The Smart City model

Master in Entrepreneurship and Innovation Management (MEIM)

Meet the speaker…

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Agenda

- Internet of Things (basic concepts)
- Technologies and problems inside IoT
- Sample applications in the IoT area
- The Smart City model
- *Lunch break (13:00 - 14:00)*
- Applications for Smart Cities
- How to design an application for a Smart City
- Lab activity (CBL + demo projects)
- Conclusions and feedbacks

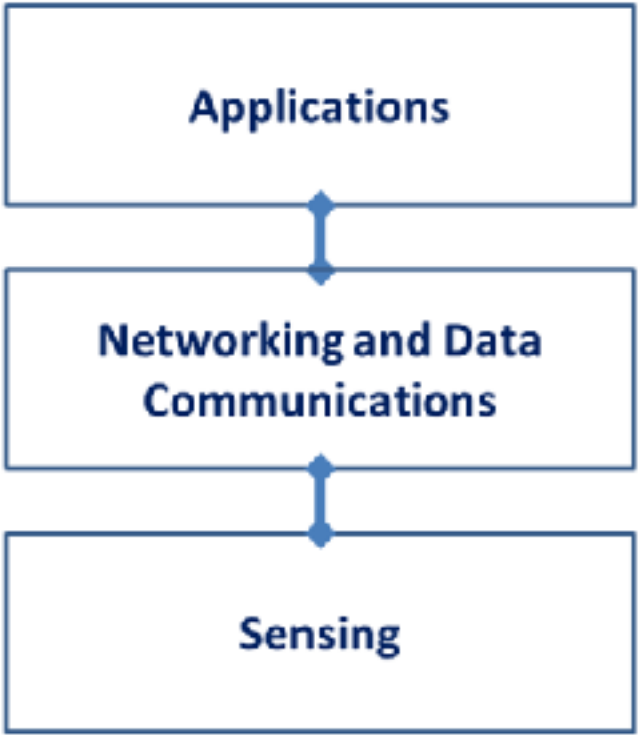
Internet of Things (basic concepts)

IoT definition

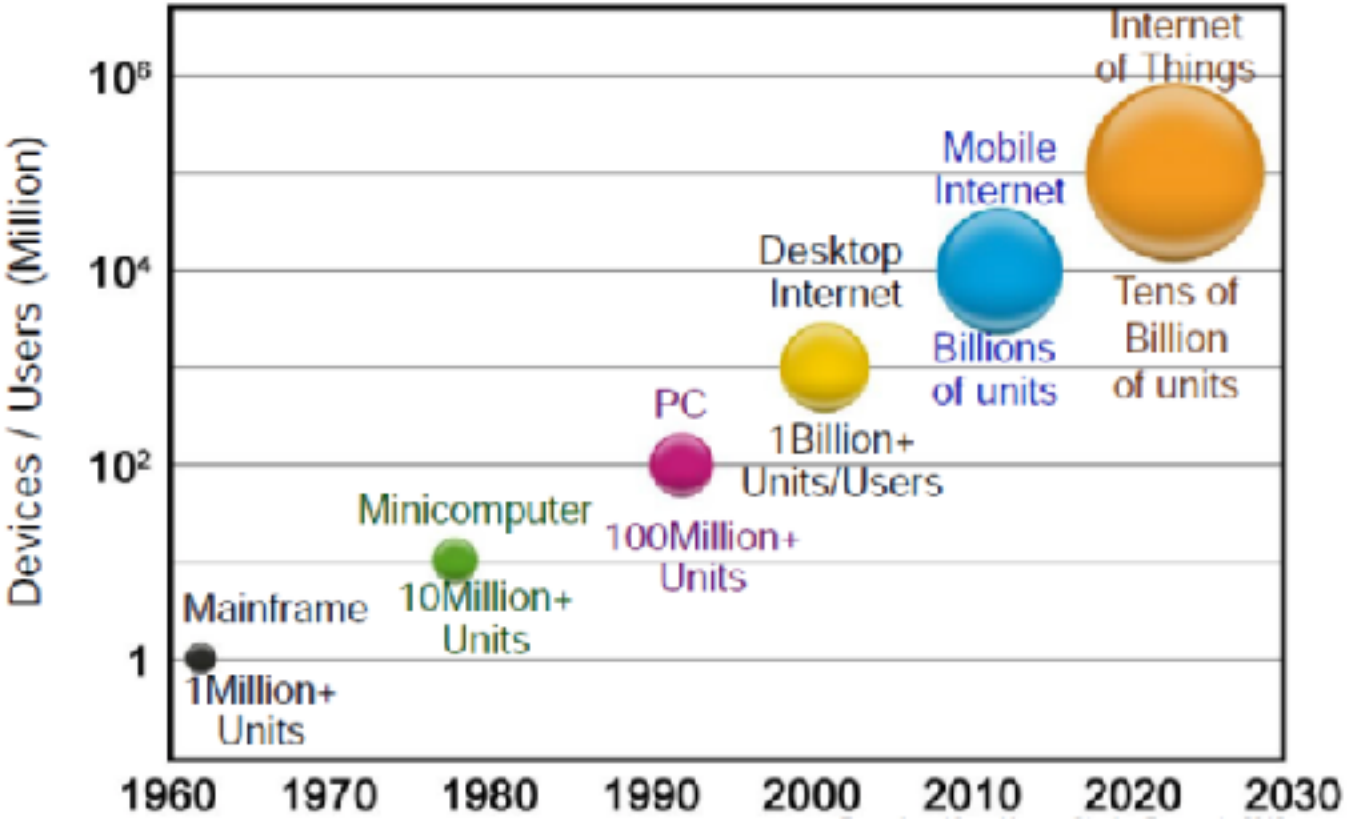
- **There is no formal and shared definition of IoT.**
  In 2014 IEEE published a special report where it defines IoT as *"**a network of items—each embedded with sensors—which are connected to the Internet.**"*
- The Internet of Things (IoT), in Italian «Internet delle cose", arises from the **convergence between sensors, data processing and network communication of specialized digital devices**, designed to be used wherever it is necessary to collect and process data, automate or integrate the operation of different devices.
- The IoT **develops the concepts of network communication at the highest level (not only on IP) to allow interaction between "things"**.

General IoT architecture (3-tiers)

- **The Internet of Things makes it possible to computerize and network "things"**, just like personal computers, tablets and smartphones have done with people.



The next big thing…



Credits: Morgan Stanley Research, 2022

Carnegie Mellon University, 1982

The birth of the IoT

- The first concepts underlying the IoT were sketched in **1982**, when some researchers from **Carnegie Mellon University** applied sensors and a network connection to a **university drinks dispenser** to find out its operating status.
- In 1991 these concepts are taken up again in a popular article by **Mark Weiser, Chief Scientist of Xerox PARC, "The computer of the 21st Century**" published in Scientific American and, more rigorously, by Reza Raji in 1994 in the IEEE technical journal.

“The Computer for the Twenty-First Century”, Mark Weiser, Scientific American, pp. 94-10, September 1991

The Computer for the 21st Century

Specialized elements of hardware and software, connected by wires, radio waves and infrared, will be so ubiquitous that no one will notice their presence

by Mark Weiser

The most profound technologies are those that disappear. They weave themselves into the fabric

is approachable only through complex jargon that has nothing to do with the tasks for which people use computers.

The idea of integrating computers seamlessly into the world at large runs counter to a number of present-day

Scientific American Vol. 265, No. 3, SPECIAL ISSUE: Communications, Computers and Networks (1991)

. . .

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

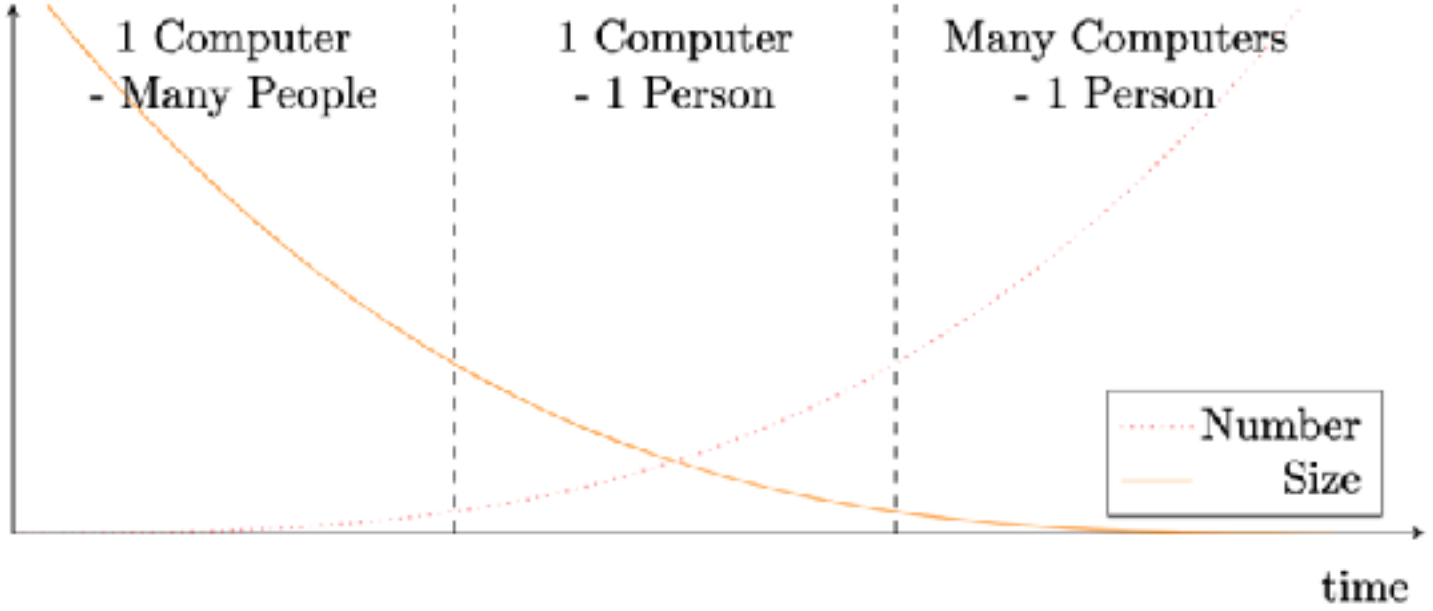
. . .

Mark Weiser “vision” (1/2)

- In 1988, Mark Weiser coined the term "**ubiquitous computing**" while teaching as Chief Technologist at Xerox's Palo Alto Research Center (PARC), California.

- Weiser's theoretical approach **outline a technological scenario in which the need to use the traditional personal computer is overcomer**.

Mark Weiser “vision” (2/2)



Weiser's vision gradually becomes a reality over time, with the lowering of the **costs of hardware devices**, with the **miniaturization** of the same and with the development of **wireless** connections.

Ubiquitous computing

- The radical discontinuity that this vision introduces lies both in wanting **to modify the conditions of the presence, in people's lives**, of the tools that process information, as well as in the intent **to** assign to these tools tasks and functions that are made **less intrusive**.

ubìquo agg. [tratto da *ubiquità*]. – Che si trova, o riesce a trovarsi, in più luoghi contemporaneamente o dappertutto; (*Treccani*).

Ubiquitous computing (enabler factors)

- The **advances in microelectronics and telecommunications** allow us to conceive a world in which the individual no longer has to bear the burden of direct and continuous management of calculation.
- In fact, in addition to being able to communicate with the user, devices are now immersed in an **interconnected environment** that makes them communicate with each other.

Ubiquitous computing (life impacts)

- The traditional machine-computer, with its frequent requests for intervention addressed to the user, leaves its location - material and symbolic - to multiply and become invisible.
- **The ability to process information becomes omnipresent, as it hides extensively in the everyday environment**.

Inversion of paradigm

- The best tools are the invisible ones (that is, the focus is on the task at hand and not on the tool.
- For example, **writing is a "ubiquitous" technology,** which does not require attention, and is ready for use at first sight.

Ubiquitous Computing (resume)

- **Processing is everywhere**, integrated and hidden in the environment (objects) around us.
- **Computers** no longer isolate us from tasks or the environment, and **are no longer the object of attention**.
- **Social impact** (similar to writing): found everywhere, from clothing labels to billboards.
- **Similar to electricity**: it pours, invisibly, through the walls of every house, in the office, in cars, etc.


PURSUIT

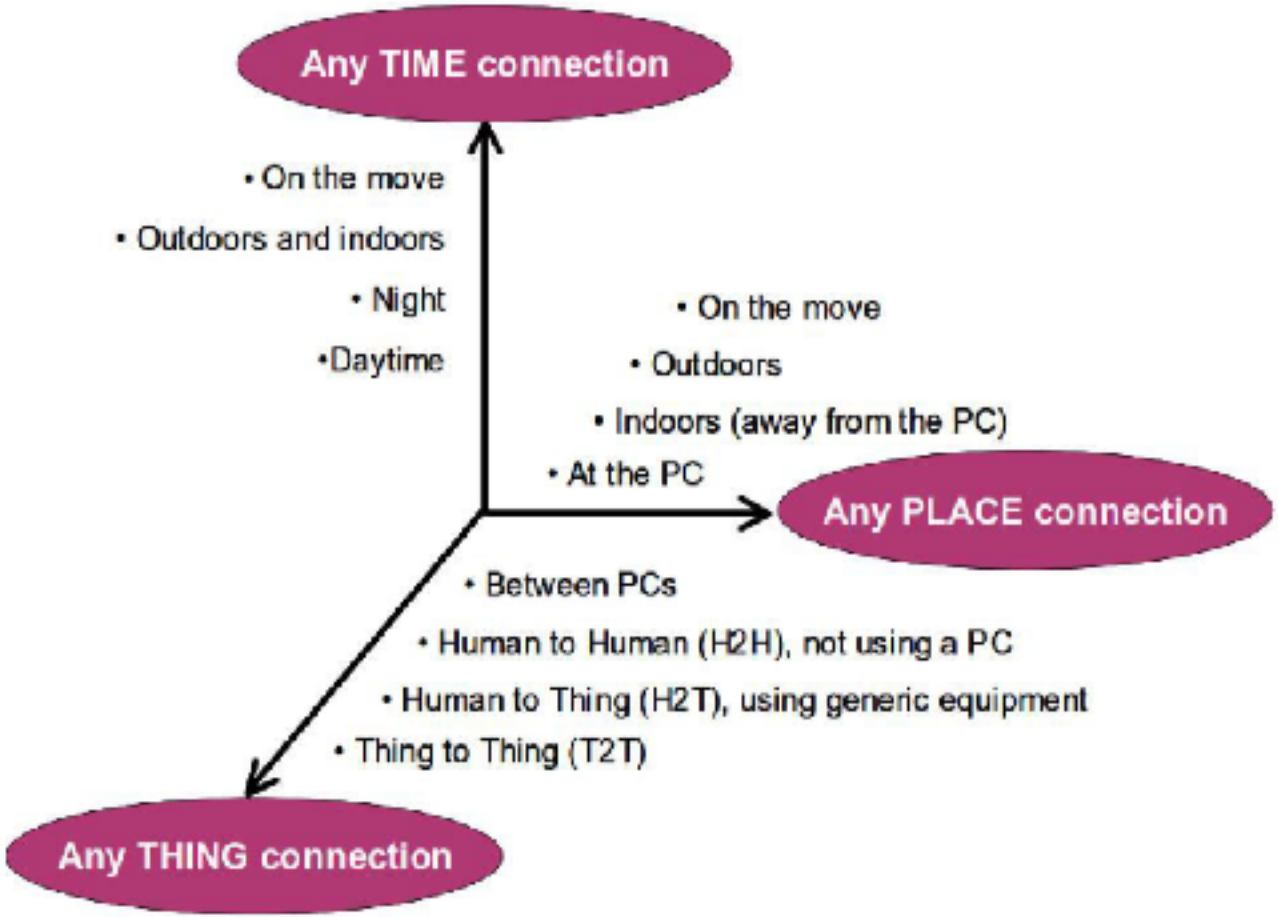
From vision to reality

- The **earliest forms of ubiquitous information** and communication networks are evident in … the **exponential use of cell phones**
- They have become an **integral and intimate part of the daily life** of many millions of people

From vision to reality (cont.)

But **the phenomenon is constantly evolving** thanks to the developments in technology:

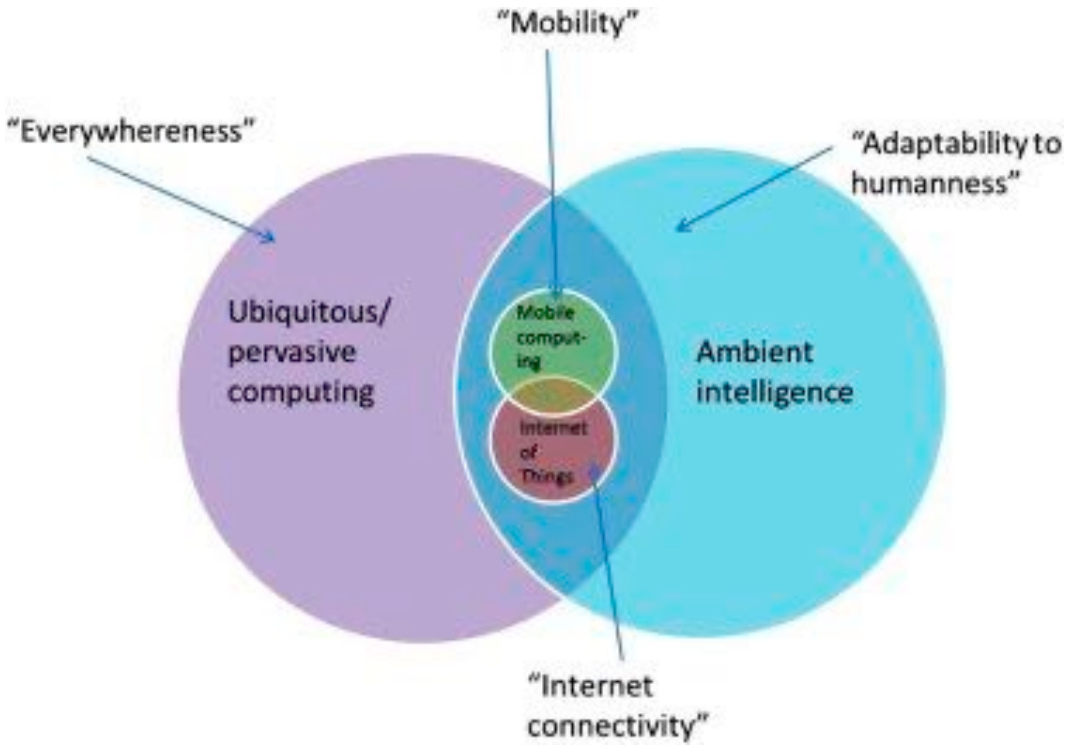
- **Integration of small short-range transceivers** into a multitude of objects of everyday life
- **New forms of communication** between people and things and between things themselves
- A new dimension has been added to the world of information and communication technology: from connectivity at any time, in any place, we will have **connectivity for anything** (any thing), **see next figure…**



Source: ITU adapted from Nomura Research Institute

Similar definitions (same vision)

- Pervasive Computing
- Sentient Computing
- Ambient Intelligence
- Wearable Computing
- Context Awareness
- …



Manwaring, et al. "Surfing the Third Wave of Computing: A Framework for Research into eObjects" (August 28, 2015).

What Ubiquitous Computing is not

- **It is not science fiction,**
  although we often rely on it to tell it.
- It is not **an impossible goal**,
  but it is already real.
- It has **nothing to do with virtual reality (VR)**,
  in fact it is the exact opposite.
- It is **not strictly related to the use of mobile devices**,
  such as a smartphone.

Technologies and problems inside IoT

Sensors and related aspects

- **Sensors are the devices that allow you to collect data** that will then be analyzed and processed in order to produce the knowledge necessary to react and make decisions, (whether they are then performed by the objects themselves as well as by automatic or manual processes).
- **The main aspects to consider in relation to sensors are:**
  - **Energy consumption**
  - **Processing and memory**
  - **Communication**

1. Energy consumption

- **It is essential that the power supply of the sensors is always active** to allow the acquisition of the data.
- While **this is not a problem for the home refrigerator**, **it may not be as simple for the sensor in the Libyan desert** or for a wearable device.
- The energy design of the device therefore becomes important in order to optimize its functionality, its duration and the need for maintenance.

2. Processing and memory

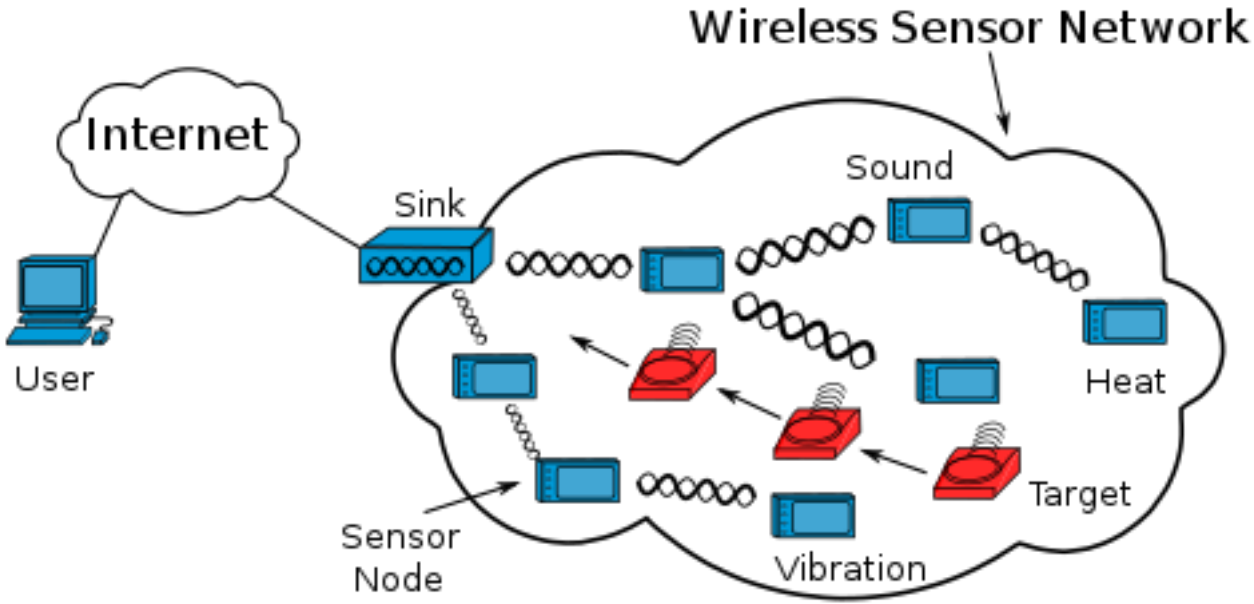
- **How much intelligence does the device have to provide?**
  How much data must be aggregated or processed and how many data should be sent raw to the central system?
- **It is necessary to seek a compromise between the communication capacity, the power of the sensor microprocessors, the energy balance of the device, and finally the cost of the device**.

3. Communication

- The communication functions are essential for **transporting information** from the place where it is collected to the central systems where it will be processed, stored and presented to the user.
- The communication **technologies available are different** and are typically related to the functionality of the sensor, the availability of electricity and the communication architecture above.
- A new class of networks has therefore appeared in recent years: the **Wireless Sensor Network (WSN)**.

WSN (Wireless Sensor Network)

The term **Wireless Sensor Network (or WSN)** indicates a specific type of computer network which, characterized **by a distributed architecture**, is made up of a set of autonomous electronic **devices capable of taking data** from the surrounding environment and **communicating with each other**.



Cloud computing & IoT

- One of the technological factors that more than others has allowed the definition and spread of the IoT paradigm is **Cloud Computing**.
- In fact, it becomes the **front-end** and **back-end** for the IoT paradigm, performing the function of **aggregator**, **custodian** and **processor, and view** of the data generated by intelligent products and processes.

Cloud computing & IoT

- The cloud allows you to **manage a large number of connections** with devices and provides the user with an interface that is always reachable.
- The cloud also offers the **flexibility to quickly scale resources** according to the number of devices or their activity, being able to manage **a rapid growth** of the installed architecture **but also reducing resources** (and therefore costs) in periods when activity decreases.

IoT challenges

- In order for the IoT to spread in a capillary way so as to fully unfold its potential, **it is necessary to address some problems** and criticalities that make the full development of IoT systems difficult (and sometimes impossible):

- **Management of the SW / HW architecture**
- **Adherence to standards** (communication, data exchange, etc.)
- **Respect for privacy**

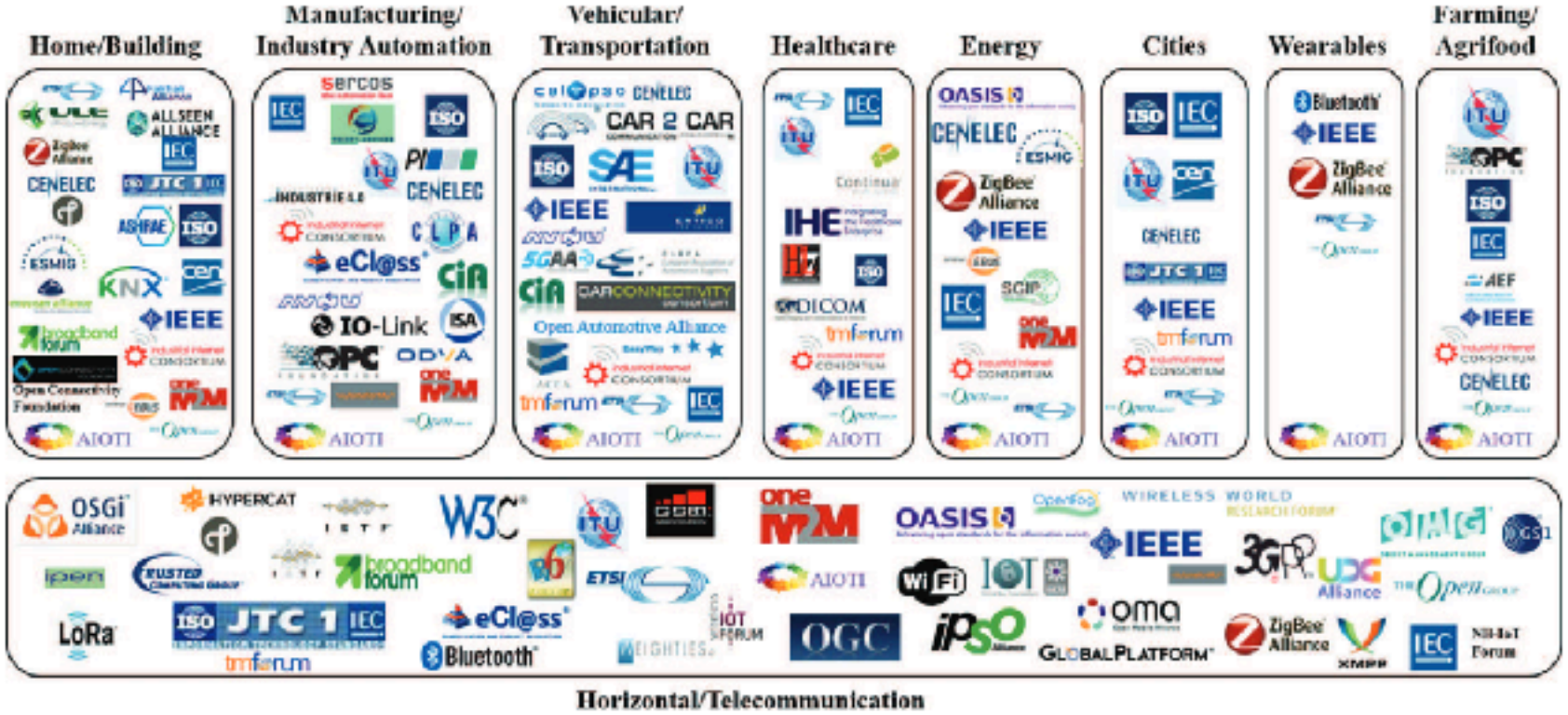
IoT architetture management

- In an IoT system it is possible to have **thousands (or even millions) of devices distributed throughout the territory** and which have extremely different characteristics.
  How does such a complex system develop and manage?
- The **design phase** of an IoT system takes on complex implications as the scale and diversity of the elements that constitute it can increase exponentially.
- Critical elements are related to development and **testing, reliability, resilience, consumption, management, maintenance and updating**.

Adherence to standards

- In the **absence of open and internationally recognized standards**, the development of complex IoT systems will be **impossible** or in any case **limited to more or less restricted and circumscribed cases**.
- There may be **different types of standards**: some already exist, but others will have to be introduced above all **to ensure interoperability** in the various application domains in which the IoT is usable.

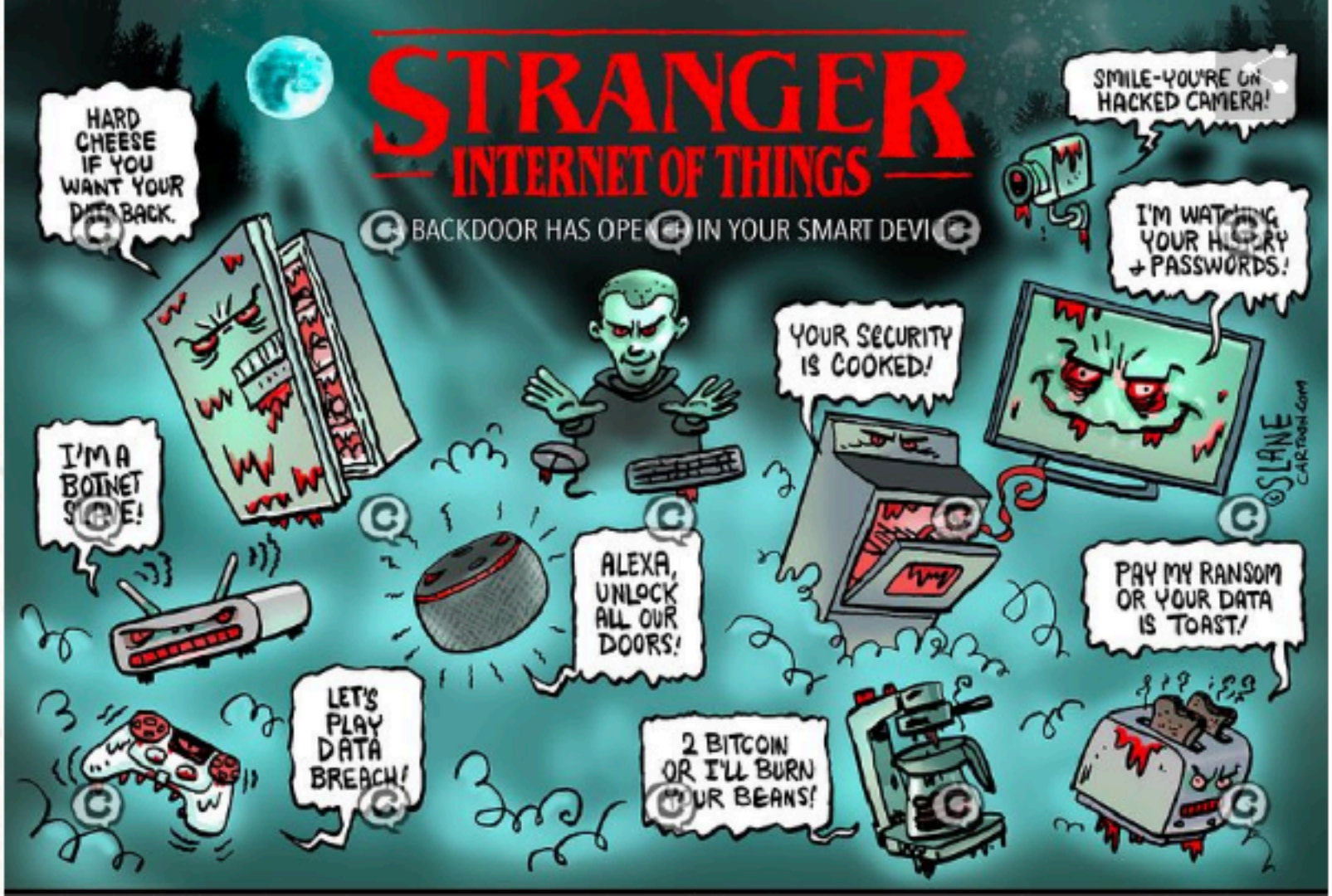
Standards scenario in IoT



Source: AIOTI WG03 (IoT Standardisation) – Release 2.7

Privacy concerns

- The existence of thousands of widespread and "**always on**" digital devices, capable of collecting a variety of different information, makes the issue of privacy particularly delicate and critical.
- **What data is it acceptable to collect? According to what modalities?** What kind of information and authorizations must be given and negotiated with users? **Who can use the data and for how long? Who keeps them and how?**
- There are probably different answers depending on the application context and the type of actor involved (public or private).


STRANGER
INTERNET OF THINGS
BACKDOOR HAS OPE IN YOUR SMART DEVI
HARD CHEESE IF YOU WANT YOUR BACK.
SMILE-YOU'RE ON HACKED CAMERA!
I'M WATCHING YOUR + PASSWORDS!
YOUR SECURITY IS COOKED!
I'M A BOTNET E!
ALEXA, UNLOCK ALL OUR DOORS!
PAY MY RANSOM OR YOUR DATA IS TOAST!
LET'S PLAY DATA BREACH!
2 BITCOIN OR I'LL BURN UR BEANS!
©SLANE

Sample applications in the IoT area

Scenarios

- **The Internet of Things is a paradigm without any, potentially, application boundaries**: from the **car** that communicates with the **road** infrastructure to prevent accidents, to **household** appliances that coordinate to optimize the use of power; from the production **plants** that exchange data with the products for the management of their life cycle; from **medical devices** that are located in an emergency room, to skis that send information on the state of the snow, or on the severity of a fall.

IoT video introduction

Internet of Things

l'innovazione parte da qui!

Smart Car

Processing data inside the cars to communicate information in real time to the consumer; **connection between vehicles** or between them and the surrounding infrastructure for accident prevention and detection.

Smart Car features

There are numerous factors that are favoring the spread of intelligent cars, but 3 in particular:

- **diversification of services** offered thanks to connectivity in cars;
- integration of driver assistance systems (Advanced Driver Assistance Systems or **ADAS**);
- integration of **smart speakers in cars** (Alexa, Google Home, etc.);

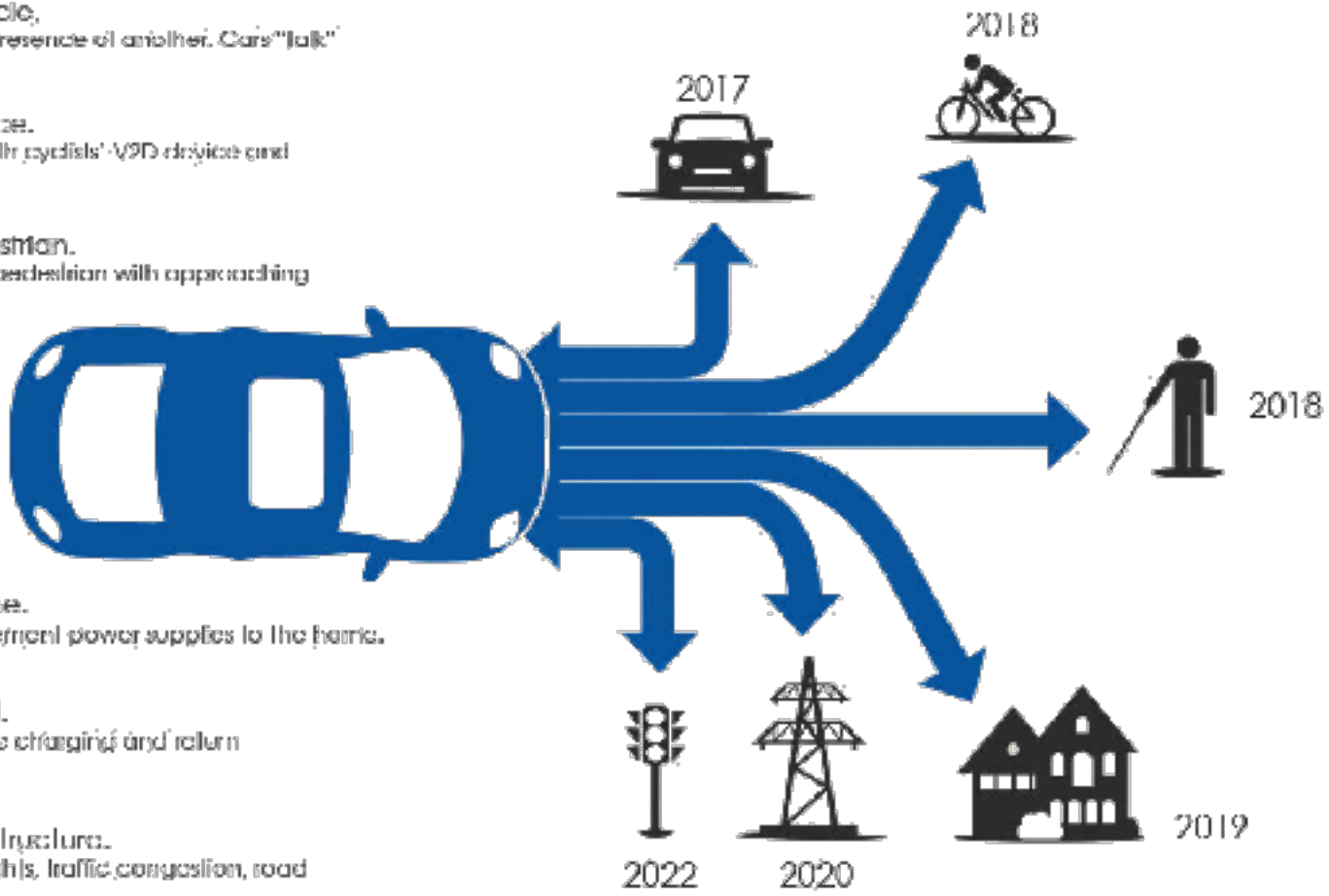
ECall

- The factor that is primarily intended to contribute to the growth of the connected car market is the European eCall legislation.
- After the entry into force, in March 2018, of the European regulatory obligation linked to eCall - according to which new **models of cars and light vans must be able to alert the emergency services in case of accidents** - the number of natively connected cars.

V2V - Vehicle-to-Vehicle.
Alerts one vehicle to the presence of another. Cars "talk" using DSRC technology.

V2D Vehicle to Devices.
Vehicles communicate with cyclists' V2D devices and vice versa.

V2P - Vehicle-to-Pedestrian.
Car communication with pedestrian with approaching alerts and vice versa.



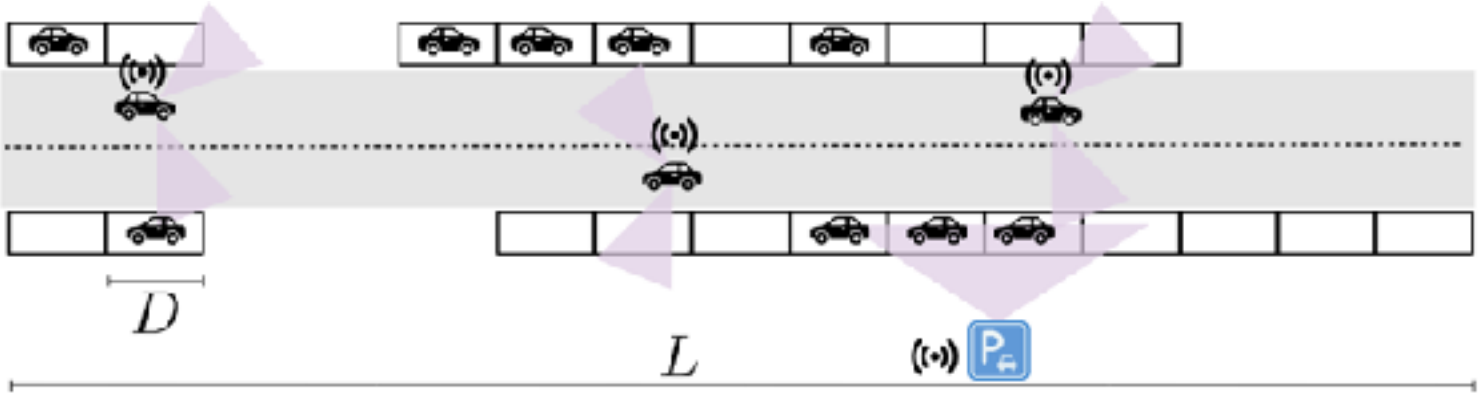
V2H - Vehicles-to-Homes.
Vehicles will act as supplement power supplies to the home.

V2G Vehicle to Grid.
Smart grid controls vehicle charging and return electricity to the grid.

V2I Vehicle to Infrastructure.
Alerts vehicles to traffic lights, traffic congestion, road conditions, etc.

Smart parking in V2V (sample)

A **road route of length L** is populated by intelligent and connected vehicles, as well as by smart parking infrastructures. Each vehicle is able to detect **parking spaces (D)** and classify them as **free or occupied**. Traffic conditions are read from a **cloud database**. By establishing communication with external information sources (other vehicles, parking lots), **each vehicle can "learn" the map of parking availability along the entire road route**.



Smart Home

Solutions for the **automatic and / or remote management of the systems and connected objects of the home**, with the aim of reducing energy consumption and improving the comfort, safety of the home and of the people inside.


BLINDS
THERMOSTAT
SECURITY CAMERAS
LIGHTING
TV/SPEAKERS
APPLIANCES
LOCKS
IRRIGATION

Main ready solutions for the “smart home”

- **Air conditioning / heating** (air conditioners, thermostats or boilers adjustable remotely or via App);
- Household appliances (remote on / off, via App or with your voice, of **dishwashers**, **washing machines**, microwave ovens);
- **Lighting** (switching on / off, adjusting the color or intensity via the App or with your own voice);
- **Security** (video surveillance and video intercom systems with the possibility of accessing images remotely and / or from Smart TV, intelligent locks that send alarms in the event of an intrusion);
- **Smart home speakers** (devices that can be controlled via voice that allow you to receive information - e.g. on the weather, traffic - and to issue commands - e.g. adjust the lights or the temperature).

Smart Doorlock

The Genie Smart Lock - A door lock that allows you to lock and unlock your home using your smart phone, bluetooth keyring or computer.

http://www.geniesmartlock.com/index.php

Smart Gardening

Bitponics gives data on plants and conditions surrounding them for better gardening.

http://www.bitponics.com/

Smart Home Security

Canary is a complete security system packed into a single, device. It adapts to your home over time and sends intelligent notifications with HD video directly to your smartphone.

http://canary.is/

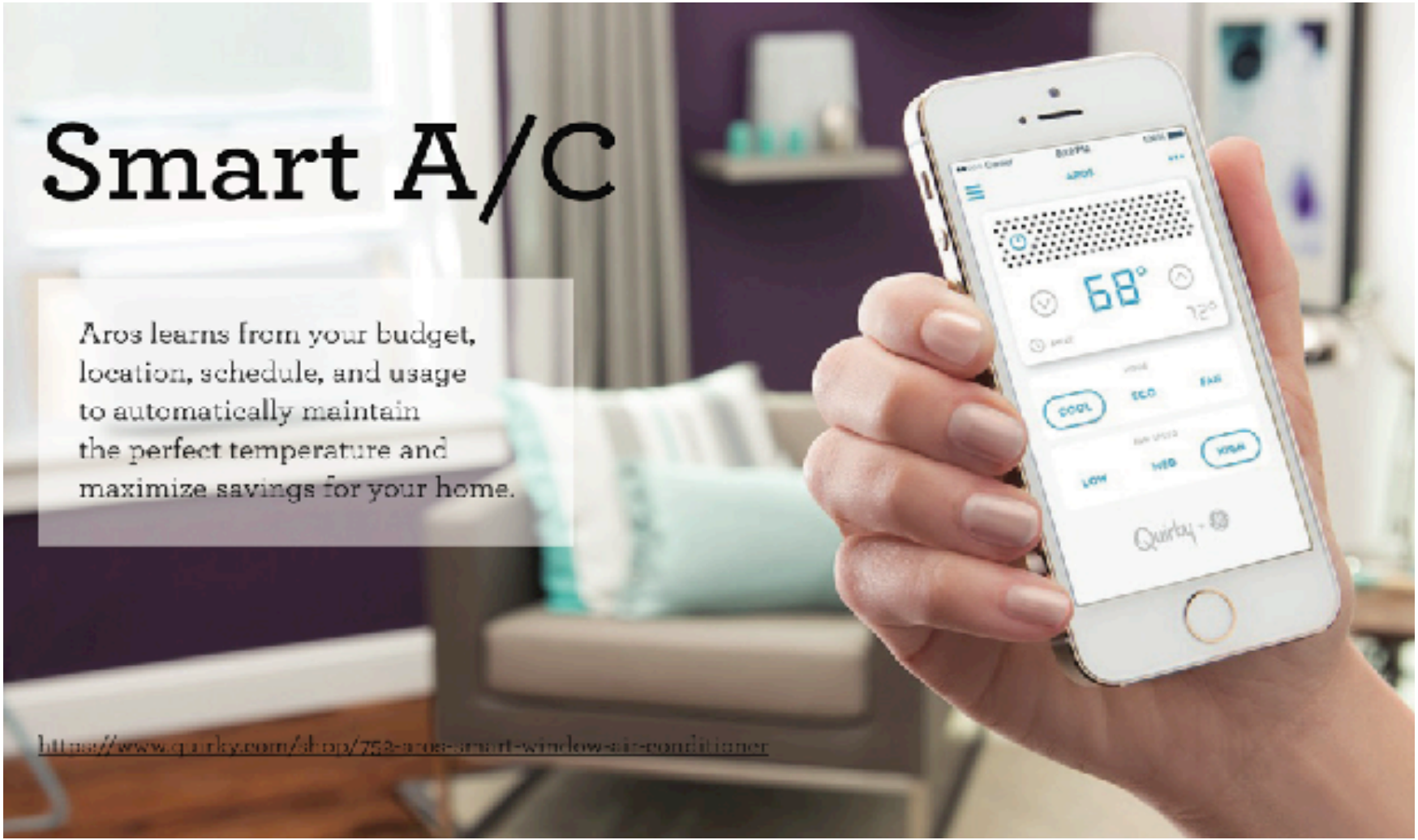
Smart Weather Station

The Netatmo Weather Station allows you to use indoor temperature, relative humidity and CO2 readings to live in a healthier home.

http://www.netatmo.com/en-US/product/weather-station/

Smart A/C

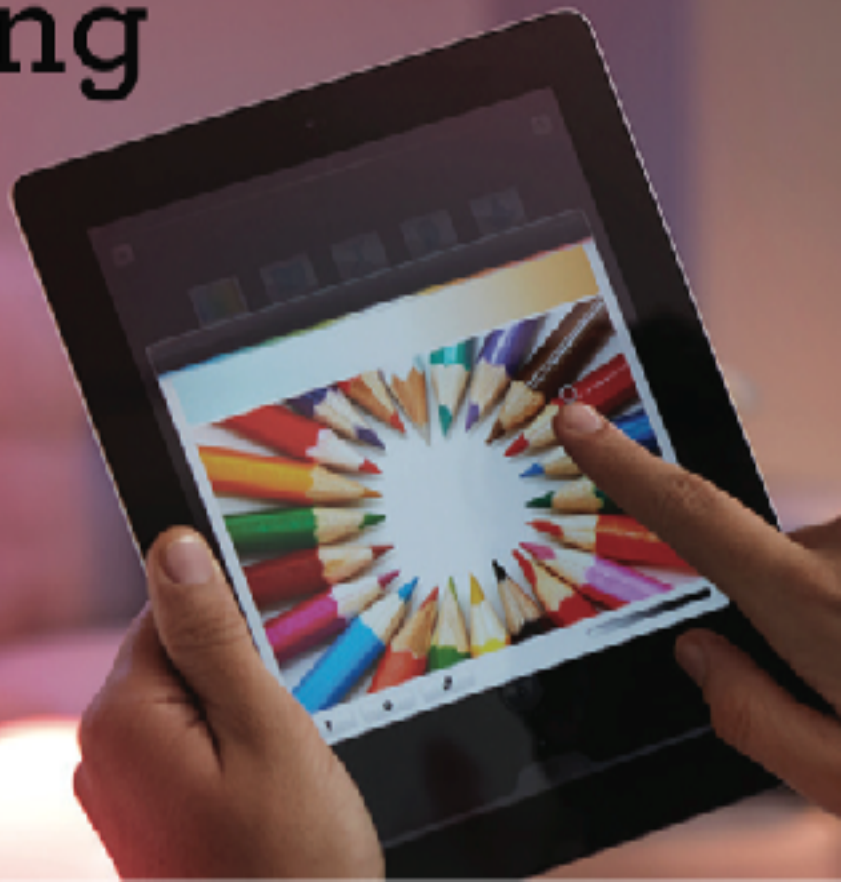
Aros learns from your budget, location, schedule, and usage to automatically maintain the perfect temperature and maximize savings for your home.



https://www.quirky.com/shop/752-aros-smart-window-air-conditioner

Smart Lighting

Control your bulbs one at a time or altogether. Find just the right shade of white. Pick that perfect tone to match the moment. Or recreate any color from a photo.



http://meethue.com/

Smart Buildings

A smart building **uses its intelligence to collect actionable data from user devices, sensors, systems, and services on the premises**.
Applying that data using artificial intelligence and machine learning (AI/ML) makes the building both programmable and responsive to the needs of the users and the building manager.

Smart Buildings

30% of urban emissions could be cut by 2050 by making buildings more efficient.

Smart Metering

Connected meters (Smart Meters) for **measuring consumption (electricity, gas, water, heat)**, correct billing and remote management.

Smart Metering (impacts)

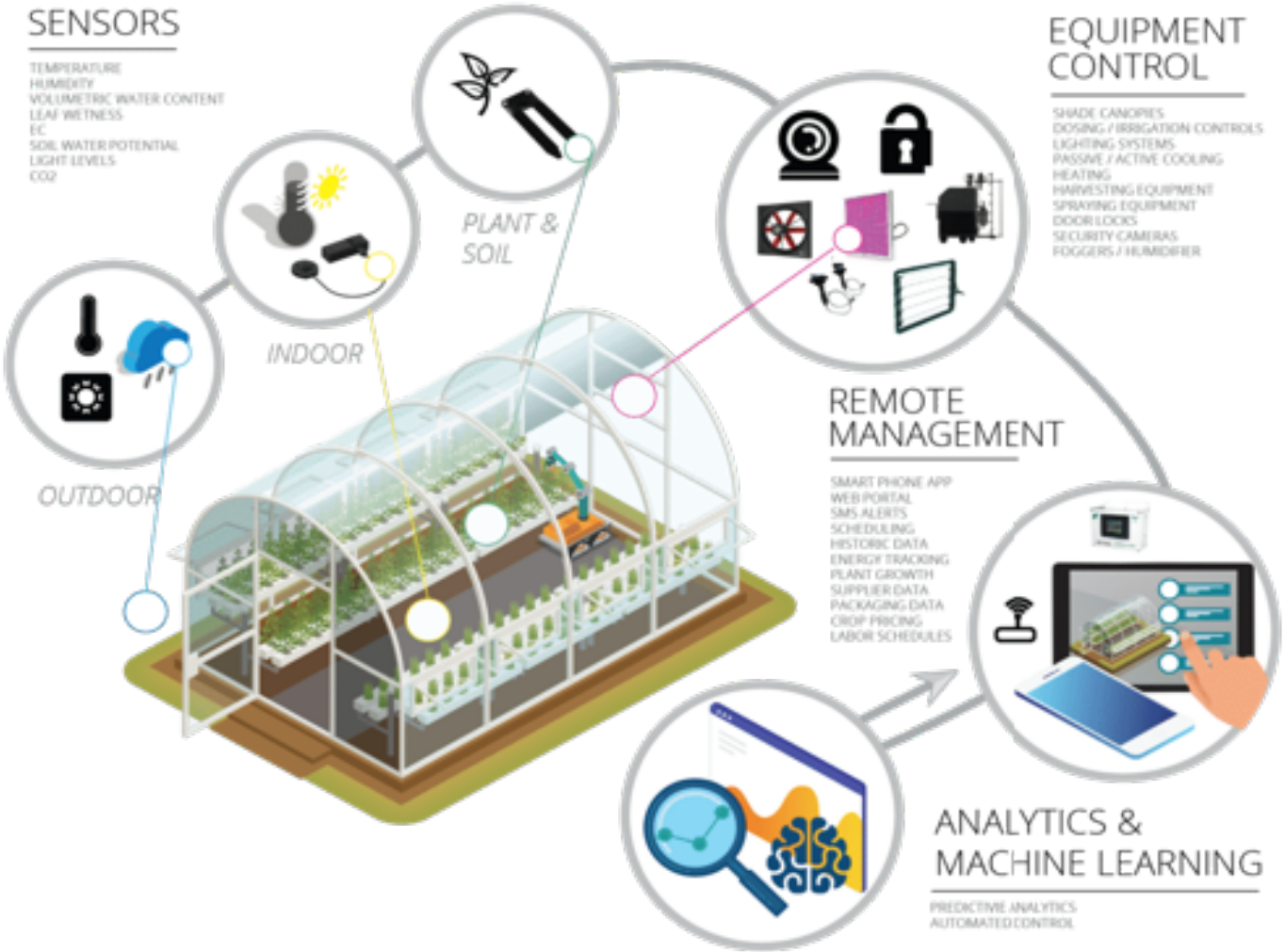
- **Smart Metering has more to do with everyday life than we think**. In fact, among the priorities of a consumer, in the first places there is that of having bills based on real consumed facts. However, to have such a result, **each user must really know how much he has consumed**.
- Through Smart Metering, therefore, **we communicate in two ways, both to the consumer and to the network that distributes energy and gas, providing useful data to both**.

Smart Agriculture

Monitoring of micro-climatic parameters to support agriculture to improve the quality of products, reduce the resources used and the environmental impact.

Smart Agriculture sub areas

- **What** all the denominations relating to **the agricultural system (smart farming, precision agriculture, etc.) have in common** is that the management of **activities** along the entire supply chain takes place on the basis of **different types of data** (position, climate, phytosanitary status and / or business-economic, etc.) collected in various ways (**sensors**, drones, satellites, etc.).
- The data is thus analyzed and used to carry out more accurate and **timely decision-making processes**, through constant monitoring and specific analyzes of the so-called **big data** (also with the use of machine learning).


SENSORS
TEMPERATURE
HUMIDITY
VOLUMETRIC WATER CONTENT
LEAF WETNESS
EC
SOIL WATER POTENTIAL
LIGHT LEVELS
CO2
PLANT & SOIL
INDOOR
OUTDOOR
EQUIPMENT CONTROL
SHADE CANOPIES
DOSING / IRRIGATION CONTROLS
LIGHTING SYSTEMS
PASSIVE / ACTIVE COOLING
HEATING
HARVESTING EQUIPMENT
SPRAYING EQUIPMENT
DOOR LOCKS
SECURITY CAMERAS
FOGGERS / HUMIDIFIER
REMOTE MANAGEMENT
SMART PHONE APP
WEB PORTAL
SMS ALERTS
SCHEDULING
HISTORIC DATA
ENERGY TRACKING
PLANT GROWTH
SUPPLIER DATA
PACKAGING DATA
CROP PRICING
LABOR SCHEDULES
ANALYTICS & MACHINE LEARNING
PREDICTIVE ANALYTICS
AUTOMATED CONTROL

Smart Health

Thanks to sensors and devices connected to patients, such as technologically advanced **bracelets** and **watches**, it is possible to collect data on the state of health of people and treat them, even remotely, **anticipating critical situations** long before they occur.

Smart Cardio

eCardio is a single component, dual-modality remote cardiac monitor.

http://www.cmrdia.com/

HAPIfork

The HAPIfork is an electronic fork that helps you monitor and track your eating habits. It also alerts you with the help of indicator lights and gentle vibrations when you are eating too fast.

http://www.hapi.com/products/hapifork.asp

Glucose Monitoring

A cellular-powered glucose meter transmits each test result to a secure server and provides instant feedback and coaching to patients. This equips doctors, nurses, diabetes educators with real-time clinical data.

http://www.telcare.com/

Blood Pressure Monitor

Simply slip on the cuff, turn on the Wireless Blood Pressure Monitor and the Health Mate app will automatically launch.

http://www.withings.com/us/blood-pressure-monitor.html

Smart Sleep System

Visualize your sleep cycles, understand what wakes you up, and compare nights. From the palm of your hand you can control your personalized wake-up, and fall-asleep programs.

http://www.withings.com/us/withings-aura.html

Smart Tooth Brush

The Beam Brush is a connected toothbrush that engages users with their daily hygiene routine.

http://www.beamtoothbrush.com/toothbrush/

The Four Industrial Revolutions

Industry 1.0

Mechanization and the introduction of steam and water power

Industry 2.0

Mass production assembly lines using electrical power

Industry 3.0

Automated production, computers, IT-systems and robotics

Industry 4.0

The Smart Factory. Autonomous systems, IoT, machine learning

Industria 4.0

- The **Industrial IoT** also represents one of the six technologies underlying the so-called **Industry 4.0** (also known as **Smart Manufacturing**).

- According to this principle, which finds its place within a broader **fourth industrial revolution**, digital **technologies** - IoT devices, but also sensors, cloud, machine learning, collaborative robotics, 3D printing - **will be able to increase efficiency and value of production** by stimulating interconnection and cooperation between all resources, external and within the company.

Industria 4.0

- With Industry 4.0, operators are facilitated in their tasks thanks to **collaborative robots and new human-machine interfaces**, which enhance both their executive and decision-making skills.
- Finally, the **entire factory will be connected to the rest of the logistics-production** system and to customers via **cloud** platforms; the data relating to the use of the products will be used to facilitate after-sales assistance, the development of new products and services, and to natively enable new business models.

Industria 4.0

- In the **vision of the future of Industry 4.0**, **the plants, workers, input materials and finished products will be equipped with sensors** that will identify them and constantly detect their position, status and activity.
- Sensors that will allow the collection of data which, once analyzed, can improve :
  - production capacity,
  - efficiency
  - safety
  - operational continuity.

Industrial IoT (IIOT)

- It represents an evolutionary path of the Internet through which **every physical object (in the factory) acquires its counterpart in the digital world**;

- At the base of the IIoT there are **intelligent objects** (that is, capable of identification, localization, status diagnosis, data acquisition, processing, implementation and communication) and **intelligent networks** (open, standard and multifunctional).

Areas of use of the IIOT

- **Smart Factory**: **production progress control**, workplace **safety**, **maintenance**, material handling, **quality control, waste management**;

- **Smart Logistics**: **traceability / monitoring of the supply chain through RFID** (Radio-Frequency IDentification) tags and sensors, monitoring of the cold chain, safety management in complex logistics centers, fleet management (eg via GPS / GPRS);

- **Smart Lifecycle**: improvement of the **new product development process** (e.g. through data from previous versions of connected products), end of life management, supplier management in the new product development phase.

The Smart City model

Definition of Smart City

- **It is not possible to give a single definition of Smart City.**
- The "**smartness**" of a city derives from its ability to collect and process information.
- Smart cities are based on the principle of **managing and exchanging data** between different areas of the city.
- A possible definition sees the smart city as an "**organism**",
  in continuous evolution that benefits from the integration and use of the best technologies available.

Possible definitions

- A smart city is an urban area in which, thanks to the use of **digital technologies** and more generally of **technological innovation**, it is possible to optimize and improve the infrastructures and **services to citizens**, making them more efficient.
- The **smart city** (in urban planning and architecture) is a **set of urban planning strategies** aimed at **optimizing and innovating public services** so as to relate the material infrastructures of cities "with the human, intellectual and social capital of those who lives " thanks to the widespread use of **new technologies of communication**, **mobility**, **environment** and **energy efficiency**, in order to improve the **quality of life** and meet the needs of citizens, businesses and institutions. (Wikipedia)

Current trends

- According to experts, **between 60 and 70% of the world's population will live in urban areas by 2050**, doubling current numbers.

- Such rapid and large-scale urbanization must be managed in order to ensure **efficiency**, **sustainability** and a **good quality of life**.

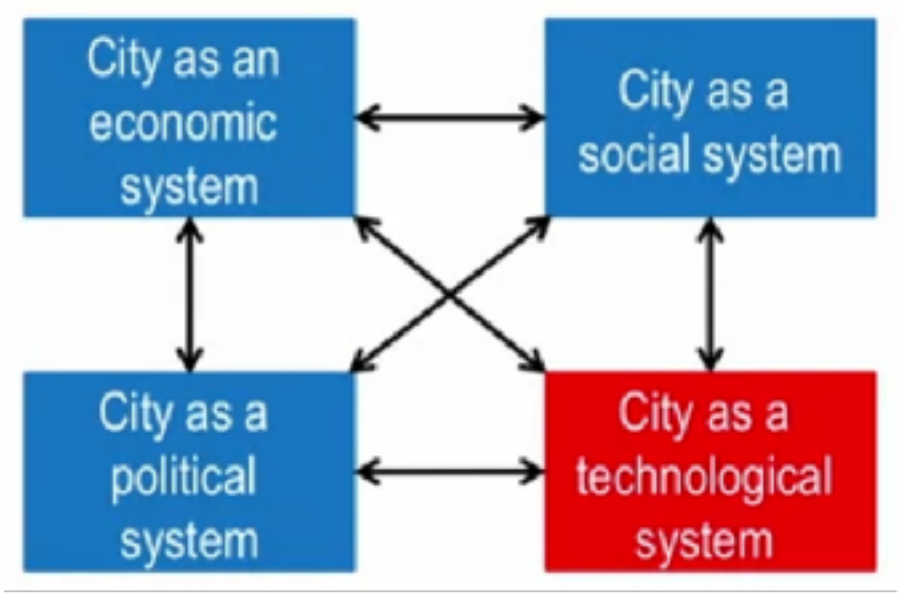
- We need to **rethink the concept of cities**, identify a whole series of dynamics and factors useful for their development, "re-design" and "re-organize" them with a view to **optimizing resources.**

ICT and Smart Cities

- **The heart of the city will be technological** and will influence the following macro areas: **economy**, **liveability**, **mobility**, **environment**, ***governance*** and **people**.
- **ICT** (information & communication technology) has been central to our lives for some time, but what changes compared to the past is its purpose:
  from a tool to improve products and processes,
  it becomes **a tool to improve people's well-being.**

The concept of "city" as a complex system

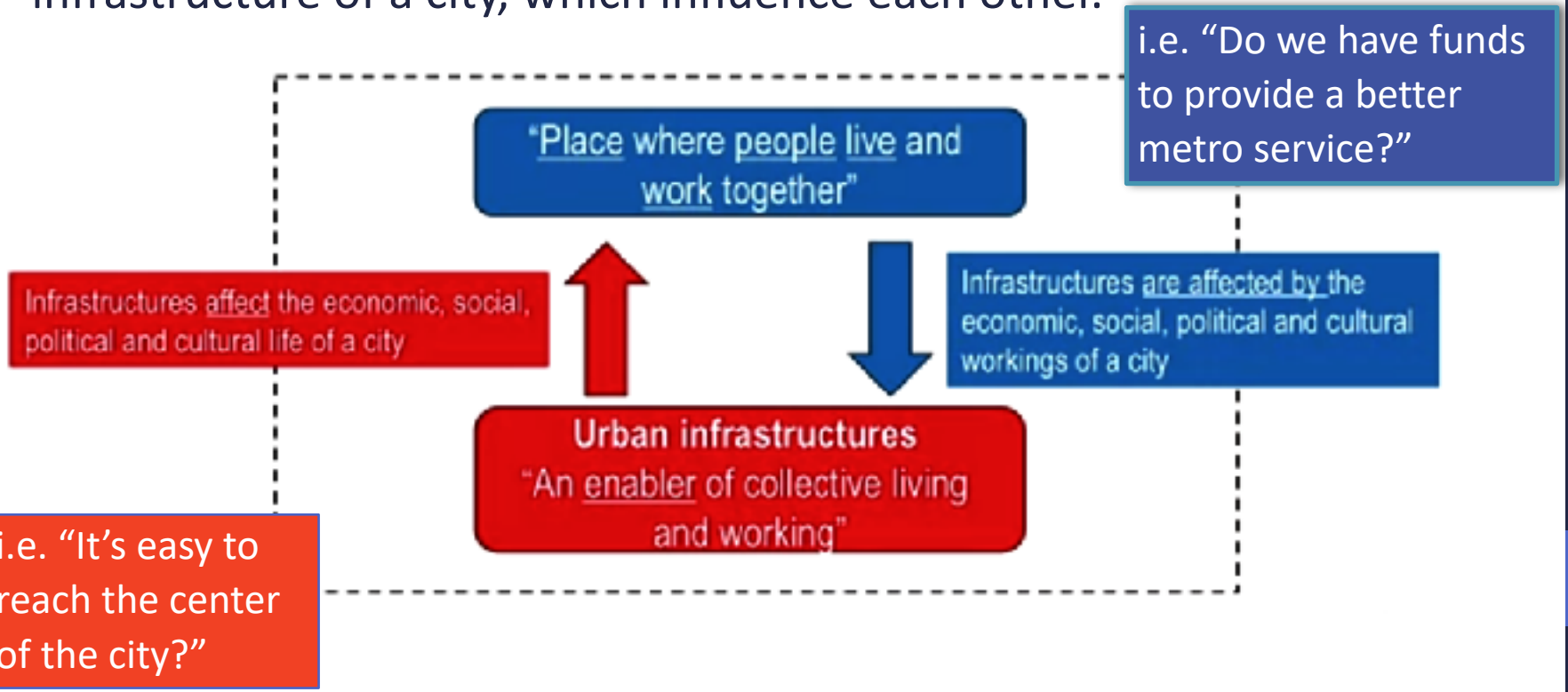
- The city can be seen as a place where people live and work together.
- A more accurate view divides the city into more specific subsystems that interact with each other.



Smart Cities - Management of Smart Urban infrastructures. Prof Matthias Finger (Ecole Polytechnic de Lausanne)

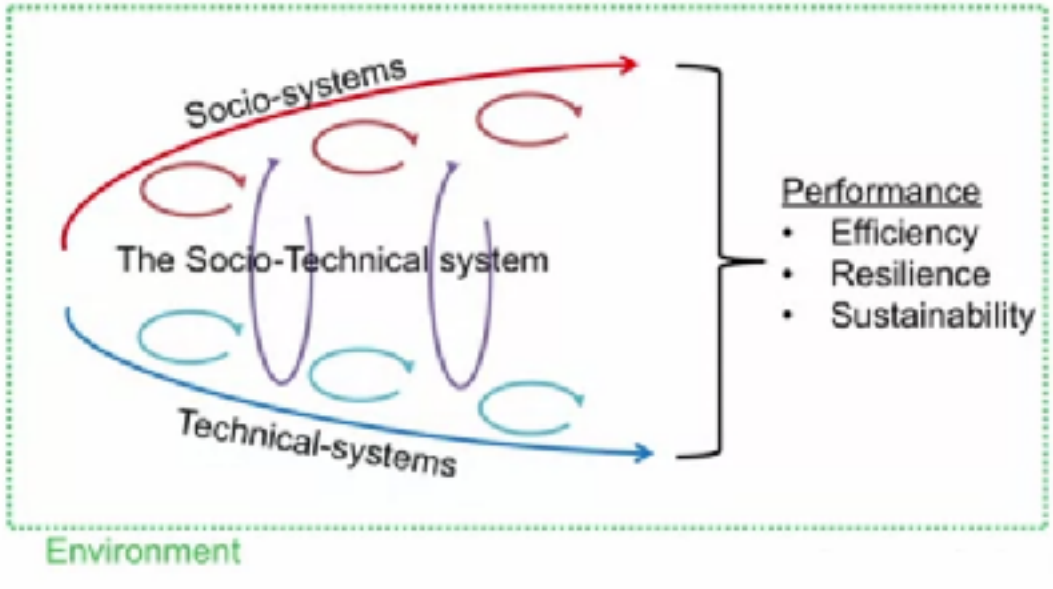
The infrastructure of the city

- There are fundamental interactions between people and the infrastructure of a city, which influence each other.



Infrastructure (feedback loops)

- The **social dimensions interact with the technical dimensions**.
- The technical dimensions interact with the economic dimensions and all this creates **feedback loops between the sub-systems** of the city.
- The **complexity of the "city" increases considerably**…



Digitalization as a new layer

- What are the advantages of **digitalization** as a tool for the governance of a smart city?

The pillars of digitalization

- **Data** generation and storage
- **Communications** and networking
- Internet of Things (**IoT**)
- **Analitycs**

Data generation and storage

- Data production potentially comes from an **ever-increasing number** of **resources** including:
  - Sensors
  - Video cameras
  - RFIDs
  - GPS
  - Smartphone
  - …

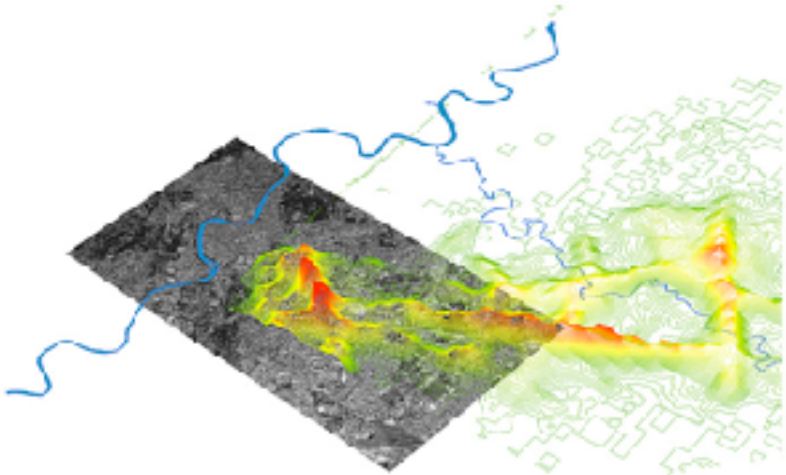
and **also at lower cost**, with ever smaller devices, and with ever lower storage costs (but with increasing capacities).

Sensing a “city”?

Prof. Carlo Ratti
SENSEable City Lab at MIT

Real Time Rome project

A night on the 9th July of the 2006…

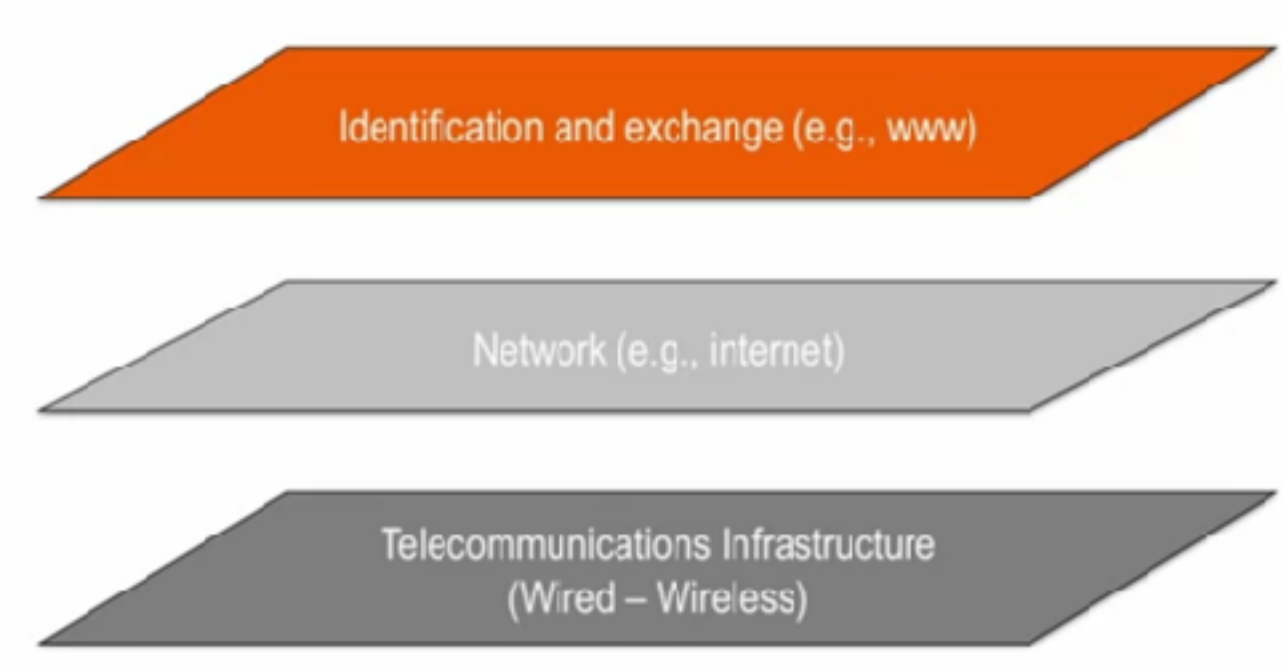


http://senseable.mit.edu/realtimerome/


sensing...
TED

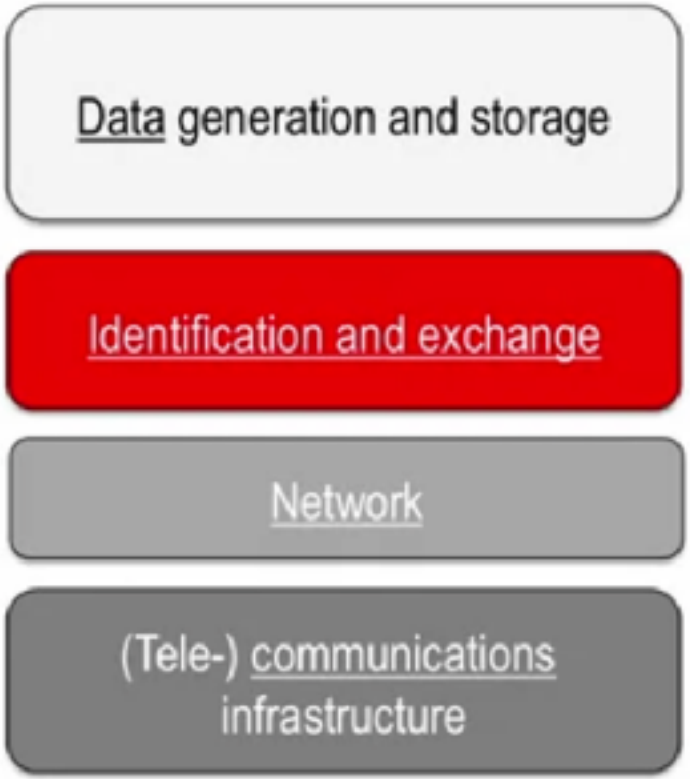
Communications and networking

- It is possible to identify 3 macro layers of the communication and networking aspects of a smart city.

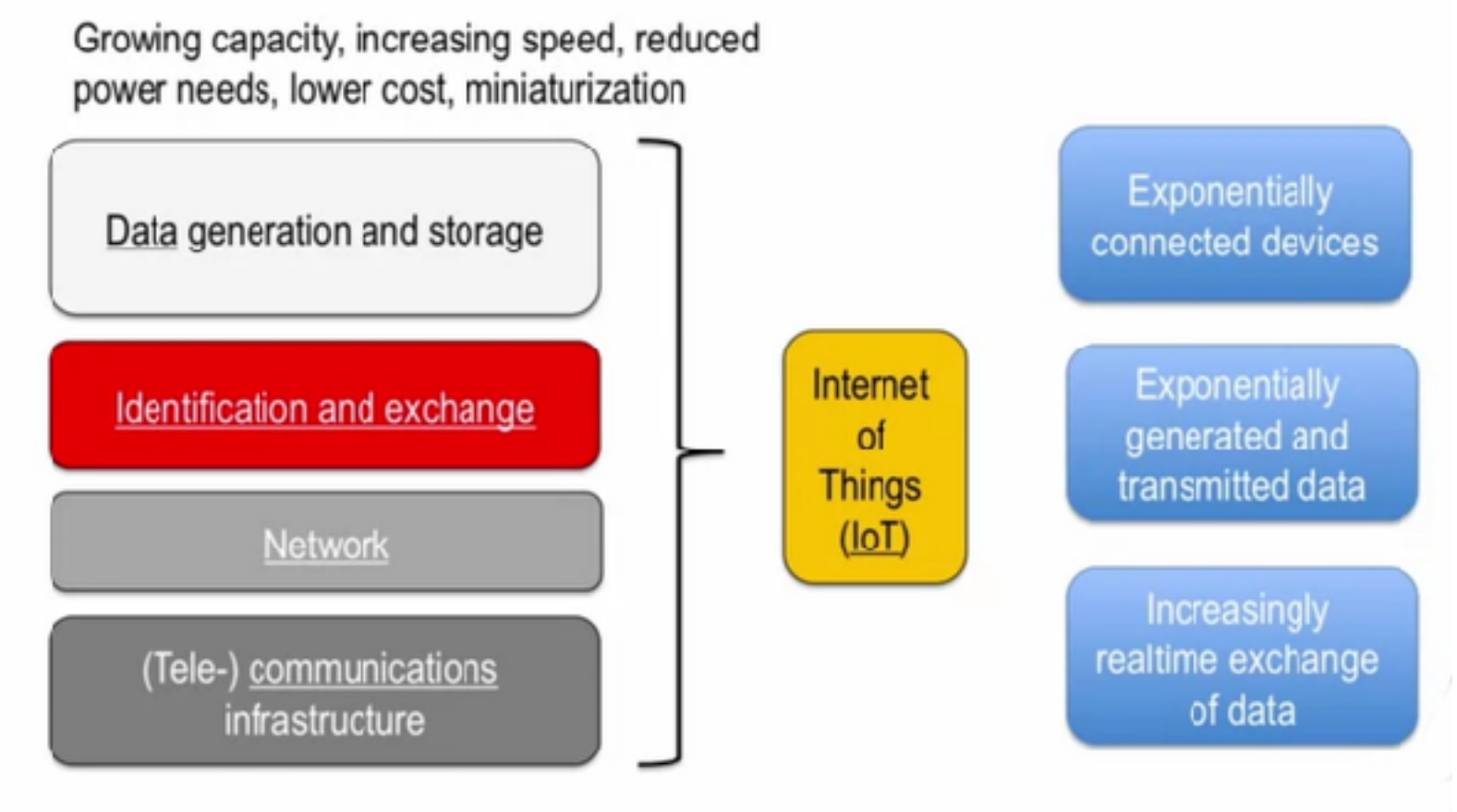


Data + Networking

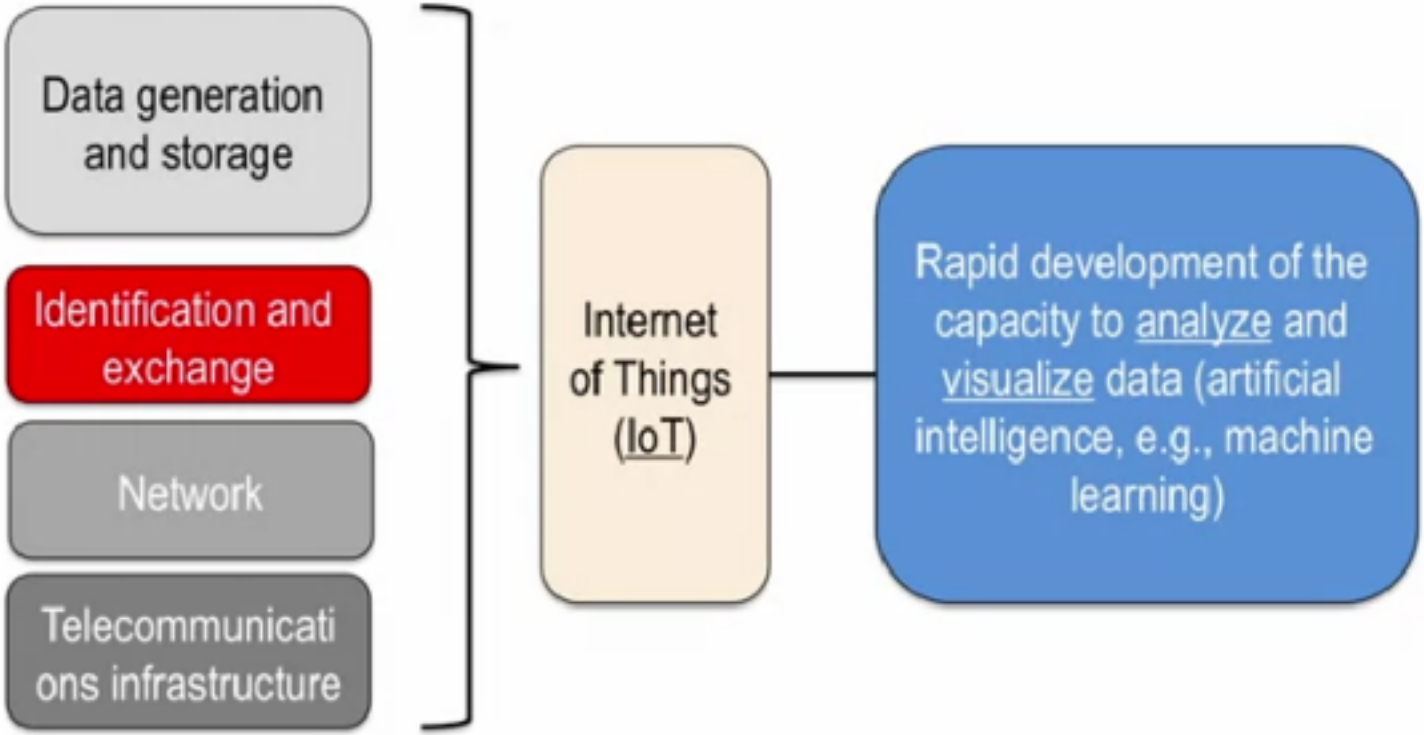
- This stack is characterized by having an increasing **storage capacity**, an increasing transmission **speed**, less and less **energy** demand, **costs** that are progressively reducing, **dimensions** that are now tending to be negligible.



The IoT scenario



The role of analytics (big data)



Effects of the digitalization process

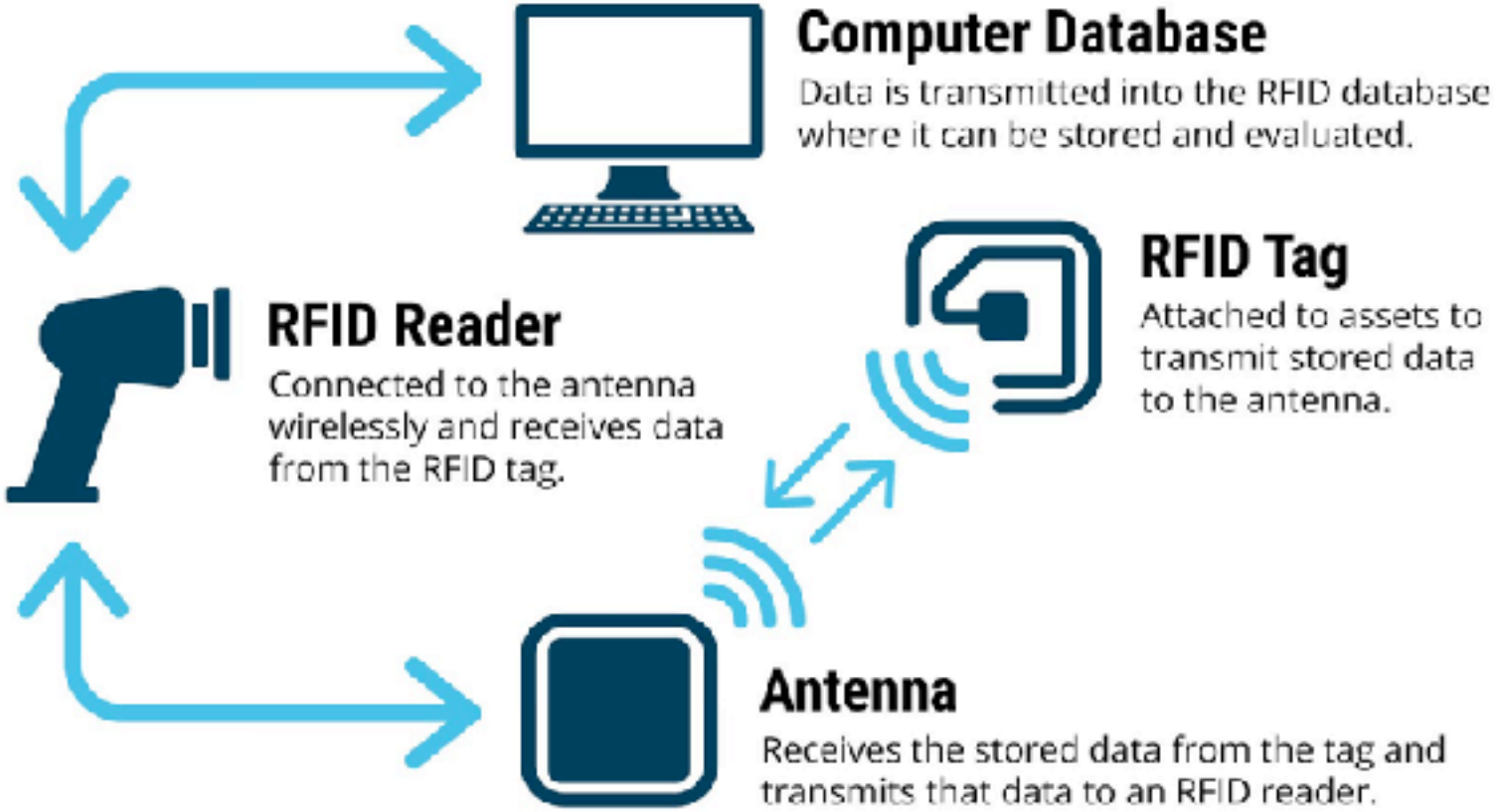
The “Trash|Track” project

Why do we know so much about the supply chain and little about the removal chain?

Prof. Carlo Ratti
SENSEable City Lab at MIT

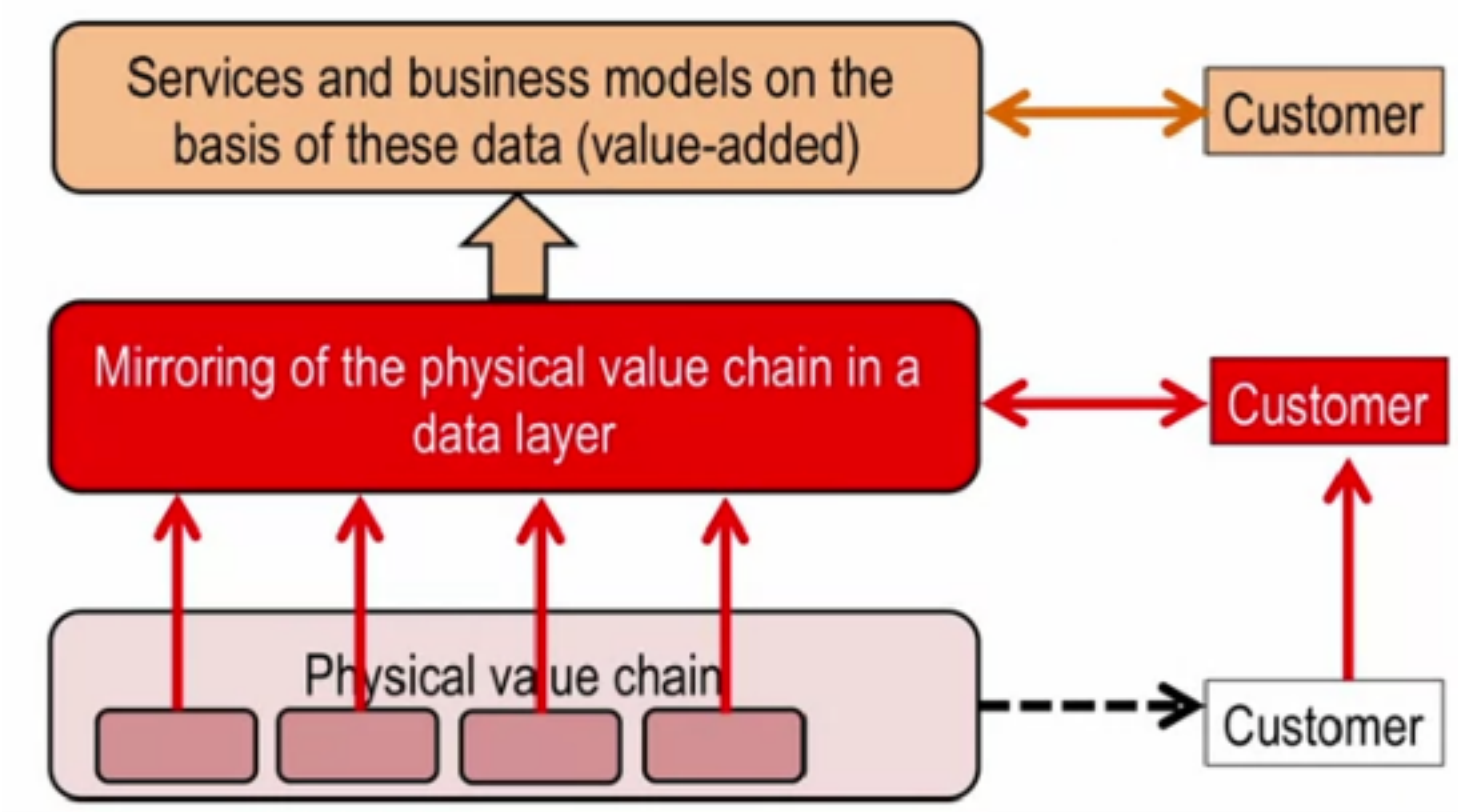
https://senseable.mit.edu/trashtrack

Tech hint: what is RFID?

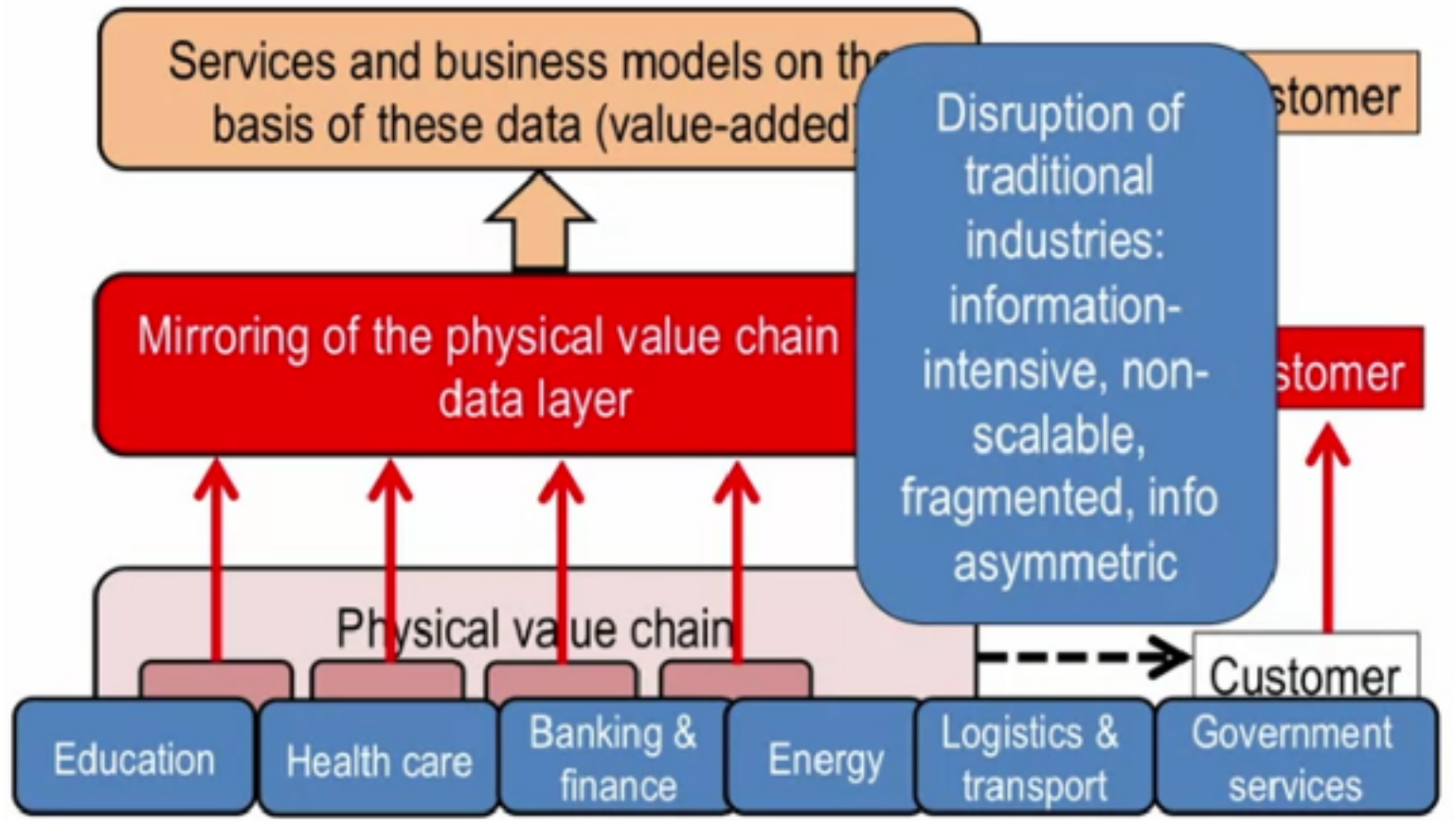


Impacts of digitalization (industry)

I.e. buy a book on Amazon

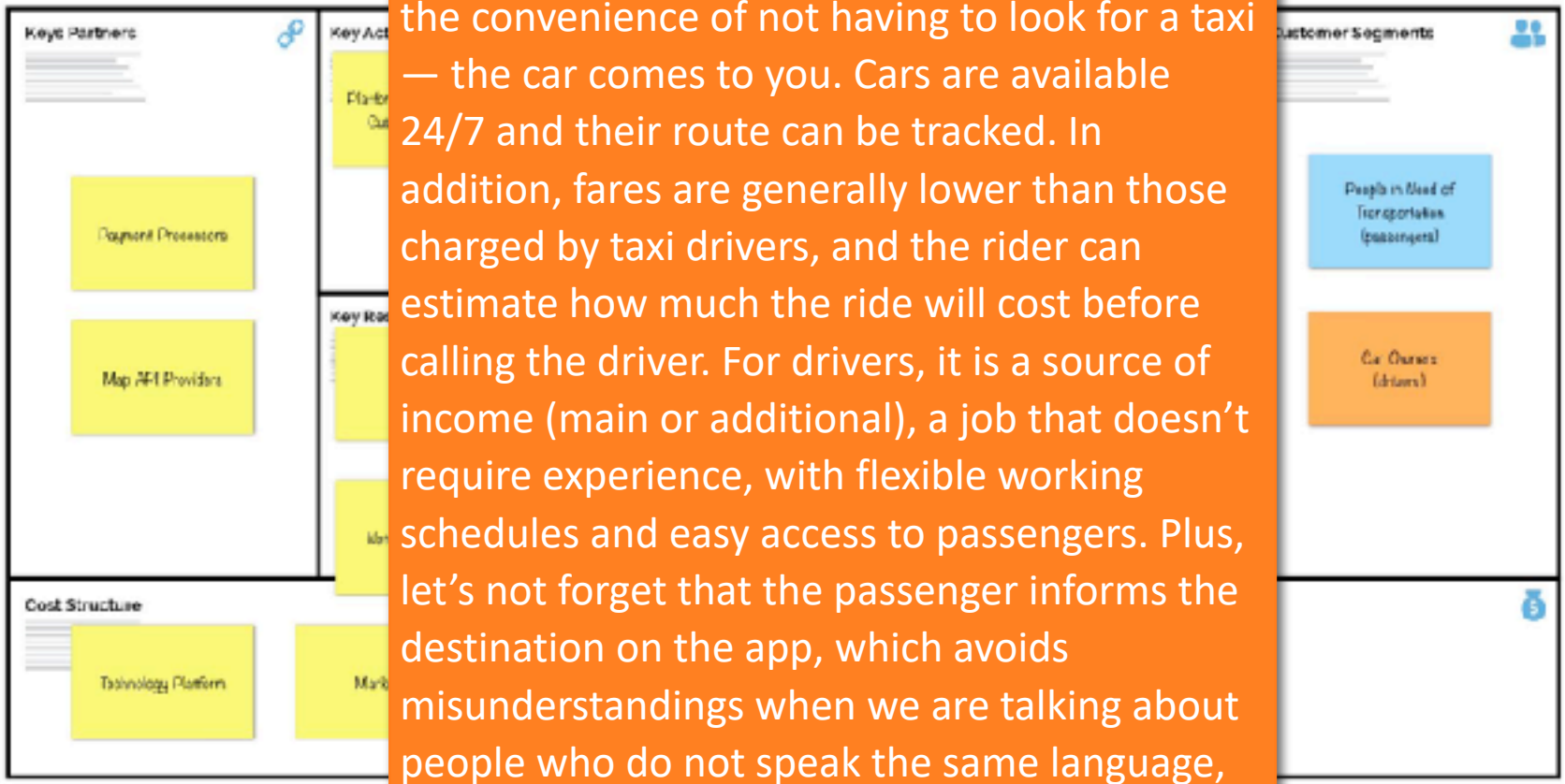


Impacts on some industrial sectors



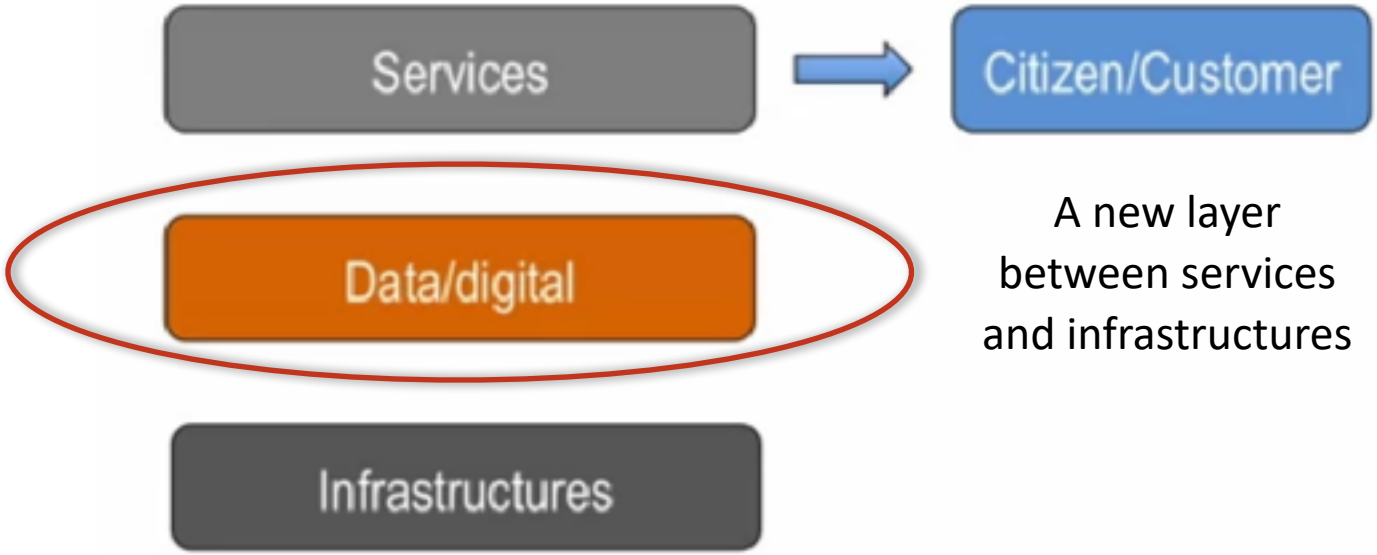
The Uber model

Uber - Business



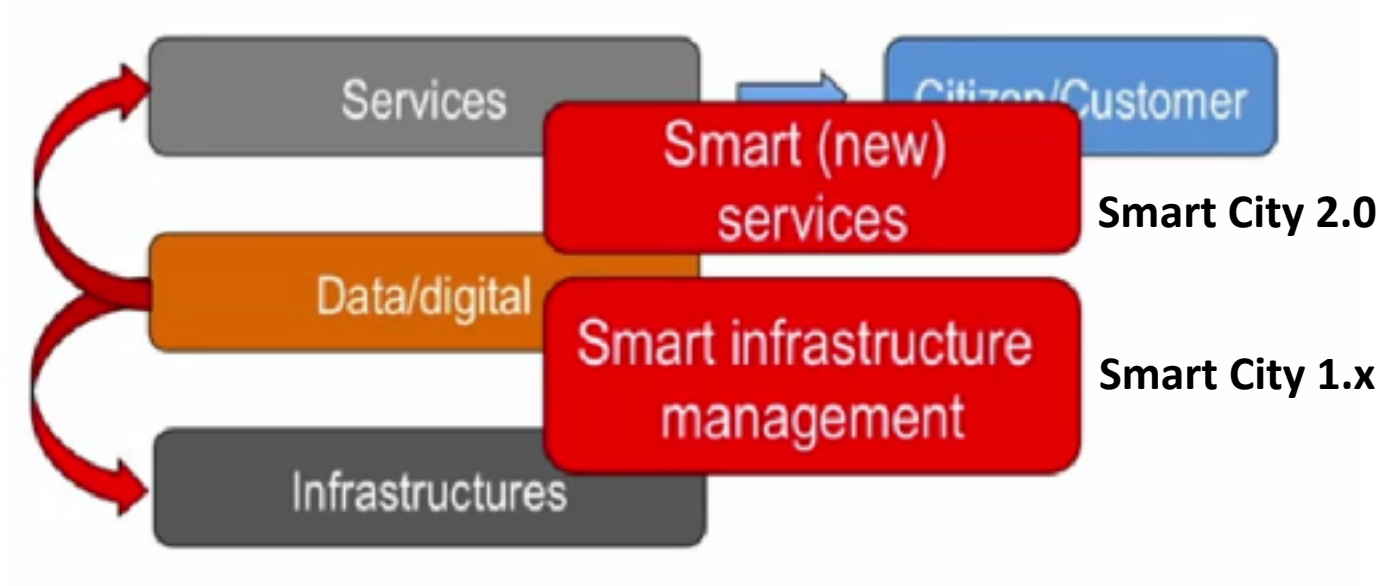
For customers, the greatest value proposition is the convenience of not having to look for a taxi — the car comes to you. Cars are available 24/7 and their route can be tracked. In addition, fares are generally lower than those charged by taxi drivers, and the rider can estimate how much the ride will cost before calling the driver. For drivers, it is a source of income (main or additional), a job that doesn't require experience, with flexible working schedules and easy access to passengers. Plus, let's not forget that the passenger informs the destination on the app, which avoids misunderstandings when we are talking about people who do not speak the same language, which is a positive point for both sides.

Digitalization impacts on infrastructures

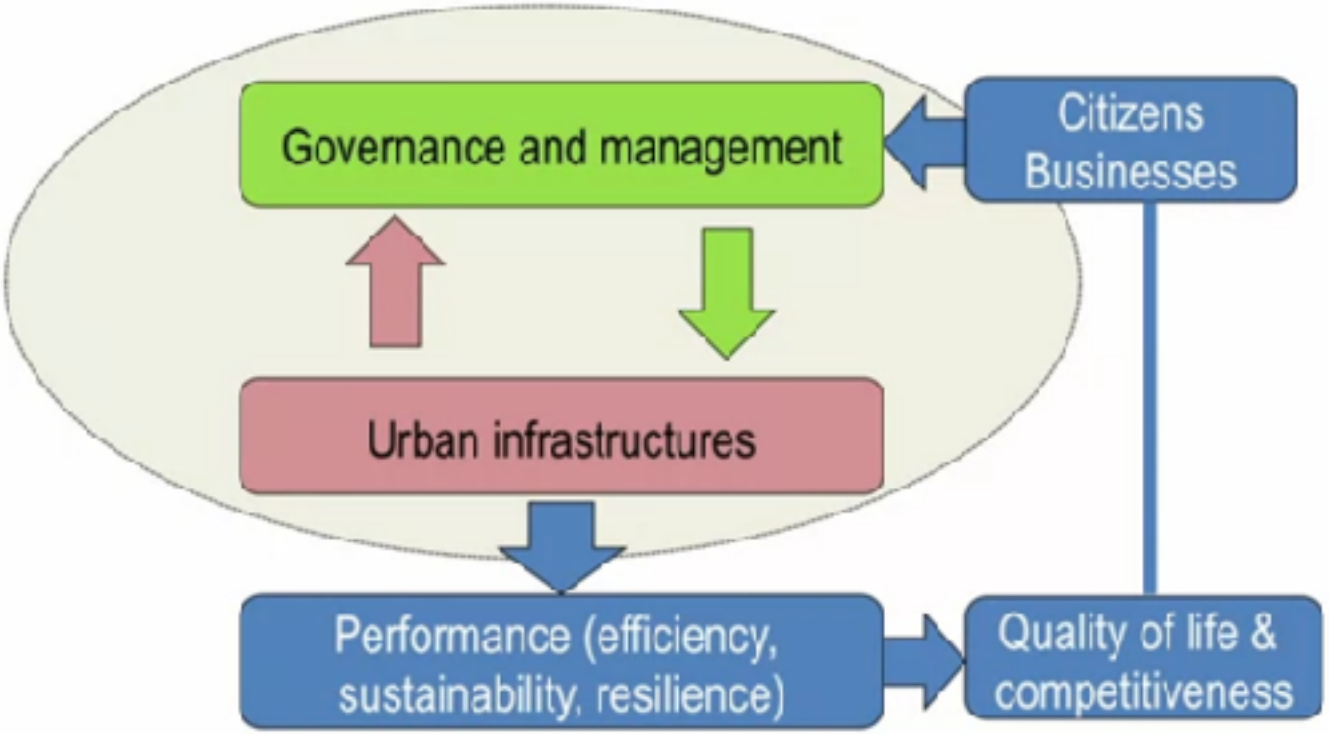


A new layer
between services
and infrastructures

Digitalization impacts on infrastructures



Infrastructures and socio-technical interactions

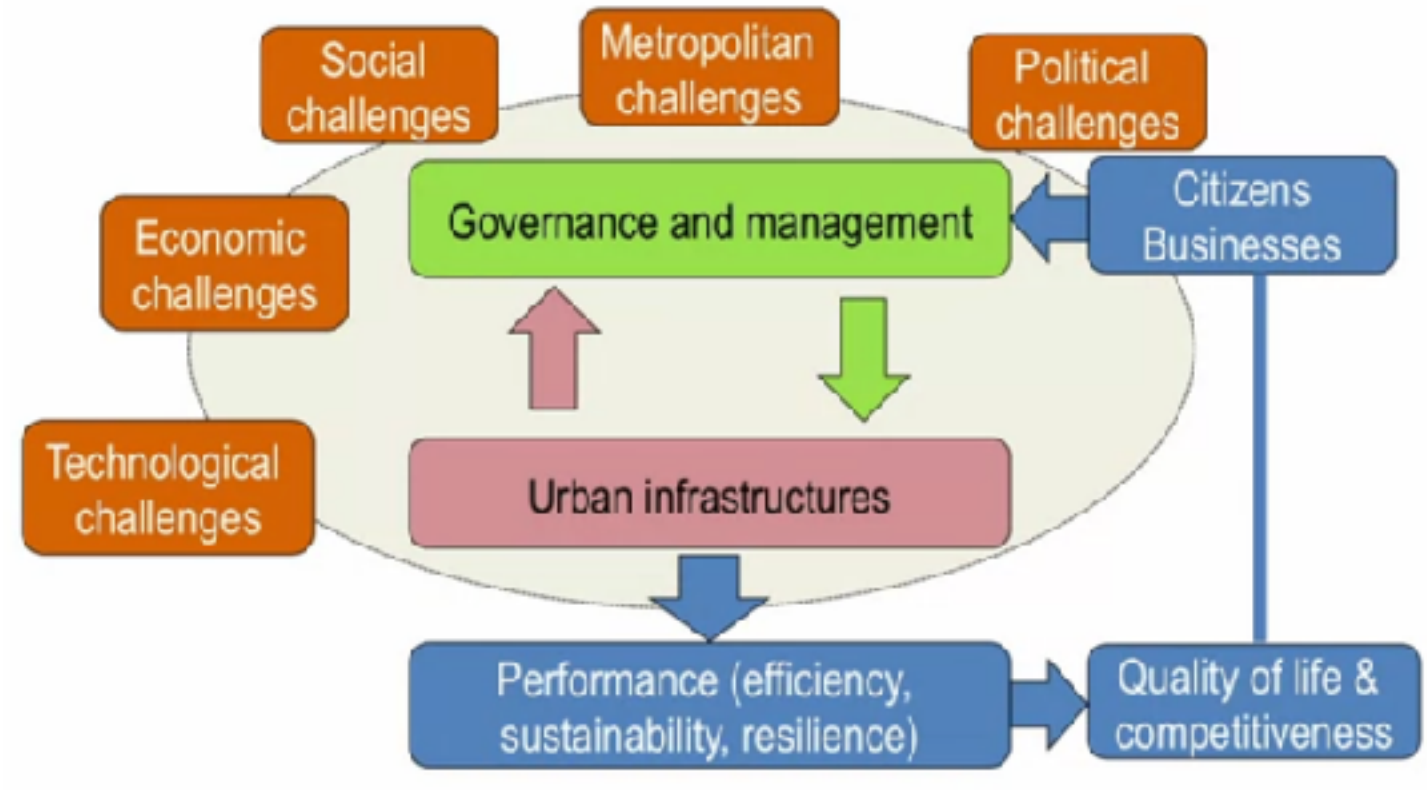


How quality is perceived by citizens and companies

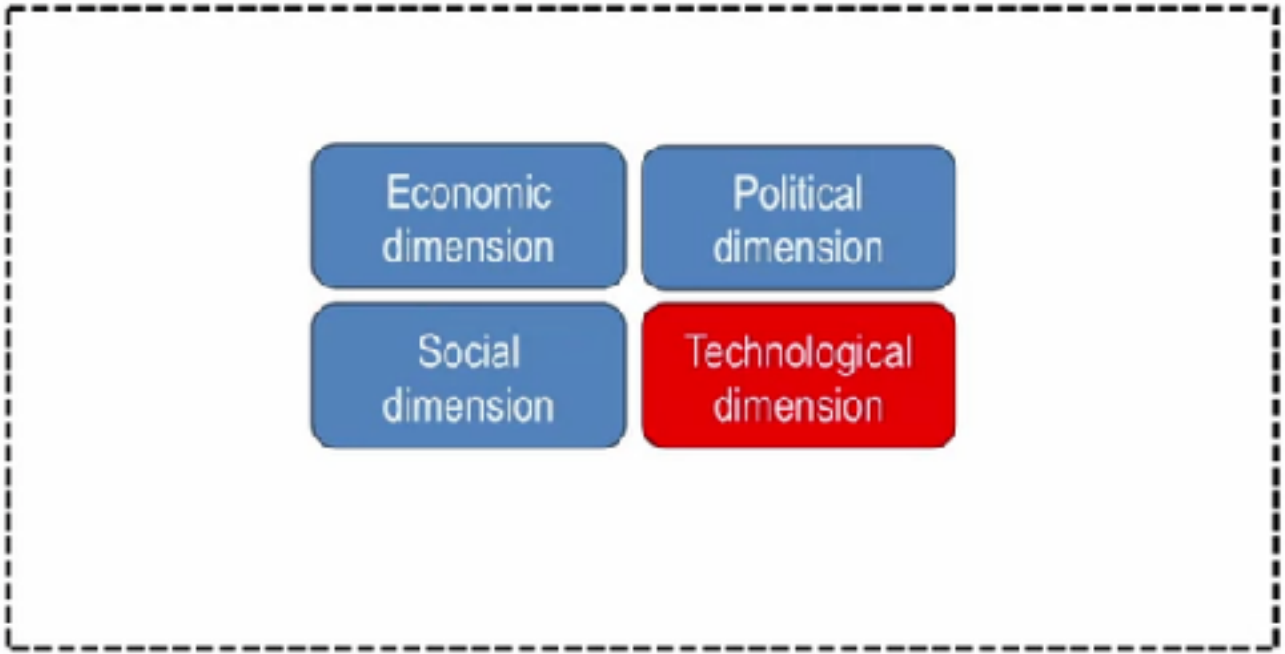
In terms of a City

Possible metrics of evaluation

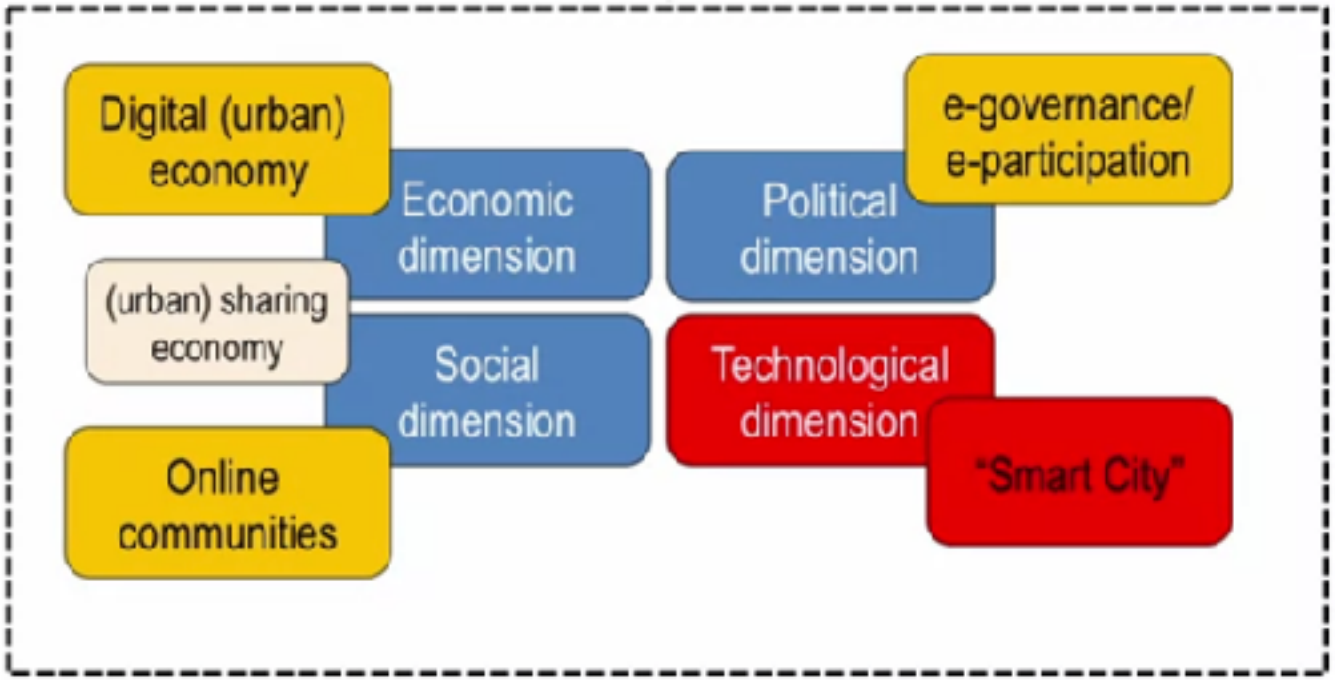
Infrastructure: challenges and digitalization



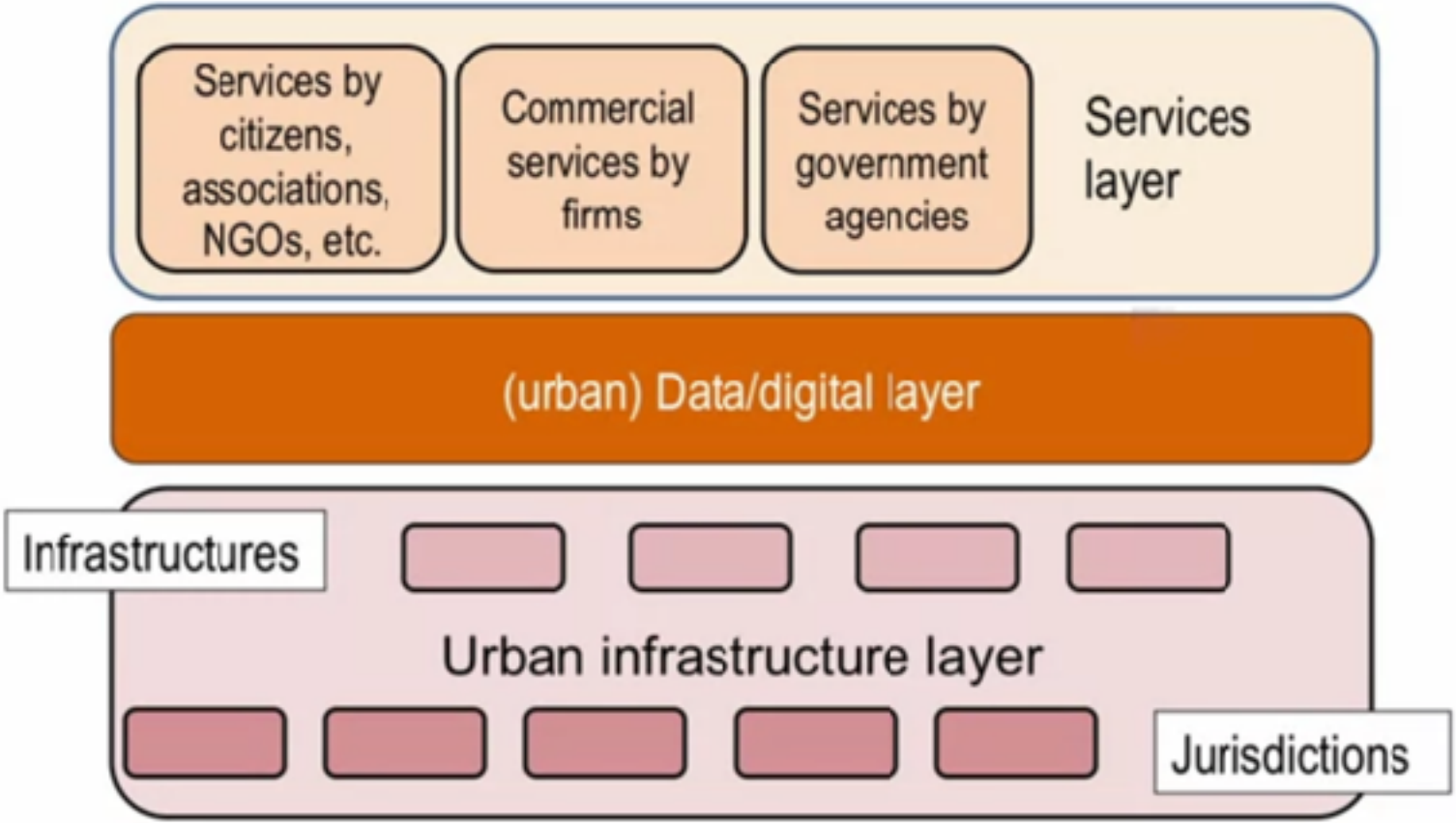
The dimensions of a smart city



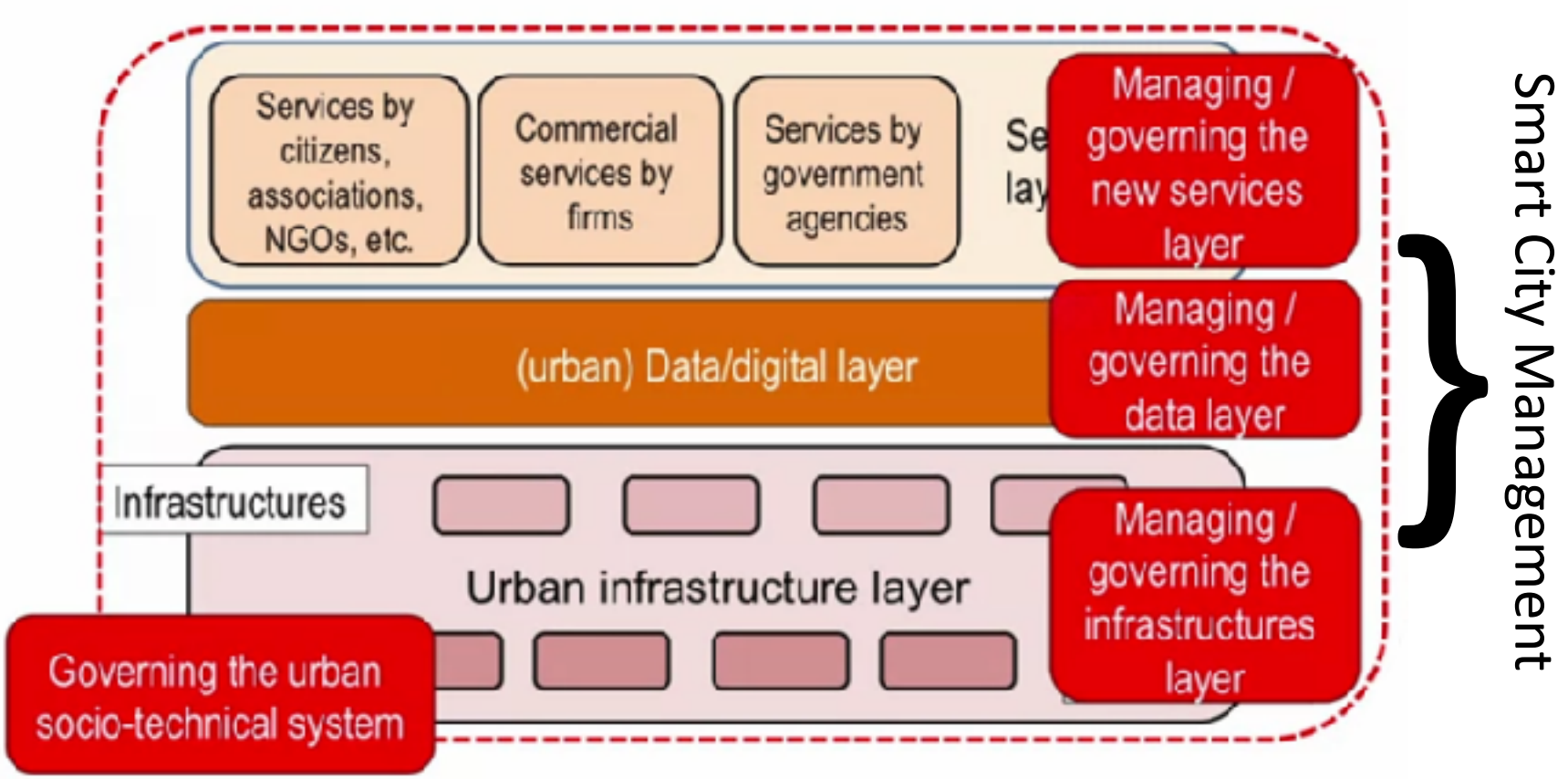
Smart City and "citizens"



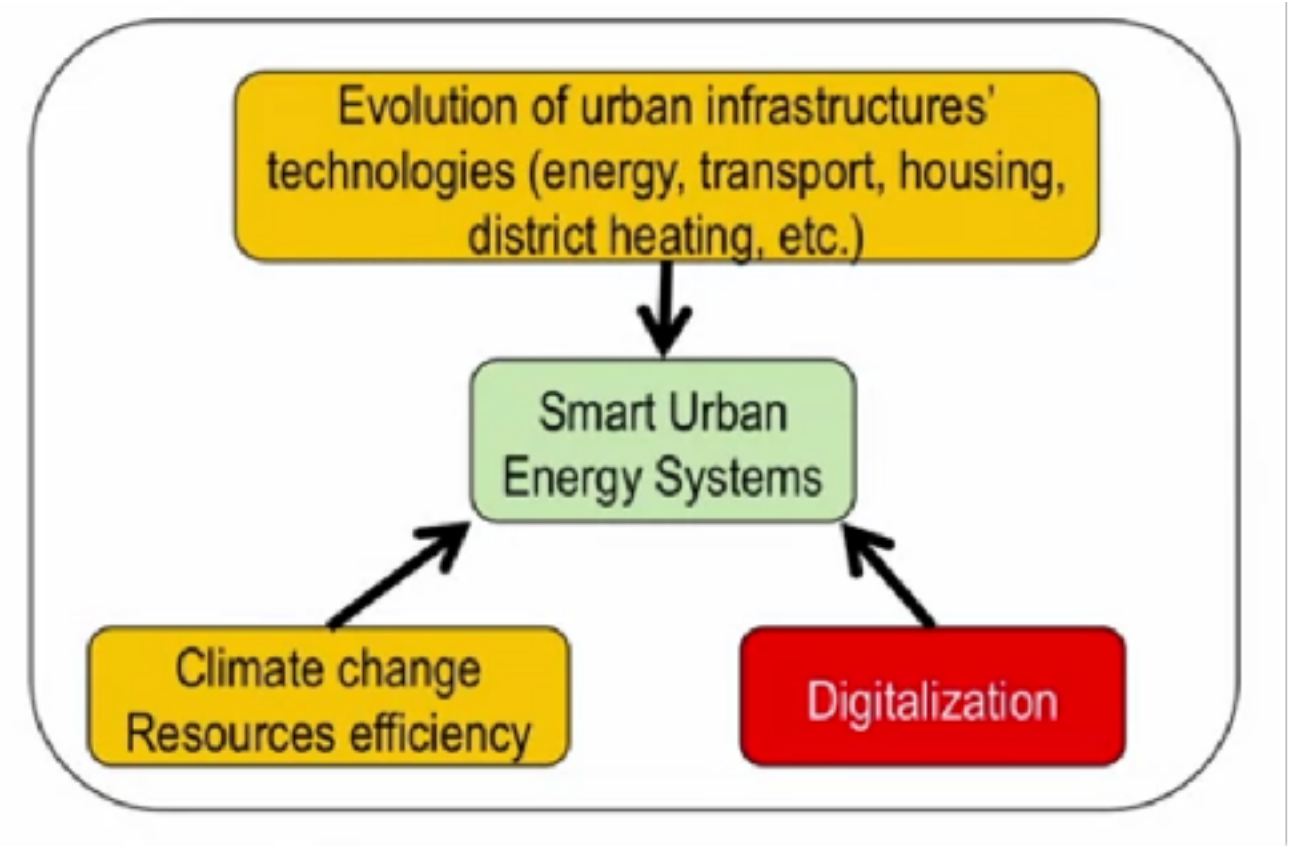
Smart City (big picture)



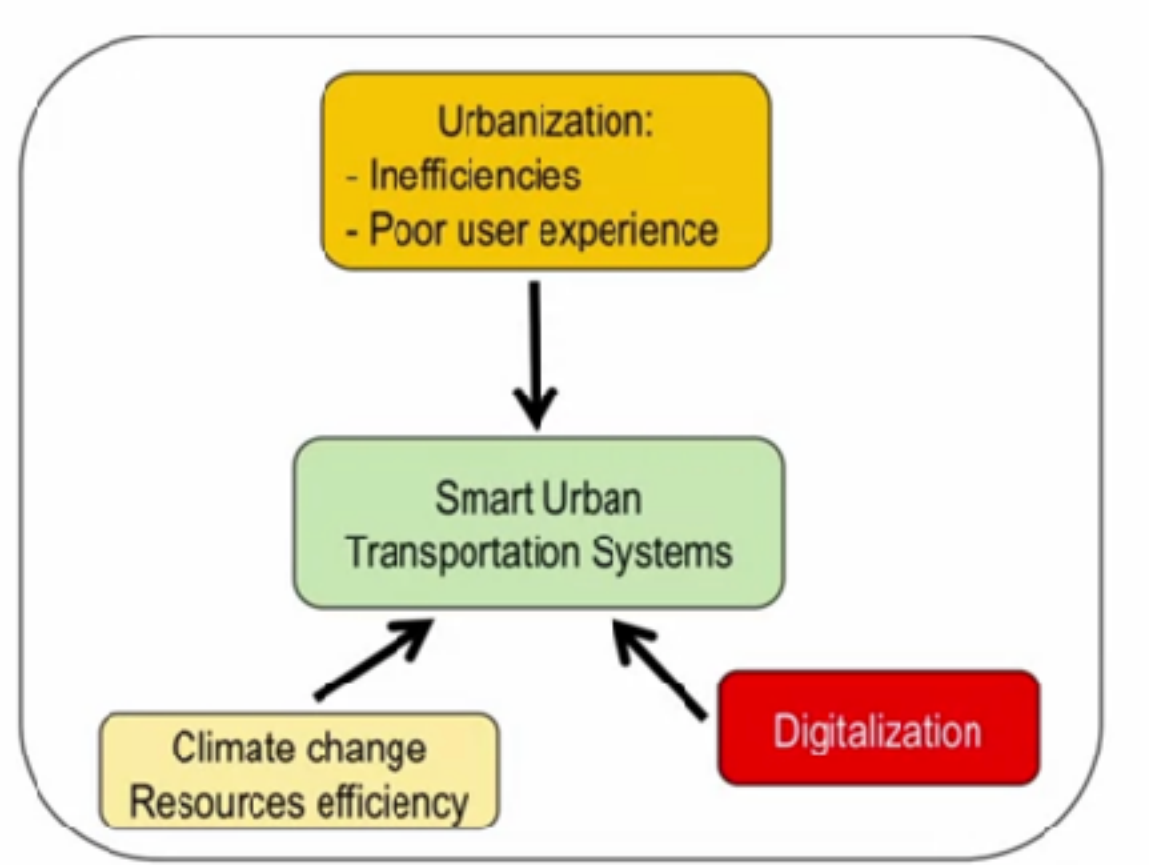
Implications on the management of the Smart City



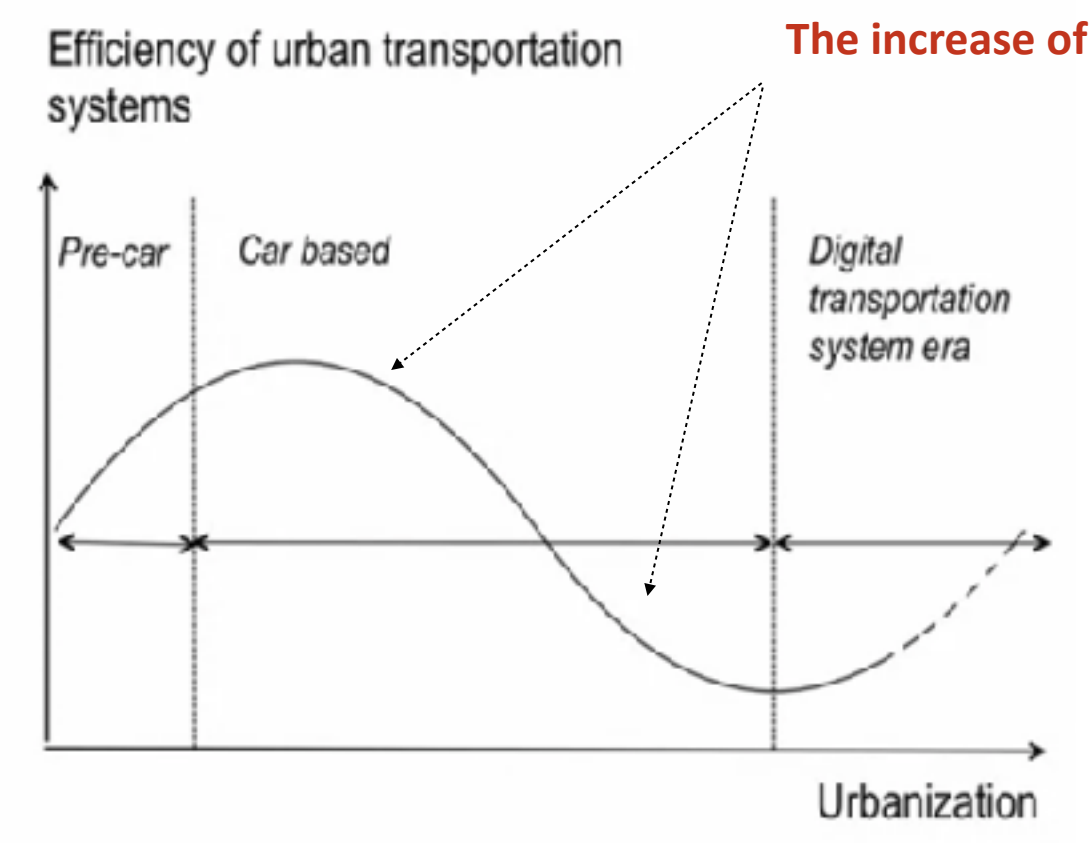
Smart Urban Energy Systems (drivers)



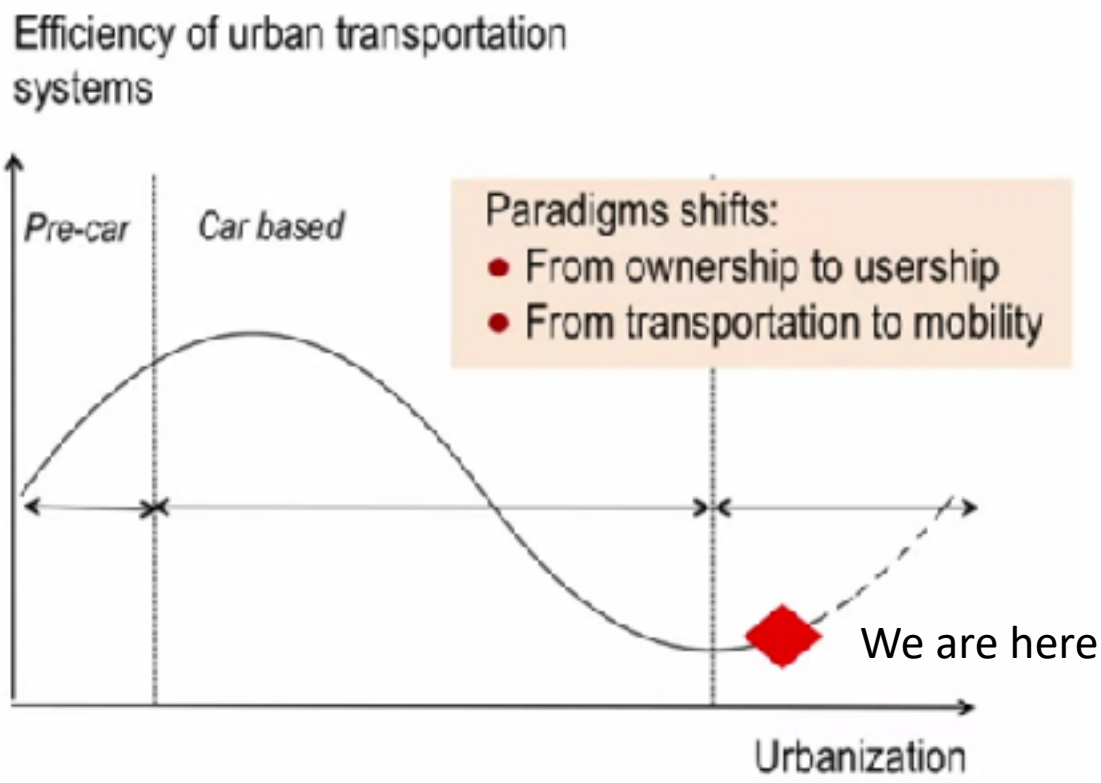
Smart Urban Transportation Systems (drivers)



Evolution of urban transport systems



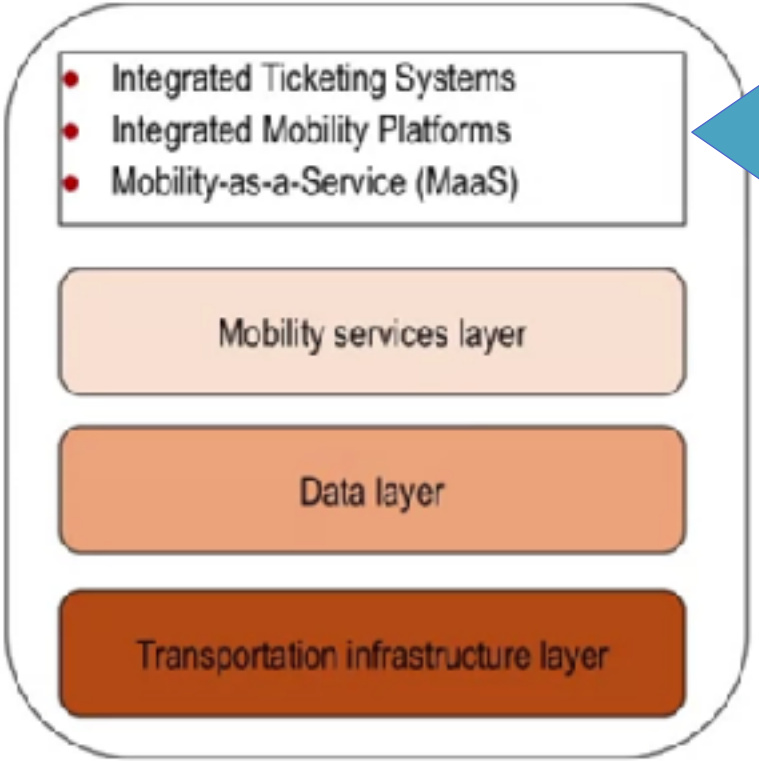
Change of paradigm



Enabling technologies in modern mobility services

- Video cameras
- Specific cameras (speed cameras)
- Integrated sensors (in road, in cars, etc.)
- Data processing and communications (wi-fi, 5G, etc)

Integration of mobility services

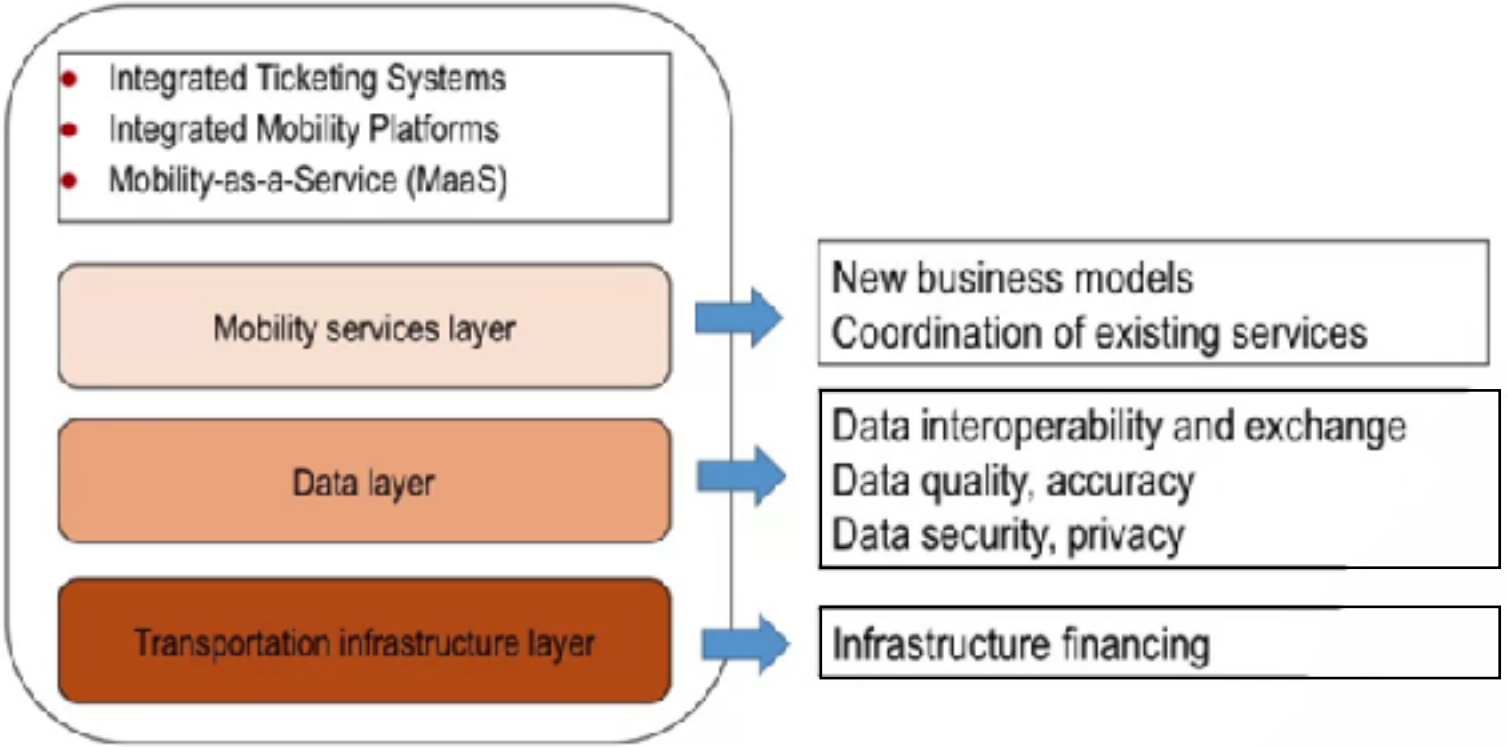


Users only use one **single ticketing system** to access and pay for different mobility solutions.

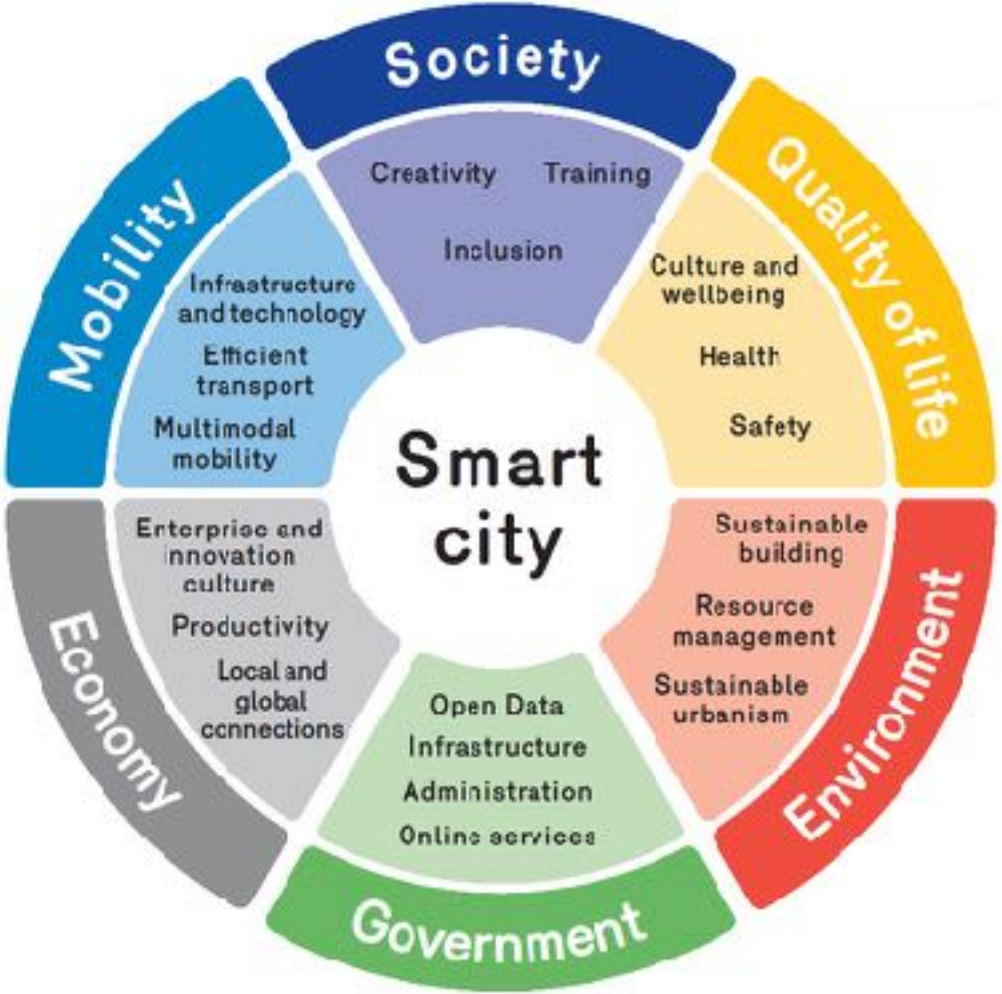
With **integrated mobility platforms**, users have access within one smartphone app to information from various transportation providers about the trip they are planning to do.

MaaS is a mobility distribution model where you pay a fee (i.e monthly) and have access to mobility solutions and mobility services depending on the package you have selected and paid for (i.e. as a Netflix for transportation.

Implications of the new mobility models



Recap: Dimensions of a Smart City



Smart Cities drawbacks

1. **Limited privacy:** Since the authorities or the government will have access to security cameras and intelligent systems connected through many different spaces, the citizens will have difficulty in maintaining their anonymity.
2. **Social control:** The people who can track and centralize the data they gather will have greater power. It can be a government, a private agency, or other authorities.
3. **Excess network trust:** Since the citizen of these smart cities will rely almost entirely on electronics and networks, they will lose autonomy in their decision-making and could become incompetent.
4. **Difficulty in social relationships:** Models like the "15 minutes" one, can create social isolation, or more specifically urban discrimination, segregations, etc.
5. **Pre-training is required:** If the people of the city don't know about technology, then they will not be able to use it. Without training, they will find it irrelevant to their daily lives and will find it difficult to utilize it.

Smart Cities sample applications

Paris: “the 15 minutes” model

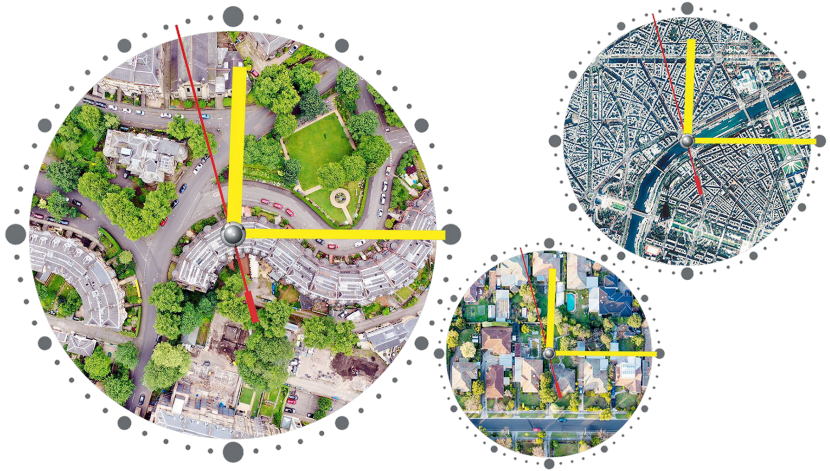
Concept:

The 15-Minute City is a model for urban development and urban mobility developed by Professor Carlos Moreno at the Sorbonne in Paris and promoted by Paris mayor Anne Hidalgo. The 15-Minute City is a city in which all residents can reach daily necessities within a short walk or bike ride from their homes. In their article from 2021, Moreno et al. introduce the concept of the 15-Minute City, which aims to ensure that city residents can perform six essential functions (living, work, commerce, health, education, and entertainment) within a 15-minute walk or bike ride from their homes. The 15-Minute City framework of this model has four components: density, proximity, diversity, and digitization.

Paris: “the 15 minutes” model

Goal:

The goal of the 15-Minute City is a more environmentally friendly and socially inclusive urban (sub)development, which should make urban life more qualitative, agile, healthy and flexible.



Main features:

1. The city should follow the rhythm of people, not cars.
2. Every square meter should serve multiple uses.
3. Urban quarters should be designed in a way, that people do not need to commute.

Paris: “the 15 minutes” model

Criticism:

In contrast to the concept’s endorsements and opportunities, it is also subject to significant criticism. Spatial distances between living, working, (local) supplies, services, leisure, and educational facilities should be kept short so that the need for transport is reduced and traffic is avoided.

Paris: “the 15 minutes” model

Conditions:

The concept does not serve as a fixed blueprint but presents a framework of ideas and principles and must be applied to the hyperlocal and socio-political context of different urban forms.

All urban residents - living in the center or sub-urbs - must have access to essential services in close proximity. To achieve this, it requires:

- **a massive spatial decentralization;**
- **a transformation of existing infrastructure;**
- **the development of new services for each neighborhood;**
- **the transformation of streets into bike lanes and pedestrian areas;**
- **new economic models that attract local businesses.**

Paris: “the 15 minutes” model

Main advantages:

1. Reduction of emissions
With essential services at your fingertips, harmful emissions are significantly reduced by increasing the quality of the air.

2. Harmonious urban development
With this approach, cities can grow more harmoniously, balancing the presence of all essential services.

3. Life quality
Better quality of life for citizens: cleaner air, less busy roads, more accessible services, greater sense of community.

Home Plus e-commerce (South Korea)

Project name	Homeplus e-commerce
Country	South Korea
City	Several
Date	
1. Smart Economy	Entrepreneurship
2. Smart Economy	Innovation
Addressed challenges	Lack of competitiveness, Economic decline
Development stage	Ongoing
Scale	Widecountry
Budget	-
Population	51.302.044
Surface	100.210 km2
Framework	[Strategy]
Goals	Efficiency and quality of life
Financed	Private
PIB per capita	28.739USD/hab
Link	

DESCRIPTION The project consists in a supermarket e-commerce for metro users. Homeplus tries to extend their influence in supermarkets in South korea without the big investment of necessary for acquiring a building. Thus, it has implemented shops for smart phone commerce in metro stations

OBJECTIVE The project aims to engage metro users in ecommerce of food. Homeplus tries with this initiative becomes in the most important supermarket in South Korea

METHODOLOGY Posters are left in metro stations walls. This posters have drown the supermarket products with the same appearance that there are in the actual supermarket. Metro users can use their smart phones for reading the QR product codes in order to buy items. The products are delivered at customers' house.

INNOVATION Use e-commerce at big scale. Trying to replicate the sensation of being in a real shop.

IMPACTS

- Number of new members rose by 76% (3 months).
- Online sales increased 130% (3 months).

FRAMEWORK South Korea's markets ranks 15th in the world by nominal GDO. It is one of the G-20 major economies. The main economic activity in South Korea is international trade. South Korea gather information in a Big Data Platform. Some of these data is open to citizens in the open government of the country.

Almost a 100 % of South Korea population is smart phone user.

South Koreans are the second hardworking people in the world. Thus, they usually make the shopping one a week.

Watt et moi (Lyon)

Project name	Watt et Moi
Country	France
City	Lyon
Date	2012 - 2014
1. Smart Environment	Energy efficiency
Challenges addressed	Energy saving and efficiency
Development stage	Pilot project
Scale	Metropolitan
Budget	Per linky: 150 € to install. 1-2 € /per hh/month over 10 year
Population	500.000
Surface	4.800 Ha
Framework	Included in Lyon Strategy
Goals	Efficiency
Financed	ERDF has invested 40M€ to modernize the electricity network.
GDP per capita	43.000 €/hab
Link	https://www.watt-et-moi.fr/

DESCRIPTION 175 000 Linky meters installed in Greater Lyon in order to provide to participants of the experiment access to a secure and free web site: consumption data (kWh, season, month, day, hour), monthly curves of consumption, comparisons and advices.

OBJECTIVE The project allows providing a new technological tool to help residents to be aware of their electricity consumption and to adapt their consumer behavior.

METHODOLOGY Experimentation with a panel of 1 000 hhs in Greater Lyon, already equipped with the smart electricity meter Linky.

INNOVATION The project is based in other implemented projects.

IMPACTS

- Participants interest for the experimentation. Good acceptance.
- The impact on their consumption. Major implication if looking for savings (consumption, expenditure).

FRAMEWORK The main economic activities in the city are Health and social services, public administration, advisory and assistance services, education and transport. Lyon has a Smart City Strategy at city level. As common ground of city data the city has a Big Data Platform.

60-80% of the city has access to broadband connections. 40-60% of the citizens are mobile internet users.

This project affects mainly to the environment. Currently the 25% of the energy is consumed in housing, 27% in industry, 34% in road transport and 20% in services sector. This energy comes from 33% from gas, 28 from electricity and 18 from diesel. Hydraulic is the most important renewable energy within the city. In Greatl Lyon is produced 7M ton of CO_2, mainly emited by energy and industrial sector following of the transportation sector.

Smart Water Metering (Kalgoorlie-Boulder)

Project name	Smart water metering
Country	Australian
City	Kalgoorlie-Boulder
Date	2011 – Ongoing
1. Smart Environment	Resources Management
Challenges addressed	Holistic approach to environmental and energy issues. Urban ecosystem under pressure
Development stage	Ongoing
Scale	Region
Budget	$4million
Population	33,769
Surface	95,575 km²
Framework	-
Goals	Sustainability and efficiency
Financed	Water Corporation and Federal grant funding.
GPD per capita	49.019€ (Australian)
Link	http://smartcitiescouncil.com/resources/smart-water-metering-solution-reduces-water-usage-10-australian-city

DESCRIPTION. Install smart water meters in customer's properties serving them to an online service that shows consumption habits and useful information to reduce the water bill through knowledge of ineffectiveness devices.

OBJECTIVE. Reduce water consumptions and habits and detect water leaks in a shorter time.

METHODOLOGY. Everblue: it has 3 main components: one in the customer's property with a radio transmitter to send radio signal to a collector mounted on a power pole or a street light pole and those transmit the information daily on to access points where the information to the systems (Mywater) where customers can access to know consumptions

INNOVATION. Smart meters as tool for reduce water piped necessity and desalination plants dependence.

IMPACTS

- Water savings: 11% + 4% more expected
- 0 complains over the first two years

FRAMEWORK. The city is situated 600 km east of Perth in a semi desert area. All the water is piped from Perth, and the cost is 7 $ per kiloliter. There were some problem to access regular meters because are located in gardens with fences.

Recover Lost Water Revenue

Project name	Recover Lost Water Revenue
Country	Canada
City	Olds
Date	2010
1. Smart Environment	Resources Management
Addressed challenges	Urban ecosystem under pressure
Development stage	Ongoing
Scale	City
Budget	-
Population	8.235
Surface	1487 Ha
Framework	Water conservation Canadian Strategy
Goals	Efficiency, Sustainable
Financed	Public administration
GPD per capita	-
Link	http://smartcitiescouncil.com/resources/iron-technology-helps-town-olds-recover-lost-water-revenues-and-achieve-conservation-goals

DESCRIPTION. The project sets acoustic sensor to be able to detect automatically leak in a shorter period of time.

OBJECTIVE. Following the Canadian water conservation policy and save money and water resources.

METHODOLOGY Leak sensors are installed permanently either indoors or outdoors on the water service pipe, usually near a water meter. The strategically placed acoustic sensors analyze sound patterns every day, detecting new, evolving and pre-existing leaks automatically. A web interface interprets the data and analyzes the recordings and graphically displays all leak sensor locations using GIS and satellite mapping images, highlighting the status and location of leak locations using colored flags. Each "leak flag" prioritizes leaks as either probable, possible, no leak likely or sensor out of status.

INNOVATION. 24x7 monitoring of distributing system's integrity. The ability to remotely monitor daily data from the sensors has helped identify loss patterns within the town's distribution system at specific locations, as well as analyze seasonal water use anomalies. To be able to identify changes in these patterns early enables the utility to be pro-active in fixing leaks.

IMPACTS In the first six months alone, 21 leaks were repaired recovering 257,691 cubic meters of water or a revenue savings of $177,336.00.

Since the completion of the Itron system deployment, non-revenue water losses have been reduced from 35% to 29%.

FRAMEWORK The Public Works and Utilities department for the Town of Olds, Alberta, is responsible for looking after the maintenance of the town's infrastructure, including roads, the water distribution system and the Wastewater Treatment Plant. Canada formally endorsed a policy to develop and implement a water conservation strategy to ensure a reduction in daily usage and consumption by all water users in October 2007.

Before project implementation the loss in the water distribution system's treated drinking water, averaged 39 percent, a startlingly high percentage with significant financial and resource management implications.
Since the completion of the Itron system deployment, non-revenue water losses have been reduced from 35% to 29%.

Greenplay

6. Project name	Greenyplay
Country	International
City	International
Date	2014 - ongoing
1. Smart People	Digital ducation
2. Smart Environment	Resources management
Challenges improved	Continuous leamship, Holistic approach to environmental and energy issues
Development stage	Ongoing
Scale	International
Budget	-
Population	-
Surface	-
Framework	-
Goals	Sustainability
Financed	Private
GPD per capita	-
Link	http://greenyplay.com/

DESCRIPTION Game app targeted for American, Canadian and European between 12 to 25 years old mobile users which gathers real life interaction, recycling ideas and virtual actions in order to achieve a green and proactive game.

OBJECTIVE Teach users to recycle from the very beginning of the waste management process through prizes and competition as main tools for enhancing and attracting people.

METHODOLOGY Mobile game application is able to read the QR codes of bins and products and relate them with their components base in order to be able to recognize which product should be deposit in which bin.

INNOVATION Combine real life and virtual experience to teach population.

IMPACTS Winner of 5.000 dollar prize for the 1st position in the 3rd Green ICT Application Challenges fostered by Telefonica and the International Telecommunication Union.

FRAMEWORK The 3rd Green ICT Application Challenges and conquest with the same idea help to foster innovation and smart solution for real city issues.

Andrey Syvkov of Belarus is the promotor of this business learning tool idea. "It is an entertaining, practical and easy-to-use system inspired by videogames, which gives it great potential among young people. What is more, even companies will find it useful as they can incorporate Greenyplay into their marketing campaigns, as will governments when it comes to presenting their educational programs", explained Mr Svyvkov.

How to design an application for a Smart City

There is no recipe… (possible steps)

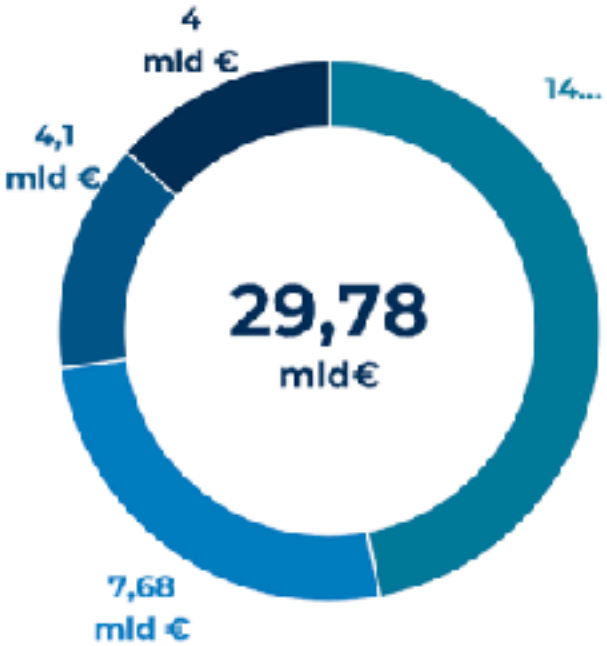
1. **Discover: Identify the problem**, opportunity or needs to be addressed through design;

2. **Define: analyze the outputs of the discover phase** and set a clear brief for sign off by all **stakeholders** (citizens, tech companies, governments, academics, researchers, etc);

3. **Develop: Envolve the citizens** to dig in the previously identified problems, opportunities or needs and design service components in detail and as part of a holistic experience while iteratively test concepts with end users;

4. **Deliver: launch the service** or present your **findings** and share lessons from development process back into the organization(s);
Learn through feedback and iterate again.

Future investments (PNRR)



Smart Factory

Missioni	mld€
M1 Transizione 4.0 e investimenti ad alto contenuto tecnologico	14

Smart City

Missioni	mld€
M1 Mobility as a Service (MaaS)	0,04
M2 Gestione del rischio di alluvione e del rischio idrogeologico	2,5
M2 Infrastrutture di ricarica elettrica	0,74
M2 Rete idrica più digitale	0,9
M3 Strade sicure	1
M5 Piani Urbani Integrati	2,5

Smart Building

Missioni	mld€
M1 Efficienza energetica di cinema, teatri e musei	0,3
M2 Sistemi di riscaldamento efficienti basati su fonti rinnovabili	0,2
M2 Smart Grid	3,6

Assisted Living

Missioni	mld€
M6 Prestazioni rese in assistenza domiciliare	4

Fonte Osservatori Digital Innovation - Politecnico di Milano (www.osservatori.net).

Lab Activities

Design a smart service for a Smart City

Methodology: Challenge Based Learning

The Challenge Learning Framework is divided into three interconnected phases: Engage, Investigate and Act. Each phase includes activities that prepare you to move to the next phase. Within each of the phases there are opportunities for mini-investigation cycles and if necessary a return to an earlier phase. Supporting the entire process is an ongoing process of documentation, reflection and sharing.

CBL phases

ENGAGE

During the Engage Phase, the Learners move from an abstract big idea to a concrete and actionable challenge using the Essential Questioning process. The goal is to personally connect with academic content through the identification, development, and ownership of a compelling challenge.

Big Ideas

A Big Idea is a broad theme or concept that can be explored in multiple ways and is important to you and the larger community. Examples of big ideas include Community, Relationships, Creativity, Health, Sustainability, and Democracy.

Essential Questioning/ Essential Question

By design, the big idea allows for the generation of a wide variety of essential questions that reflect personal interests and the needs of the community (e.g. Why is this important to me? Where does this concept intersect with my world? etc.). At the end of the Essential Questioning process is the identification of one Essential Question that has personal meaning.

Challenges

The challenge turns the essential question into a call to action to learn deeply about the subject. A challenge is immediate, actionable and builds excitement.

The Engage phase concludes with the identification of a compelling and actionable Challenge statement.

INVESTIGATE

Building from the Challenge, learners develop contextualized learning experiences and conduct rigorous, content and concept-based research to create a foundation for actionable and sustainable solutions.

Guiding Questions

The Investigation phase begins with generating questions related to the Challenge. The questions include everything that needs to be learned to develop an informed solution to the challenge. The questions are categorized and prioritized creating an outline for the learner's journey.

Guiding Activities/Resources

Any resource or activity that helps answer the guiding questions and develop an innovative, insightful, and realistic solution can be used. Examples of Guiding Resources include: online content and courses, databases, textbooks, and social networks. Examples of Guiding Activities include: simulations, experiments, projects, problem sets, research, and games.

Synthesis

Once all of the Guiding Questions have been addressed and the results of the Guiding Activities recorded, the learners analyze the accumulated data and identify themes.

The Investigation phase concludes with reports and presentations that demonstrate the learners have successfully addressed all of the Guiding Questions and developed clear conclusions that will set the foundation for the solution.

ACT

In the Act Phase evidence-based solutions are developed and implemented with an authentic audience and the results evaluated. The learners combine a desire to make a difference with a demonstration of content mastery.

Solution Concepts

Having completed the Investigation phase, the learners have a solid foundation to begin developing solution concepts. Solution concepts may involve plans for a campaign to inform or educate, school or community improvement projects, product development, or other activities.

Solution Development

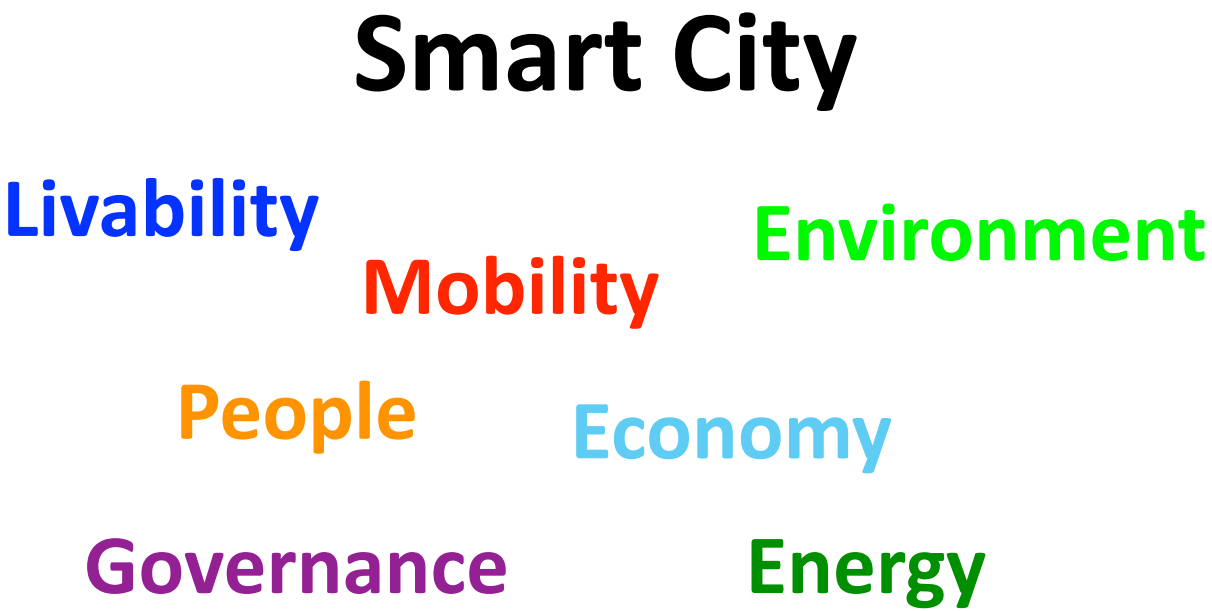
After the solution concept is approved, the learners develop prototypes, experiment and test. This iterative design cycle will most likely raise new Guiding Questions requiring further research and swing them back into the Investigation Phase.

Implementation and Evaluation

After developing their solutions, the learners implement them, measure outcomes, reflect on what worked and what didn't and determine their impact on the challenge.

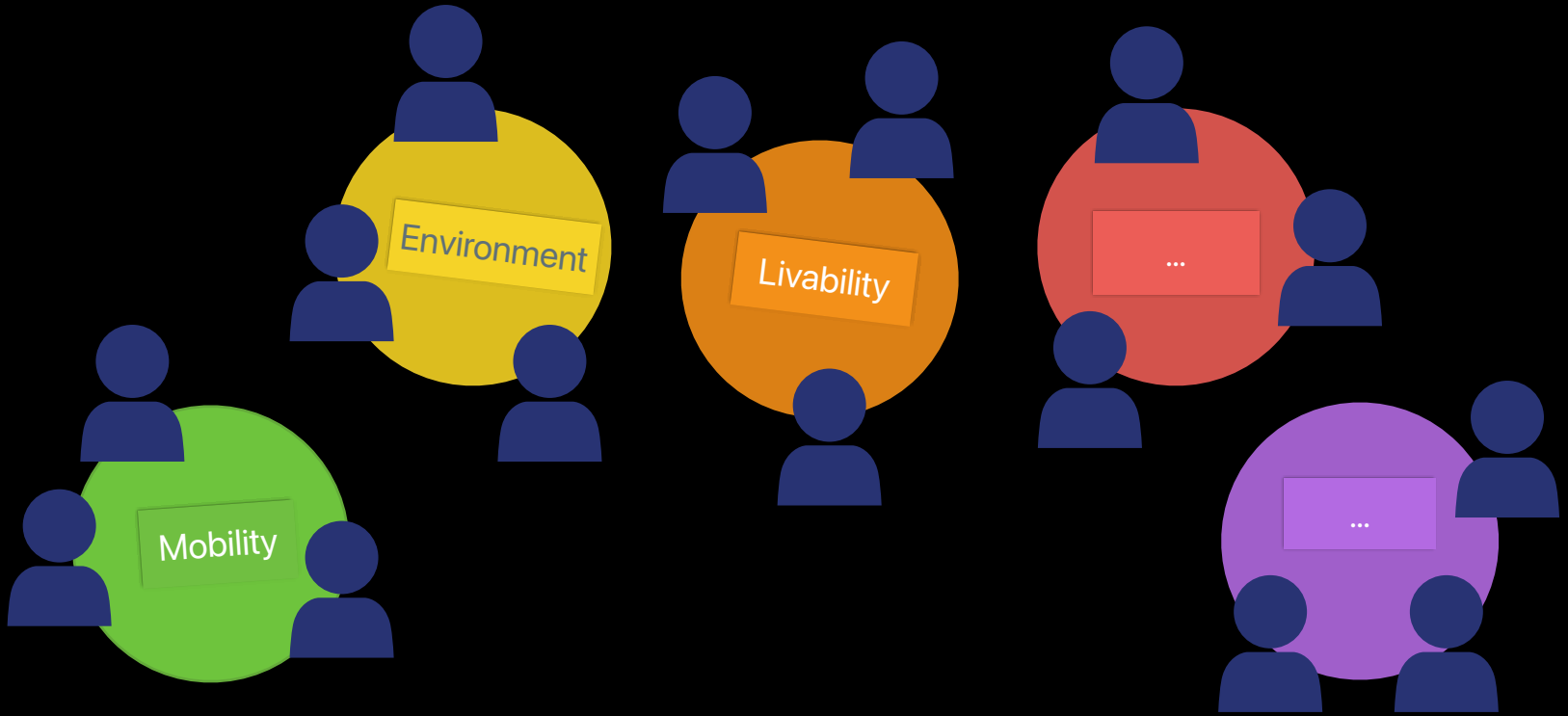
When implementation is complete, learners can continue to refine the solution or develop a completion report and share their work with the rest of the world.

Smart City and big ideas



Challenge Based Learning

(Short Smart City Version)



Team Building.
Each team share (more or less) the same big idea

Big Idea

A Big Idea is a broad concept that can be explored in multiple ways.

SAMPLE

What is Your Big Idea?

Hint: What is your group passionate about?

Environment

REFLECT • SHARE • DOCUMENT • REFLECT • SHAR

ENGAGE

- Big Idea
- Essential Question
- Challenge

Essential Question (EQ)

The Essential Question personally connects the group with the Big Idea making it meaningful to the specific context.

What is your group's EQ?

Hint: Why do you care (as a team) about the Big Idea?

How can we save the Amazon forest?

REFLECT • SHARE • DOCUMENT • REFLECT • SHAR

ENGAGE

- Big Idea
- Essential Question
- Challenge

Challenge

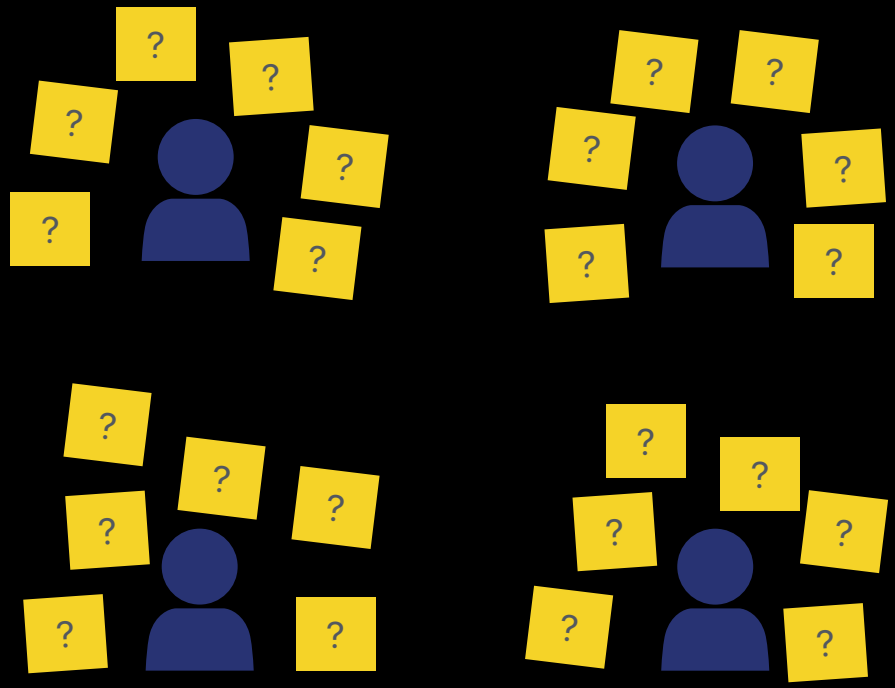
The Challenge turns the essential question into a call to action by charging participants to learn deeply about the subject and create a solution.
A challenge is **immediate**, **actionable** and **builds excitement**.

SAMPLE

What is your Challenge?

Hint: Make the EQ Actionable!

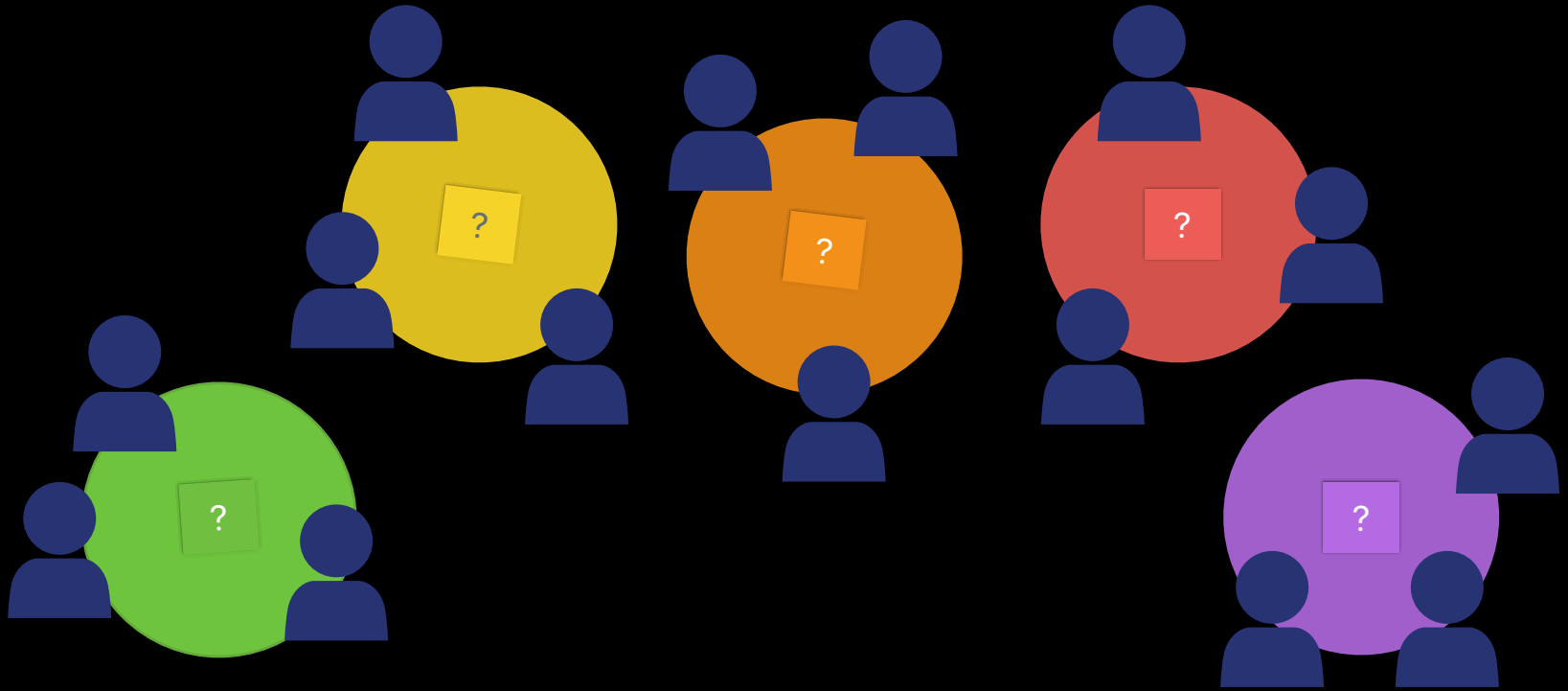
Reduce the waste of paper!



Creating Essential Questions

- Develop a **personal** set of Essential Questions about the big idea.
- Create at least 4/5 questions (in 10 **minutes**).

- One question per sticky note.



Choose one EQ per each table (also refining/adding questions) and define your challenge!!!

(20 mins)


Big Idea
Essential Question
Challenge
Environment
How can we save the Amazon forest?
Reduce the waste of paper!

Investigate

Develop and implement contextualized learning experiences and conduct rigorous, content- and concept-based research to create a foundation for actionable and sustainable Solutions.

Phases

1. General

Curiosity driven research about the Big Idea and Challenge.

2. Domain

Specific research related to the refined (more specific) challenge.

3. Applied

Research connected to building the actual solution.

Steps

1. Guiding Questions

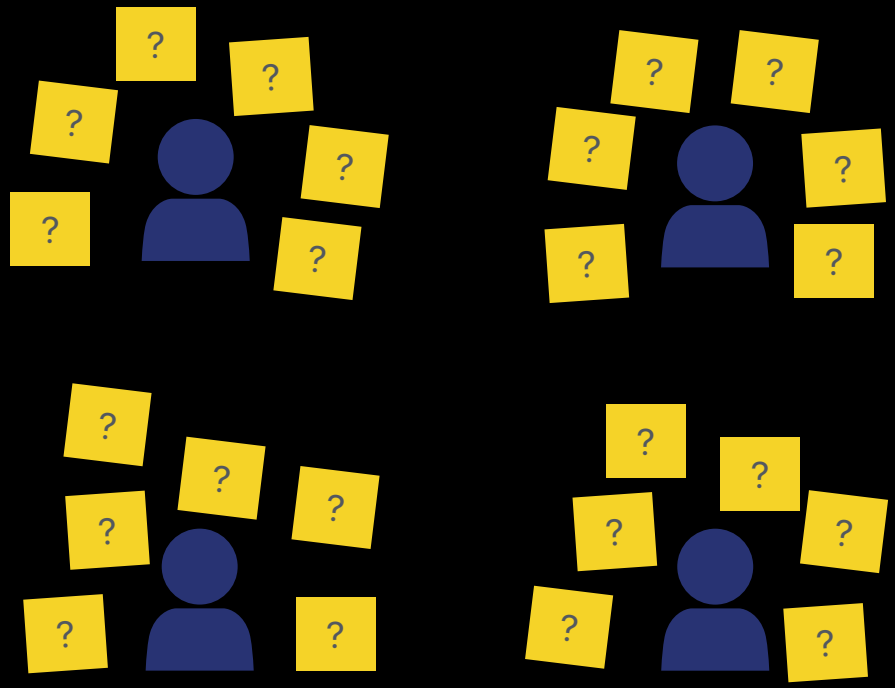
Guiding Questions provide a map for the learning process and represent all of the knowledge needed to successfully develop a solution.

2. Activities/Resources

The Guiding Activities and Resources include any and all methods and tools available to the learners to answer the Guiding Questions.

3. Synthesis

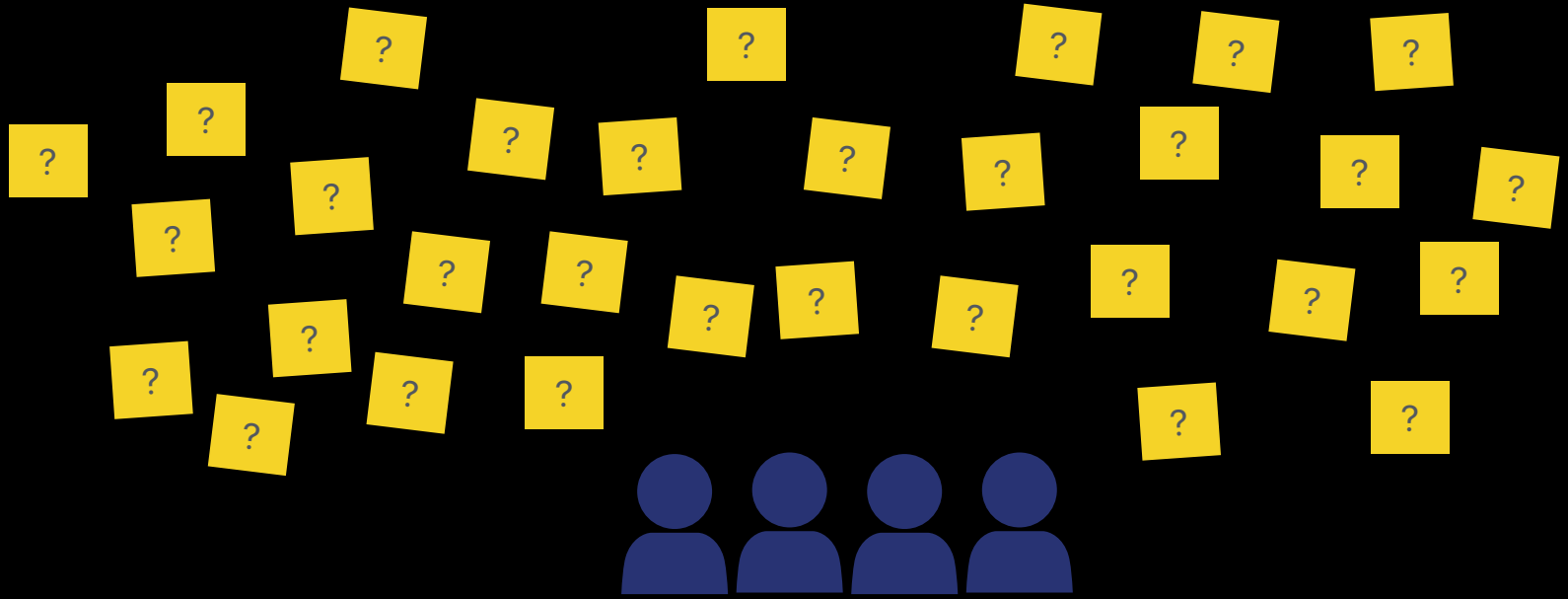
The synthesis threads together the research findings and makes a case for proposed solutions.



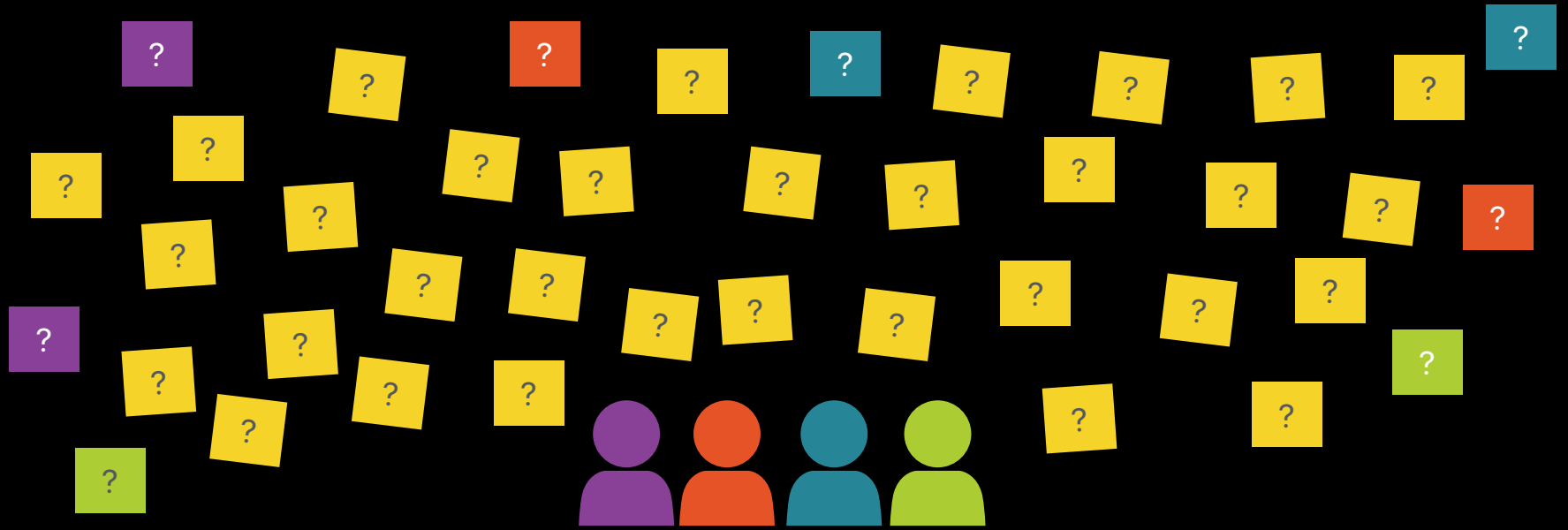
Creating Guiding Questions

- Develop a **personal** set of Guiding Questions about the Challenge.
- All types of questions are encouraged: **What, When, Why, What if, Why**, etc.
- Create as many questions as you can.
- One question per sticky note.

(10 minutes)



Combine all of the questions and read them - add more if they come to mind.
(20 minutes)



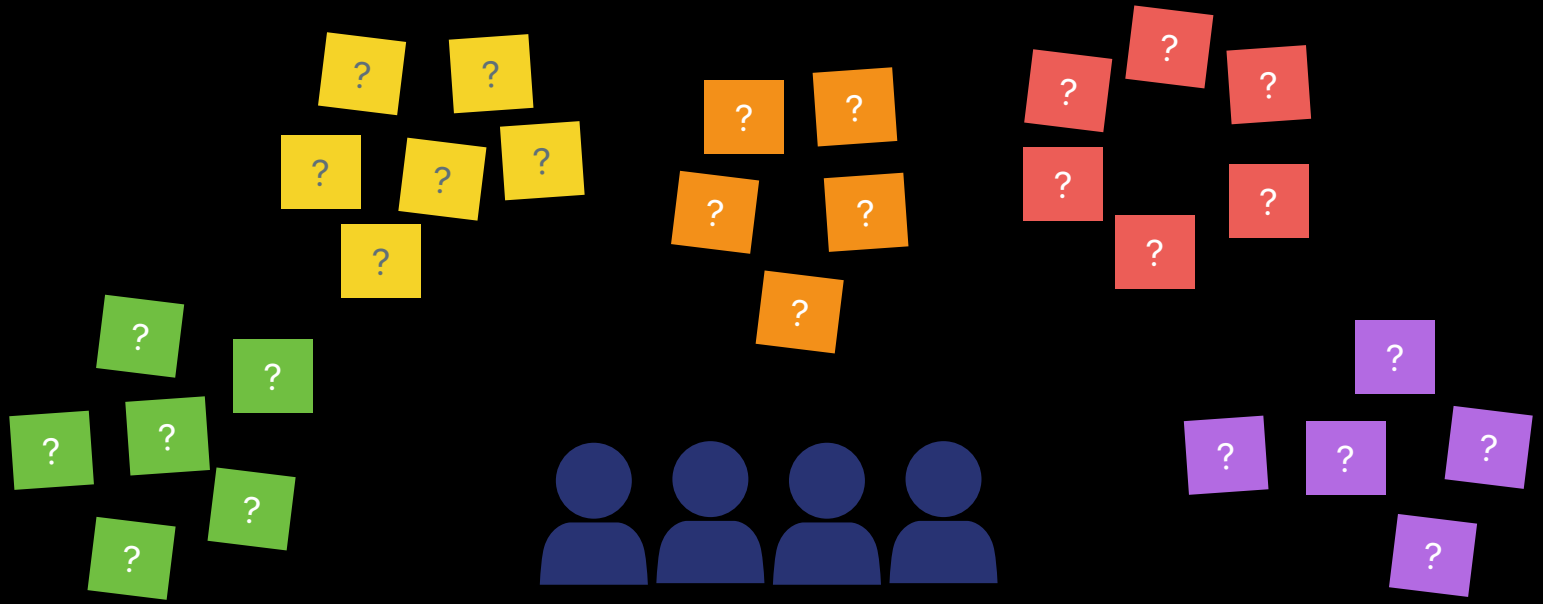
Peers or outsiders are invited to review the questions.

Add missing questions and ...

Peers or outsiders are invited to review the questions.

VOTE (sticky notes)

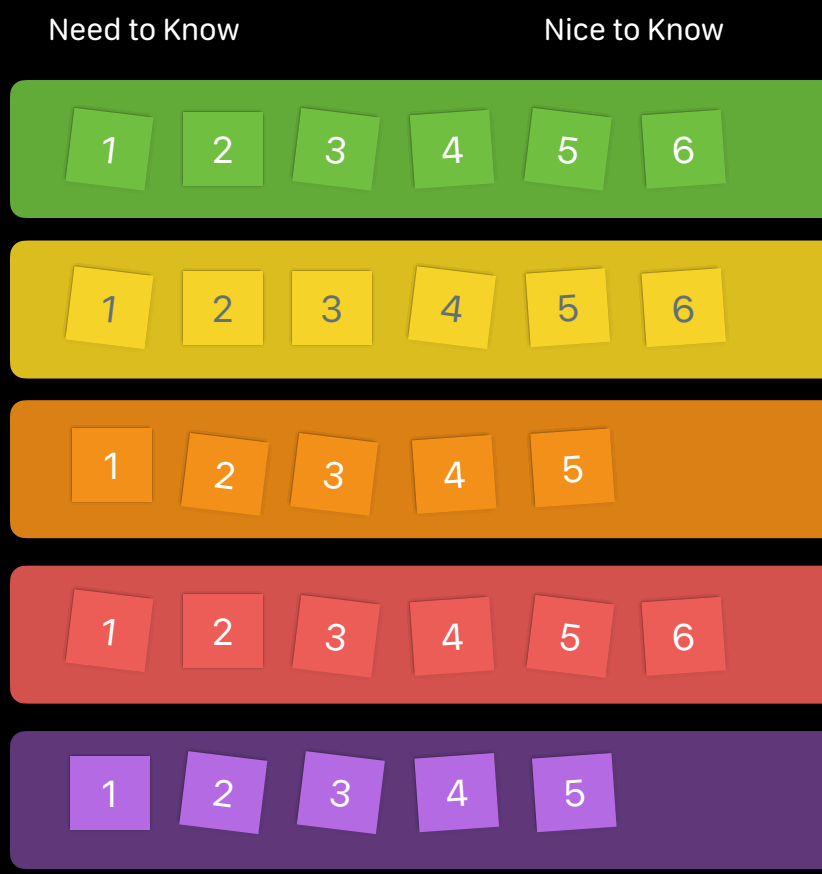
(10 minutes activity)



Combine like questions, and develop categories
(subjects, themes, etc.) and assign a priority to each question

- The Guiding Questions are prioritized based on the connection with the Big Idea.
- Highest ranked questions must be researched and answered.

(20 minutes activity)



Steps

1. Guiding Questions

Guiding Questions provide a map for the learning process and represent all of the knowledge needed to successfully develop a solution.

2. Activities/Resources

The Guiding Activities and Resources include any and all methods and tools available to the learners to answer the Guiding Questions.

3. Synthesis

The synthesis threads together the research findings and makes a case for proposed solutions.

Guiding Questions

Guiding Activities/Resources

lessons, independent learning, etc.

?s

?s

?s

?s

?s

- Web Research
- Survey Creation/Distribution
- Interviewing/Focus Groups
- Survey Results Analysis
- Observing and Identifying Patterns

Guiding Questions	Guiding Activities/Resources lessons, independent learning, etc.	Findings What we learned
?s		
?s		
?s		
?s		
?s		

The findings are recorded after each guiding activity to keep a running research journal. You may “divide and conquer” and collaborate with other groups during the investigation. Once all the findings are collected they will be synthesized.

Steps

1. Guiding Questions

Guiding Questions provide a map for the learning process and represent all of the knowledge needed to successfully develop a solution.

2. Activities/Resources

The Guiding Activities and Resources include any and all methods and tools available to the learners to answer the Guiding Questions.

3. Synthesis

The synthesis threads together the research findings and makes a case for proposed solutions.

Guiding Questions

Guiding Activities/Resources

lessons, independent learning, etc.

Findings

What we learned

Synthesis

Our Informed Opinion

?s

?s

?s

?s

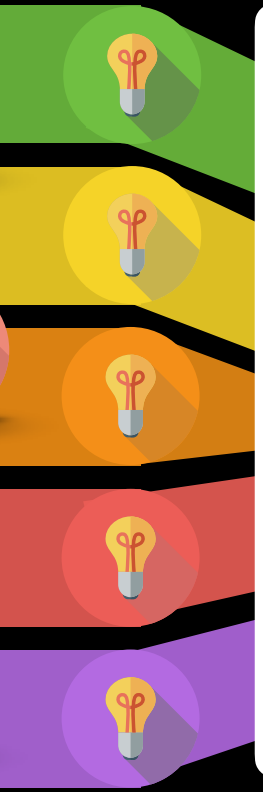
?s

After Investigating the challenge we learned:

Depending on the Challenge and the Investigation some groups may need to refine the challenge and complete another round of domain focused investigation.

Findings

What we learned



Synthesis

Our Informed Opinion

After Investigating the challenge we learned:

Revised Challenge

What we really meant was this:

Domain Research

Now what do we need to learn?

Revised Synthesis

Now we think this:

Solutio

Since we learne

Synthesis

Our Informed Opinion

After Investigating the challenge
we learned:

Revised Challenge

What we really meant was this:

Domain Research

Now what do we need to learn?

Revised Synthesis

Now we think this:

Solution Concept

Since we learned this we should do this:

Revised Challenge

What we really meant was this:

Domain Research

Now what do we need to learn?

Revised Synthesis

Now we think this:

Solution Concept

Since we learned this we should do this:

Solution Description

And because of this the app should:

?

Synthesis

what we learned

Solution Concepts

Since we learned this we should do this:

Statement

And because of this the app should:

Prototyping

What does it look like and do?

Phases

1. General

Curiosity driven research about the Big Idea and Challenge.

2. Domain

Specific research related to the refined (more specific) challenge.

3. Applied

Investigation connected to building the actual solution.

Act

In the Act phase the solution is implemented by presenting it to stakeholders and evaluating the success. Using this feedback the solution can be refined.

DEFINITIONS

WHAT IS **IDEATION**?

Ideation is the process of **brainstorming and generating** ideas for **opportunity areas identified in a problem space.**

WHAT IS A **CONCEPT**?

A **detailed visual/verbal description** of a design solution. It outlines how the solution **provides value to** the people **who use the service**, to the people **who deliver the service and to the business**.

Adapted from Harmonic Design Inc.

Smart City Challenge: Efficient Waste Management

Challenge Description:

The city is facing a waste management problem due to inefficient collection and disposal methods.

Garbage bins are often overflowing, resulting in environmental pollution and health hazards.

The challenge is to develop a smart solution that optimizes waste collection and promotes recycling to create a cleaner and healthier city environment.

Solution Sample: Smart Waste Management System

Solution Overview: The proposed solution is a smart waste management system that utilizes IoT (Internet of Things) technology and data analytics to optimize waste collection and recycling processes in the city.

1. **Smart Garbage Bins**: Install smart garbage bins equipped with sensors in strategic locations throughout the city. These bins can detect the fill level of waste in real-time. When the bin reaches a predefined threshold, it sends a signal to the waste management system indicating the need for collection.

2. **Route Optimization**: Leverage data analytics and machine learning algorithms to optimize waste collection routes. The system analyzes the real-time fill level data from the smart bins and identifies the most efficient collection routes. This helps reduce fuel consumption, minimize collection time, and optimize the workload of waste management personnel.

3. **Mobile Application:** Develop a mobile application for citizens to report overflowing bins or request special waste collection services (e.g., hazardous waste, large items). The app should include a map displaying nearby garbage bins and their fill levels. Users can also receive notifications about recycling initiatives, waste management guidelines, and upcoming collection schedules.

4. **Recycling Incentives:** Encourage recycling by implementing a reward system. The waste management system can track and analyze recycling participation data from the smart bins. Citizens who actively recycle can earn points or rewards that can be redeemed at local businesses or utility providers. This incentivizes recycling behavior and increases community engagement.

5. **Data Analytics and Monitoring:** Utilize data analytics to generate insights and make informed decisions. The system can analyze historical data on waste generation patterns, identify peak periods, and allocate resources accordingly. Real-time monitoring of the waste management system allows for proactive maintenance and immediate response to any issues.

Benefits:

- Efficient waste collection reduces overflow, prevents littering, and improves the cleanliness of the city.
- Optimized routes reduce fuel consumption, leading to cost savings and reduced carbon emissions.
- The mobile application enhances citizen engagement, provides real-time information, and encourages recycling.
- The reward system incentivizes recycling behavior and promotes a sustainable and eco-friendly environment.
- Data analytics enables better resource allocation, operational efficiency, and proactive maintenance.

Note: The solution sample provided above is a high-level overview. The actual implementation may involve more technical details, integration with existing waste management infrastructure, and collaboration with local authorities and stakeholders.

Present your Smart City service

Big Idea:

Essential Question:

Challenge:

Solution Concept:

- General description
- Target
- Data needs
- Technical requirements
- Business model
- Limitations

From design to lab testing

Cup Carbon

A Multi-Agent and Discrete Event Wireless Sensor Network Design and Simulation Tool

Cup Carbon introduction

- CupCarbon is a **Smart City and Internet of Things Wireless Sensor Network** (SCI-WSN) simulator.
- Its objective is to **design, visualize, debug and validate distributed algorithms** for monitoring, environmental data collection, etc., and to create environmental scenarios such as **fires, gas, mobiles**, and generally within educational and **scientific projects**.
- Not only it can help to visually **explain the basic concepts of sensor networks** and how they work; it may also support scientists to test their wireless topologies, protocols, etc.

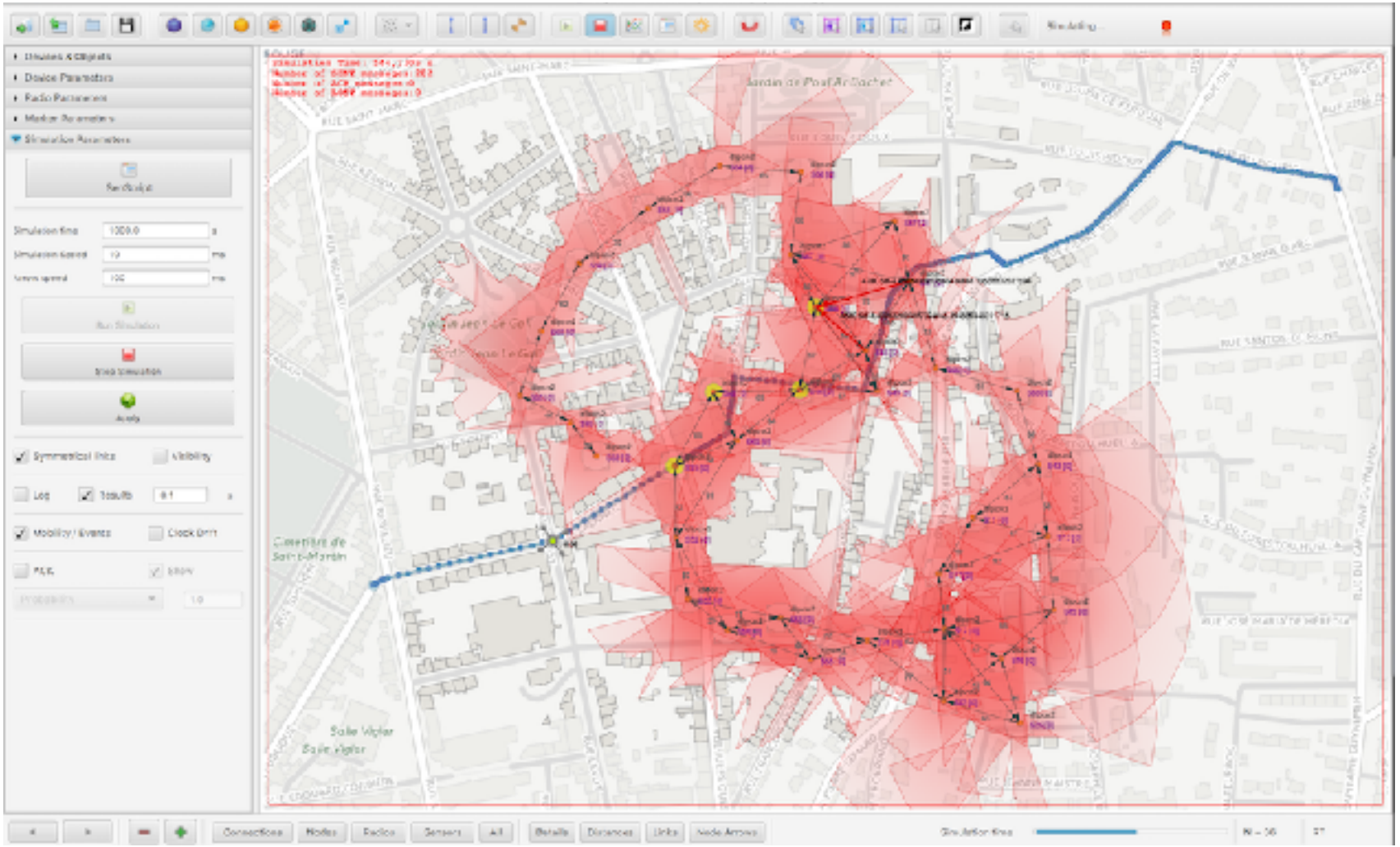
Simulations environments

CupCarbon offers **two simulation environments**:

- The first simulation environment enables the design of **mobility scenarios and the generation of natural events** such as fires and gas as well as the simulation of mobiles such as **vehicles and flying objects (e.g. UAVs, insects, etc.).**
- The second simulation environment represents **a discrete event simulation of wireless sensor networks** which takes into account the scenario designed on the basis of the first environment.

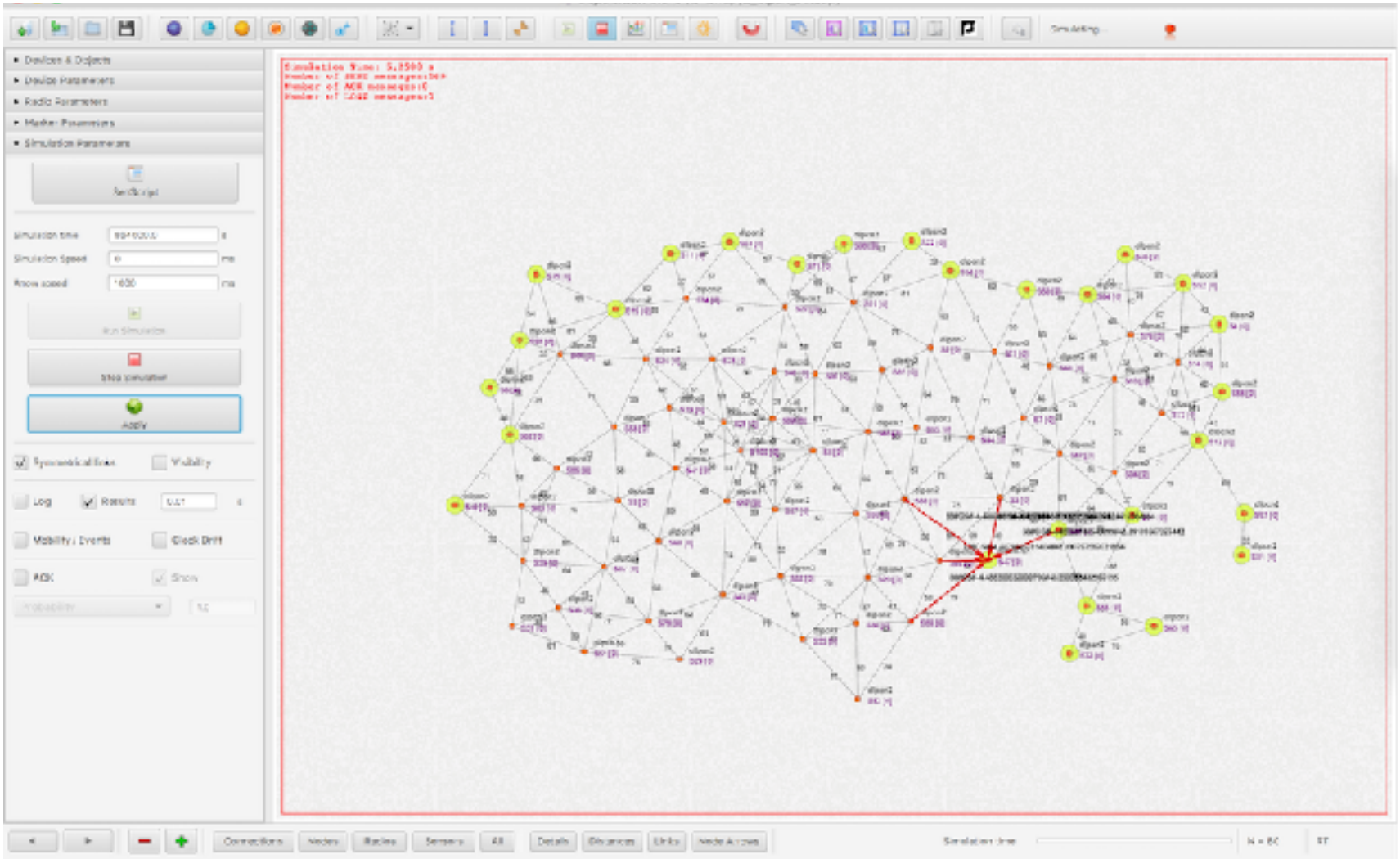
Networks

- Networks can be designed and prototyped by an ergonomic and easy to use interface using the **OpenStreetMap (OSM)** framework **to deploy sensors directly on the map**.
- It includes a script language called **SenScript**, which allows to program and to configure each sensor node individually.
- From this script, it is also possible to **generate codes for hardware platforms** such as **Arduino/XBee**.
- This part is not fully implemented in CupCarbon, it allows to generate codes for simple networks and algorithms.



Nodes and protocols

- CupCarbon simulation is based on the **application layer of the nodes (scripting)**.
- This makes it a real complement to existing simulators.
- **It does not simulate all protocol layers due to the complex nature of urban networks** which need to incorporate other complex and resource consuming information such as buildings, roads, mobility, signals, etc.


Devices & Objects
Device Parameters
Radio Parameters
Mobility Parameters
Simulation Parameters
Apply

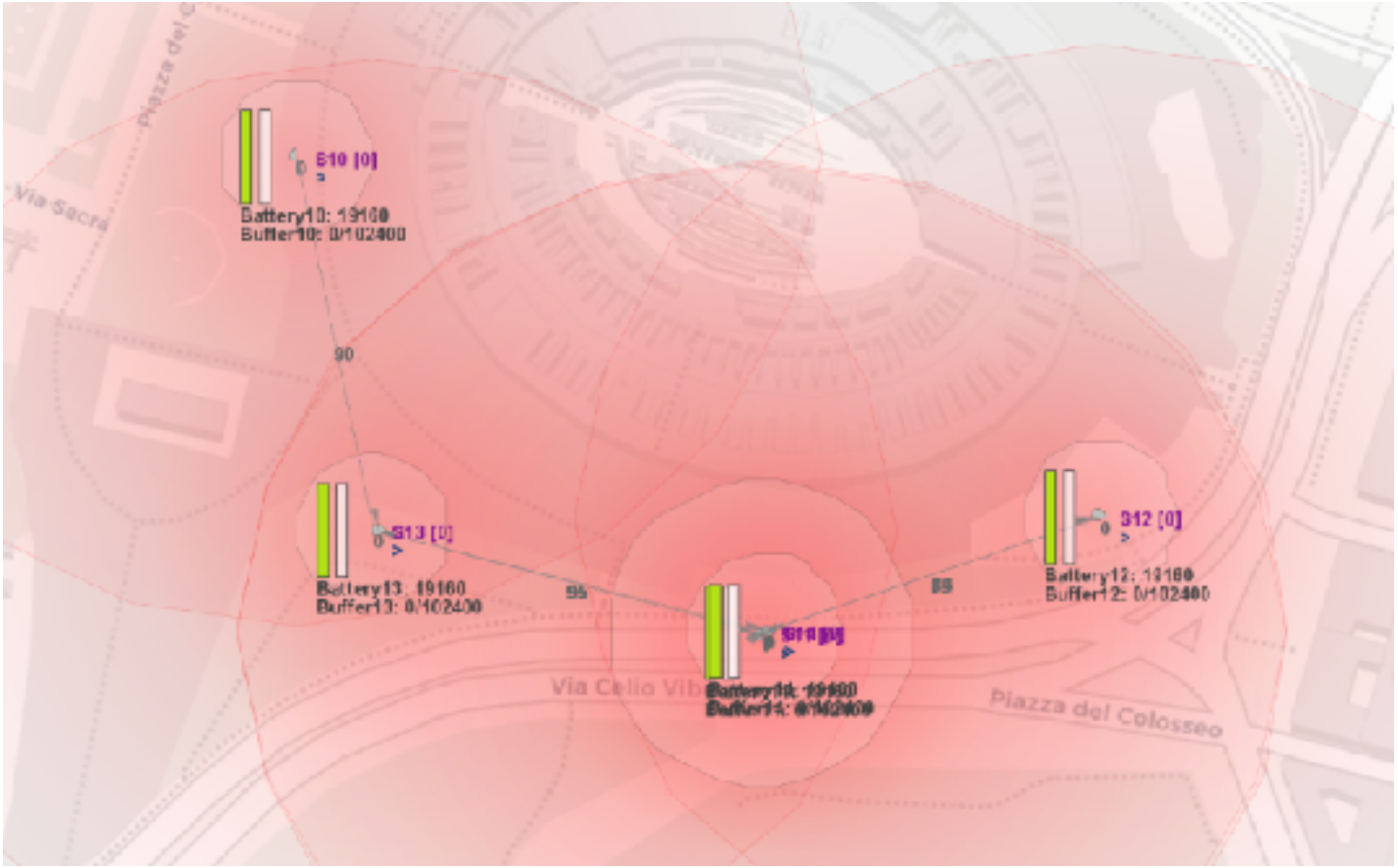
Scenarios

- CupCarbon offers the possibility **to simulate algorithms and scenarios in several steps**. For example, there could be a step for determining the nodes of interest, followed by a step related to the nature of the communication between these nodes to perform a given task such as the detection of an event, and finally, a step describing the nature of the routing to the base station in case that an event is detected.
- **CupCarbon allows to configure the nodes dynamically** in order to be able to split nodes into separate networks or to join different networks, a task which is based on the network addresses and the channel.

Energy and protocols

- The energy consumption can be calculated and displayed as a **function of the simulated time**.
- This allows to clarify the structure, feasibility and **realistic implementation** of a network before its real deployment.
- The propagation visibility and the interference models are integrated and includes the **ZigBee**, **LoRa** and **WiFi** protocols.

Energy consumption (batteries)



Credits

CupCarbon represents the main kernel of the **ANR project PERSEPTEUR** that aims to develop algorithms for an accurate simulation of the propagation and interference of signals in a 3D urban environment.

www.cupcarbon.com

Software requirements

- CupCarbon U-One 5.1 (2021)
- Based on Oracle Java 1.8 (Java FX jar embedded)
- A runnable JAR provided
  - SET environment variables PATH, JAVA_HOME, as needed.
- IDE Eclipse (2021 edition)
  - needed to recompile source

Cup Carbon workbench

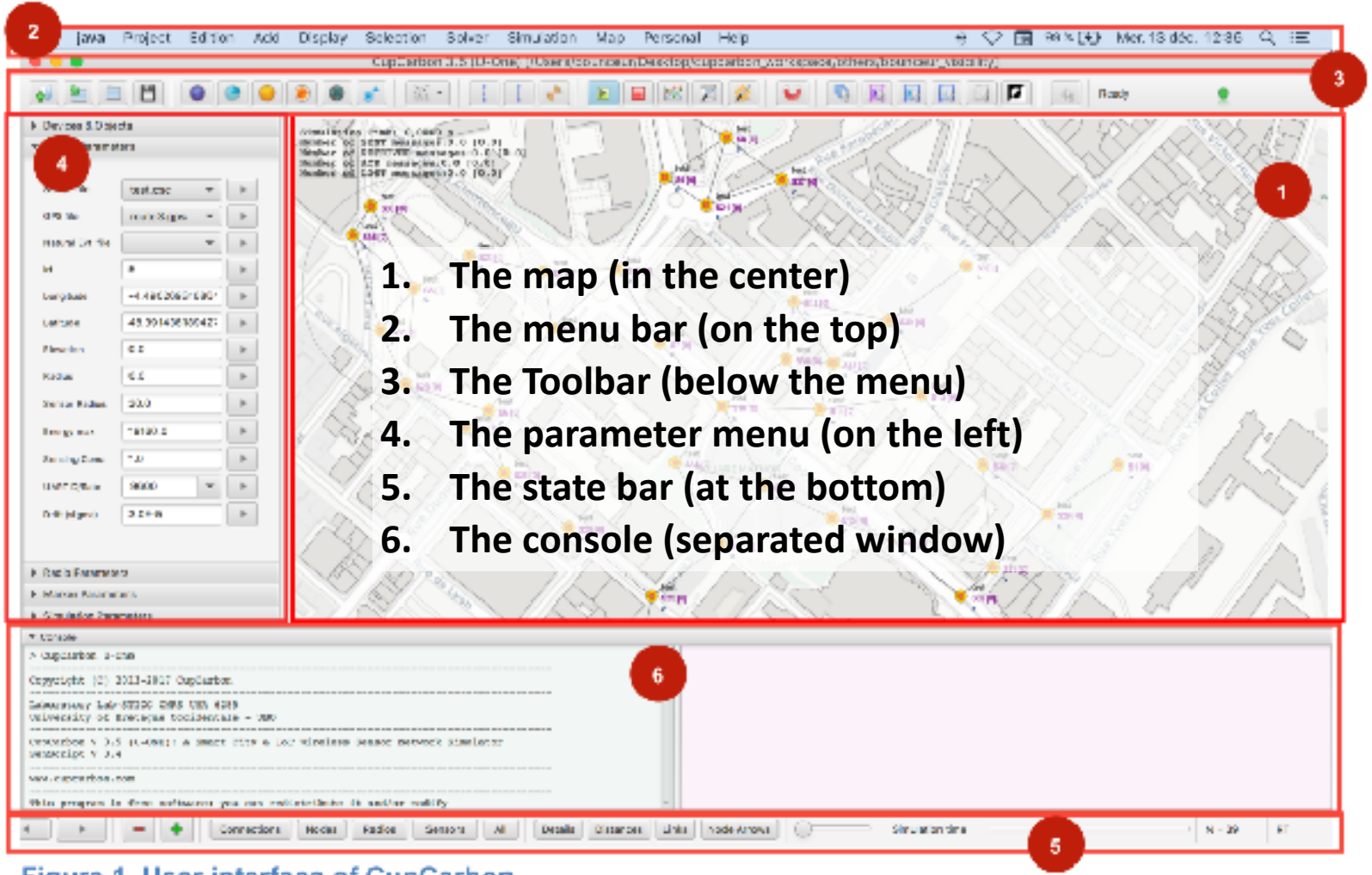
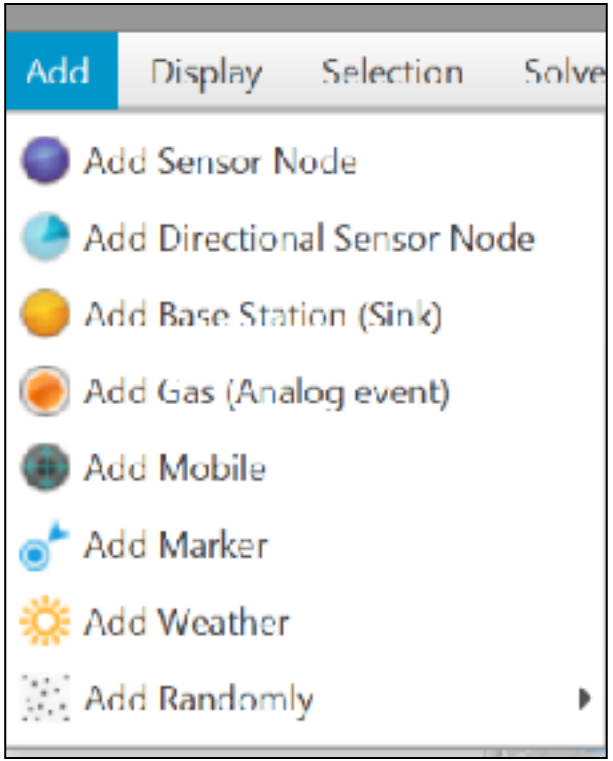


Figure 1. User interface of CupCarbon.

Add Menu

- The **Add** menu allows to add objects on the map.

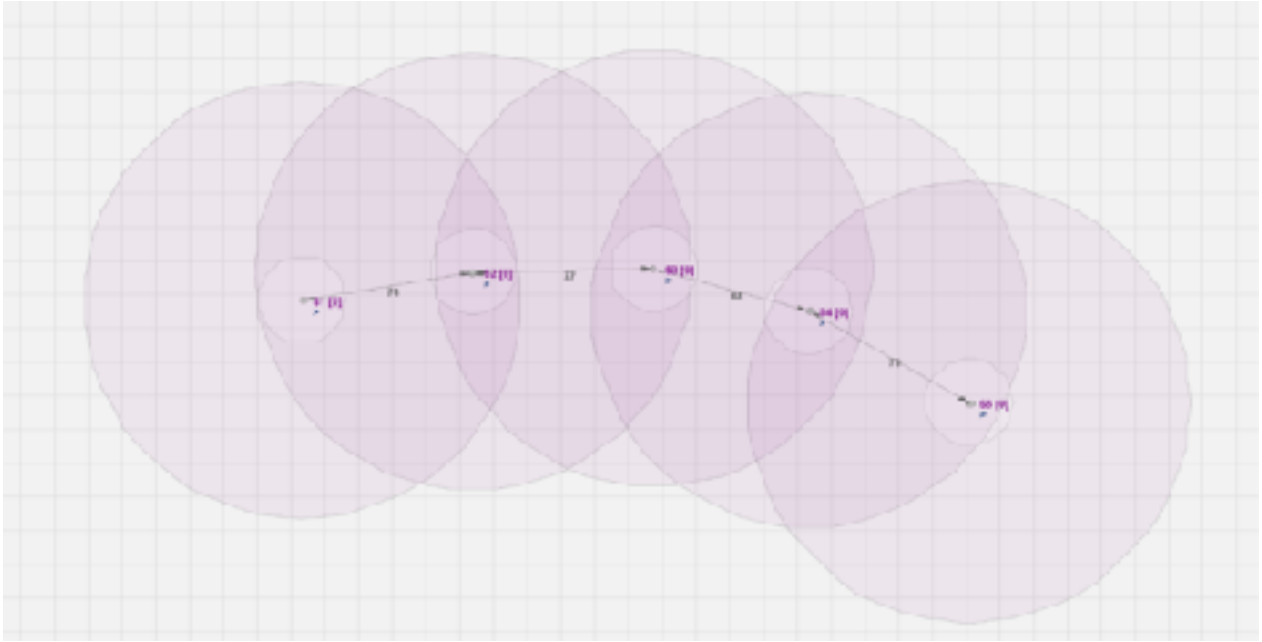


Sensor node

- A sensor node is an object that **can detect any digital event (motion event like mobiles), send and receive data.**
- It can be also **mobile**. The visible parameters of a sensor node are: the **radio range**, the **radio of the sensor unit** and the **name**.
- A sensor node has many parameters; it can contain many **radio modules**, a **battery** and a **sensing unit**.

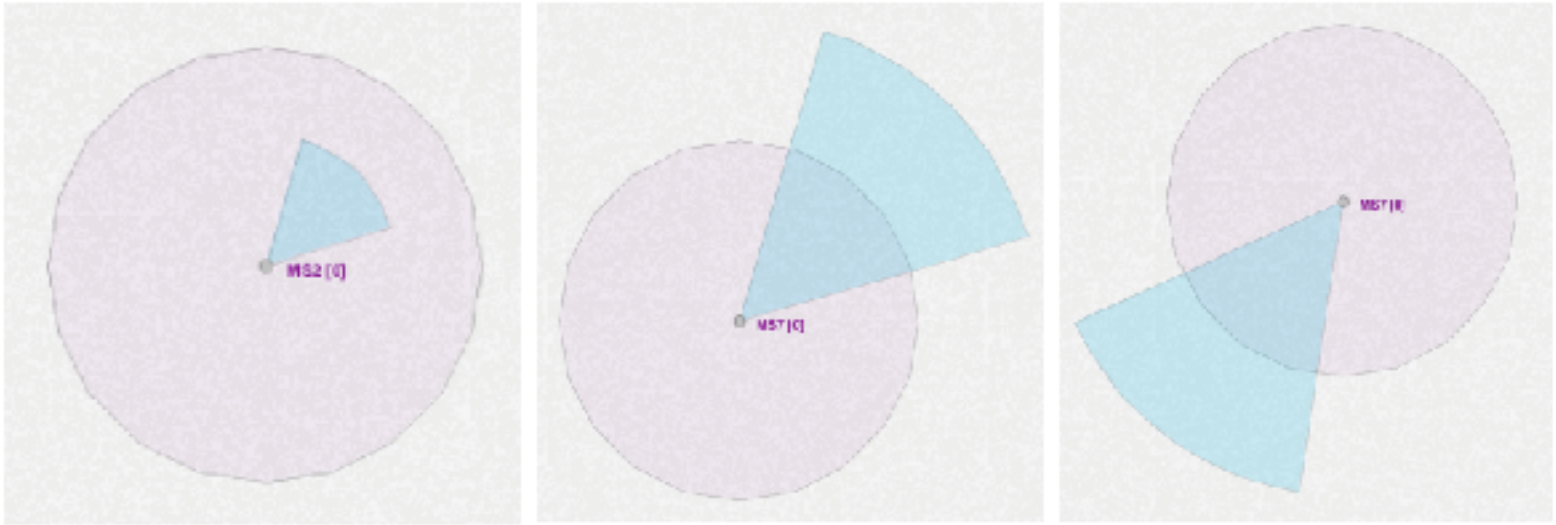
Add multiple sensor nodes

- It’s possible to add many sensor nodes that can directly communicate between each other, if added in the covered range distance.
  An arrow shows the communication and direction link.



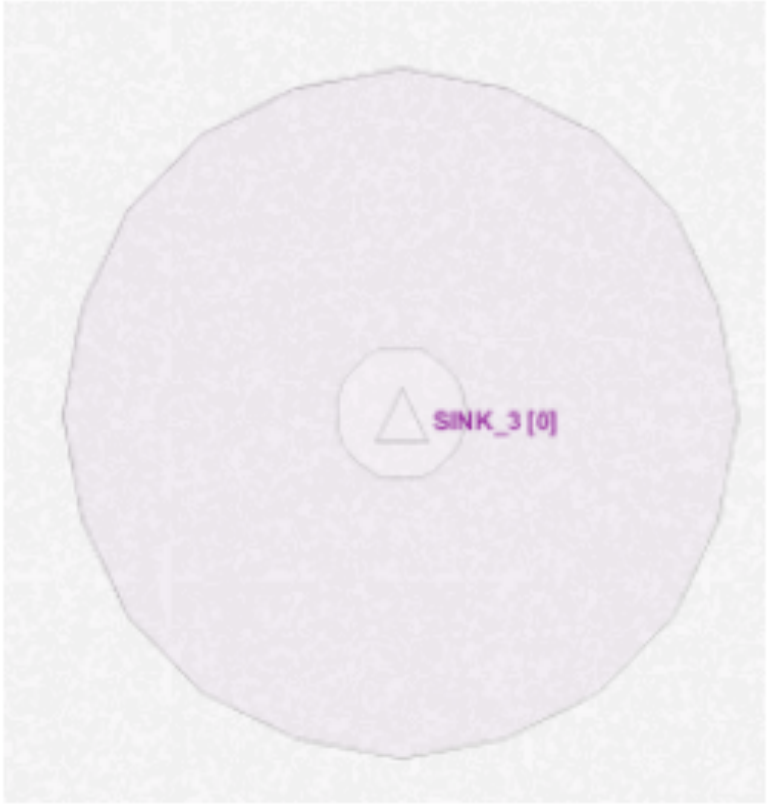
Directional Sensor Node

- The Directional Sensor Node is the same as the classical sensor node with another type of sensing unit, which is directional.
- This last **is not circular**, it has a form of a **cone** that can be modified with the SenScript and manually.



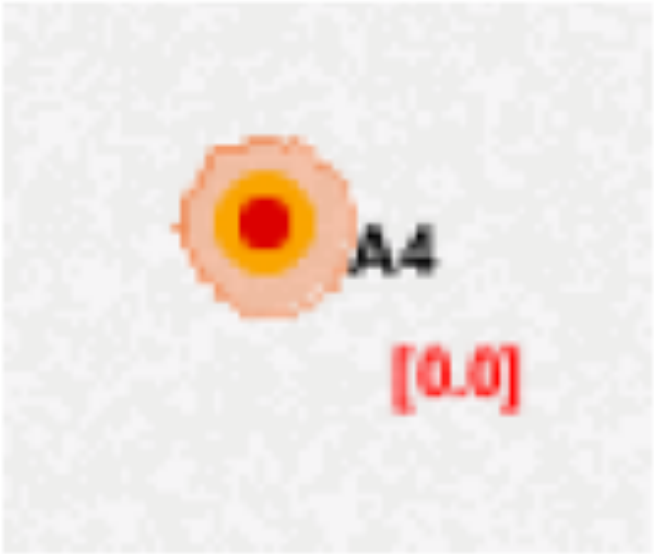
Base station (sink)

The base station is exactly the same object of the **sensor node** with the exception that it has an **infinite battery**.



Gas (analog event)

- Used to generate analog events in order to simulate environment parameters like the **temperature**, the **humidity**, gasses, etc.
- This object requires the use of the **Natural Event Generator** window in order to generate files with the desired values.
- Mainly, the generated values are based on the **Gaussian distribution**. However, it is possible to add an existing, real or not, data file.

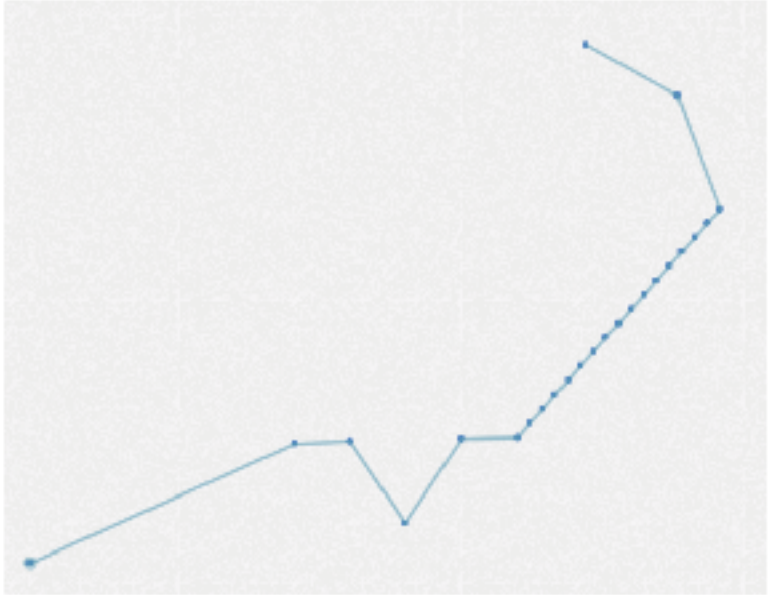


Mobiles

- Used to simulate mobile nodes.
- Markers are also used to create routes followed by mobiles.
- Each mobile must have its own **route**.
- They are used also to **generate digital events** (on/off)

Markers

- Used mainly to generate **routes for mobiles** (or mobile sensors).
- They are used also to generate **random** sensor nodes, **create new buildings**, and to indicate the area of generating buildings or random sensor nodes.

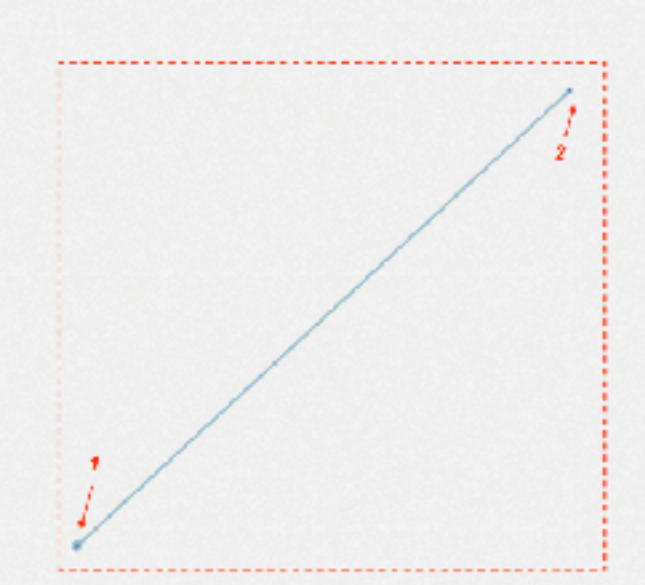


Weather

- A Meteo (weather) node is **used to add a variating temperature related to the environment**.
- This is useful for the battery consumption models that are dependent to the weather.
- To generate temperatures during a day, many days or many hours one use the **Natural Event Generator**.
- It is possible to add **only one weather** node in the project.

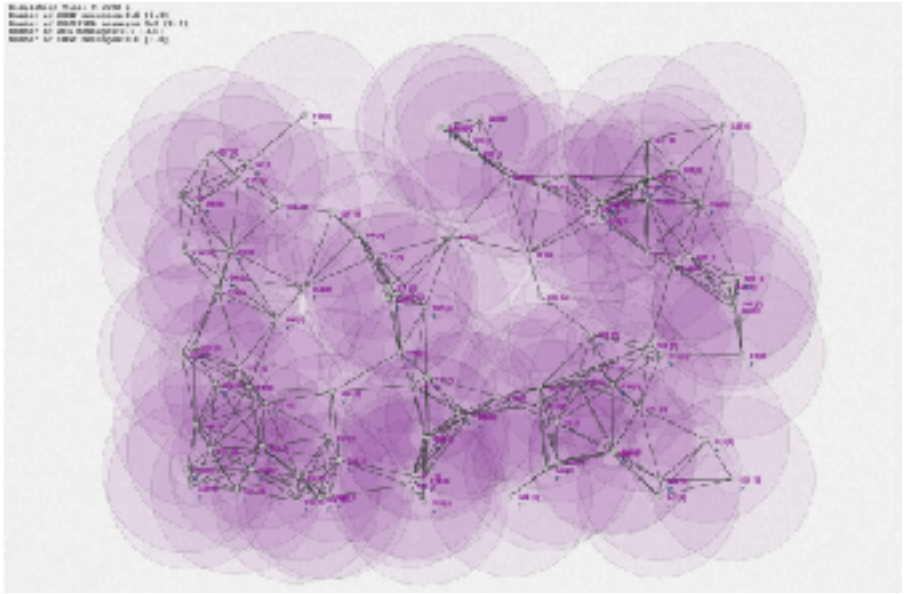
Randomly add sensor nodes

- It allows to **add randomly a certain number of sensor nodes in a selected area**.
- To use this option, first, **two markers must be added**. The first marker must be in the bottom left of the map and the second one in the top left of the map.
- The **red rectangle** on the figure **shows the area where the sensor nodes will be added randomly**.



Randomly add sensor nodes

- Once the two markers are added, click on the **number of sensor** nodes to add.
- In the figure, an example of adding randomly 100 sensor nodes is shown.



SenScript ver. 5

- SenScript is the script used to program sensor nodes of the CupCarbon simulator.
- It is a script where **variables are not declared and without types, but they can be initialized (set command)**.
- For string variables use the quotes, i.e. “hello”
- A variable is used by its name.
- It is possible to use the instruction function to add complex and **additional functions programmed in Java** (in a source code mode only).

SenScript ver. 5 (samples)

- SenScript: **set x “abcd”**
- SenScript: **set y x**
- SenScript: **println y**
- SenScript: **println “y”**

Java: **String x = "abcd";**

Java: **String y = x;**

send

- **send “hello” 2**

→ Sends string “hello” to the sensor having an id=2

- **send p 2**

→ Sends the value of p to the sensor having an id=2

- **send p**

→ Sends the value of p in **a broadcast mode**

- **send p ***

→ Sends the value of p in **a broadcast mode** (the same as send p)

- **send p * 3**

→ Sends the value of p in broadcast **except the sensor having an id=3**

receive

```
receive x
```

→ Wait until receiving data in the buffer and assign it to x.

This is a blocking function,
if there is not data in the buffer then it remains blocked on this instruction.

loop / delay

- **loop** - start the loop section of commands
- **delay t** - waits t **millisec** before executing the next instruction

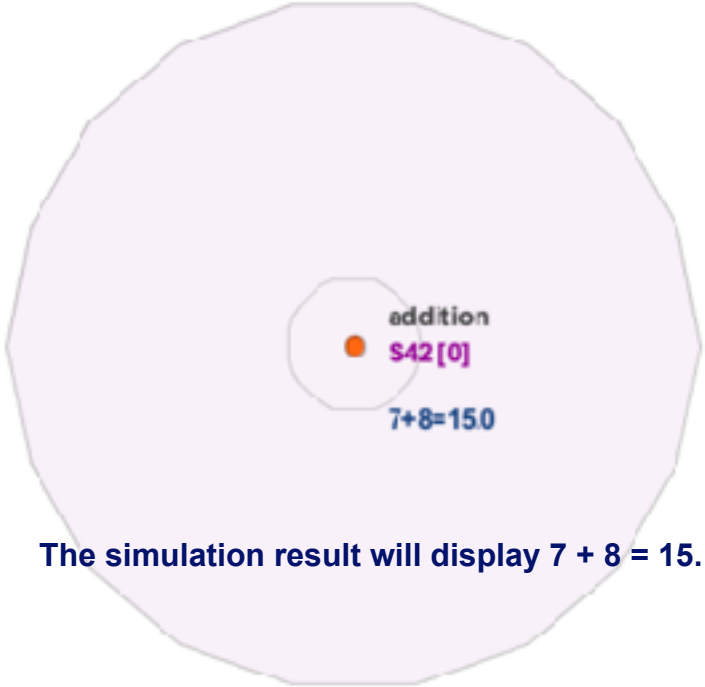
Sample code (prints «hello» every second)

```
loop
print hello
delay 1000
```

Simple test (variables)

Some simple calculations on board. Add a node, create the script below and assign it to the node, then simulate.

```
loop
set a 7
set b 8
set x a+b
print a "+" b "=" x
stop
```



The simulation result will display 7 + 8 = 15.

Simple test (game of lights)

1. Add some sensor nodes on the map.
2. Write a simple script that marks a sensor (or not) on a random basis and load the script for each sensor.

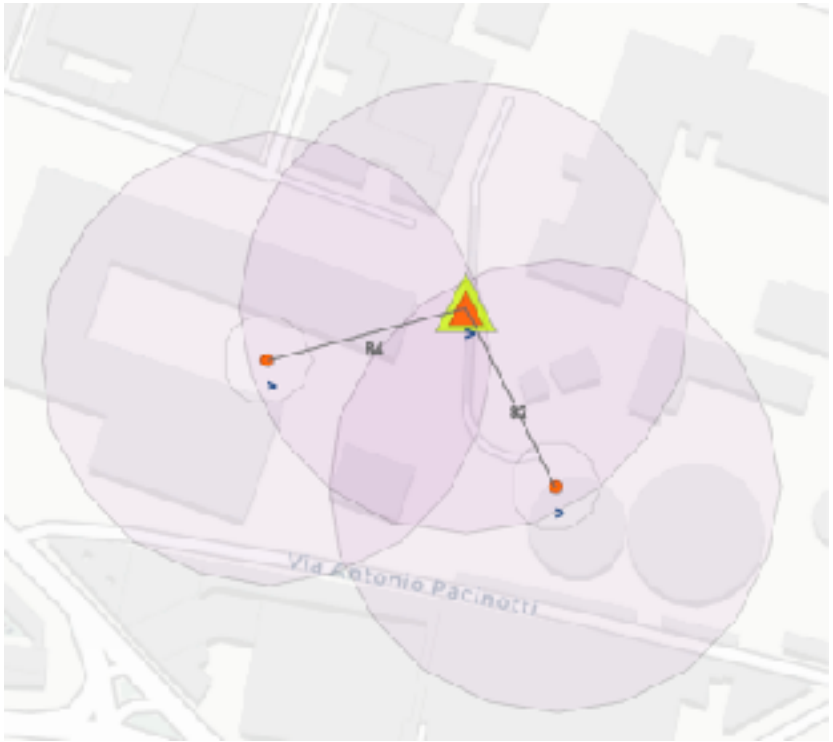
A marker node represents in the reality a sensor node with a switched on led. It helps to do a visible action rather than displaying messages. Marking a node is done by the SenScript command **mark 1**. Unmarking sensor node is done by the command **mark 0**.

led script

```
loop

rand x

if(x<0.5)
 mark 1
else
 mark 0
end

delay 1000
```

Hello Sink (cupcarbon)

- Create a **WSN with two sensor nodes and one sink**.
  The first sensor node 1 will send a message to the sink with 1, and the second node 2 will send a message to the sink with 0.
- The sink node will print/log the received message and will be marked (**led on**) if it receives 1 and unmarked
  (**led off**) if it receives 0.



Hello sink (scripts)

```
loop
read d
if d=="1"
  mark 1
else
  mark 0
end

delay 1000
```

Sink script

Note IF ELSE END instruction..

```
loop
send 1
delay 2000
```

Node 1 script

```
loop
send 0
delay 3000
```

Node 2 script

Thanks.

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