IS4: LESSON 5

Machine Learning Design Workflow

Edge←→Fog←→Cloud

Internet of Things (IOT) and its applications

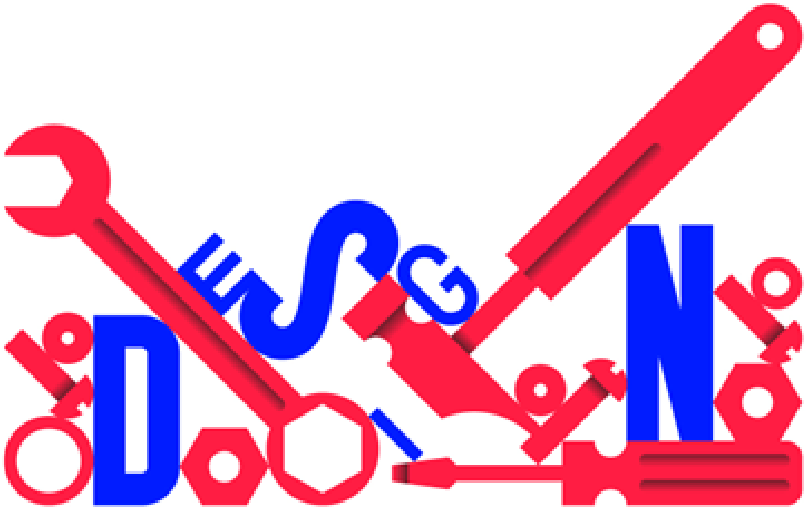
Outline

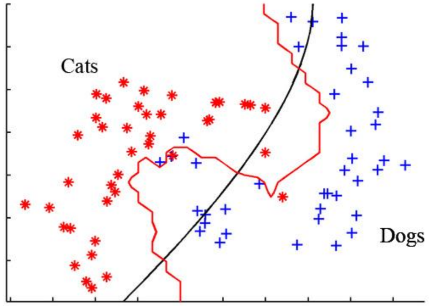
- Design of applications with ML
  - The ML workflow
  - Selection of the best ML technique
- Edge←→Fog←→Cloud
- The Internet of Things (IoT)
- Main points

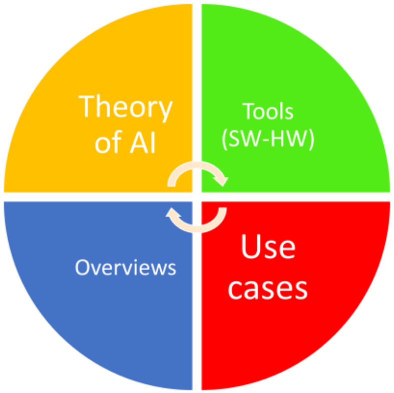
THEORY

Design

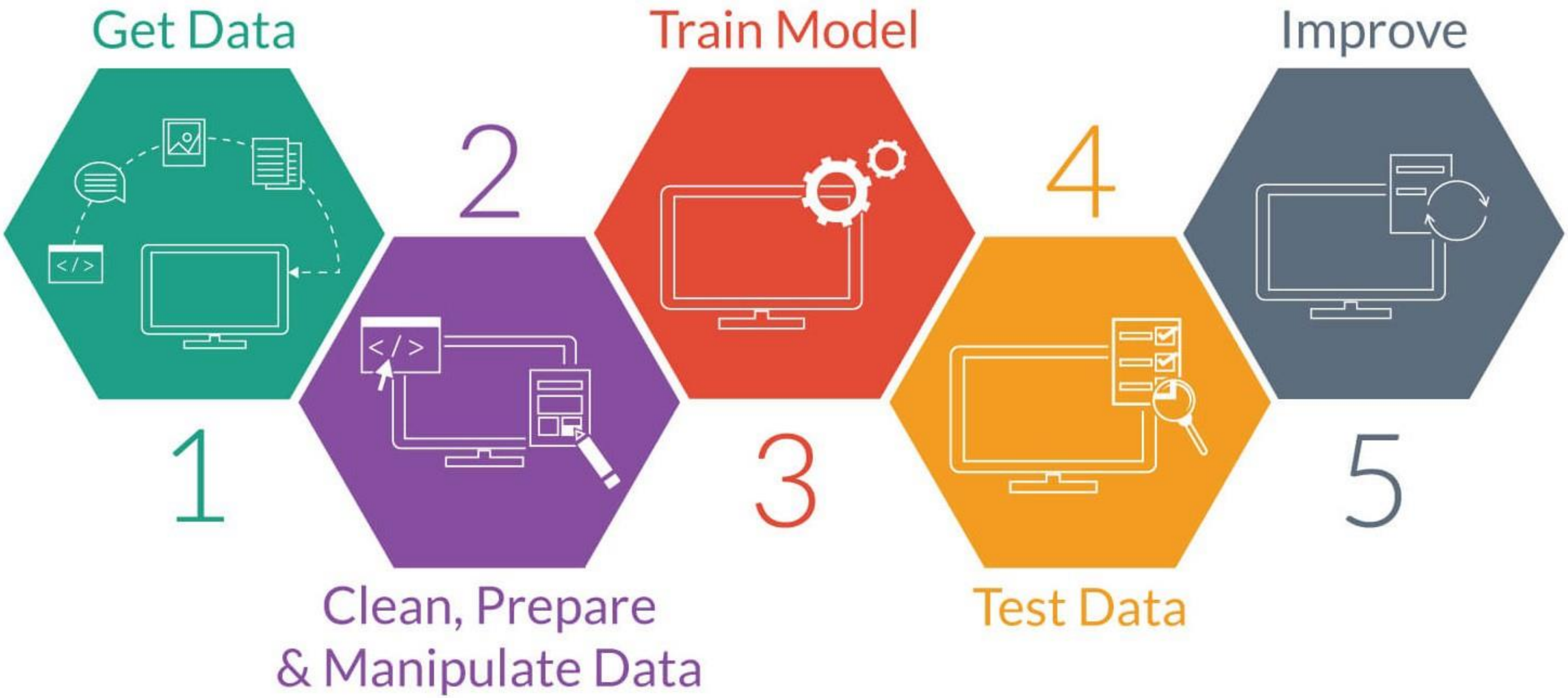
Of Intelligent Systems







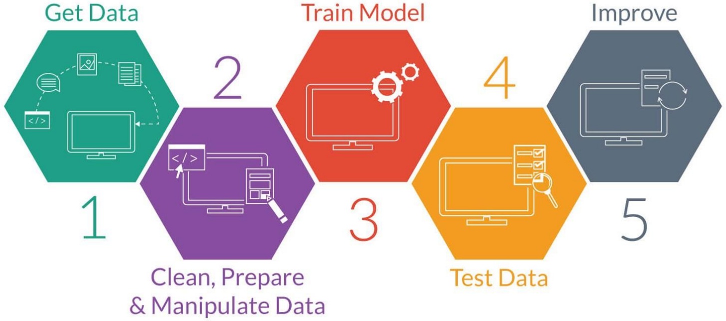
ML workflow



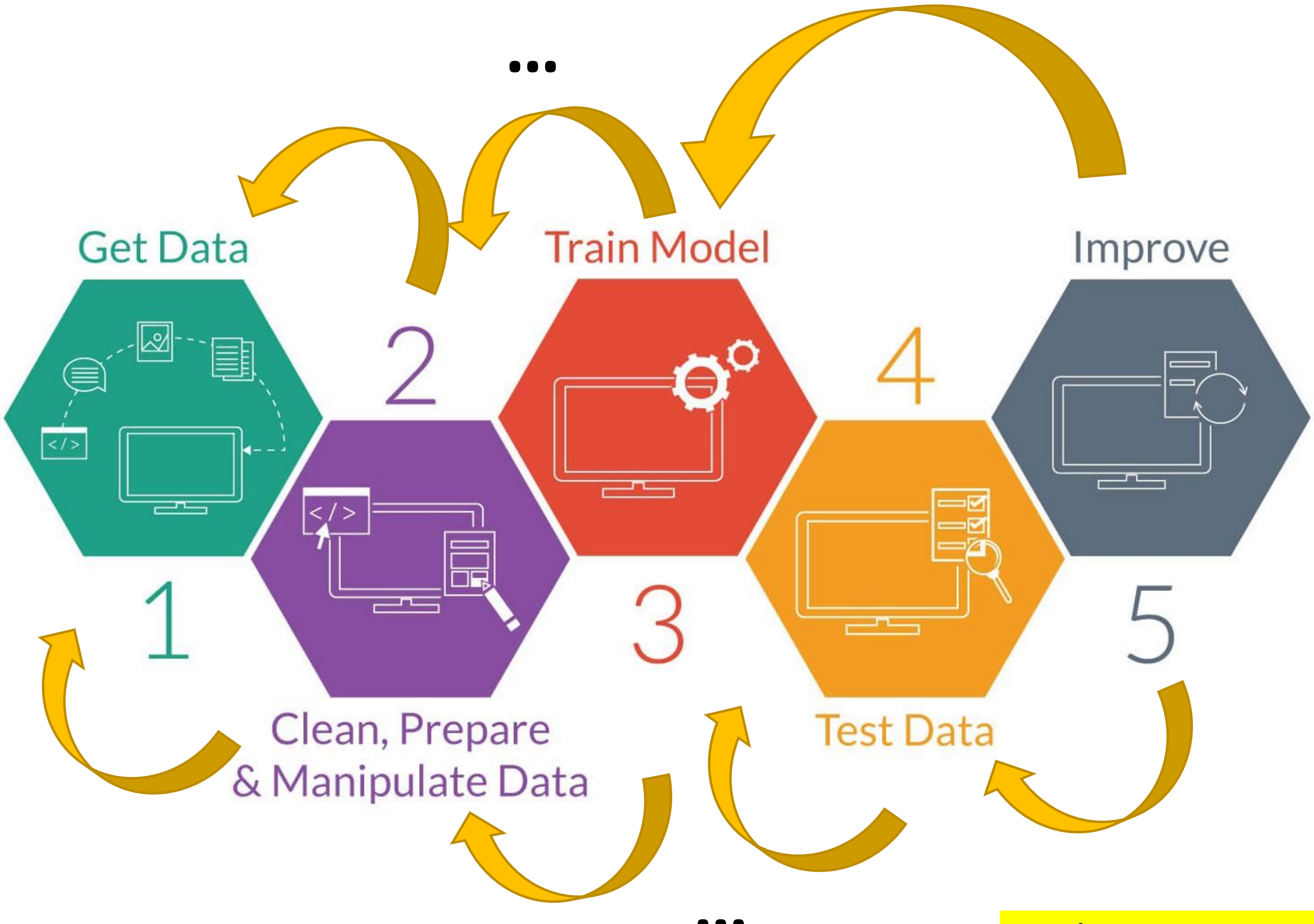
Get Data
1
2
Clean, Prepare
& Manipulate Data
Train Model
3
4
Test Data
Improve
5

ML in Practice

- Understanding domain, prior knowledge, and goals
- Data integration, selection, cleaning, pre-processing, etc.
- Learning models
- Interpreting results
- Consolidating and deploying discovered knowledge
- Loop



ML workflow *(revisitated)*



Do the jump you need!

The Right Technique

- Selection of the right AI technique requires intimate knowledge about the problem as well as the techniques under consideration

- Real problems may require a combination of techniques (AI and/or nonAI) for an (sub) optimal solution

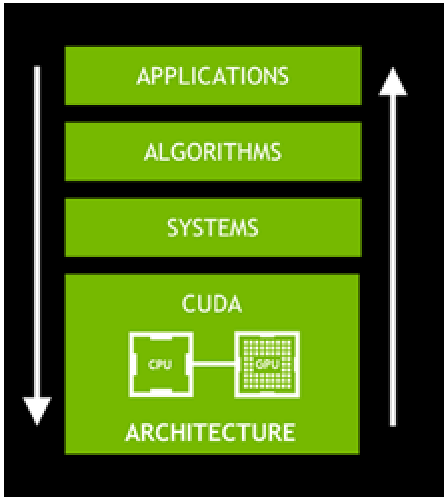
  → Hybrid approaches

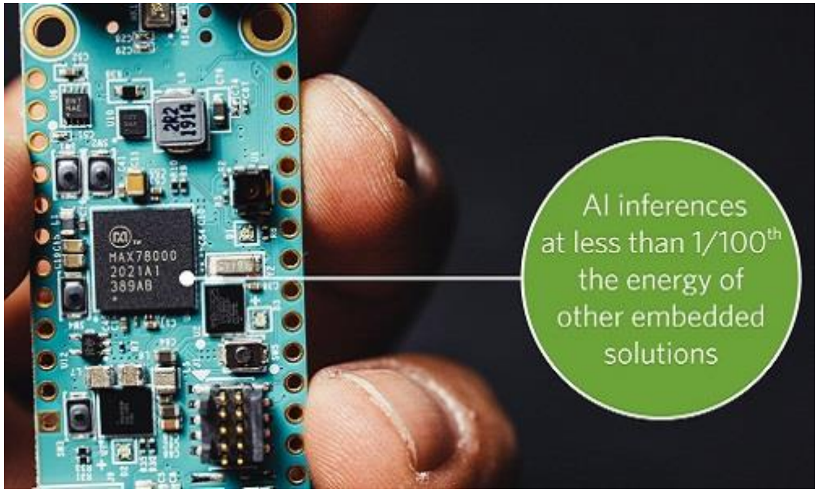
Selection of the AI technique

1. *Study the task's requirements*
2. *Evaluate which technique fulfils those requirements more completely*
3. *Rank the possible solutions with respect to the*
   - *Applicability,*
   - *Cost,*
   - *Performances,*
   - *…. Other features?*

Features to be considered about the models/tools

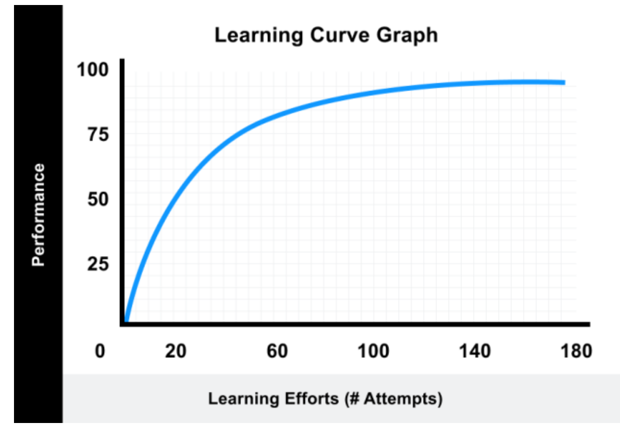
- Accuracy
- Explainability
- Response speed
- Scalability
- Compactness
- Flexibility
- Embeddability
- Ease of use
- Autodidactic

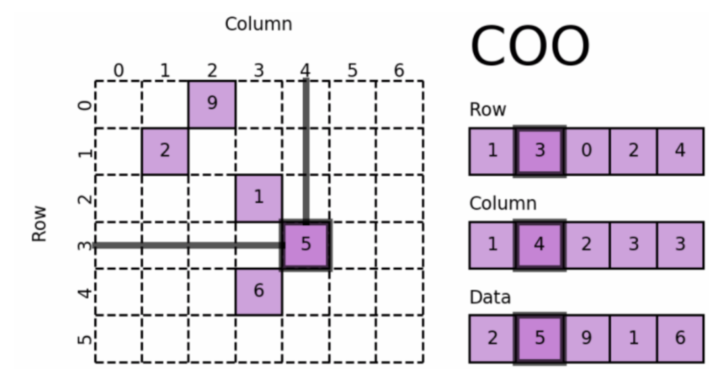




Features to be considered about the models/tools (2)

- Learning curve
- Development speed
- Tolerance for complexity
- Tolerance for noise in data
- Tolerance for sparse data
- Independence from experts
- Computing ease/difficulty



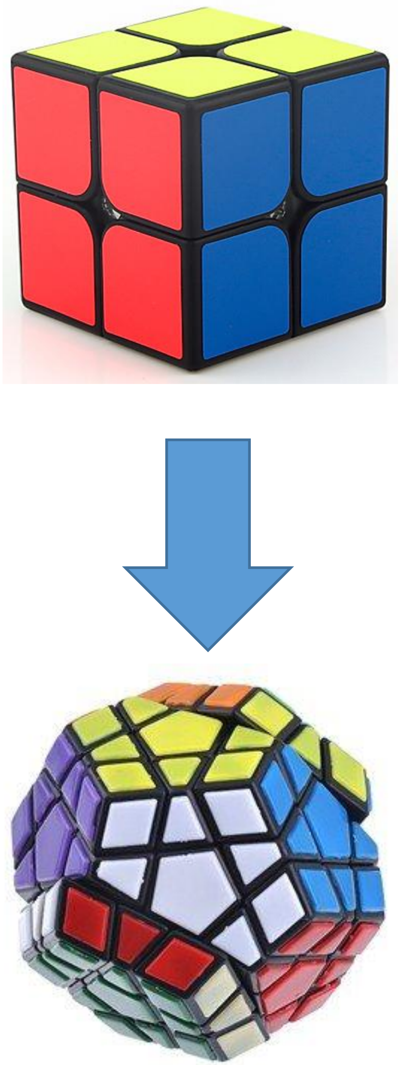


*Selection of the **best** AI technique*

- *A given problem can be solved in several ways*
- *Even if 2 techniques produce solutions of a similar quality, matching the right technique to a problem can save on time & resources*
- *Characteristics of an optimal technique:*
  - *The solution contains all of the required information*
  - *The solution meets all other necessary criteria*
  - *The solution uses all of the available (useful) knowledge*

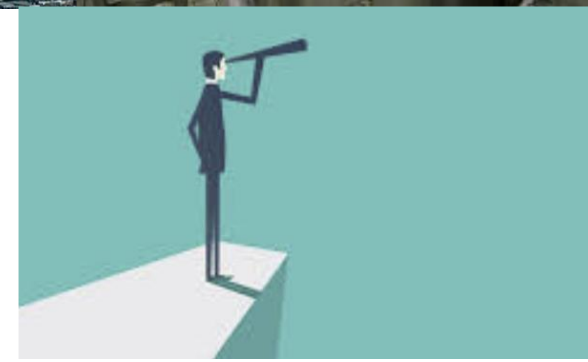
Applications of the Occam's razor

- *Do not waste your time*
  - *Your designing time*
  - *Processing time…. (large models!)*
- *First of all, USE CLASSICAL MODELS. Example:*
  - *k-NN (k-Nearest Neighbor Classifier)*
  - *DTREE (decision tree)*
- *Start with simple neural networks before to consider DEEP LEARNING models*
- *Increase the topology and neurons gradually*
- *Go "deep" only if it is really necessary*





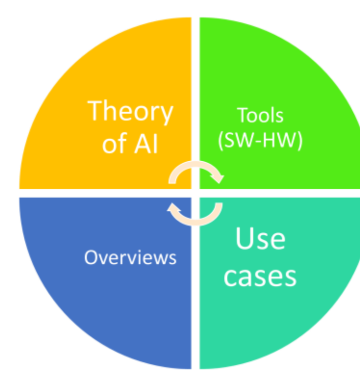




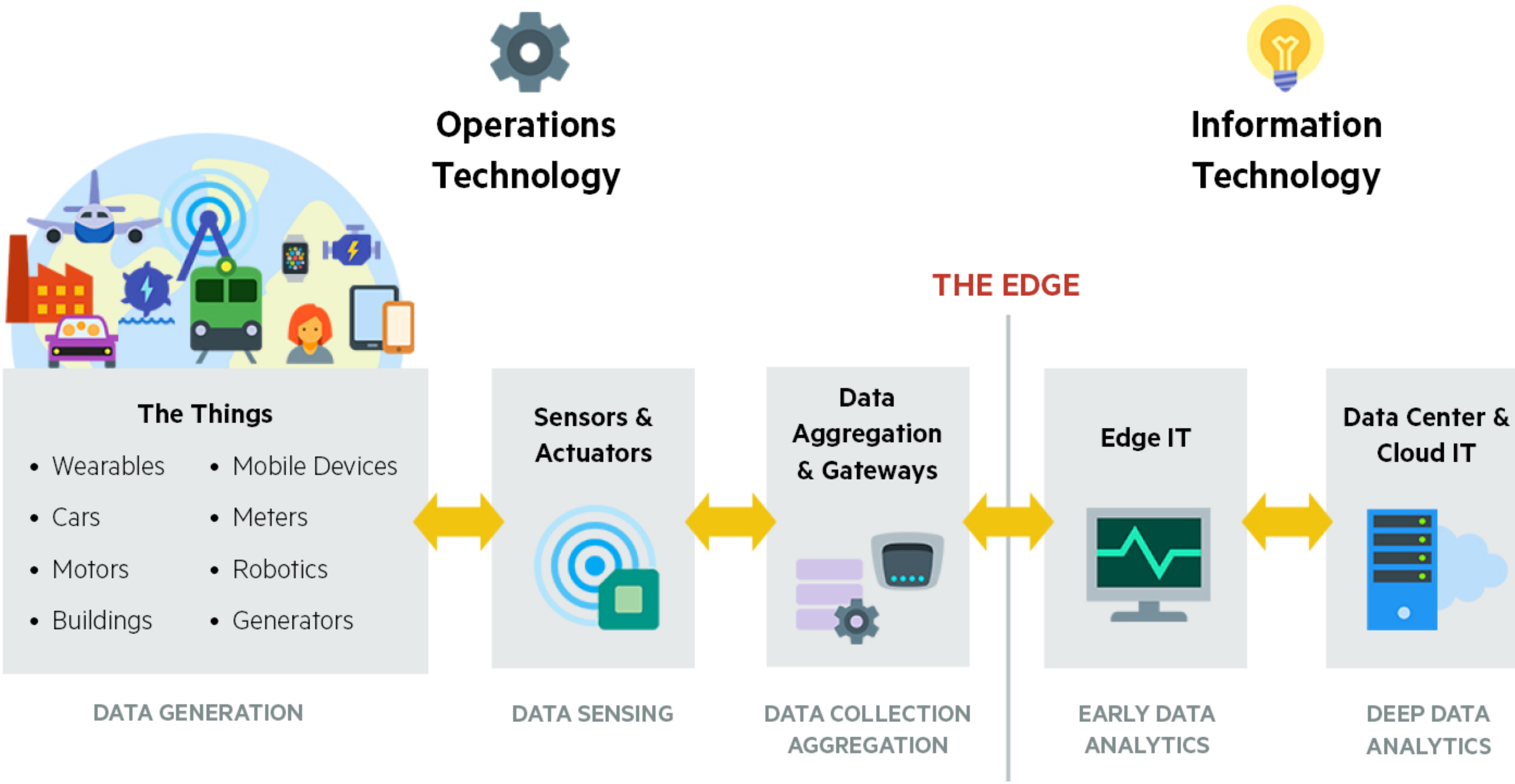
Overview

Edge←→Fog←→Cloud

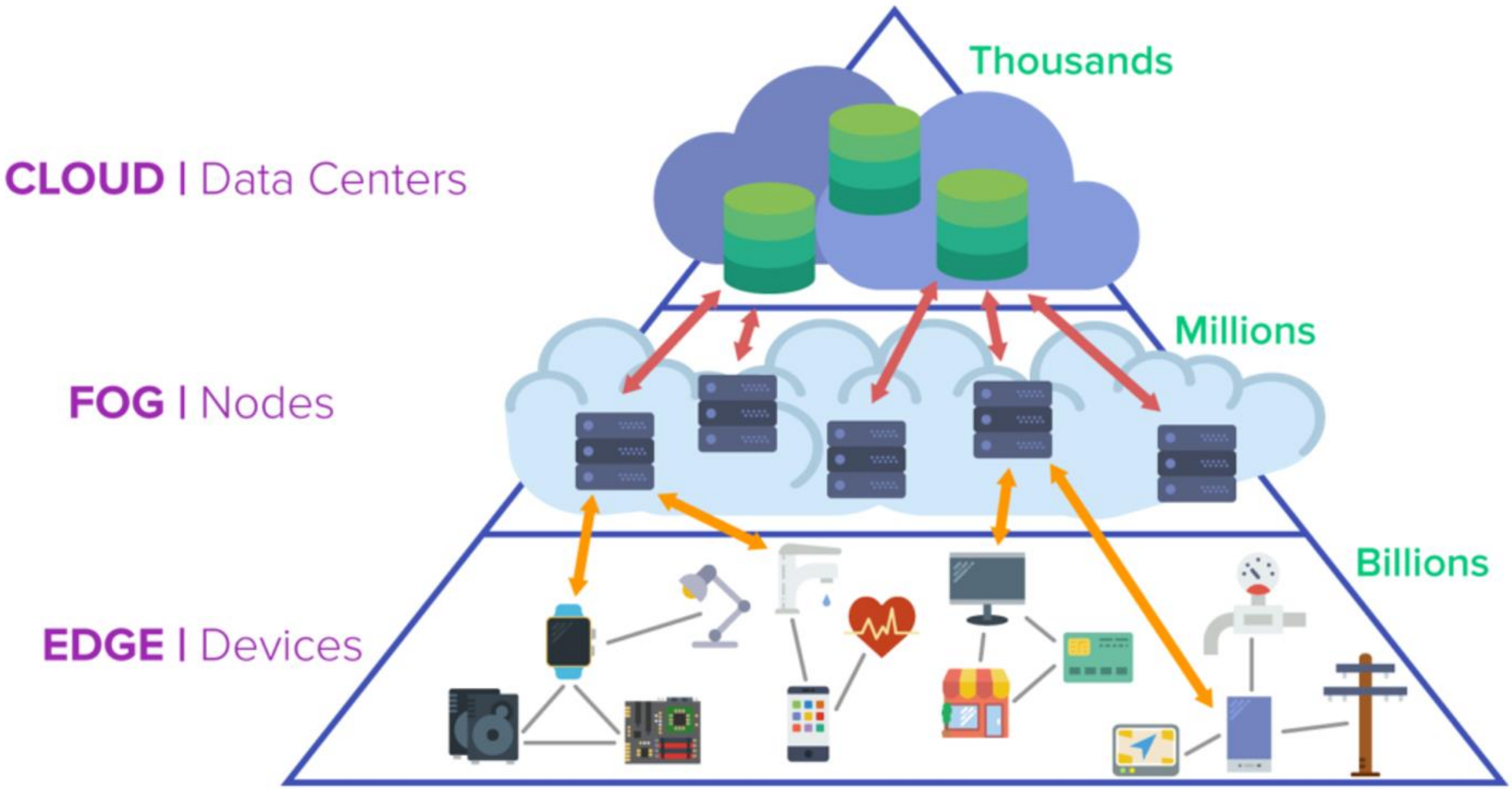
Computation <u>where</u>?



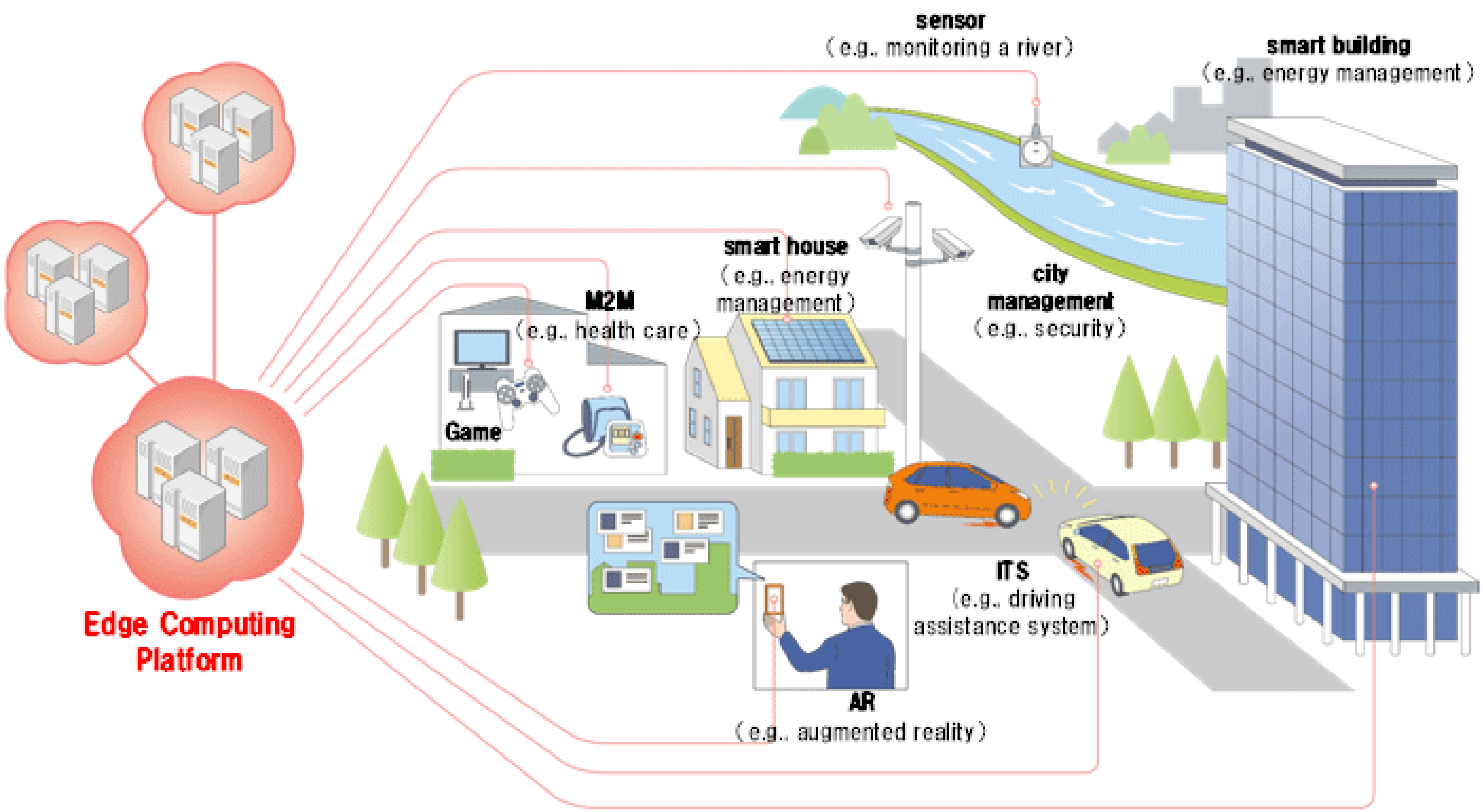
The Edge


Operations Technology
Information Technology
THE EDGE
The Things
• Wearables
• Cars
• Motors
• Buildings
• Mobile Devices
• Meters
• Robotics
• Generators
Sensors & Actuators
Data Aggregation & Gateways
Edge IT
Data Center & Cloud IT
DATA GENERATION
DATA SENSING
DATA COLLECTION AGGREGATION
EARLY DATA ANALYTICS
DEEP DATA ANALYTICS

Edge←→Fog←→Cloud

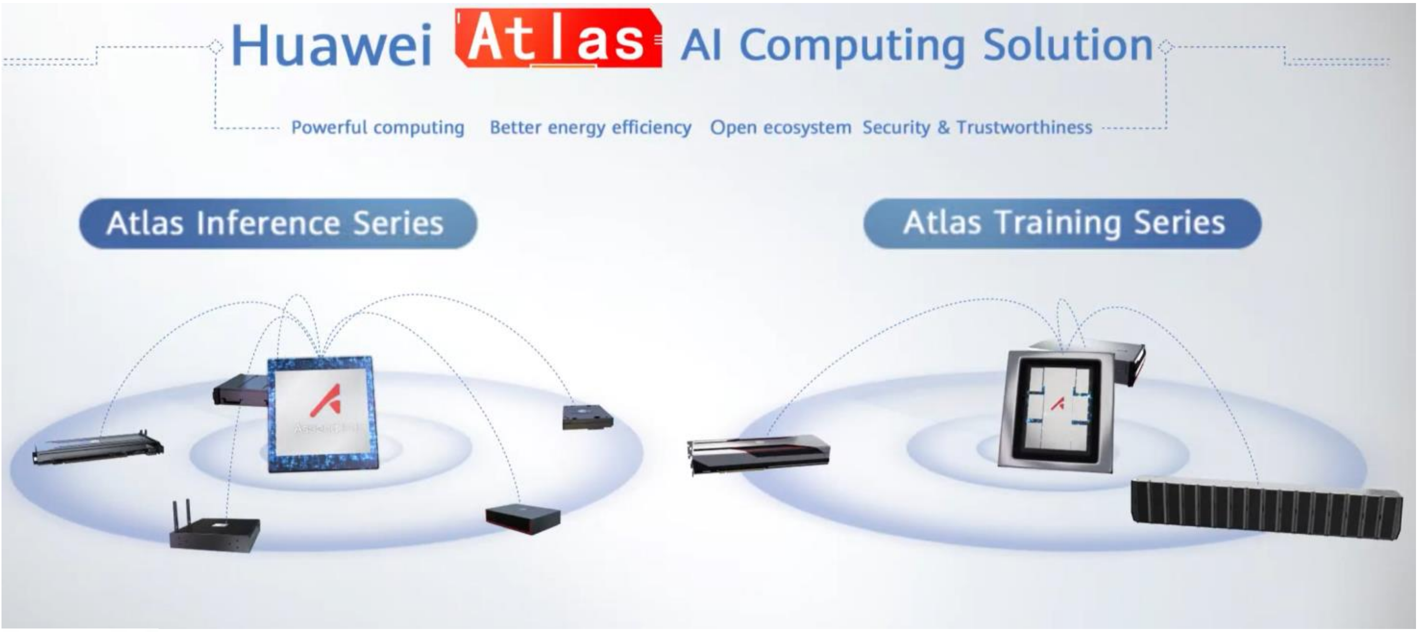


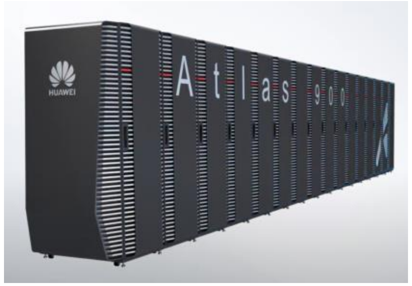
AI+Fog Computing → opportunities



Edge-Cloud use case
Huawei Atlas
AI Computing Solution

https://www.youtube.com/watch?v=K-7xKcwlGVg





A digital word: challenges for environment and industries

Players are facing huge challenges but across the globe relevant initiatives are present

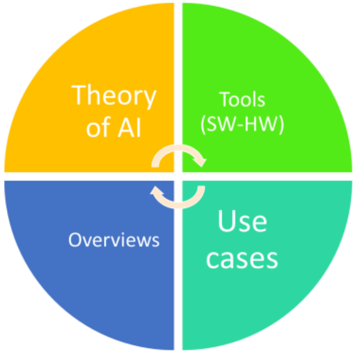
- *Internet of Things (IoT)*
- *Industry 4.0*

- *Artificial intelligence*

  →*increasing relevance in every application!*

THEORY
Internet of Things

Computation of (small) devices



Internet of things (IoT)

- *Since 2000, when IPv6 was first introduced, and 2007, when the 6LoWPAN wireless networking extension was released, virtually all IP-connected devices, wired and wireless, can be connected.*
- *Such networks, known as the "Internet of Things," is generating huge interest among developers of industrial-control networks.*

IoT

Past ideas** and **Myths

- *The alarm clock wake you a little bit before for the increasing traffic..*
- *The fridge is asking for more milk*
- *…*

Present** and **future

- *Self checking devices*
- *Autoconfigurations and updates*
- *Personal health sensors connected to the hospitals*
- *Cars communicating each other*

Three Types of IoT Data Sources

- ***Passive data***
- ***Active data***
- ***Dynamic data***

IoT **Passive** Data Sources

- *Is the ability to consume data from sensors that don't actively communicate.*
  - *These are sensors that must be activated before they can transmit data, and they only produce data when asked to do so.*
  - *For example, a sensor that measures ground water saturation only produces current data when the API is invoked.*
- *Passive data does not mean a passive data/IoT application.*
  - *Indeed, since the sensors need to be managed, the application must take on the logic needed to do so.*
  - *These are typically sensors that are low power and exist in remote locations.*

*IoT **Active** Data Sources*

- *It means that the sensor is typically streaming data, such as from a jet engine.*
- *Different from passive data sources where you have to ask constantly for data.*
- *→ Need to absorb the data in near real-time, and the applications need sophisticated IoT data communications capabilities.*
- *Data can't be lost, it must be correctly parsed from the stream, and placed in the correct format for both storage and processing.*

*IoT **Dynamic** Data Sources*

- *The most sophisticated and the most useful.*
- *These are devices with sensors that communicate dynamically (bidirectional) with IoT applications, such as a smart thermostat.*
  - *These types of sensors carry out a "conversation" with IoT applications.*
  - *Providing a full range of capabilities:*
    - *Ability to change the data that's produced,*
    - *Change the format of the data,*
    - *Change the frequency,*
    - *Deal with security issues*
    - *Automated software updates to dynamically deal with issues/versioning/calibration.*

*IoT **Dynamic** Data Sources*

- *Data from dynamic data source is like an IoT application **talking** to another application.*
- *They do not just deal with data points that devices produce, but **can alter the data** produced to meet the needs of the target IoT application.*
- *These are also self- and auto-configurable.*
- *These dynamic capabilities really **provide the best IoT capabilities**.*
- *Here we can implement AI systems!*

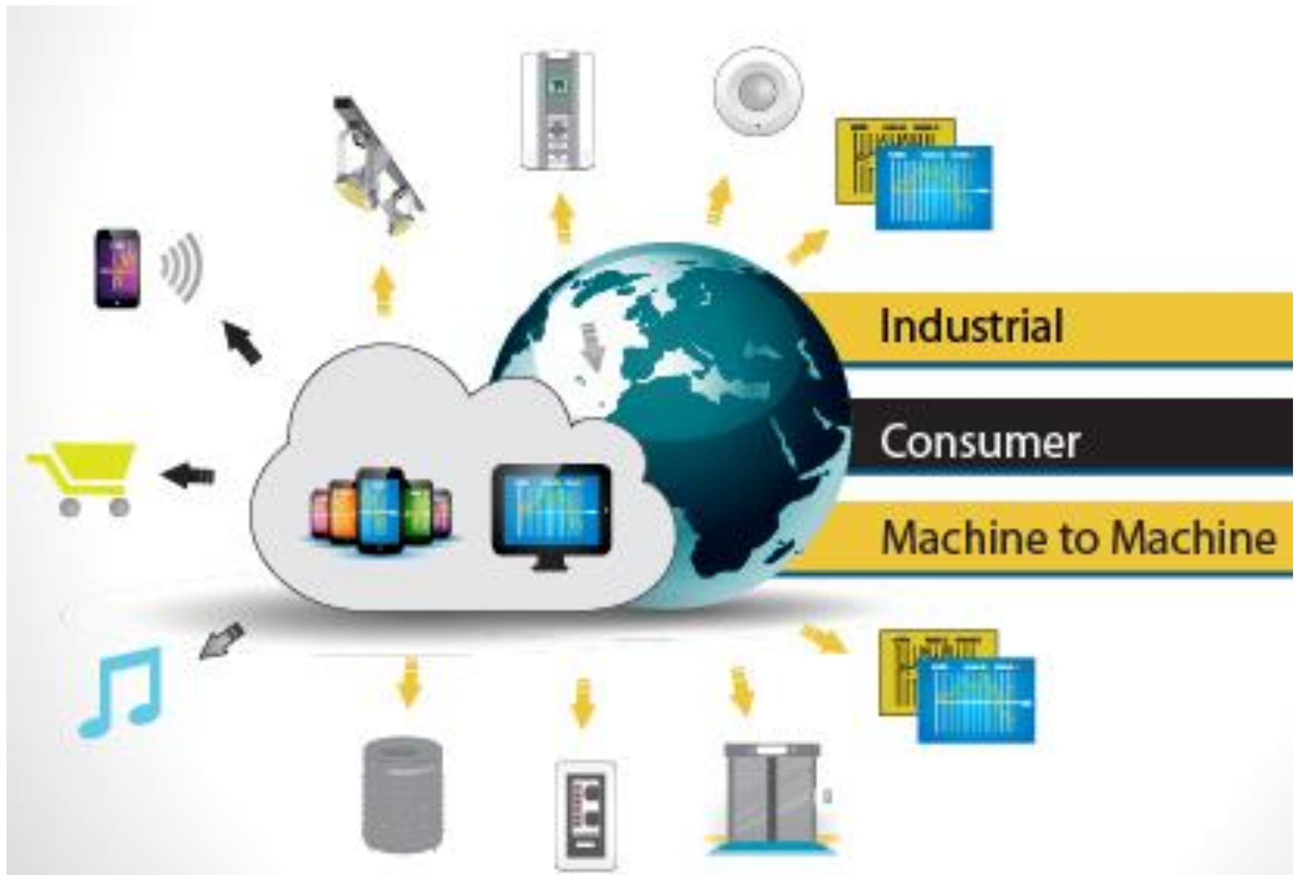
Nest = Simple thermostat + AI → Google bought the Nest company for $3.2 billion in 2014

3 categories based on the usage/client

- *Consumer **IoT** includes the connected devices such as smart cars, phones, watches, laptops, connected appliances, and entertainment systems.*
- *Commercial **IoT** includes things like inventory controls, device trackers, and connected medical devices.*
- *Industrial **IoT** covers such things as connected electric meters, waste water systems, flow gauges, pipeline monitors, manufacturing robots, and other types of connected industrial devices and systems.*

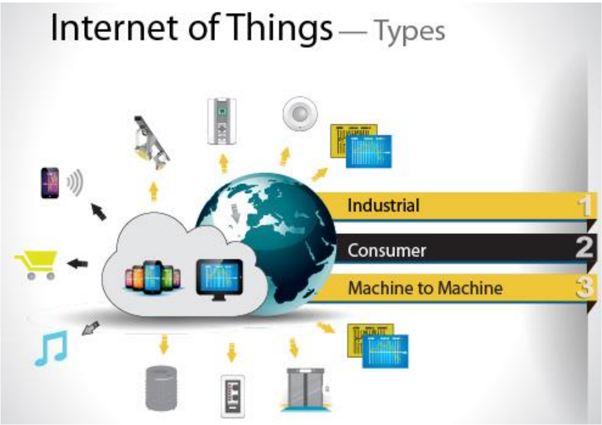
IoT: 3 main protocols

Different Features about
- Realtime
- Deterministic
- Human inter.
- Security



In a **deterministic** system, every action, or cause, produces a reaction, or effect,

Consumer *IoT*



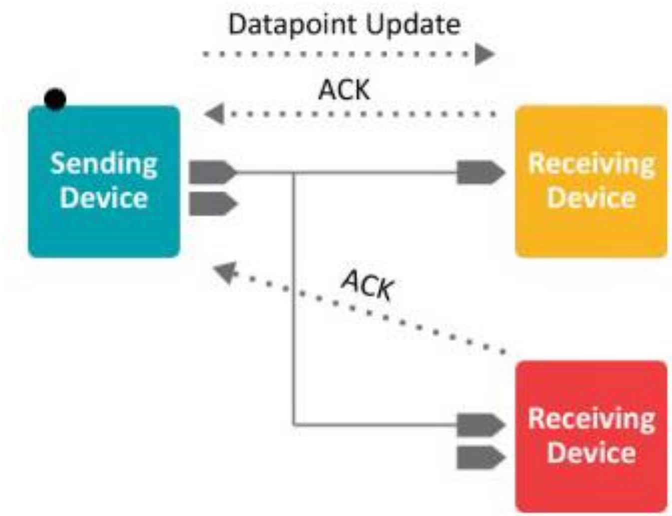
Examples:

- Viewing a video on a cell phone,
- Starting up an exercise monitor to send your statistics to your account in the cloud,

Features:

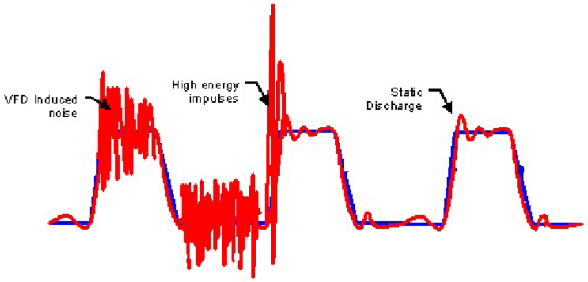
- non-real-time
- non-deterministic
- a human interacting with a device
- In case of failure, a human can recover or restart the application
- In the consumer IoT, communications run between client/server and are often streaming large amounts of data.

<u>Industrial</u> Internet of things (IIoT)

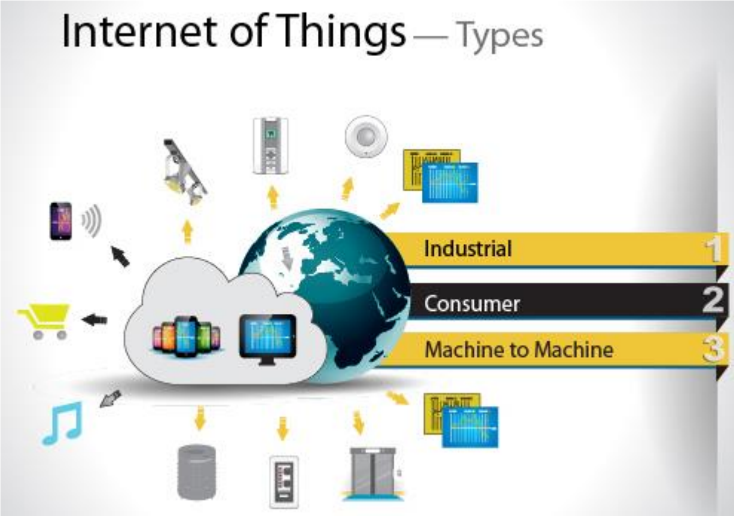


Features

- Resilience to failures
  - Packet recovery
  - Real-time requirements
  - Reliable network-wide delivery
- Security
- Physical connectivity requirements (a lot of electromagnetical interf.)
- Control services



Machine to Machine *IoT*



Typical of client/server-based application-monitoring architecture of M2M are vehicle-tracking systems, systems that monitor a building's mechanisms for signs of wear, or systems that track mobile hospital equipment

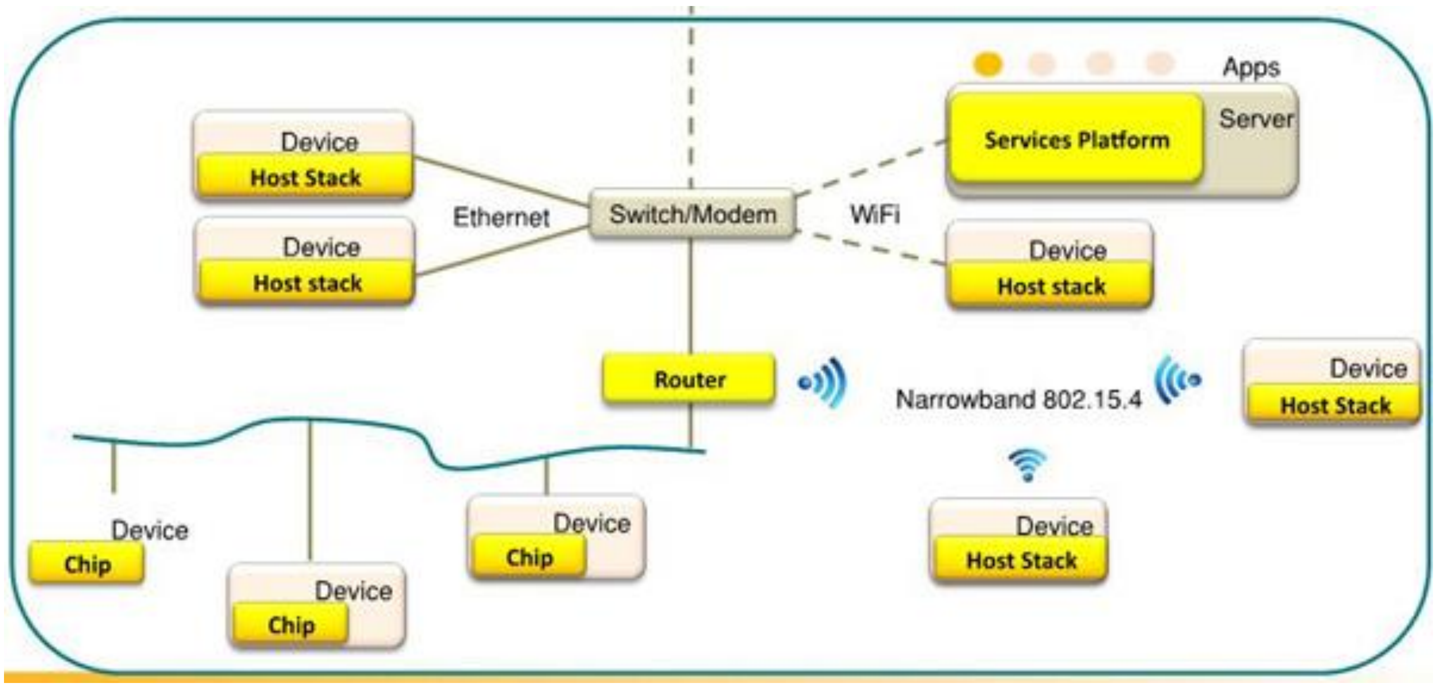
It uses client/server communications and sends smaller amounts of data (device identifier, position coordinates, and a time stamp).

What is important:

- the **reliability of communications** (no human operator or user to aid in recovery from error).
- The items the **data locates are valuable**, as well as the knowledge of where they are at any given point. Cost is incurred when the information is not available or is unreliable

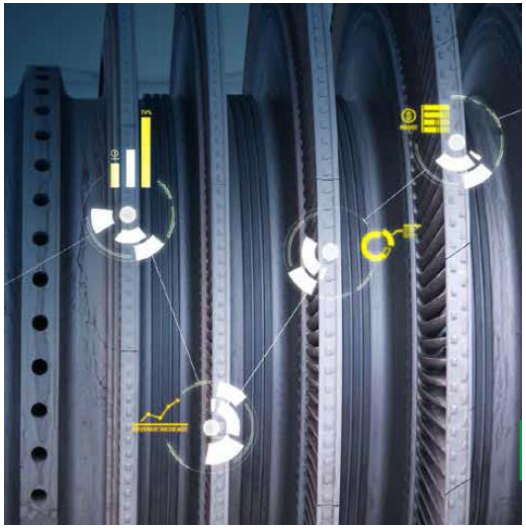
Industrial Internet of Things: typical structure of nodes

- *Characterized by many-to-many connections where groups of nodes work together on a single task.*



Industrial Internet of things: typical applications

- According to Oxford Economics IIoT is one of the future major trends with significant implications for the global economy impacting
  - manufacturing,
  - mining,
  - agriculture,
  - oil and gas,
  - utilities.
- Durable physical goods, general to conduct business, such as organizations that operate hospitals, warehouses and ports or that offer transportation, logistics and healthcare services.



Sensors embedded in objects and machinery with wireless connection

Oxford Economics Ltd. is a leader in global forecasting and quantitative analysis

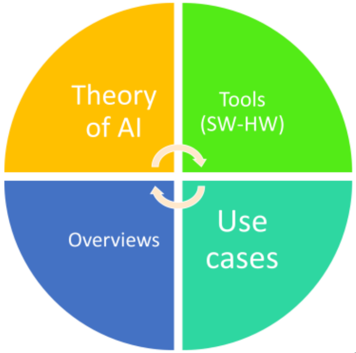
A global impact… the smart city

THEORY

Internet of Everything

Seamless interconnection and

autonomous coordination



The Internet of Everything:
Networked Connection of People, Process, Data, Things

People

Connecting people in more relevant, valuable ways

Process

Delivering the right information to the right person (or machine) at the right time

Data

Leveraging data into more useful information for decision making

Things

Physical devices and objects connected to the Internet and each other for intelligent decision making

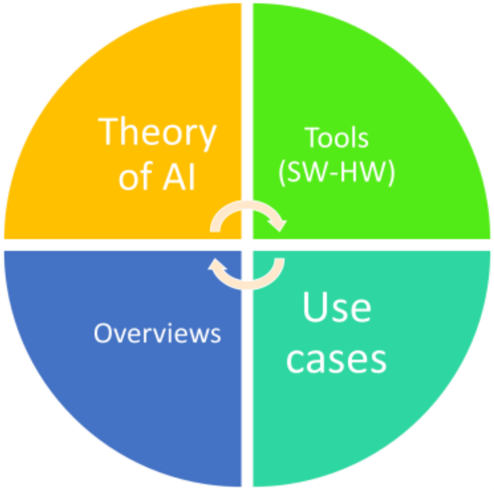
Internet of Everything (IoE)

- *The seamless interconnection and autonomous coordination of massive number of computing elements and sensors, inanimate and living entities, people, processes and data through the Internet infrastructure, is an emerging research direction towards enabling the Connected Universe from molecular sensors to vehicles and people.*
- *Enormous potential to transform the way we connect with and understand the Universe*
    - *Enabling new methods of interfering with the processes at the single-molecular level and extending the human consciousness*
    - *To control with smart agents collaboratively sensing and acting upon the environments never explored by any other paradigm before.*
- *The realization of IoE demands novel engineering solutions to overcome the unique connectivity, spectrum scarcity, miniaturization, interoperability and energy-efficiency challenges.*



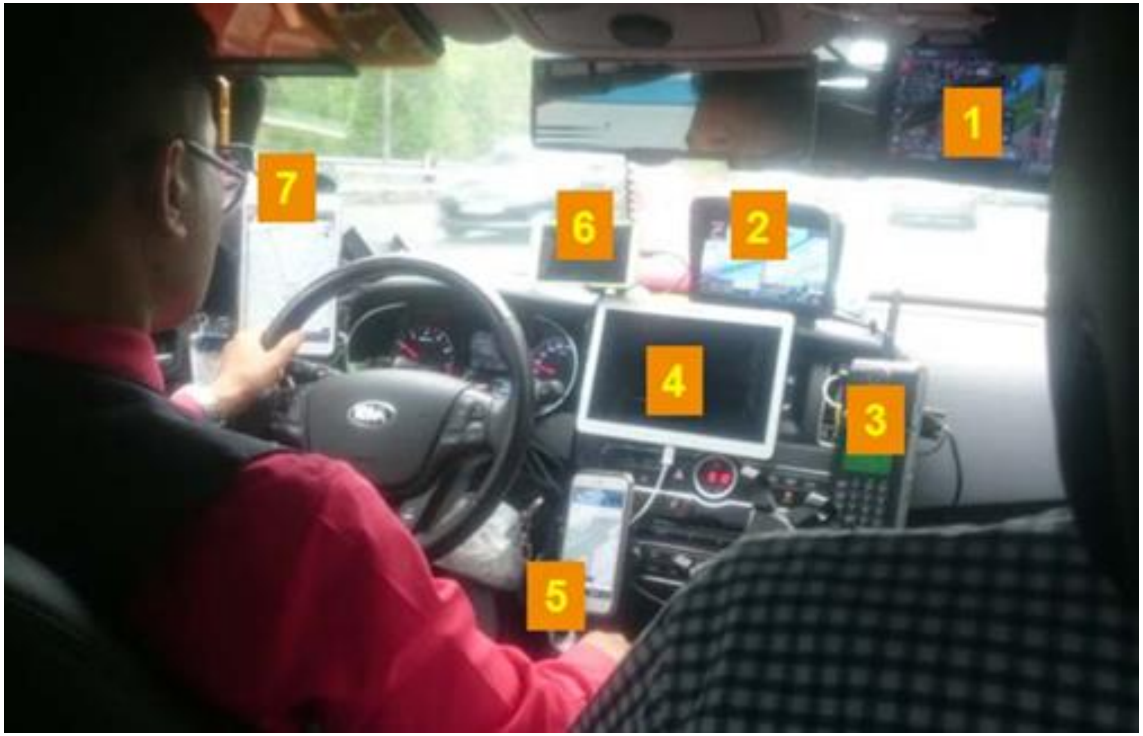

Overview
Intelligent transportations

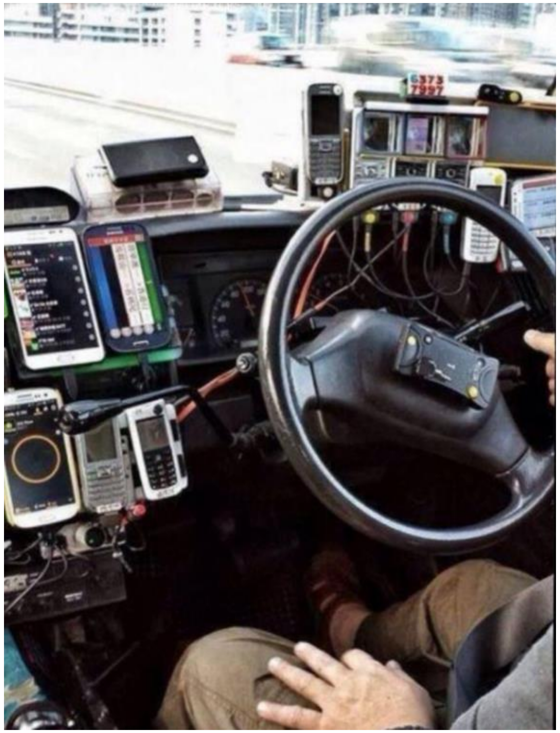
Current application and trends



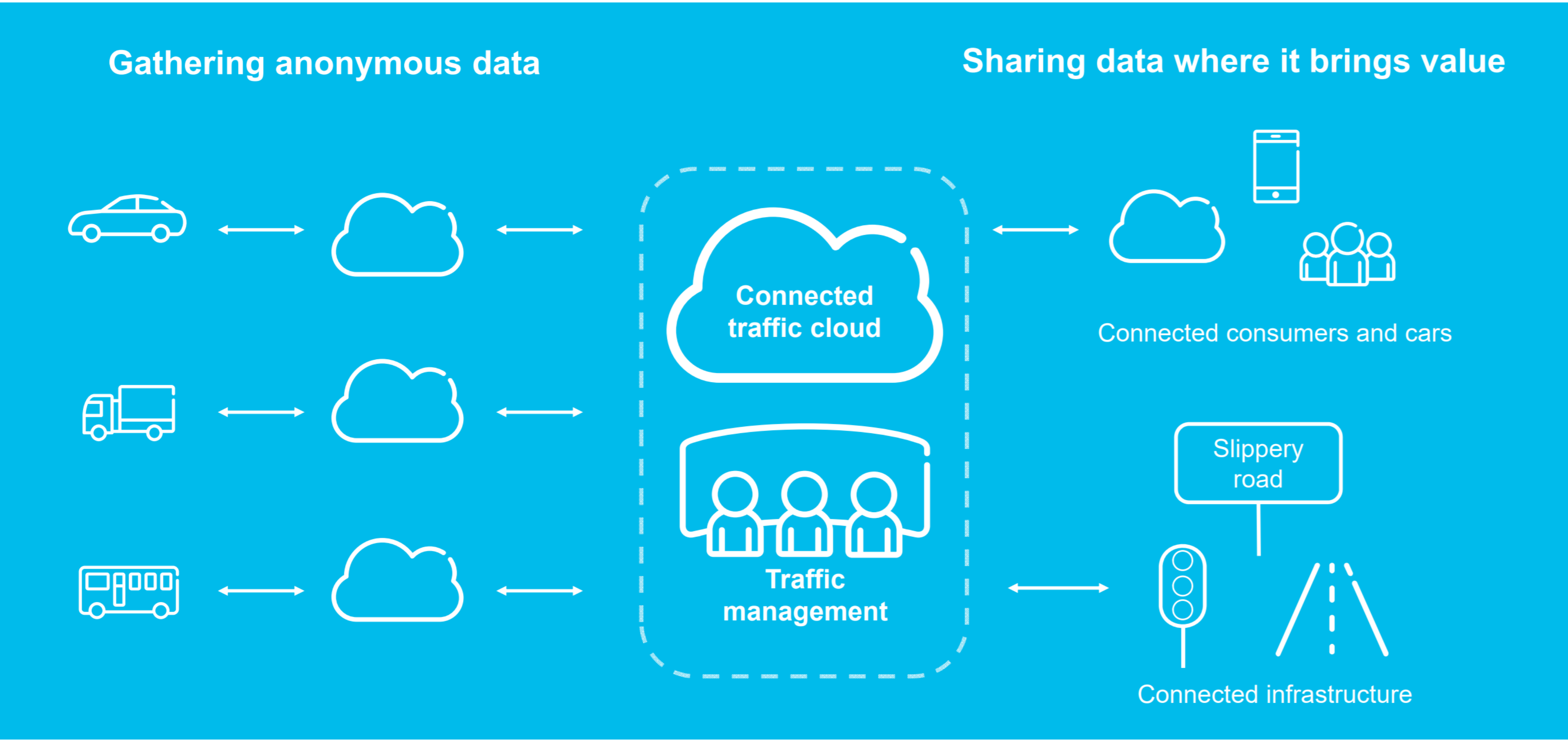
What is not…

The connected taxi driver….



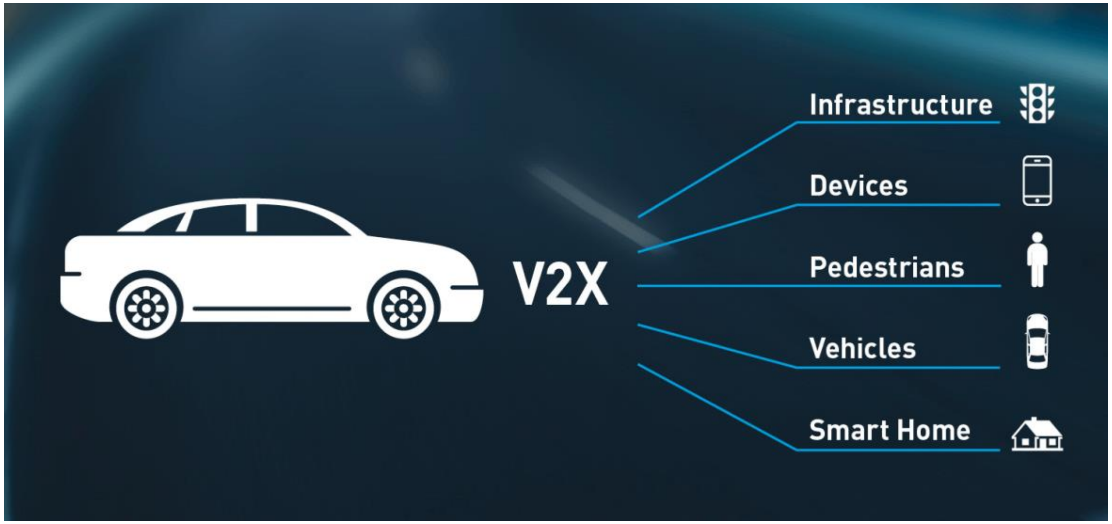


Instead we want ….

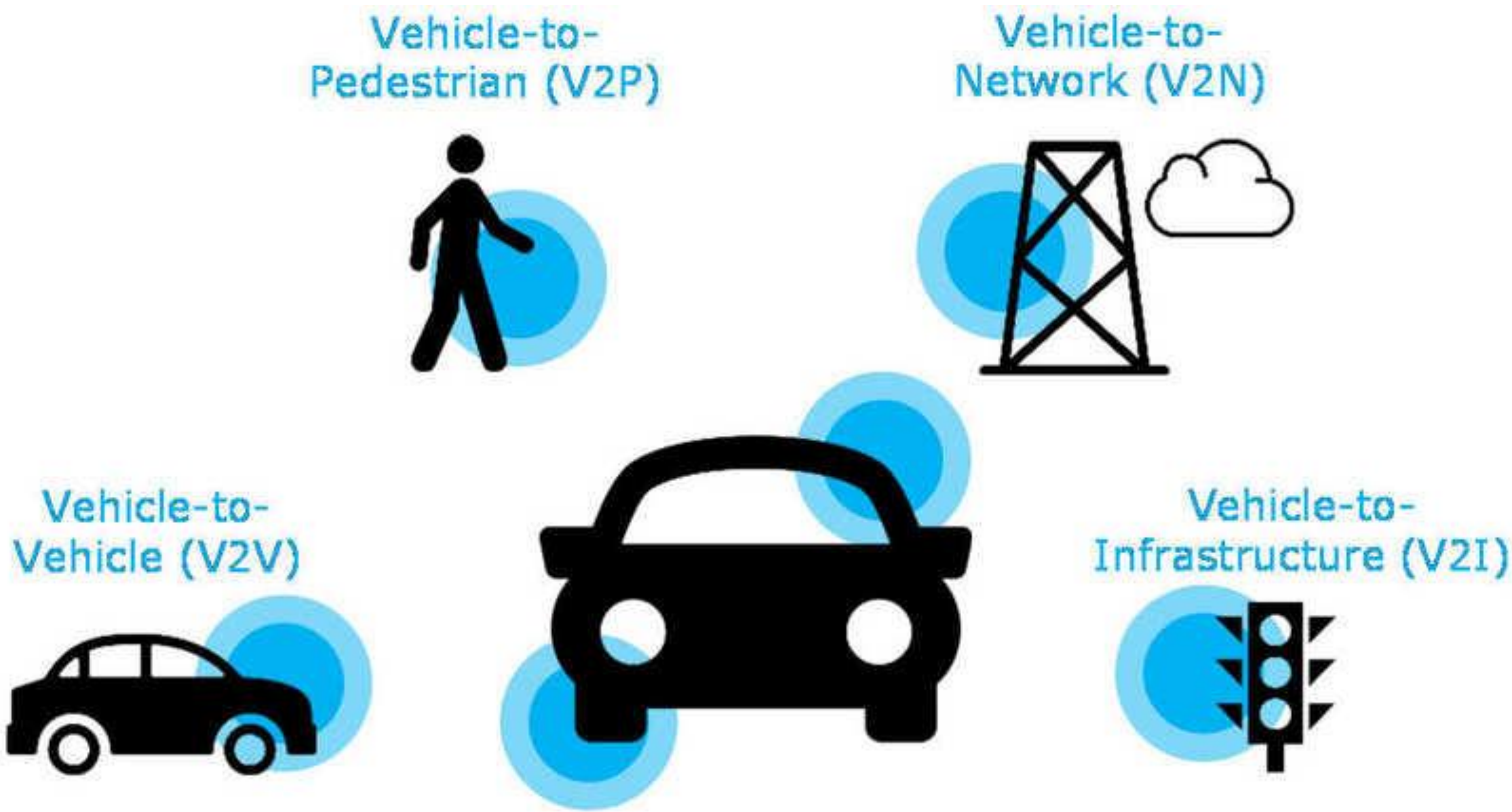


Vehicle to everything (V2X)

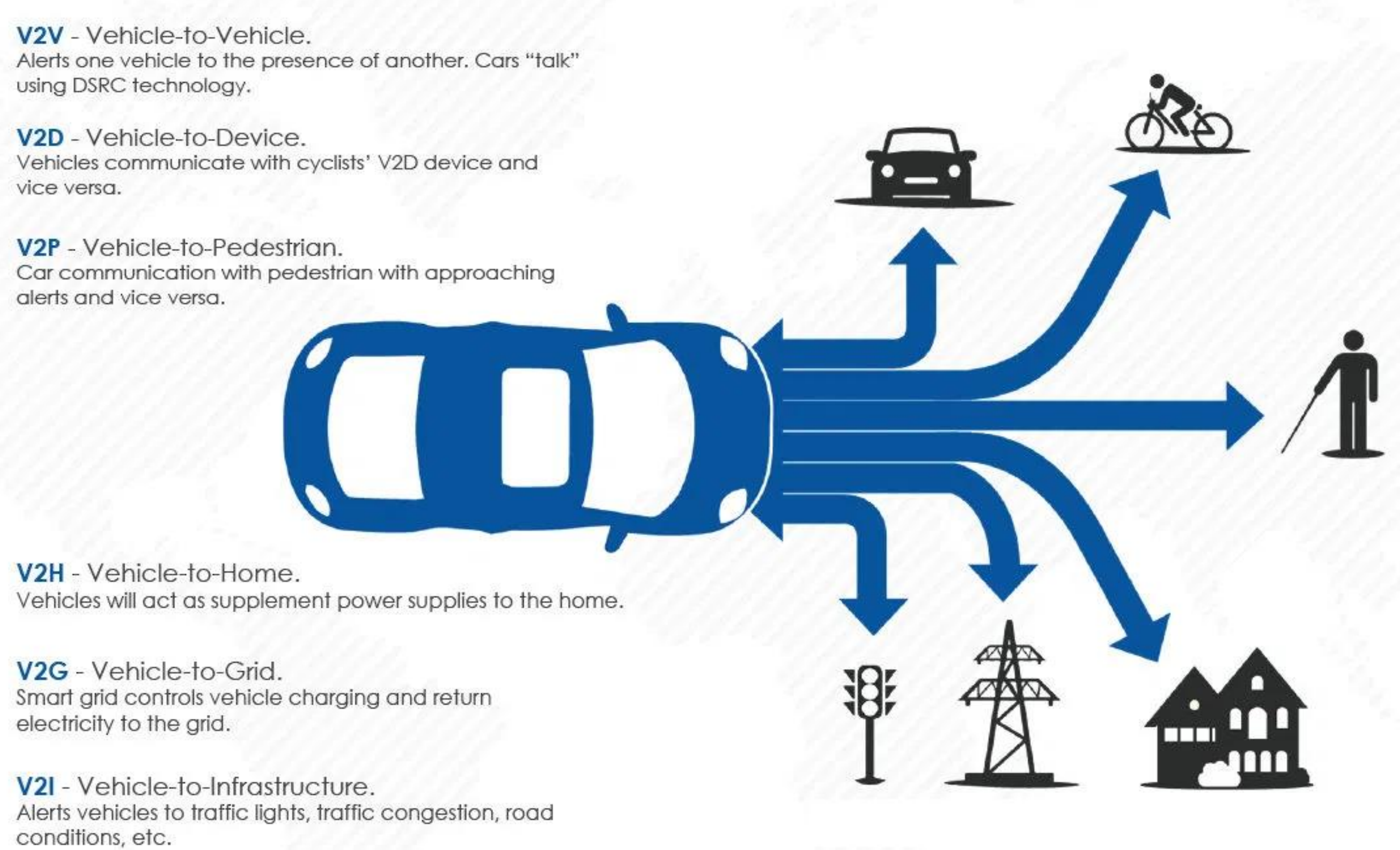
- Vehicle to everything (V2X) is a term that refers to
  - high-bandwidth
  - low latency
  - highly reliable communication between a broad range of transport and traffic-related sensors.
- 5G mobile networks will be key to providing connectivity for vehicle to vehicle (V2V) and vehicle to infrastructure (V2I)



Elements of the V2X



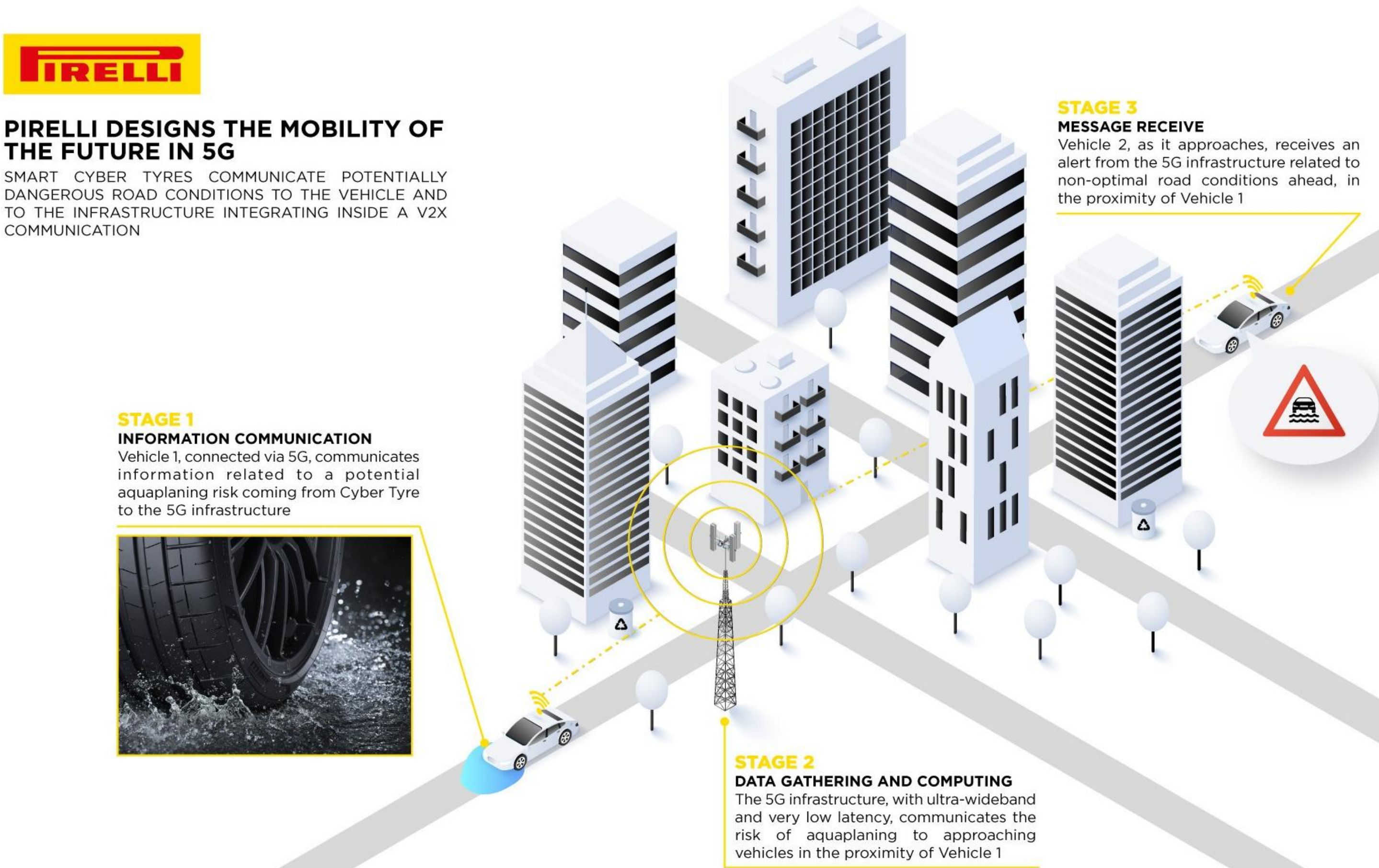
Road map for V2X
(think to electric/hybrid cars)



Functions of V2X

Image to be a pedestrian approaching a zebra crossing: traffic lights can switch color; cars will be warned before.
→ More fluid and safe circulation

From a small sensor → smart city



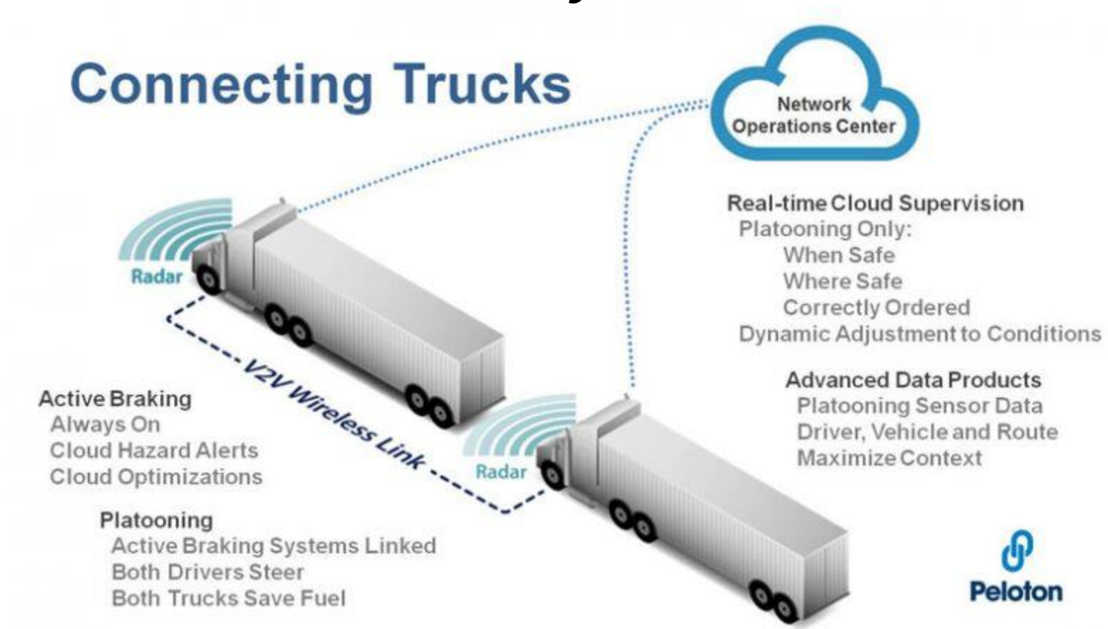
The tyre sensors are in contact with the road

- → The tyre sensors detect potential danger on road surfaces (water, poor grip, …)
- → The car adapts its control and driving assistance systems
- → The car provides the same information to other cars and the infrastructure

Pirelli, Ericsson, Audi, Tim, Italdesign and KTH
5G enhanced ADAS (Advanced Driver Assistance Systems)

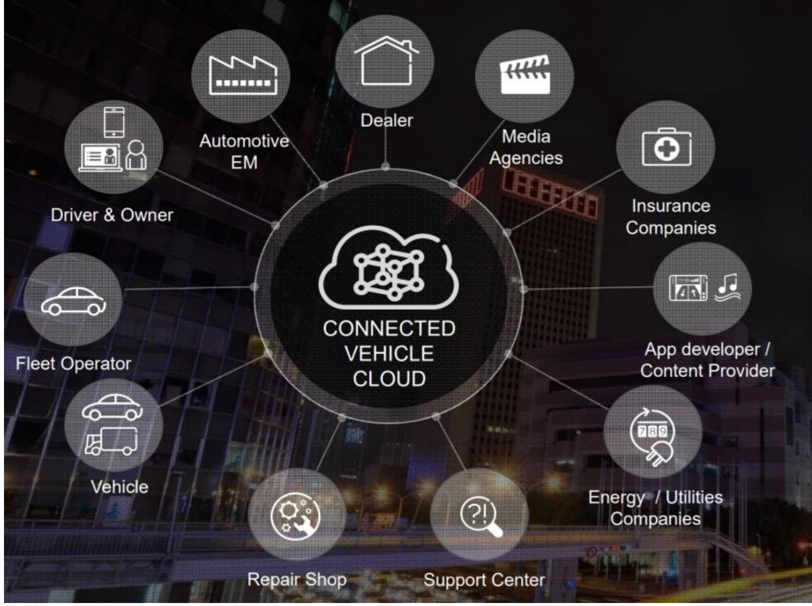
IoT: Platooning veichles

- ***IoT-enabled platooning** is an innovative transport system where trucks can drive closely together – one after another – using a common communication system based on V2V IoT*



Tesla, Volvo, Iveco, Scania, …
are prototyping
Market introduction 2022

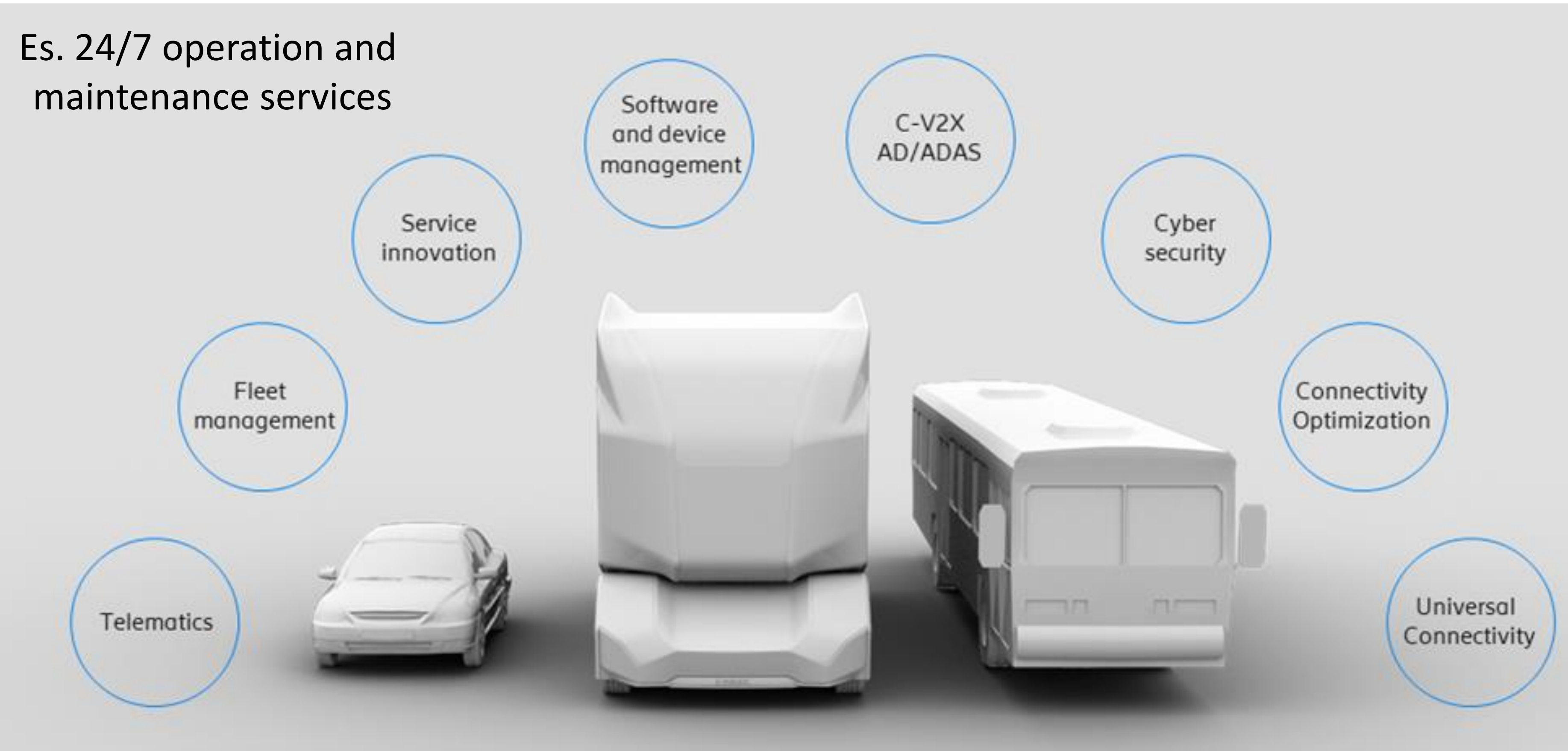
Connected Vehicle Cloud (Ericsson)



- *Is a digital service **platform that enables vehicle manufacturers to rapidly develop and manage new services for connected** vehicles.*
- *Connected Vehicle Cloud is the most complete connected car platform on the market.*
- *Fontrunners in automotive IoT are using it to connect >4 million vehicles and counting, across more than 130 countries.*

Some of the capabilities enabled by Connected Vehicle Cloud …

Es. 24/7 operation and maintenance services



Intelligent transportation systems

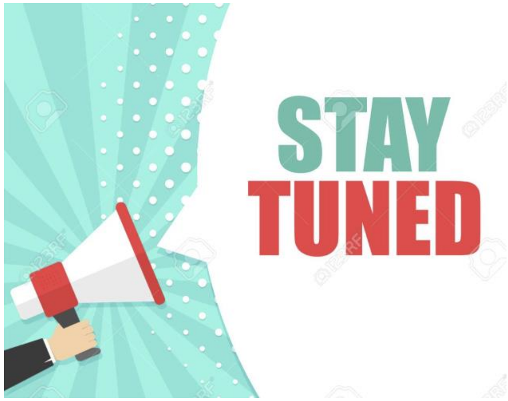
- *Advanced systems for of transport and traffic management (highway, city, region level)*
- *Enabling users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks using artificial intelligence*
- *Examples:*
  - *Calling for emergency services when an accident occurs*
  - *Using cameras to enforce traffic laws*
  - *Signs that mark speed limit changes depending on conditions and weather conditions*
  - *Collision avoidance systems*

Intelligent transportation systems: key features

- ***Wireless communications***
    - *Short-range communications (up to 350 m using IEEE 802.11)*
    - *Longer range communications using infrastructure networks such as WiMAX (IEEE 802.16), Global System for Mobile Communications (GSM), or 3G, 4G, 5G*
- ***Computational technologies***
    - *Micro controllers on sensors and car devices*
        - *IoT, dynamic data devices*
    - *Virtual sensors (e.g., the ice presence sensors)*
- ***Heterogenous data fusion***
    - *From sensors, surveillance cameras, smartphones, GSM towers*
    - *Different protocols and artificial intelligence!*

Sensors, IoT, Protocols, Cloud, Networks!

- *From a sensors, to cars, connectivity, protocols, storage and cloud processing, etc.. How to deal with it?*
- *Standards and HW-SW architectures will help the design and the deployment → Your work*
- *How to add "intelligence"?*
- *Let's see how in the next lesson!*



Main points

- Design of applications with ML (very important topic)
  - The ML workflow
  - Selection of the best ML technique
- Edge←→Fog←→Cloud
- The Internet of Things (IoT)
- Application of intelligent systems to IoT
  - Smart cities
  - Smart transportation