Pervasive Computing

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Purpose of this lecture

Show that:

- pervasive computing is an evolution of computing towards more services
- It is the consequence of constant progress in wireless networks, computing power, miniaturization, storage capacity and social acceptance
- pervasive computing raises huge expectations in a number of domains and can bring great benefits
- software is key

Structure of this lecture

Computing evolution

Pervasive computing

Enablers

Pervasive computing today

The future of pervasive computing

Challenges and conclusion

Computing industry – 10-year cycles

80's **Hardware / process optimization**

IBM

IBM RECEIVED 3 NOBEL PRIZES IN PHYSICS (1973, 1986, 1987)

70's

Computing industry – 10-year cycles

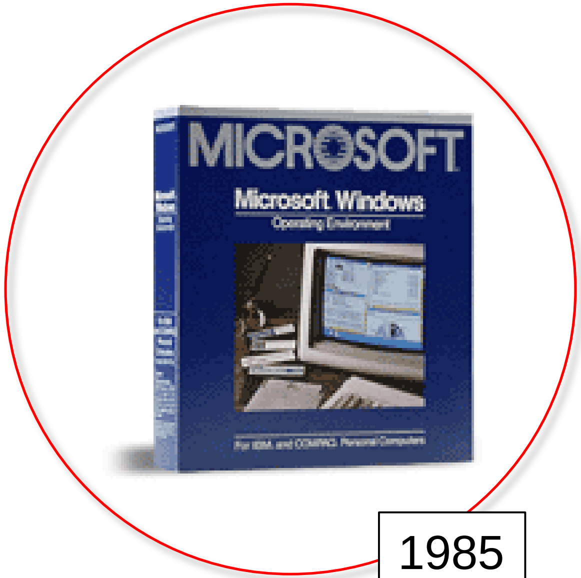
80's **Hardware / process optimization**

IBM

90's **Software / productivity**

Microsoft

THE ORIGINAL NAME OF MICROSOFT WAS "MICRO-SOFT"



1985

Computing industry – 10-year cycles

80's **Hardware / process optimization**

IBM

90's **Software / productivity**

Microsoft

00's **Web / information retrieval**

Google

GOOGLE HAS AN INDEX
WITH MORE THAN
3 BILLION WEBSITES

1996

Computing industry – 10-year cycles

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Microsoft

00's **Web / information retrieval**

Google

10's **Mobile / App store**

Apple

IN THE FIRST 12 MONTHS 65000 APPS WERE ADDED TO THE APP STORE

2008

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Google

10's **Mobile / App store**

Apple

20's **Pervasive computing / ???**

GOOGLE PURCHASED NEST FOR $3.2 BILLIONS

2018

A clear trend

Better support to

- perform repetitive tasks
- access information
- provide added-value services

Smarter interaction

- natural interfaces
- reduce cognitive overload

Example 1

“I am going home from my office at usual hours”

My mobile pops up and suggests me to take an alternative road because of an accident.

“You should avoid the ring and go through town.”

Example 2

"I am in a restaurant in Tokyo. There is no English menu"

My mobile downloads and launches the Yomiwa app.
It suggests me to use it to translate the menu.

"I launched Yomiwa for you.
You should try. It works well!"

Example 3

“I am going back to Paris. My connection is late”

My mobile is aware that I could not sleep in the plane and reserve a massage at the airport.

“I made a reservation for you at the Spa, terminal 2A”

Expectations

Information and services should

appear/be launched when I need them

take into account my preferences, emotions, behavior

communicate with me in a natural way

don’t annoy me

disappear when I don’t need them anymore

Requirements

To do so, future software applications have to

1 – Capture contextual information

about you (where you are, what you do, your emotions)

about the environment

about the computing resources available

2 – Determine what to do

Provide Information and/or services

Store data for future use

3 – Communicate through natural interfaces

no interaction with "computers as computers"

avoid cognitive overload

Pervasive computing

Pervasive computing is a step in that direction

This technology

- was envisioned a few decades ago (Weiser – Xerox)
- has already a prominent place in our live
- will be everywhere in a near future

Other names: ubiquitous computing, Internet of Things, ...

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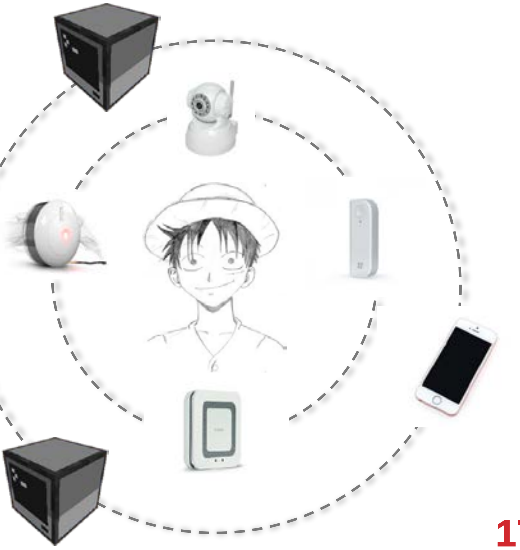
Challenges and conclusion

Pervasive computing

Pervasive computing promotes the integration of smart, networked devices in our living environments in order to provide us services.

Those services

- are context aware
- require minimal and natural interaction
- bring real added value
- are easy to administrate by end-users



Smart devices

Tiny devices in our environment

integrated into everyday objects

capable of sensing the environment and acting upon it

mostly invisible

Medium-size computers that we can use

mobile phones, laptops, etc.

extended with convenient interfaces

Big computers in data centers

in dedicated areas

Smart, networked devices

All these computers must communicate and collaborate

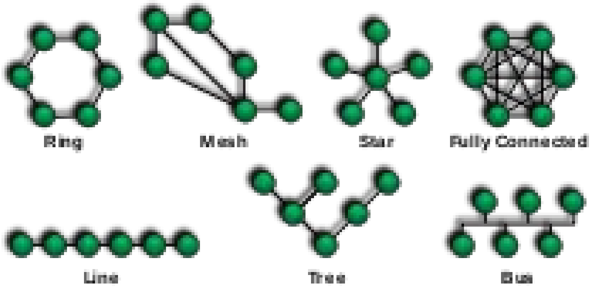
pervasive computing relies on a myriad of networked elements

Networks are heterogeneous and inter-connected

different transmission media (wired or wireless)

different topologies (bus, star, ring, fully connected)

different scale (local, home, city, world)



Context-awareness

Pervasive systems are context-aware by nature

- it refers to the ability to gather information about its environment at any given time and **adapt** behaviors accordingly

Very challenging in practice. Pervasive system have to decide

- what to gather
- when to gather
- how to adapt

Impact is essentially at the software level

- lot of research needed

Added-value services

Services must make sense and provide value

complex or simple

based on small or large scale architecture

the trend is to go towards complex architecture

Invisible

Internet of objects

devices should be blended in our living environment

devices and services should not require advanced administration from users

Mark Weiser's quote

"the most profound technologies are those that disappear. They weave themselves in the fabric of everyday life until they are undistinguishable from it"

Natural interaction

Pervasive computing is inspired by desktop applications

- Use of the most advanced desktop means of interaction
- Speech, gesture, writing
- virtual reality

Summary

Pervasive computing is all about providing relevant SERVICES to human anywhere, anytime.

Core properties of pervasive systems

- based on networked computing and storage facilities
- everywhere but invisible
- natural interaction with people (when needed)
- context-aware
- minimum administration

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Why today?

Constant technological progress

- Processing
- Networking
- Data Centers
- Software engineering
- AI rebirth

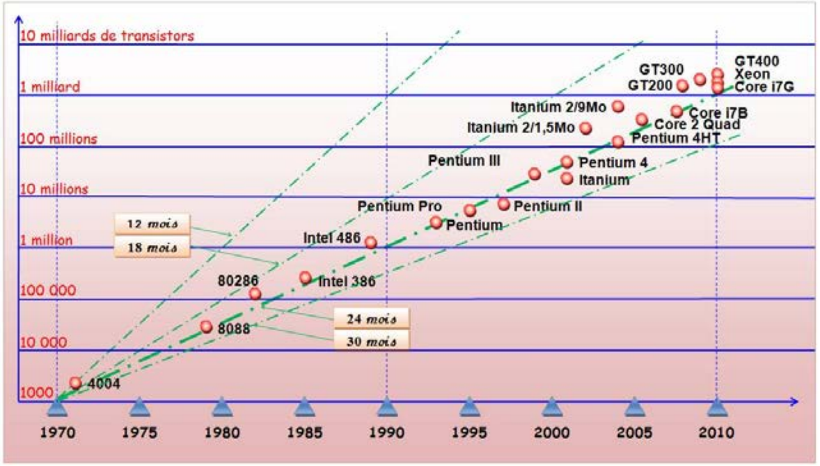
Social acceptance

- Mobile, Web and robotics entered general public
- Public perception may even be ahead of technology
- Most people not concerned by privacy issues

Processing: Cheaper, smaller, faster

Since 1975, the number of transistors in a dense integrated circuit has doubled approximately every two years.

Moore's law is still valid (but will end eventually – 10 more years is the most common prediction)



Allows the creation of affordable communication-enabled devices, powerful mobile devices and also ultra-powerful computers.

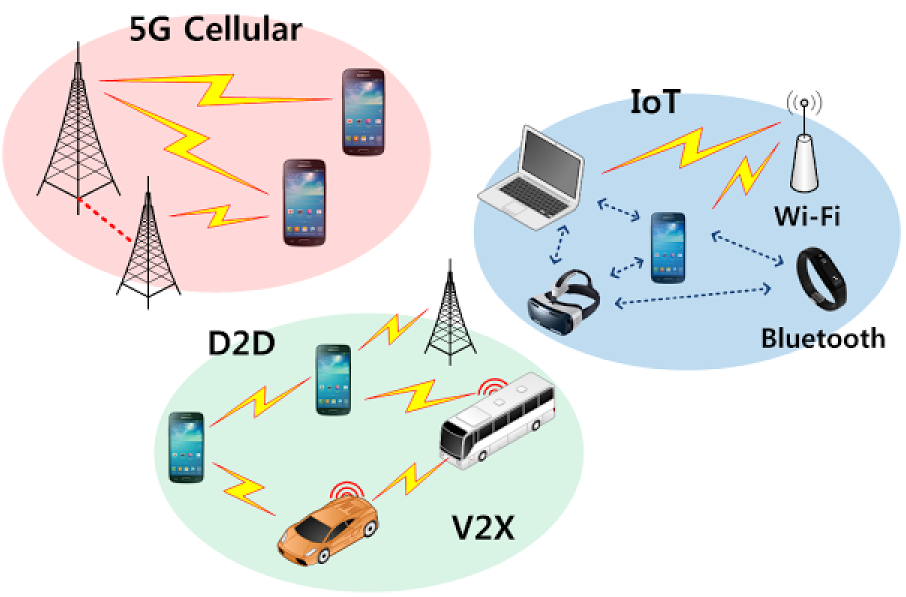
Networking: Cheaper, faster, all-terrain

Networks allow increased connectivity between devices, computers

Fiber – the number of bits/second increases exponentially

5G - 100 times faster than 4G

local networks - Wi-Fi, Bluethooth, Zwave, Lora, ind. Ethernet, ...



Here, standards play an important role

Data centers: bigger, cheaper, more energy-efficient

Huge data centers are available to house computing and storage

fast Internet connectivity

non stop operation (deployment, computing, etc.)

mass-storage

still energy-consuming (eat up as much electricity as small towns)

Allows the storage of large amount of data and quick calculations

Software engineering : more flexible

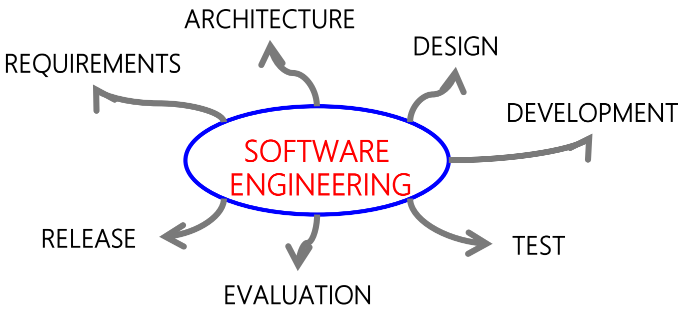
1968: Creation of the Software Engineering field

- 50 years of continuous improvements (and failures!)
- Software complexity, size, instability continue to grow too

Modern techniques and processes are being developed :

- Component-based software engineering
- Service-oriented computing
- Autonomic computing
- Agility and continuous integration

Allows flexible, self-managed software systems.

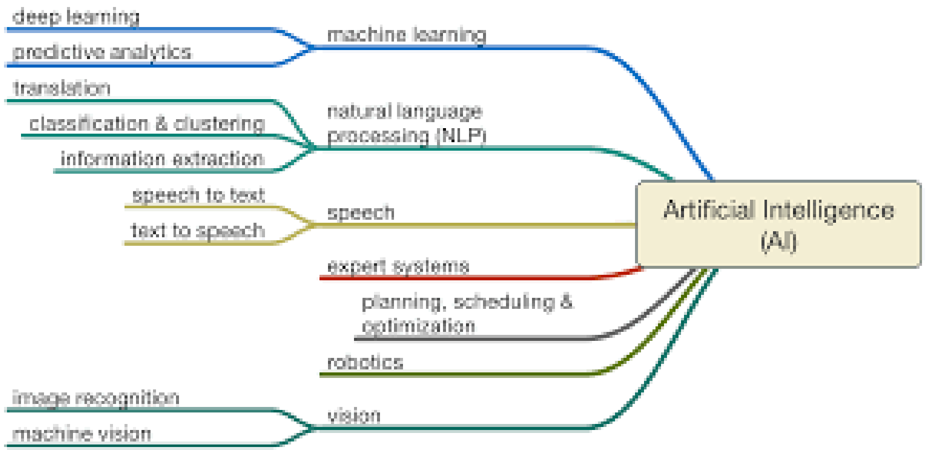


AI rebirth

20 years ago, Artificial Intelligence was dead

In the last few years, AI has been re-discovered

- Focus on smart algorithms, not on human imitation
- Natural language (Siri, Google Now, Cortana, Viv, ...)
- Vision
- Machine Learning
- Expert systems



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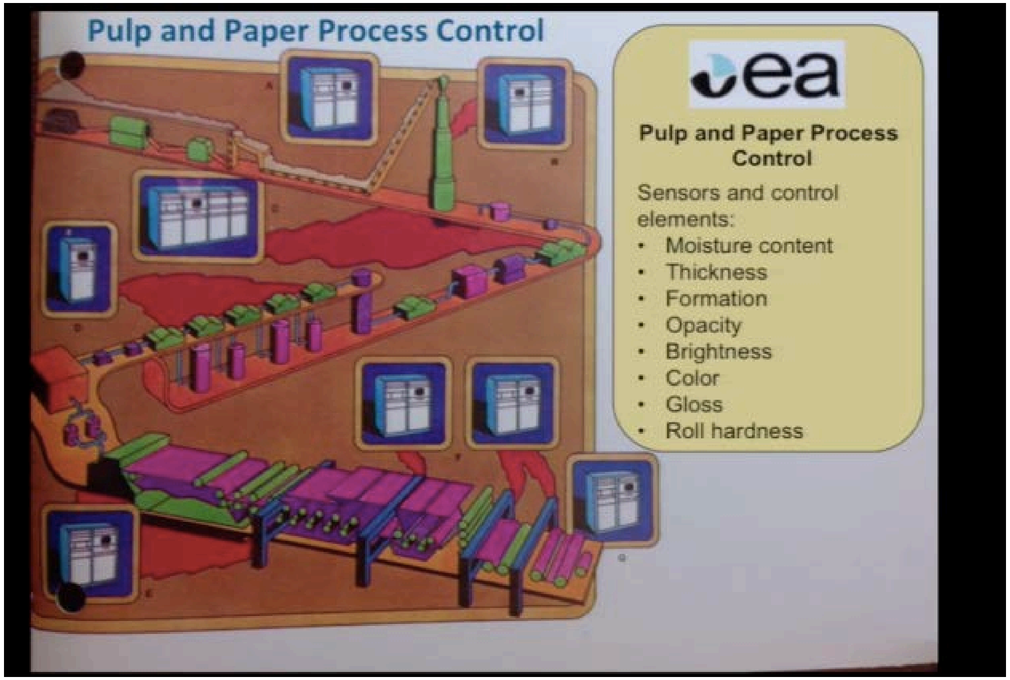
Pre-pervasive era

The idea of pervasive applications emerged in the manufacturing industry

use of sensors to control and monitor process

very limited connection with IT

Ex: paper industry



Pervasive today

Many sensor based applications

- GPS applications
- GSM applications
- RFID applications

Mobile based application

- extremely popular
- advanced results

Emergence of smart spaces

GPS trackers

Device using the *Global Positioning System* to determine and track their location (stored in the device or sent to a computer)

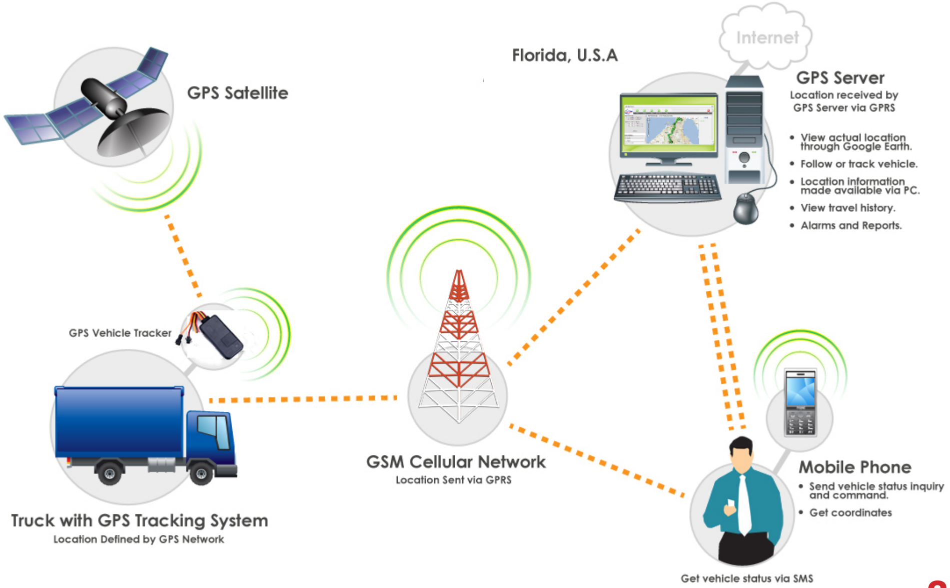
cameras (time and location)

commercial fleets

race tracking

adventure sports

animal tracking

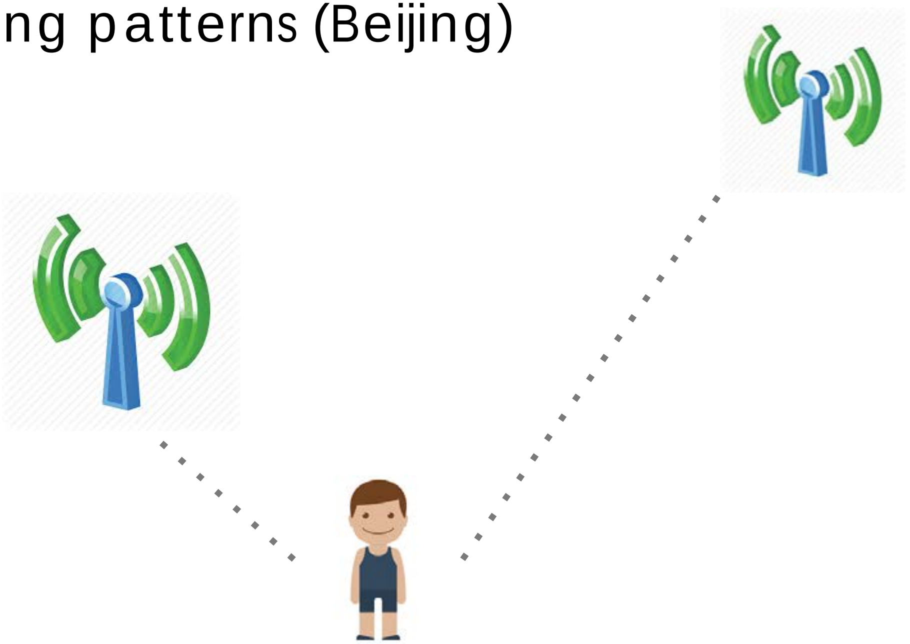


GSM trackers

The Global System for Mobile communication (GSM) signals allow to determine the location of a phone and its user

- power of the signal
- triangulation if several antennas are reachable
- less accurate than GPS
- Used to track commuting patterns (Beijing)

Extended with maps information (semantics)



RFID applications

Billions of active RFID chips in the world

in wine boxes – to ensure quality preservation during transport

in shoes – to track you and connect with friends

in clothes – to support stock management

in passports – to communicate your information and photo

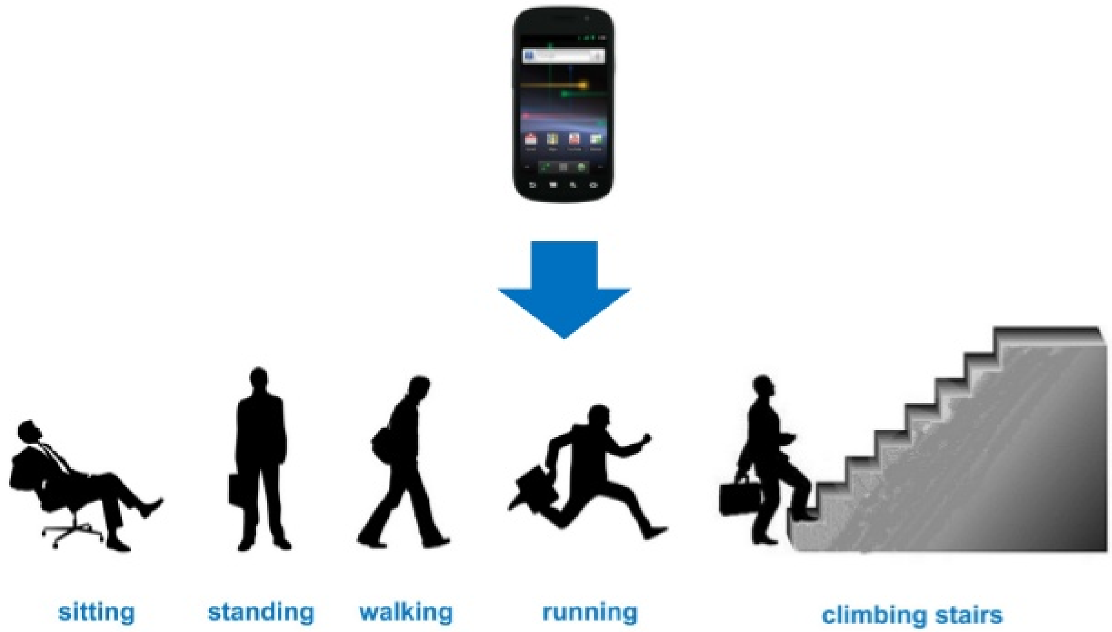
badges – to enter buildings

Smart phone applications

Smart phones includes many sensors

- Accelerometer
- Gyroscope
- Magnetometer (compass)
- Light detector
- Proximity sensor
- Pedometer
- Heart rate
- Fingerprints

APPLE REACHED A BILLION PHONES IN NOV. 2014



Conclusion about current applications

These are the first pervasive applications in the market

They provide rich, added-value services but

- sensors are specific and dedicated
- sensors are not shared
- All available sensors are not used
- hard to extend

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Smart environments

Uniting physical and computing environments with the intention of providing more services

- Creation of “homogeneous” places
- Collaborating devices
- collaborating applications

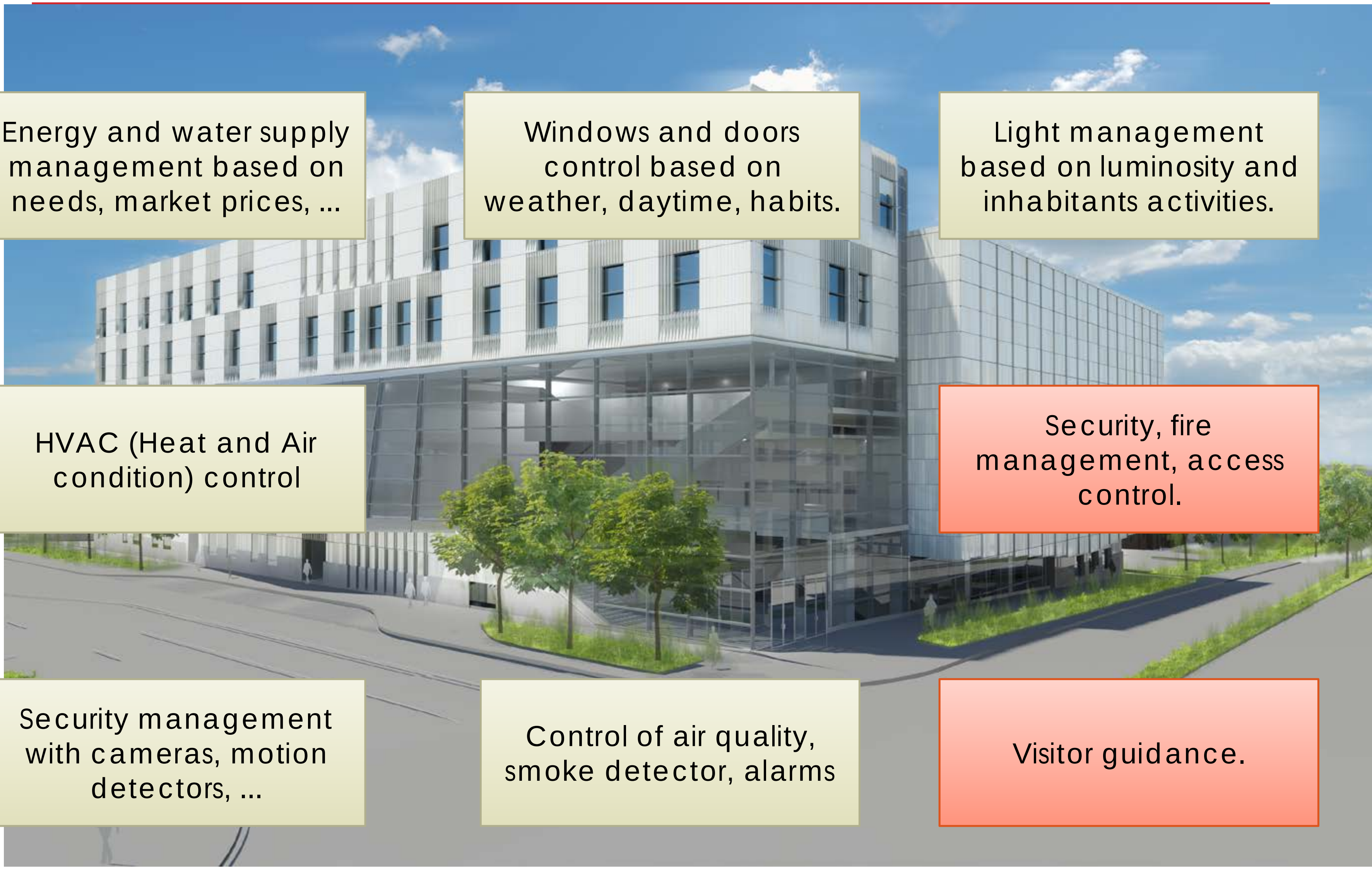
IT IS ALL ABOUT COHERENT SERVICES

Smart meeting room

Smart home

- Energy and water supply management based on needs, market prices, …
- Windows and doors control based on weather, daytime, habits.
- Light management based on luminosity and inhabitants activities.
- HVAC (Heat and Air condition) control
- Health applications: fall detection, activity, number of steps
- Security management with cameras, motion detectors, …
- Control of air quality, smoke detector, alarms
- Purchase of missing or broken item or food

Smart building



Smart city

Smart Energy

Smart Transport

Smart Buildings

Smart Water

Smart Care

Smart city: combination of vertical solutions

Smart Care

- Smart Houses
- Sound monitoring
- Electromagnetism monitoring
- Pollution monitoring

Smart Transport

- Smart Roads
- Traffic monitoring
- Smart cars and bus
- Smart Trains

Smart Energy

- Lights management
- Smart Building
- Smart grids
- Smart Parking

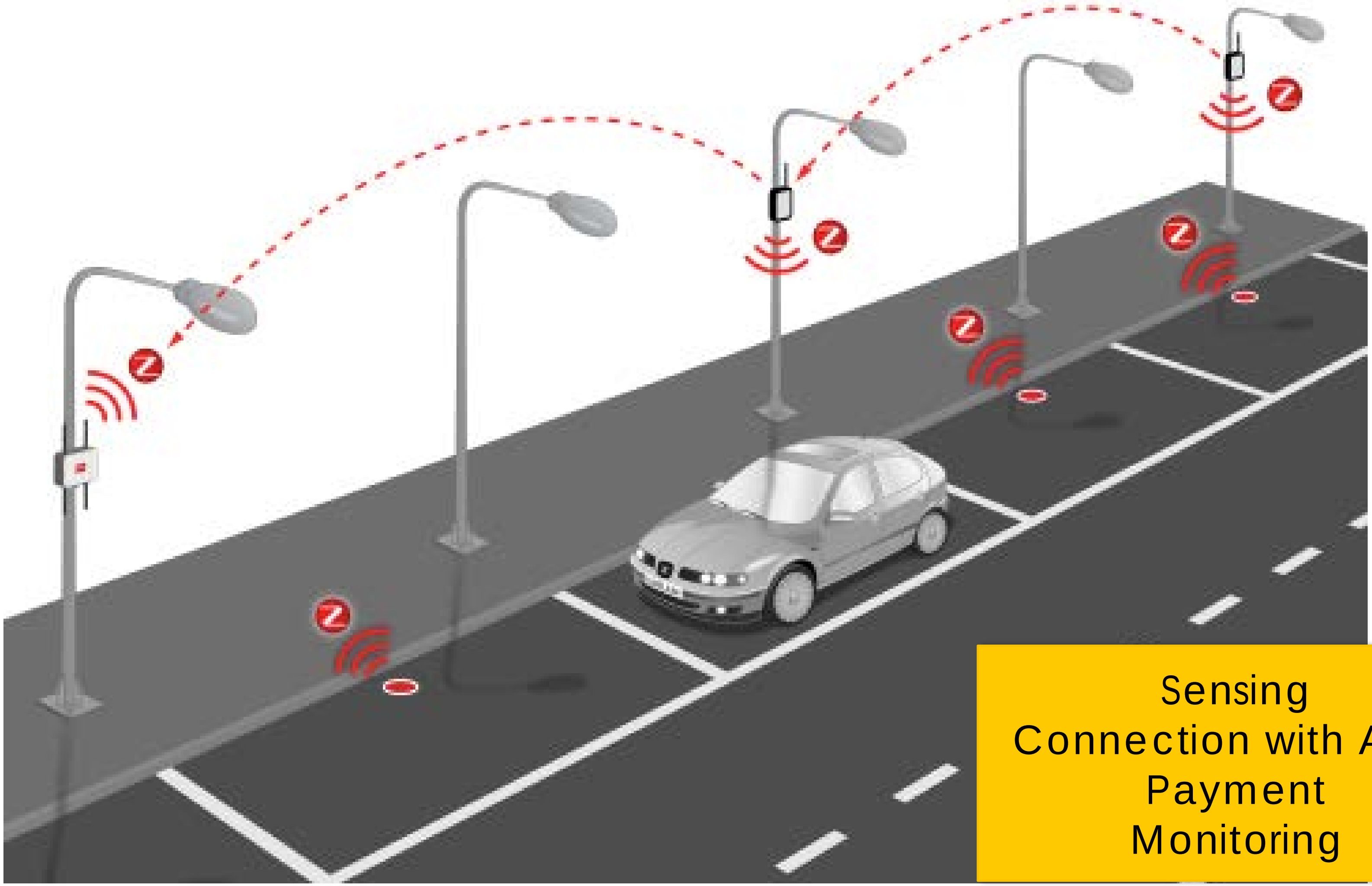
Security

- Video surveillance
- Activity recognition
- Emergency service
- People counting

Smart Lightning

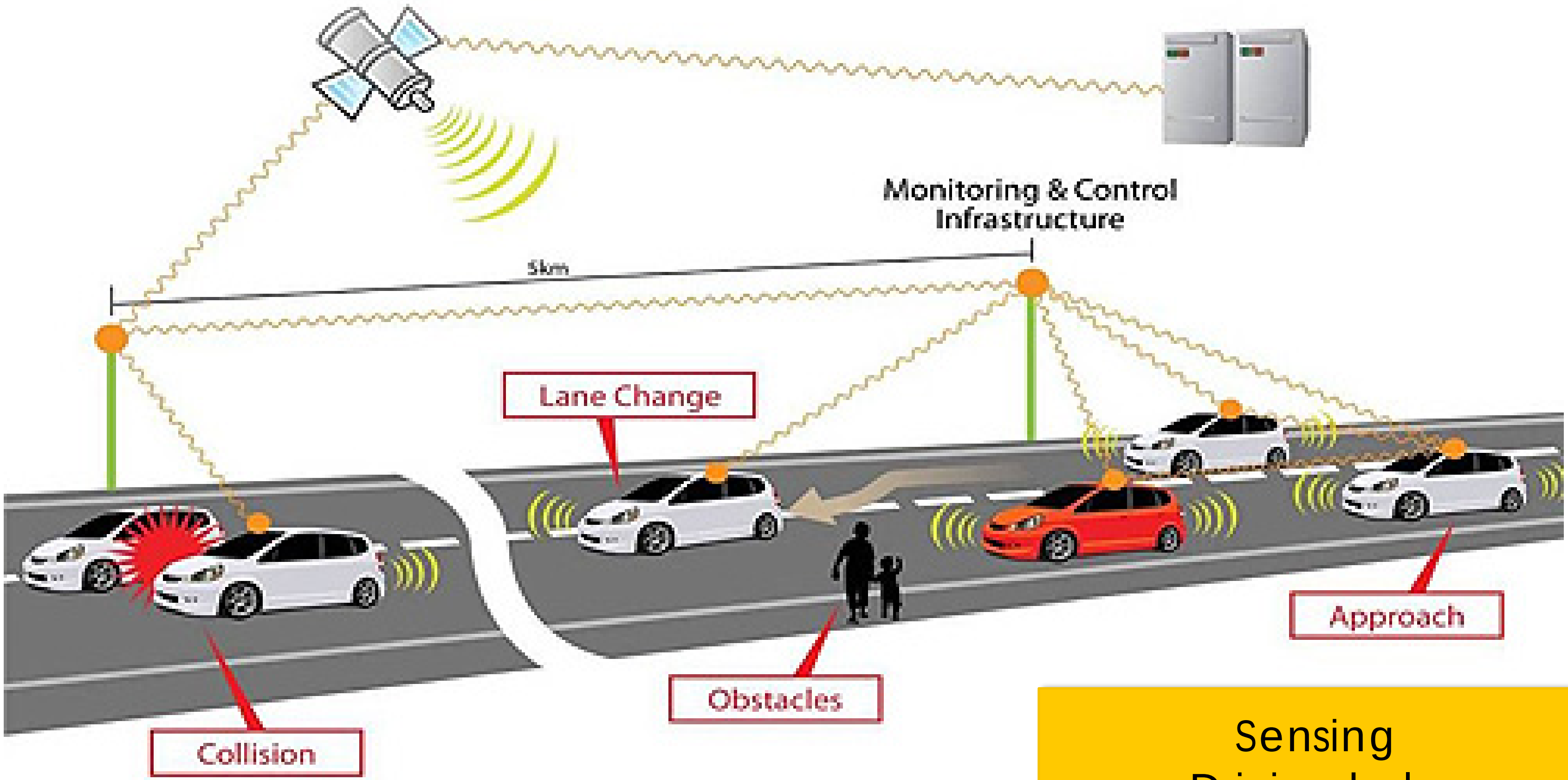
Sensing
Light monitoring
+ camera Surveillance
+ gateway features

Smart parking



Sensing
Connection with Apps
Payment
Monitoring

Smart car



Sensing
Driving help
Route monitoring
Entertainment

Health Care - examples

Health care is typically an horizontal domain

need the collaboration of all domains

the global IoT healthcare market is expected to grow from $35 billions in 2015 to $160 billions in 2020

Examples

Fall detections (home, office, streets)

Medical fridge for storing vaccines, medicine, organic elt

Sportsmen care

Patient surveillance

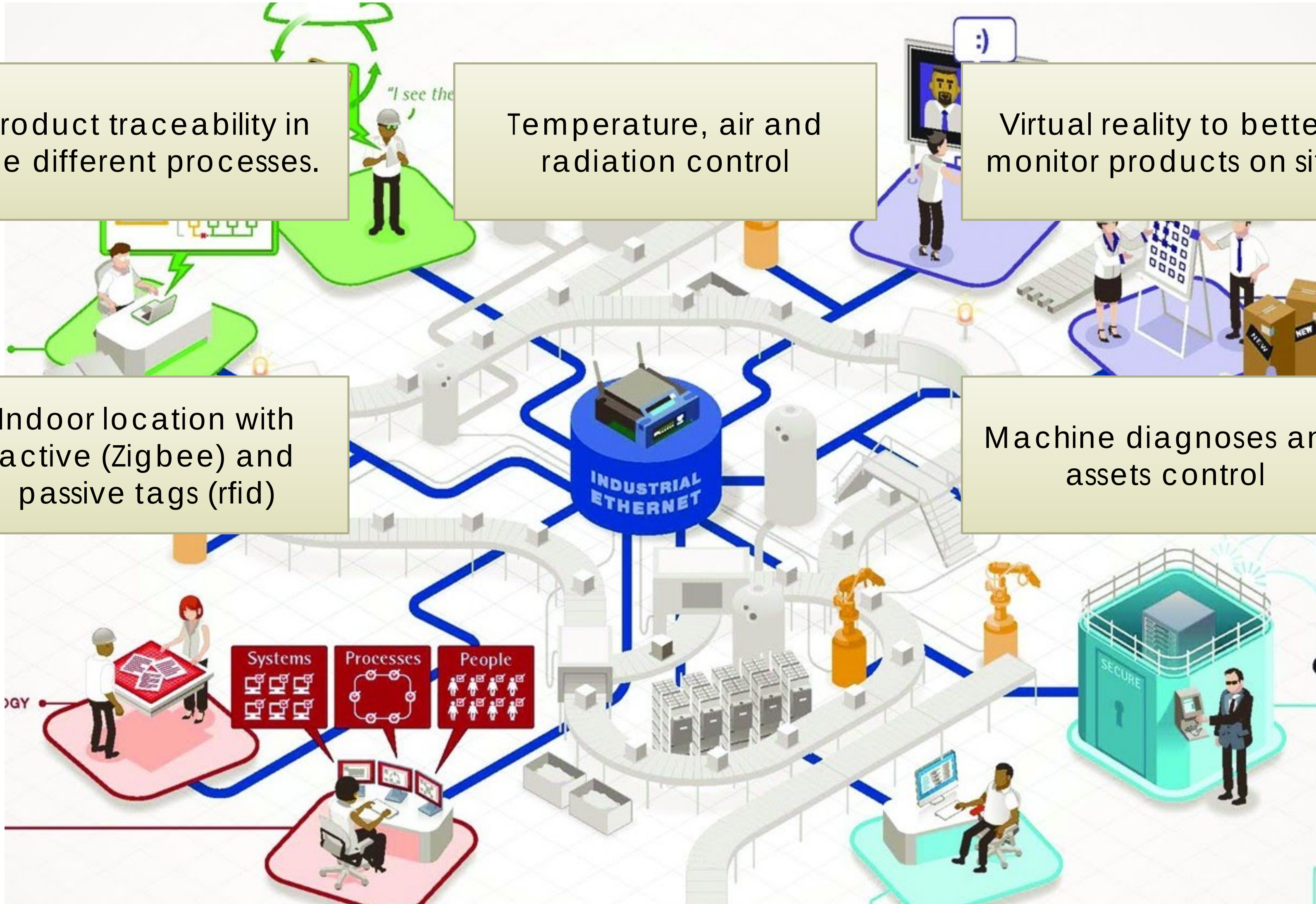
Ultraviolet radiations (to warn people in certain hours)

Smart plant (Industry 4.0)

Product traceability in the different processes.

Temperature, air and radiation control

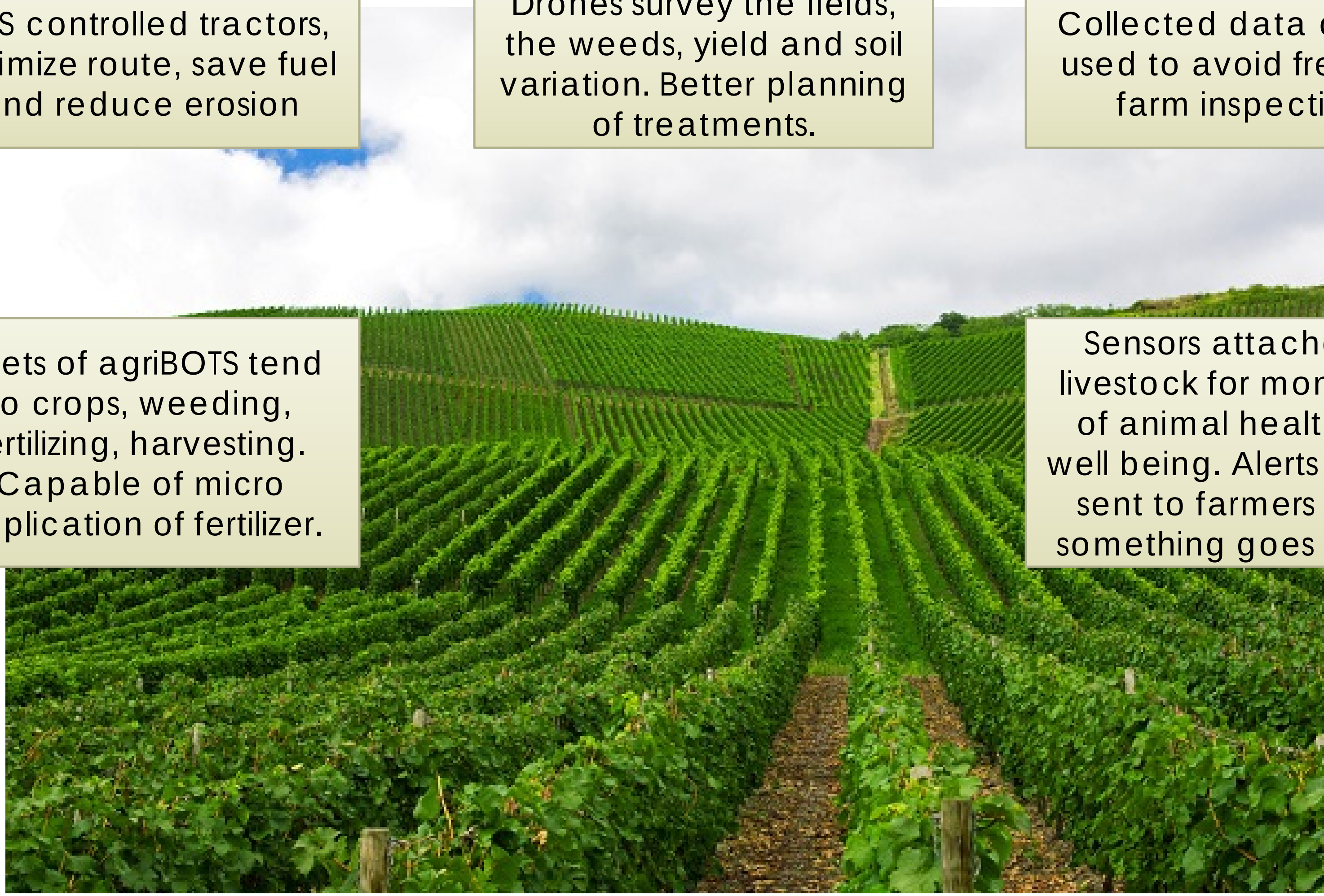
Virtual reality to better monitor products on site



Indoor location with active (Zigbee) and passive tags (rfid)

Machine diagnoses and assets control

Smart agriculture



GPS controlled tractors, optimize route, save fuel and reduce erosion

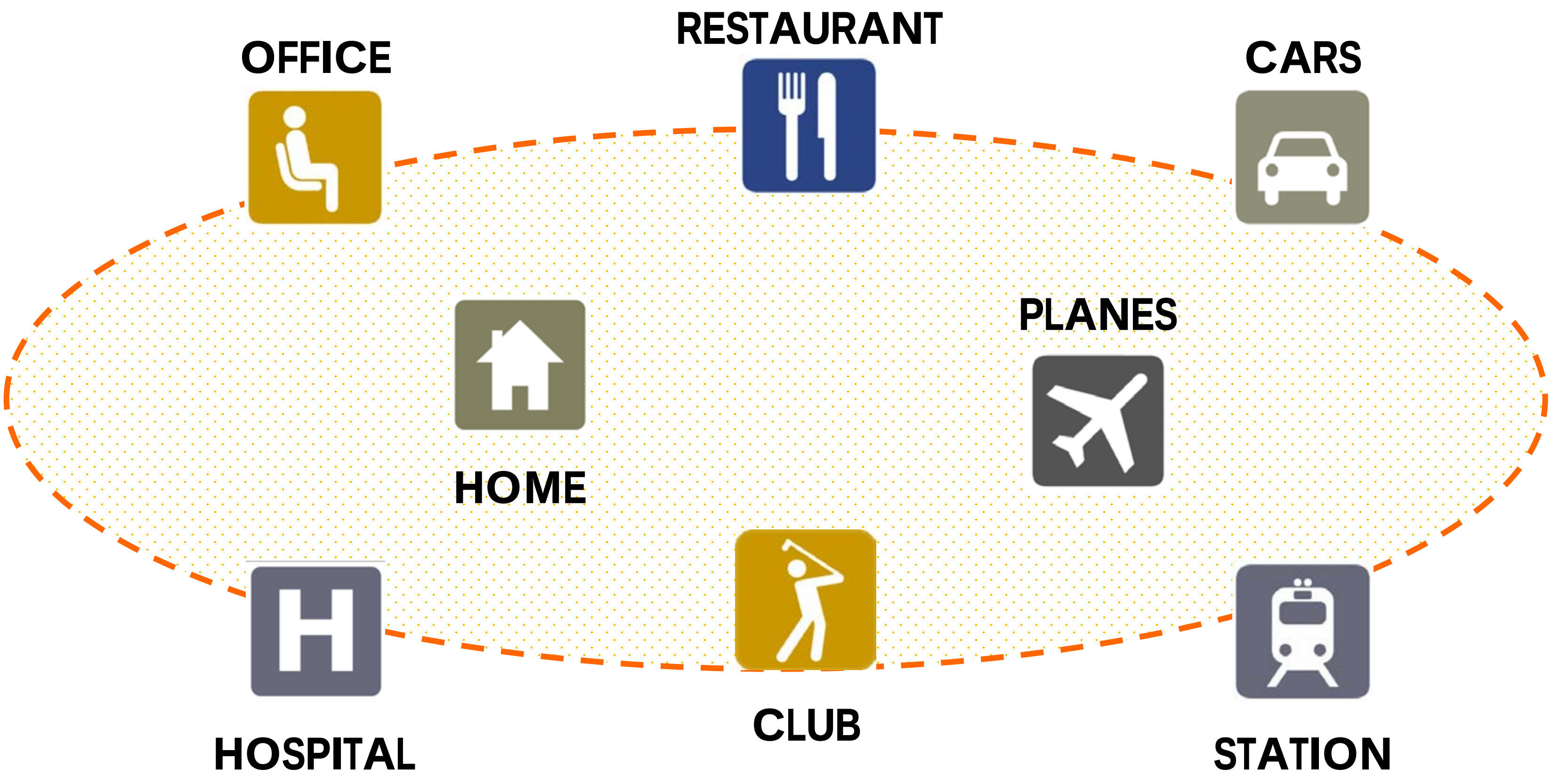
Drones survey the fields, the weeds, yield and soil variation. Better planning of treatments.

Collected data can be used to avoid frequent farm inspection.

Fleets of agriBOTS tend to crops, weeding, fertilizing, harvesting. Capable of micro application of fertilizer.

Sensors attached to livestock for monitoring of animal health and well being. Alerts can be sent to farmers when something goes wrong.

Longer term: smart spaces integration



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Conclusion

Pervasive computing has the potential to

- improving the quality of life
- improving business process
- empowering personalization of services

The IoT market is expending rapidly in many domains

- home and buildings
- city
- infrastructure
- industry
- health
- entertainment

Industrial impacts

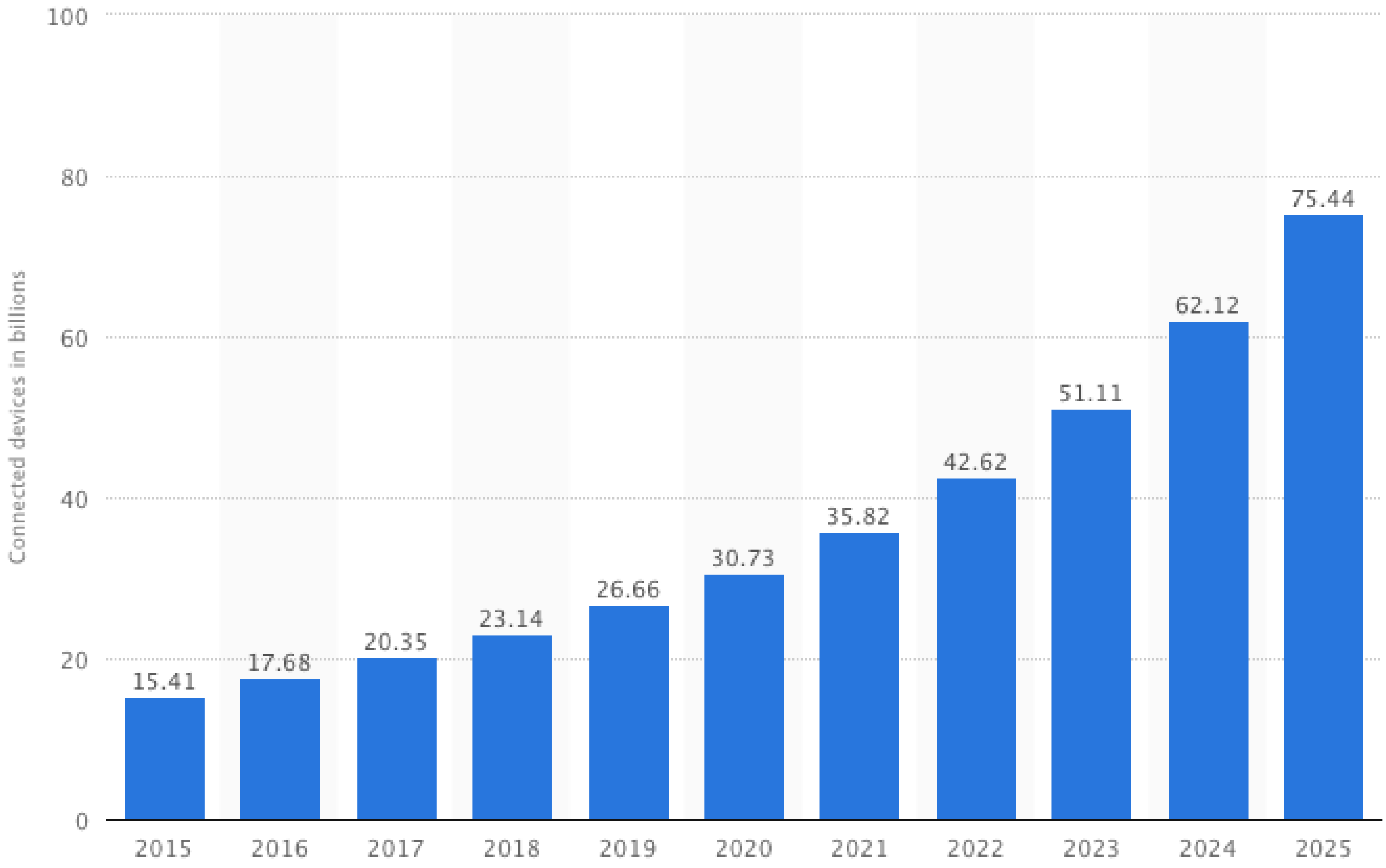
Restructuration and alliances

- creation of IoT divisions in most IT and electronics companies
- great strategic alliances to develop services
  - IBM and Apple
  - IBM and AT&T
  - IBM and ARM
  - Apple and CISCO

Huge investments. In 2017:

- Samsung invests $16 billions in chips manufacturing
- Bosch invests $1 billion in a chips plant (Dresden)
- Tsinghua Unigroup invests $28 billions in a new plant
- Intel invests $7 billions in its Arizona plant

Number of connected devices (billions)



Wearable – market Trends

Wearable market trends by category (Millions)

	2013	2014	2015
Wearable cameras	6,6	13,6	15,8
Smart glasses	0,01	2,2	10,5
Smart watches	1,2	7,4	25
Healthcare	13,5	22,6	34,2
Activity trackers	32,5	42,6	57,5
Smart clothing	0,03	0,7	1,2

Sociological brakes

What are some of the barrier of developing pervasive

Lack of perceived value	36%
Concern with price	23%
Concern with privacy	23%
Others	18%

Technical brakes

Many technological elements are there (CPU, size reduction, cheap mass storage, sensors, etc.)

Scientific progress are however still needed

architecture understanding and evaluation

context-awareness

natural interfaces

autonomic behavior

SERVICE!


'SMART' WASHING MACHINES
I WOULDN'T CALL BEING ABLE TO TURN IT ON REMOTELY, 'SMART.' PICKING MY SOCKS UP OFF THE FLOOR, WASHING THEM AND HANGING THEM OUT TO DRY, THAT WOULD BE SMART.
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