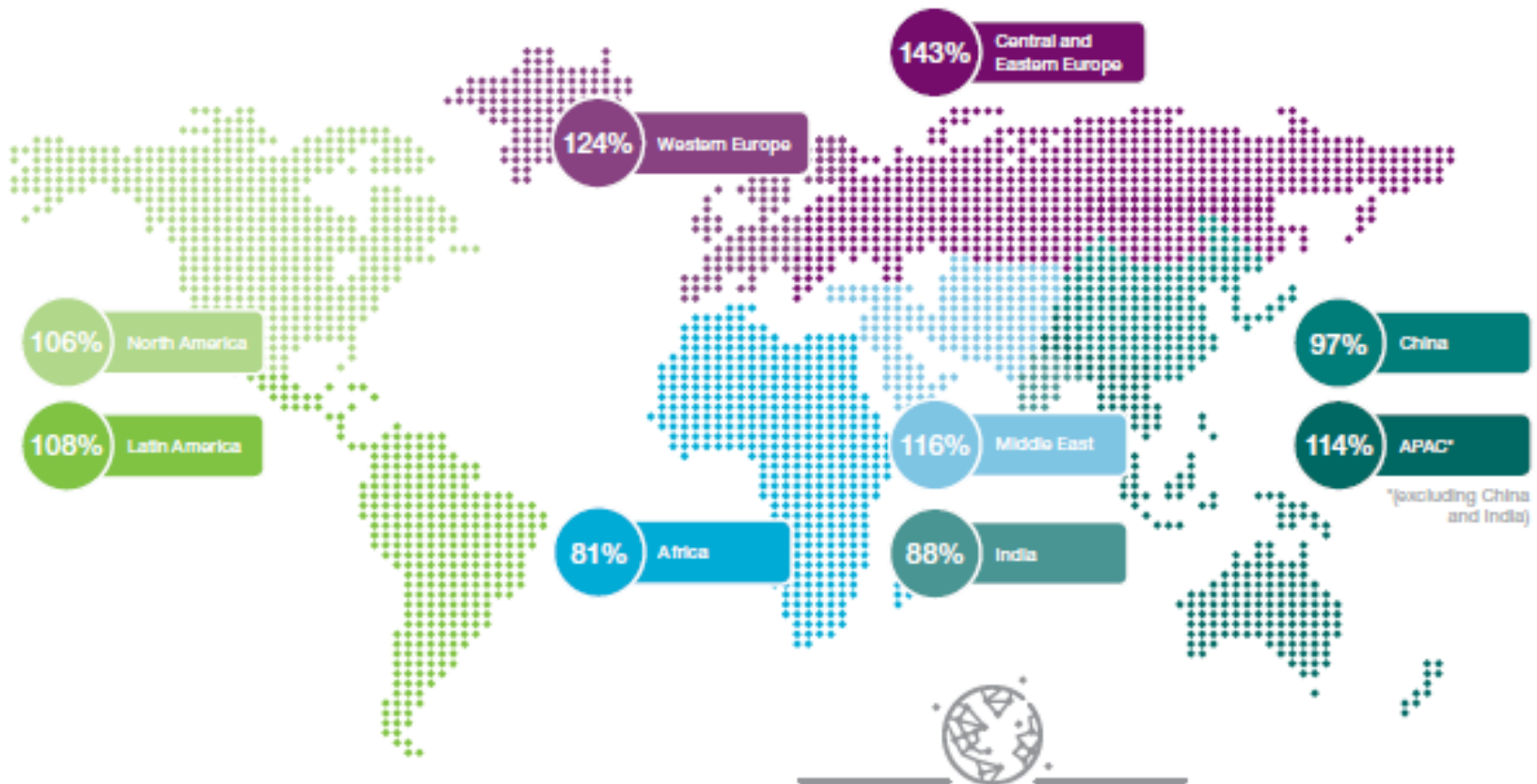|	2016	2022
Wide-area IoT	0.4	2.1
Short-range IoT	5.2	15.5
PC/laptop/tablet	1.6	1.7
Mobile phones	7.3	8.6
Fixed phones	1.4	1.3
	16 billion	29 billion

MOBILE SUBSCRIPTION (Ericsson mobility report, june 2017)

The number of mobile subscriptions exceeds the population in many countries, which is largely due to inactive subscriptions, multiple device ownership or optimization of subscriptions for different types of calls. As a result, the number of subscribers is lower than the number of subscriptions. Today, there are around 5.2 billion subscribers globally compared to 7.6 billion subscriptions.

5.2 BILLION subscribers

- 143% Central and Eastern Europe
- 124% Western Europe
- 106% North America
- 108% Latin America
- 81% Africa
- 116% Middle East
- 88% India
- 97% China
- 114% APAC* *(excluding China and India)

INTERNET OF THINGS

Many application fields

• energy and resource metering
  – many meters, even from different vendors, form a reconfigurable network for billing. New node can be added. No real-time, easy, available now

• smart grids
  – energy distribution, from primary substation down to secondary and users, together with renewable plants and energy storage systems is a real-time network (protections, management of energy flows). Next future

• intelligent transportation
  – infrastructure interact in real-time with vehicles and vehicles interact each other in order to minimize accidents and slow-down. Difficult, privacy and responsibility concerns. Future

• smart buildings & buildings automation (energy, thermal)
  – elevators cooperate each other and with lighting and thermal management, to keep constant and low the energy consumption; quite difficult, now managed by a Central Controller. Next future

• ambient assisted living

AMBIENT ASSISTED LIVING

Peoples with disabilities

• strong and well-tailored home automation, not exactly internet of things, to reduce hospitalization and increase the quality of life:

- many remotely controlled devices and structures
- intelligent doors and windows
- real-time monitoring systems (e.g. cameras, medical devices), telemedicine
- robots and exoskeletons
- costly and strongly personalized systems, ad hoc programmed, available now
- next "IoT" example: a medical device indicates an increase of sugar in blood and a future smart coffee machine reduces the sugar dosage in the coffee

Normal people, ambient assisted living is IoT at home

• Now: practically no-home automation (few remote control, some automation for security).

• Next Future: smart automation for energy saving (appliances cooperate each other not to overcome the fare limit (e.g. 3kW); difficult, now managed by a Central Controller. Next future: each appliance interact with its own cloud, a home descriptor allow a general management of energy sources and loads)

IoT at home

Normal people, ambient assisted living is IoT at home
- Some "smart" devices are appearing, but M2M is still far:
    - refrigerator knowing the content and relate expiry date and suggesting shopping or suitable recipes
    - television learning our preference and signaling events (social, web)
    - smart scales with body and health monitoring
    - cleaning robots learning paths and avoiding obstacles
    - smart heating and refrigerating systems with control of the indoor air quality
    - smart cameras for baby protecting

- Future scenarios:
    - a home that recognize your health and adapt itself to your needs
    - a home that changes behavior according to the inhabitants in that room in order to increase their quality of life

- Limits:
    - cost with respect to real needs and benefits (just for rich people)
    - privacy and security (e.g. sniffer for obd2 connector mandatory for car)

IoT at home: smart refrigerator

Smart refrigerator (2000, LG Internet Digital DIOS)

• A refrigerator recognizing and tracking its content, also managing purchase and interacting with other appliances

• a smart refrigerator has a local Human Machine Interface (HMI) and Apps

• a smart refrigerator knows what is inside because:
  – the user communicates (by local HMI or by App) what is putting inside and what is taking
  – the user passes the barcode (camera, food recognition) or RFID
  – it has sensors to recognize and weigh food (load cells)
  – the user puts food in identified and sensorized shelves and trays and containers
  – it manages purchases

• A smart refrigerator can also manage information about the state of food and the expiry date:
  – if the user communicates these information
  – if it has sensors (cameras, gas sensors, RFID)

• A smart refrigerator can suggest food:
  – according to a diet prescription and to available food

IoT at home: smart scale

Smart scale (2009, Withings WiFi Body Scale)

• A scale recognizing the user and communicating weight, BMI (Body Mass Index, weight divided by height squared), fat mass and other indicators to cloud for tracking, recording and applications. It can be configured (e.g. height)

• some complex smart scales can be considered as medical devices, tracking:
- Dual Frequency BIA (Bioelectrical impedance analysis)
- bone mass, visceral fat, muscle mass, BMI, weigh
- basal metabolic rate (BMR - the amount of energy you expend each day when at rest), heart rate
- other (e.g. weather, air quality)

• a smart scale can be connected to:
- smart refrigerator to purchase the right food
- activity tracker to adjust prescription
- climate controller for indoor optimal setting
- many Apps concerning diet and activity

• A smart scale normally:
- does not measure the height (setting)
- recognizes the user mainly by the weight

INTERNET OF THINGS: tests

Tests

1) …. is a typical communication of Internet of Things [d]

a. USB   b. Bluetooth   c. GSM   d. M2M

2) Internet of things is available now in the field of… [a]

a. Energy and resource metering   b. intelligent transportation

c. Smart Grids   d. smart buildings & buildings autom.

3) A smart scale with internet connection and health monitoring functions…. [c]

a. Is a IoT device in the metering field
b. Is a IoT device in the smart building & buildings automation field
c. Is a IoT device in the ambient assisted living field
d. Is not a IoT device because it is not certified as medical device

4) A smart scale normally recognize the user by… [d]

a. BMI   b. the height   c. the impedance   d. the weight