



Introduction to the Internet of Things

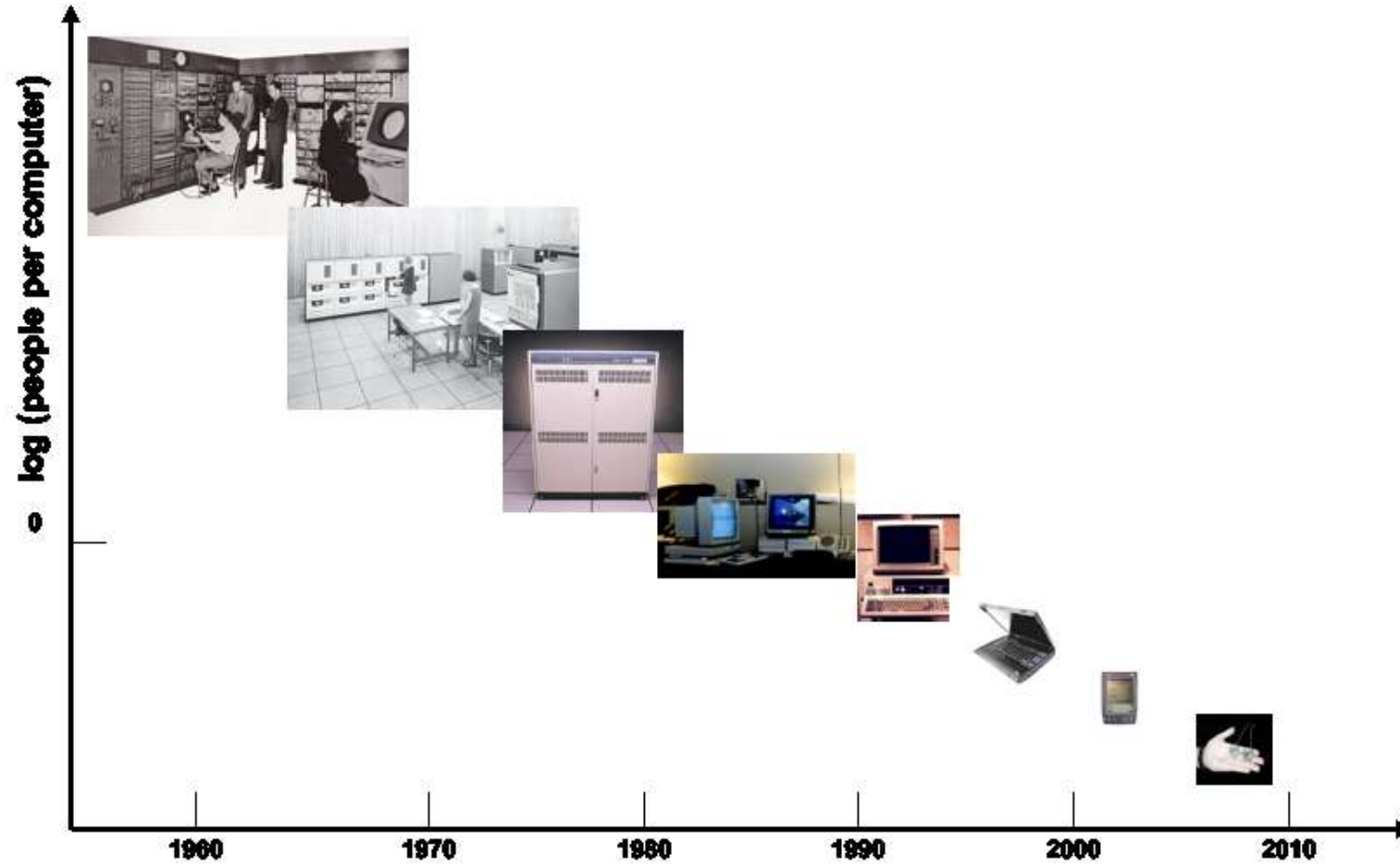


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Vision



[Culler:2004]





History of IoT

- The first **telemetry** system was rolled out in Chicago way back in 1912. It is said to have used telephone lines to monitor data from power plants.
- Telemetry expanded to weather monitoring in the 1930s, when a device known as a **radiosonde** became widely used to monitor weather conditions from balloons.
- In 1957 the Soviet Union launched Sputnik, and with it the Space Race. This has been the entry of **aerospace telemetry** that created the basis of our global satellite communications today.





History of IoT

- Broad adoption of M2M technology began in the 1980s with wired connections for **SCADA** (supervisory control and data acquisition) on the factory floor and in home and business security systems.
- In the 1990s, **M2M** began moving toward wireless technologies. ADEMCO built their own private radio network to address intrusion and smoke detection because budding cellular connectivity was too expensive.
- In 1995, Siemens introduced the first cellular module built for M2M.



History of IoT

"Machine to Machine" (M2M)
(~1970s +)



Internet of Things Beginnings



Carnegie Mellon Internet
Coke Machine (1982, 1990)



Internet Toaster
(1990)



Trojan Room Coffee
Pot
(first webcam)
(1991)

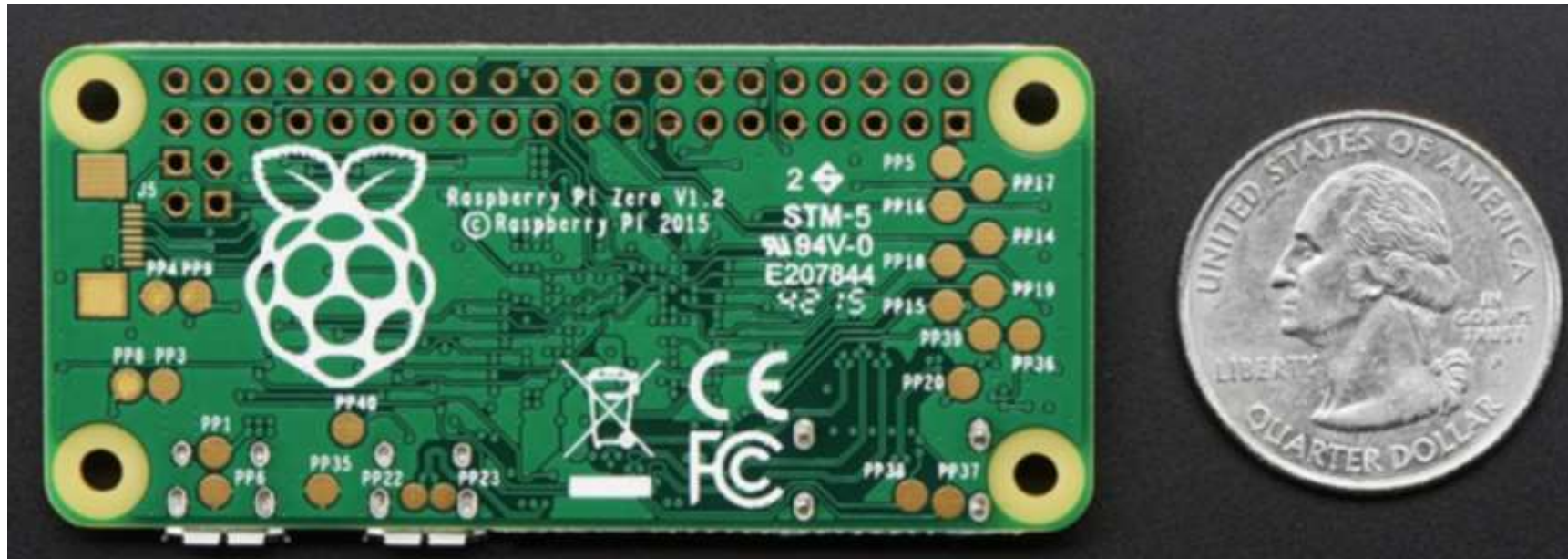


Why IoT now?

- *Ubiquitous Connectivity*
- *Widespread Adoption of IP*
- *Computing Economics*
- *Miniaturization*
- *Advances in Data Analytics*
- *Rise of Cloud Computing*



RPi Zero: \$5





IoT Definition

- **Wikipedia:** The Internet of Things (IoT) refers to **uniquely identifiable objects** and their virtual representations in an **Internet-like structure**.

[http://en.wikipedia.org/wiki/Internet_of_things - 21-Jun-2014]

- **Cisco:** The Internet of Things (IoT) is the network of physical objects accessed through the Internet, as **defined by technology analysts and visionaries**. These objects contain **embedded technology to interact** with internal states or the external environment. In other words, when objects can sense and communicate, it changes how and where decisions are made, and who makes them.

[<http://www.cisco.com/web/solutions/trends/iot/overview.html> - 21-Jun-2014]





ITU Definition

- Recommendation **ITU-T Y.2060** provides an overview of the Internet of Things (IoT). It clarifies the concept and scope of the IoT, identifies the fundamental characteristics and high-level requirements of the IoT and describes the IoT reference model.
- Date: 2012-06-15



ITU Definition

“The IoT can be viewed as a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ICT).”

Source: Recommendation ITU-T Y.2060





Things

Things are objects of the **physical** world (physical things) or of the **information** world (virtual world) which are capable of being identified and integrated into communication networks. Things have associated information, which can be static and dynamic.

Source: Recommendation ITU-T Y.2060





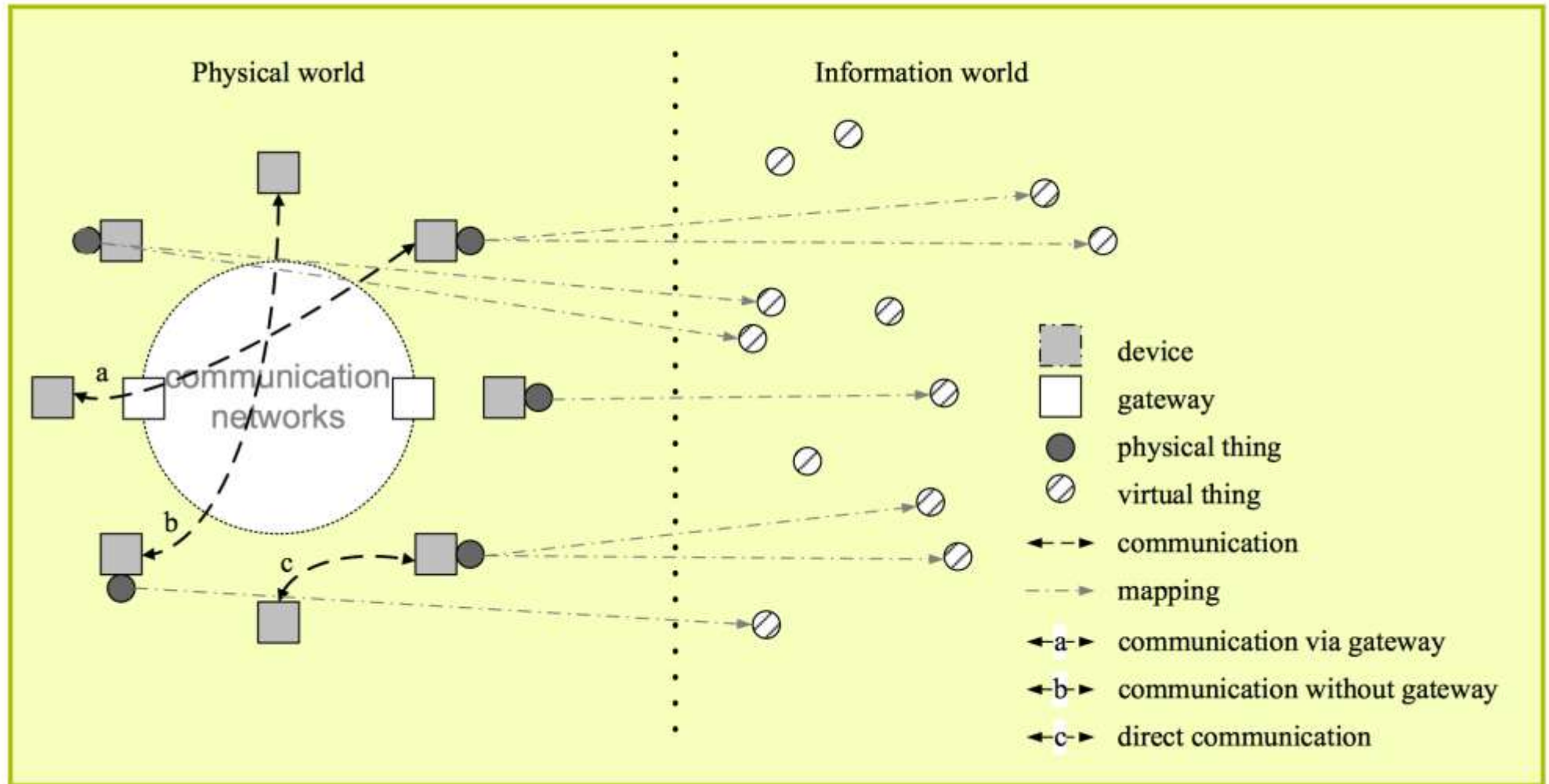
Things

Physical things exist in the physical world and are capable of being sensed, actuated and connected. Examples of physical things include the surrounding environment, industrial robots, goods and electrical equipment.

Virtual things exist in the information world and are capable of being stored, processed and accessed. Examples of virtual things include multimedia content and application software.

Source: Recommendation ITU-T Y.2060

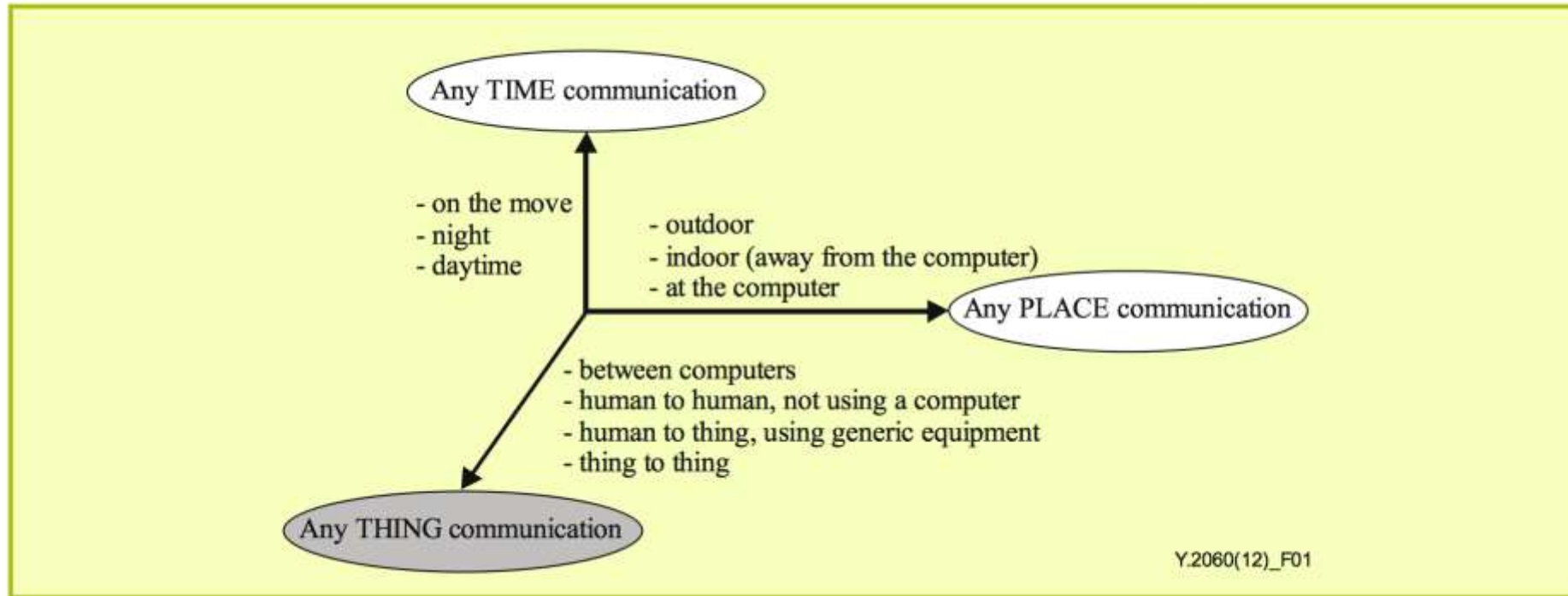




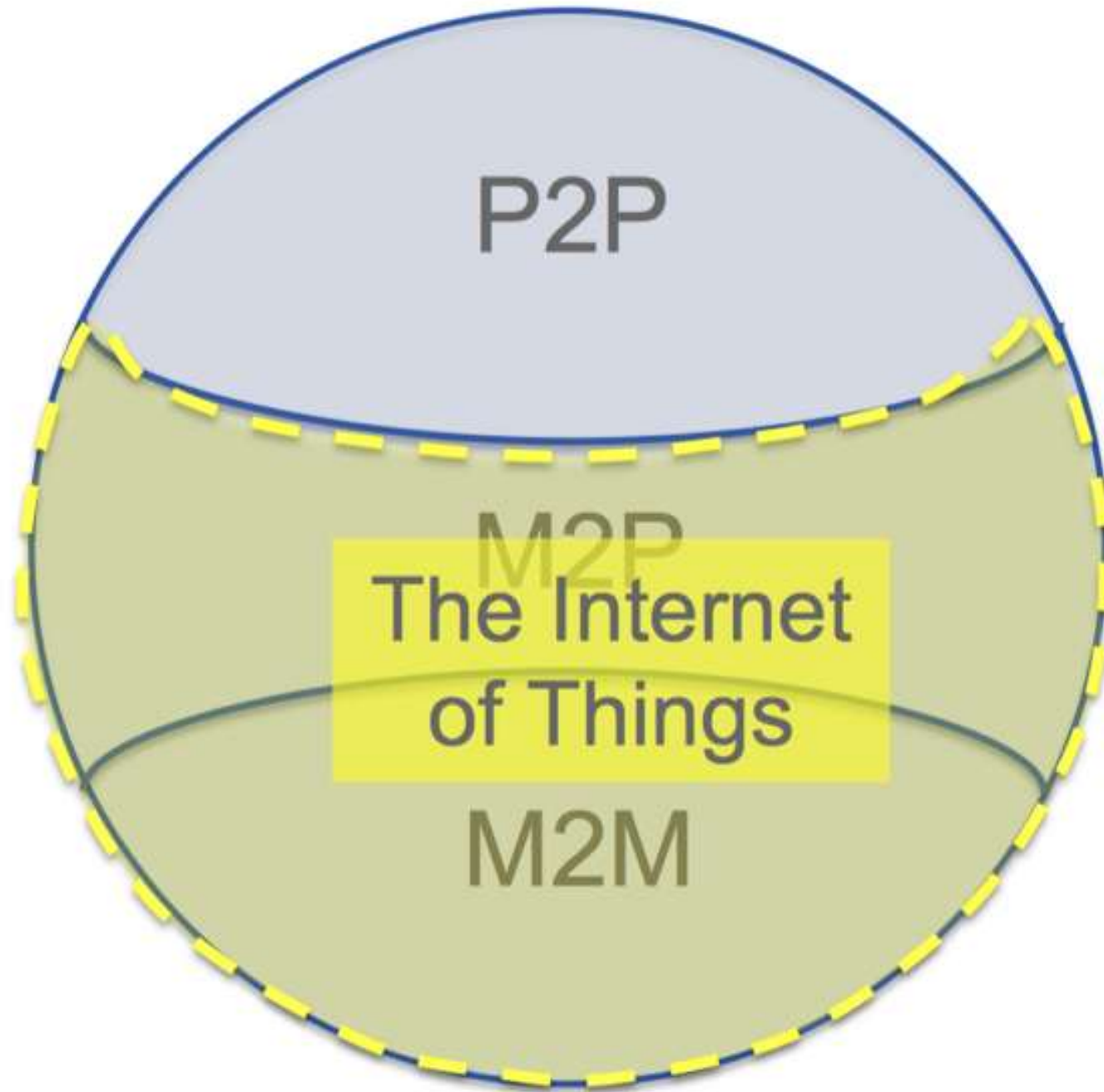
Source: Recommendation ITU-T Y.2060



Any-Time/Place/Thing



Source: Recommendation ITU-T Y.2060





ITU Definition

A device is a piece of equipment with the **mandatory capabilities of communication** and **optional capabilities of sensing, actuation, data capture, data storage and data processing**. The devices collect various kinds of information and provide it to the information and communication networks for further processing.

Some devices also execute operations based on information received from the information and communication networks.

Source: Recommendation ITU-T Y.2060





Fundamental characteristics

- **Interconnectivity:** With regard to the IoT, anything can be interconnected with the global information and communication infrastructure.
- **Heterogeneity:** The devices in the IoT are heterogeneous as based on different hardware platforms and networks. They can interact with other devices or service platforms through different networks.
- **Dynamic changes:** The state of devices change dynamically, e.g., sleeping and waking up, connected and/or disconnected as well as the context of devices including location and speed. Moreover, the number of devices can change dynamically.

Source: Recommendation ITU-T Y.2060





Fundamental characteristics

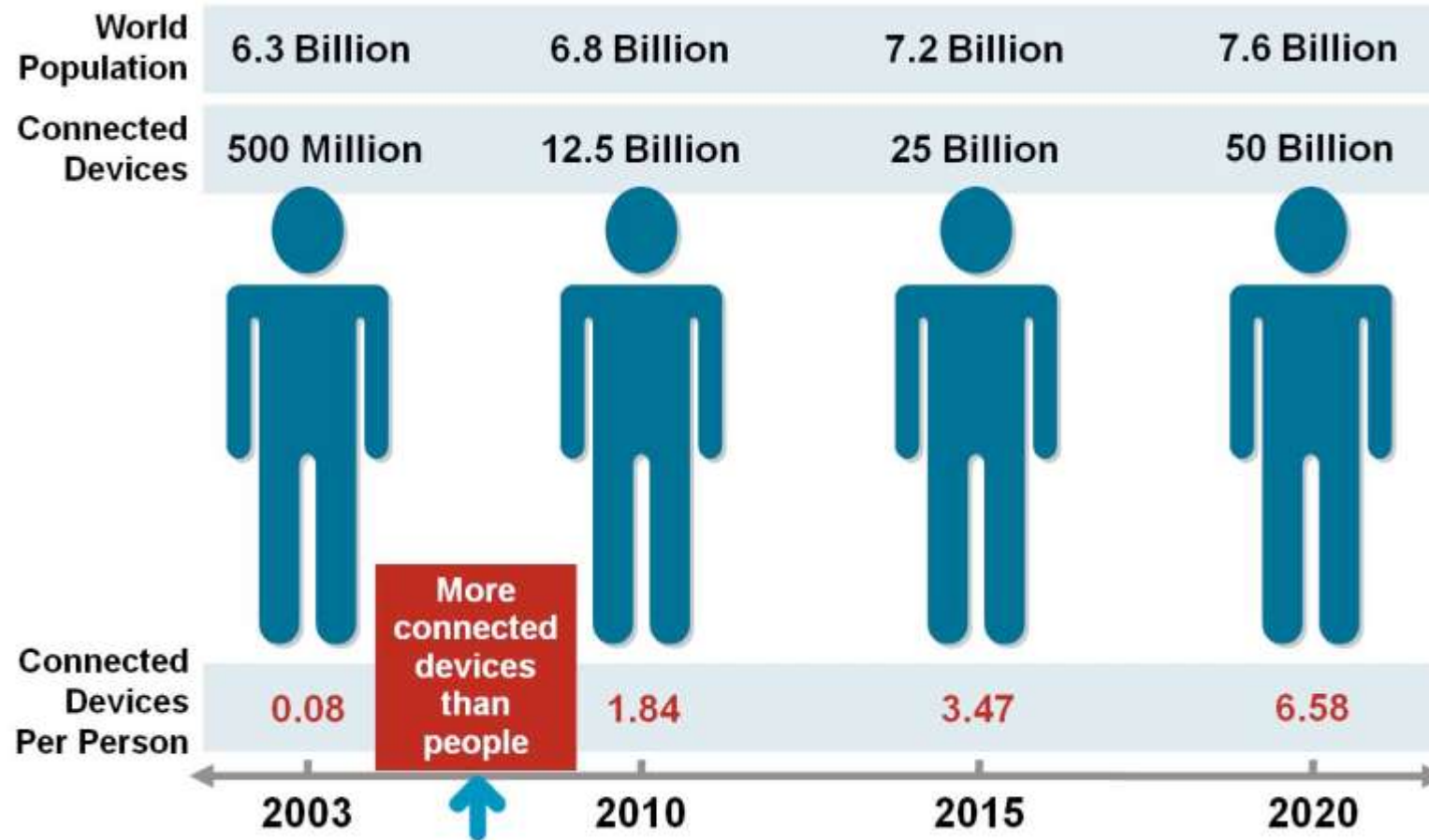
- **Enormous scale:** The number of devices that need to be managed and that communicate with each other will be at least an order of magnitude larger than the devices connected to the current Internet. The ratio of communication triggered by devices as compared to communication triggered by humans will noticeably shift towards device-triggered communication.

Source: Recommendation ITU-T Y.2060





Predictions



Source: Cisco IBSG, April 2011





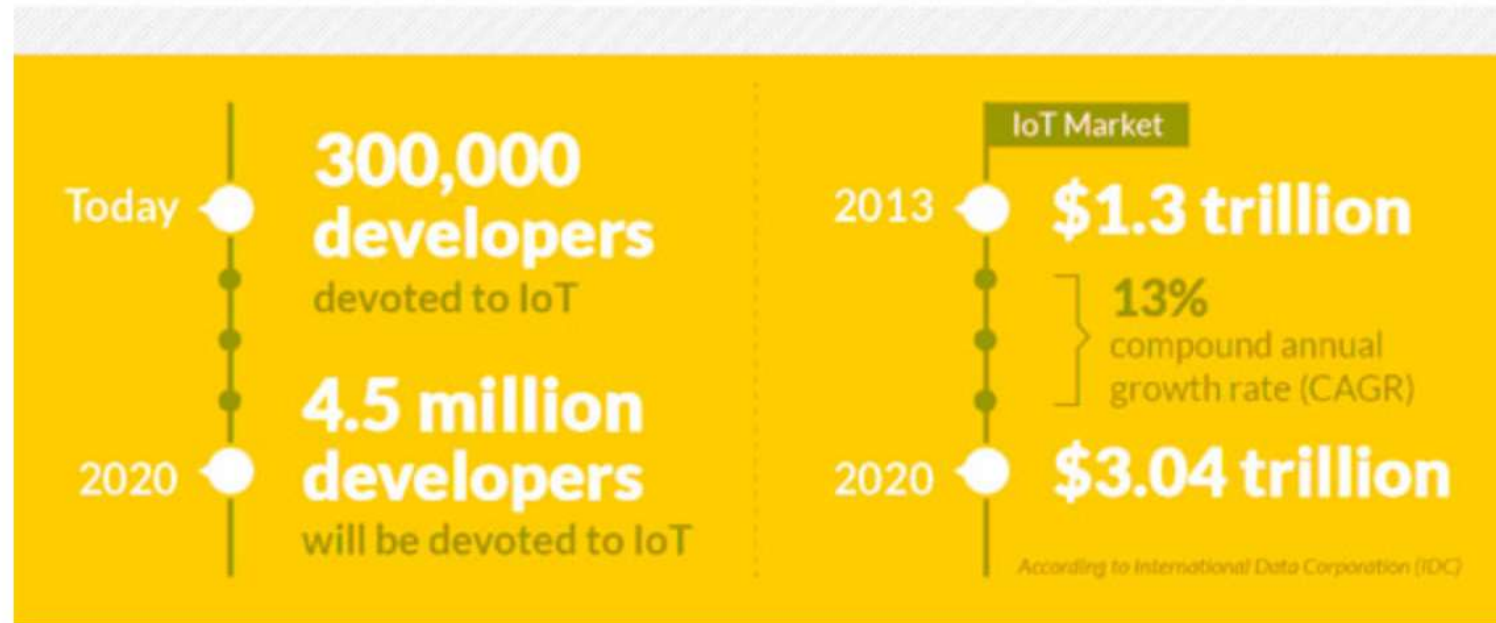
Predictions

IoT is being enabled by advances in

miniaturization

wireless connectivity

increased data storage capacity



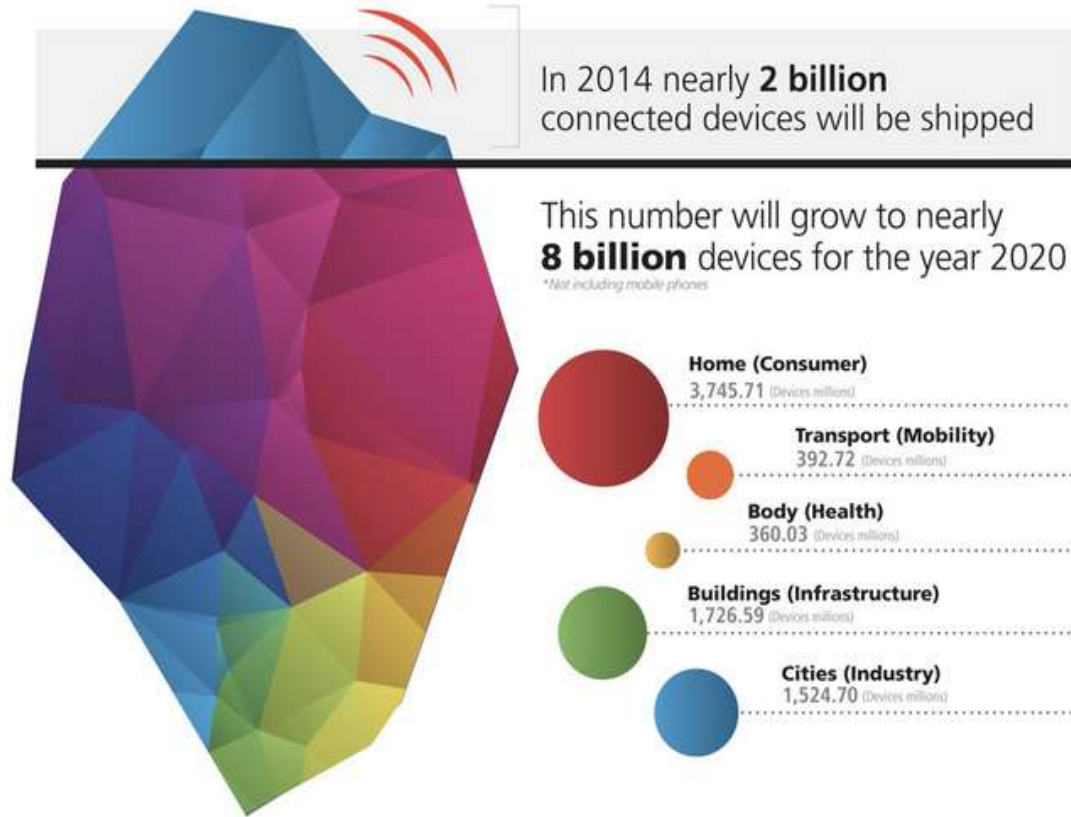
PwC's 6th Annual Digital IQ survey





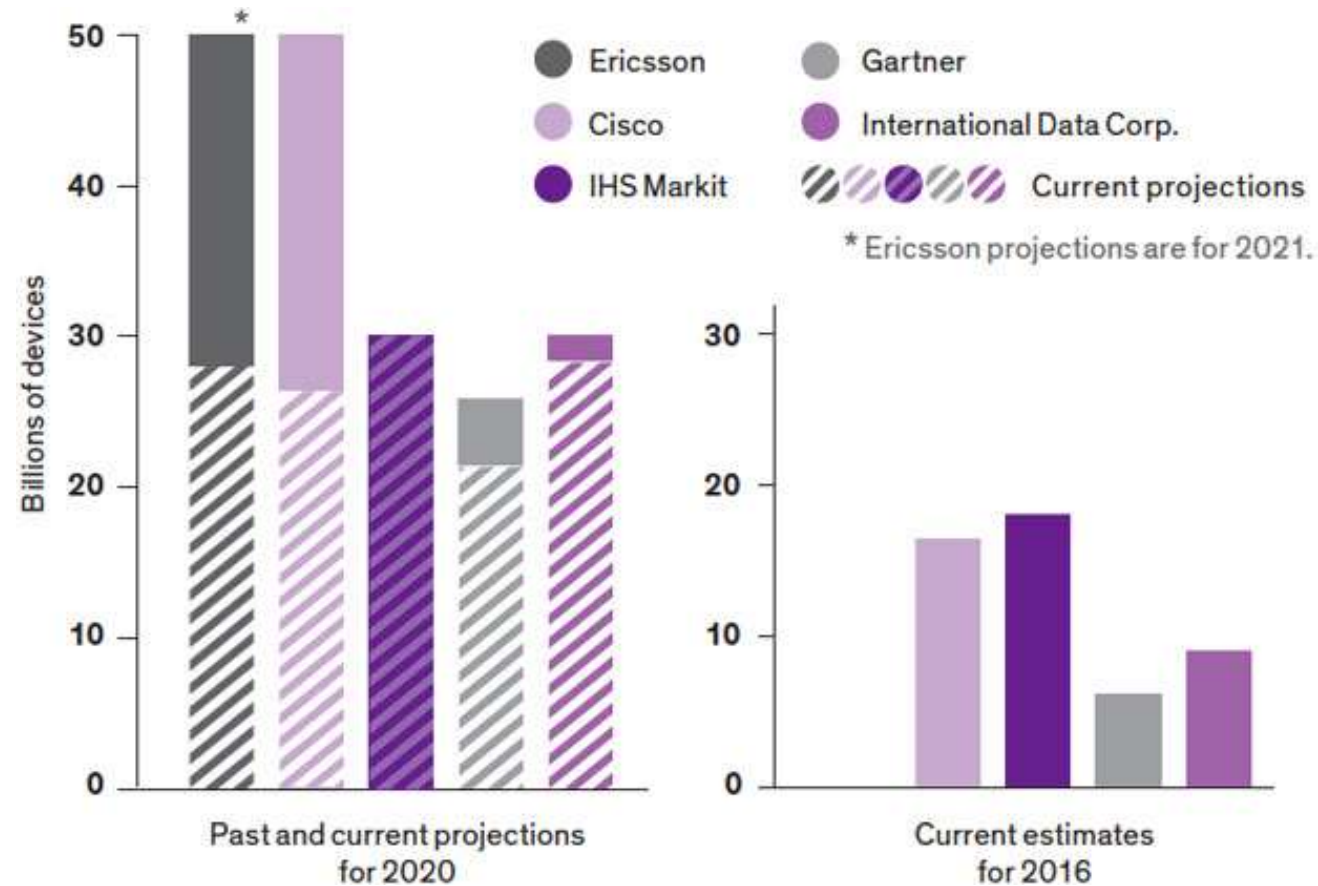
Predictions

Connected Devices



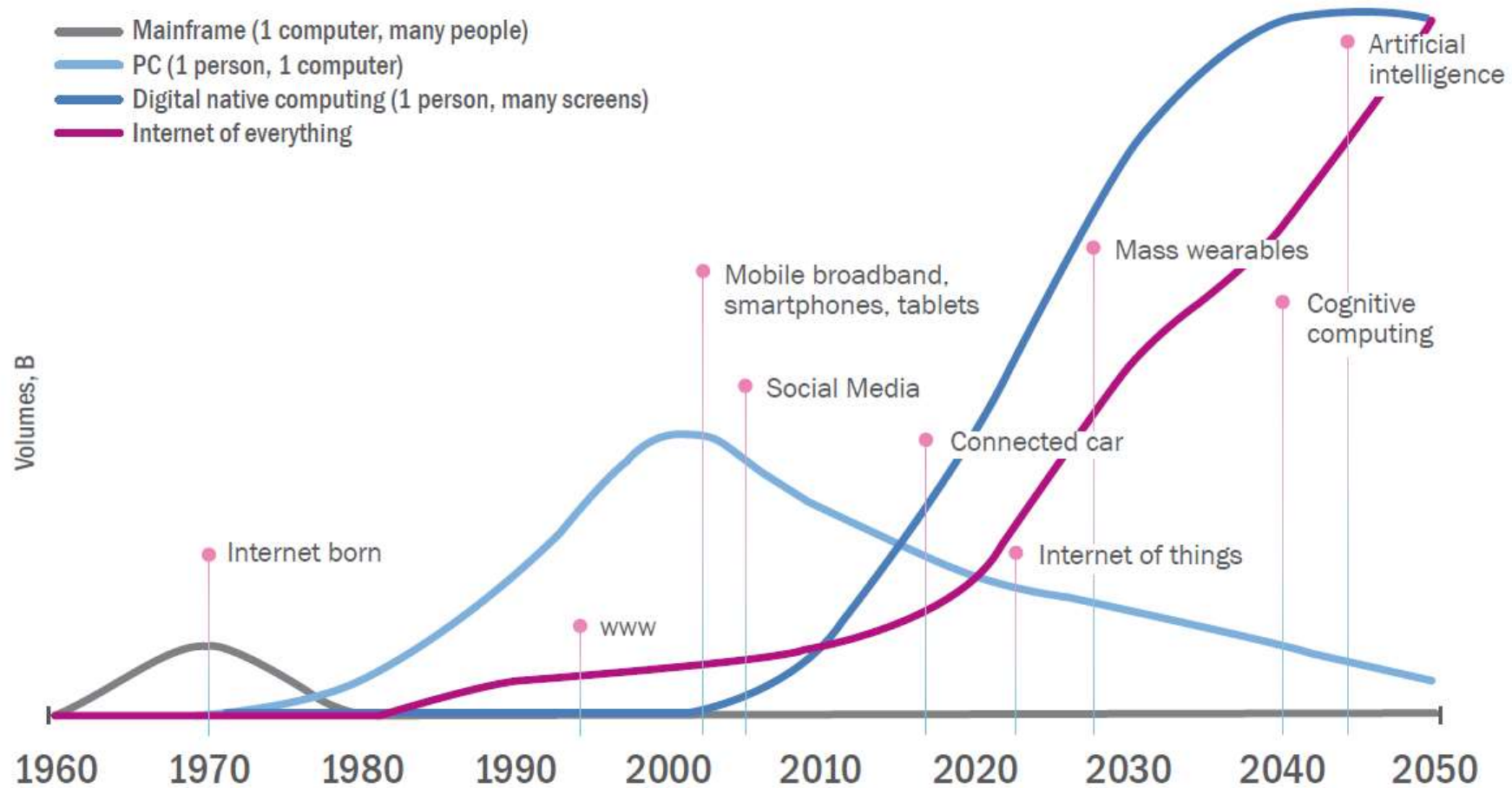


Internet of Fewer Things





One to many to any: ICTs from happy few to the masses

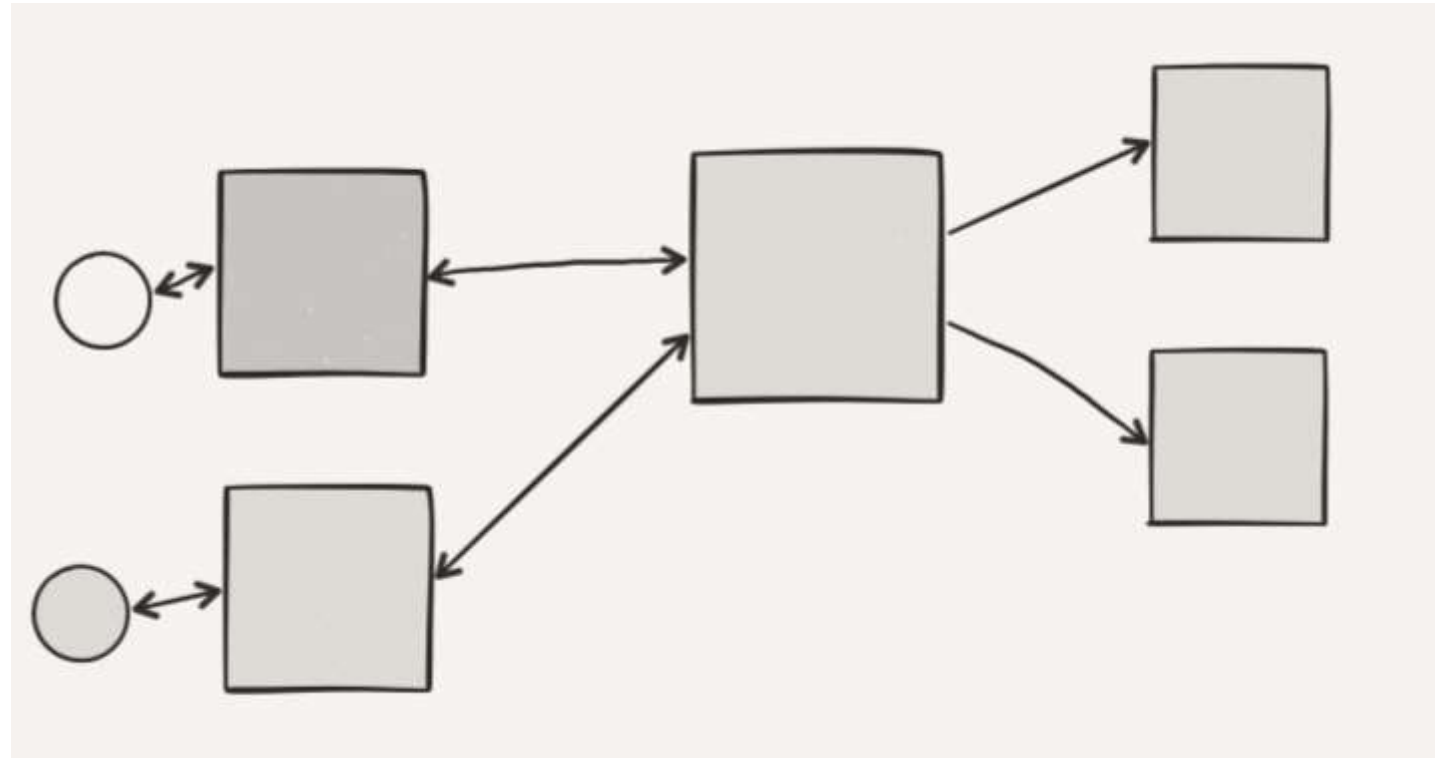


Digital revolution: are we ready? | Mario Maniewicz, Chief, Infrastructure, Enabling environment and ICT applications, ITU/BDT





IoT Architecture



Node

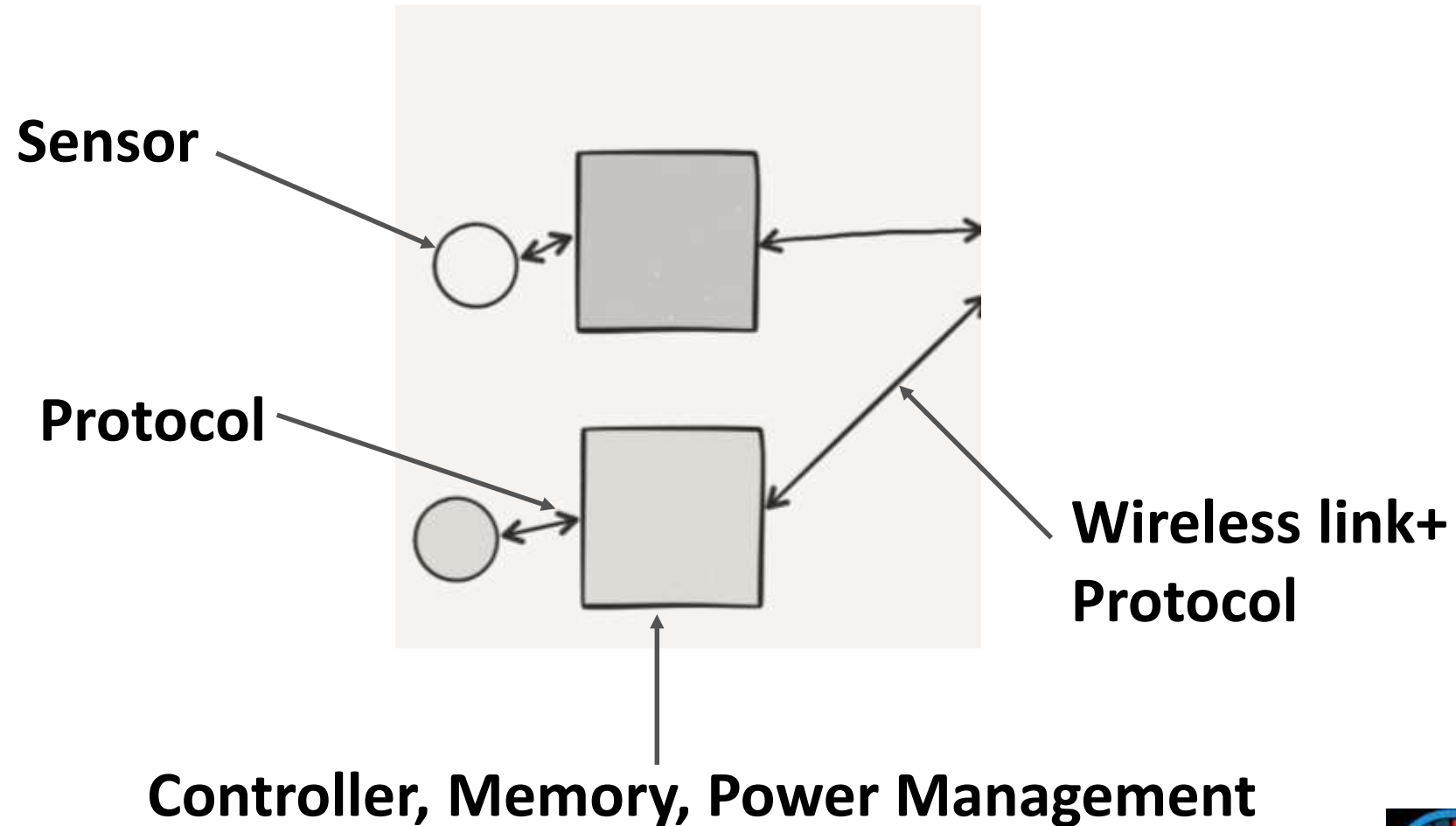
Gateway

Services



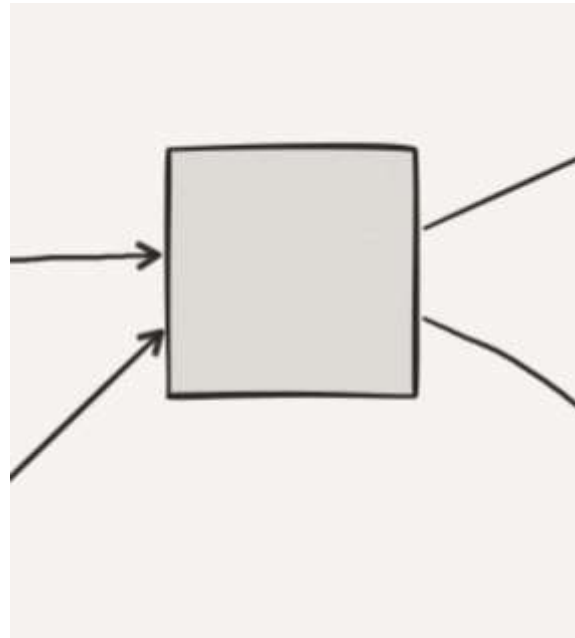


IoT Architecture: node





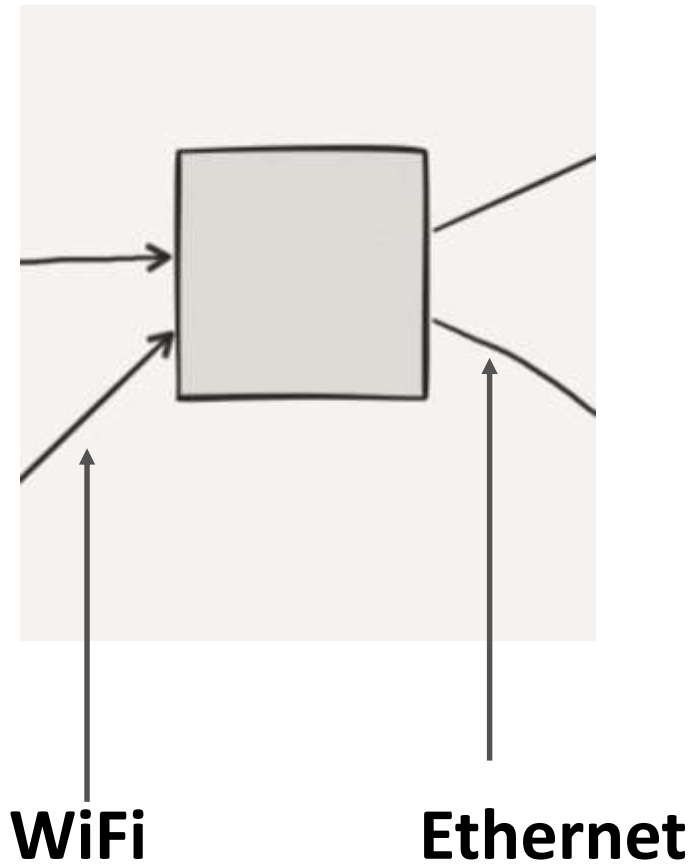
IoT Architecture: gateway



Input same standard as Output?

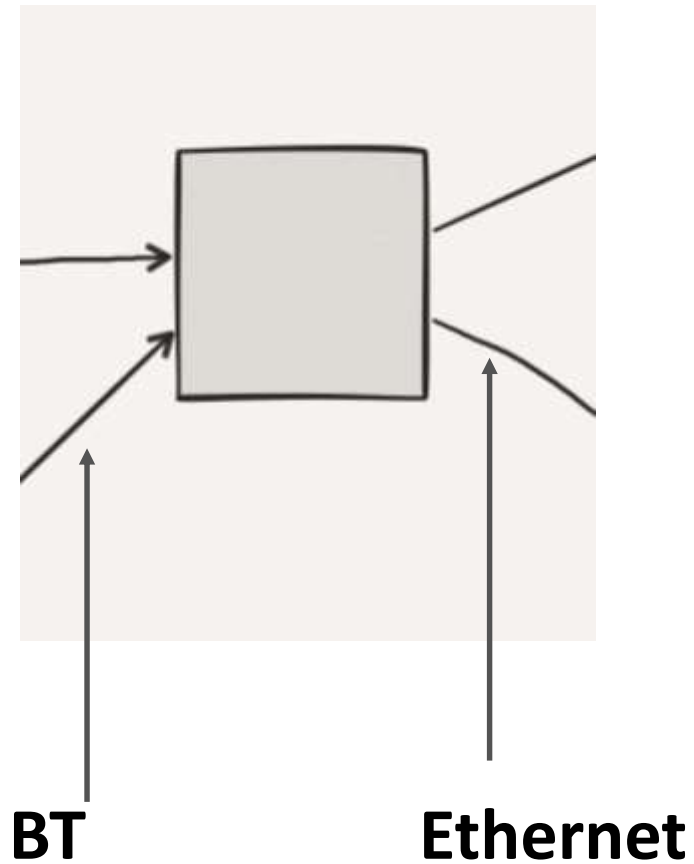


IoT Architecture: ~~gateway~~ access point



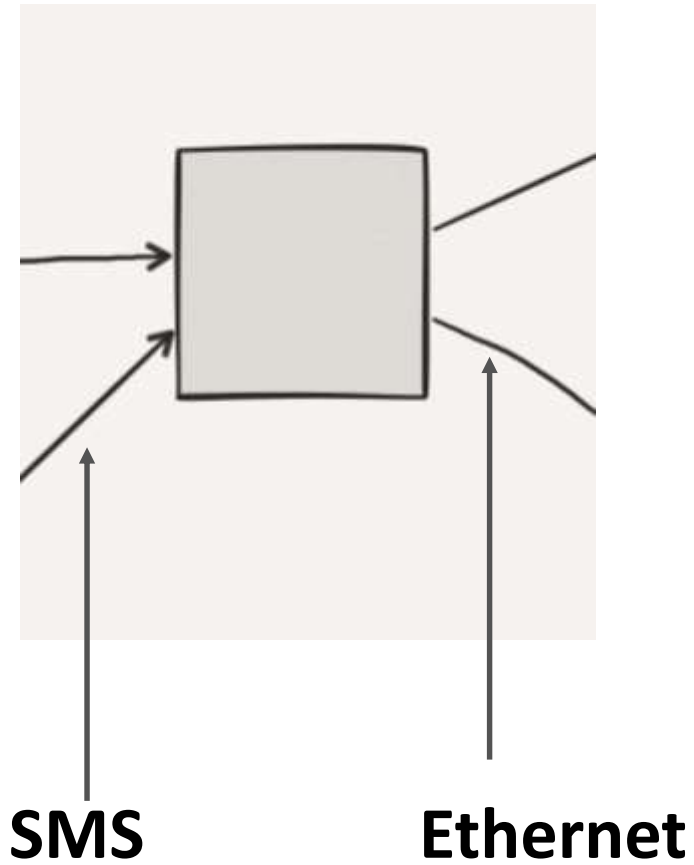


IoT Architecture: gateway!



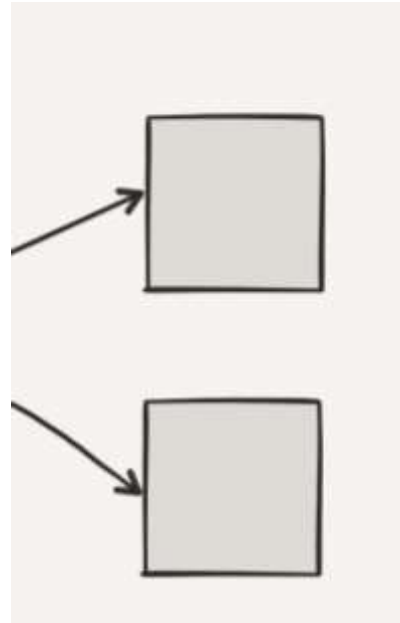


IoT Architecture: gateway!





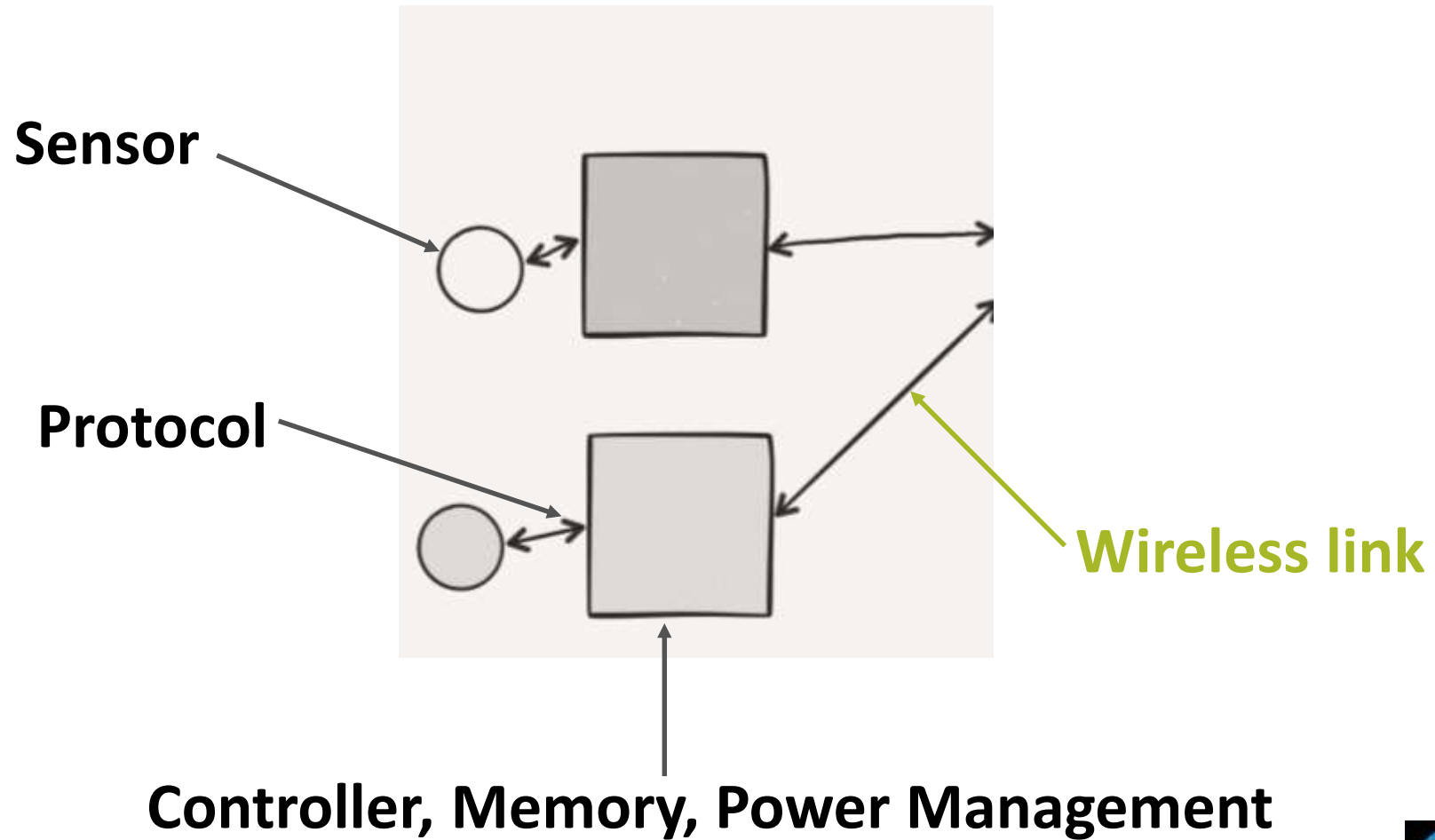
IoT Architecture: services



Graphing
Machine Learning
Alerting



IoT Architecture: node



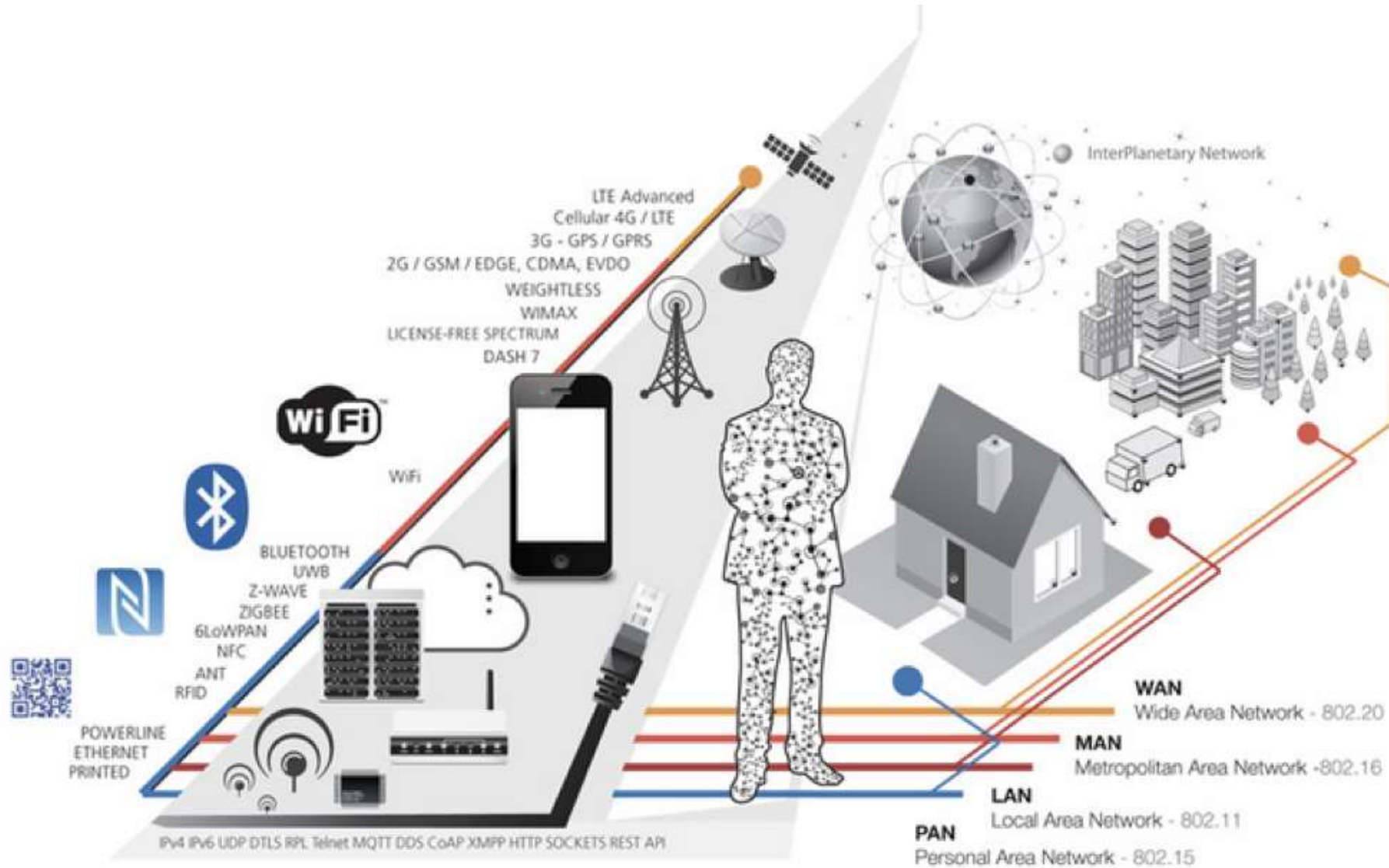


Network Connectivity

Key aspects when considering network connectivity:

- **Range** - are you deploying to a single office floor or an entire city?
- **Data Rate** - how much bandwidth do you require? How often does your data change?
- **Power** - is your sensor running on mains or battery?
- **Frequency** - have you considered channel blocking and signal interference?
- **Security** - will your sensors be supporting mission critical applications?







IPv6

Smart Objects will add tens of billions of additional devices

There is no scope for IPv4 to support Smart Object Networks

IPv6 is the only viable way forward

Solution to address exhaustion

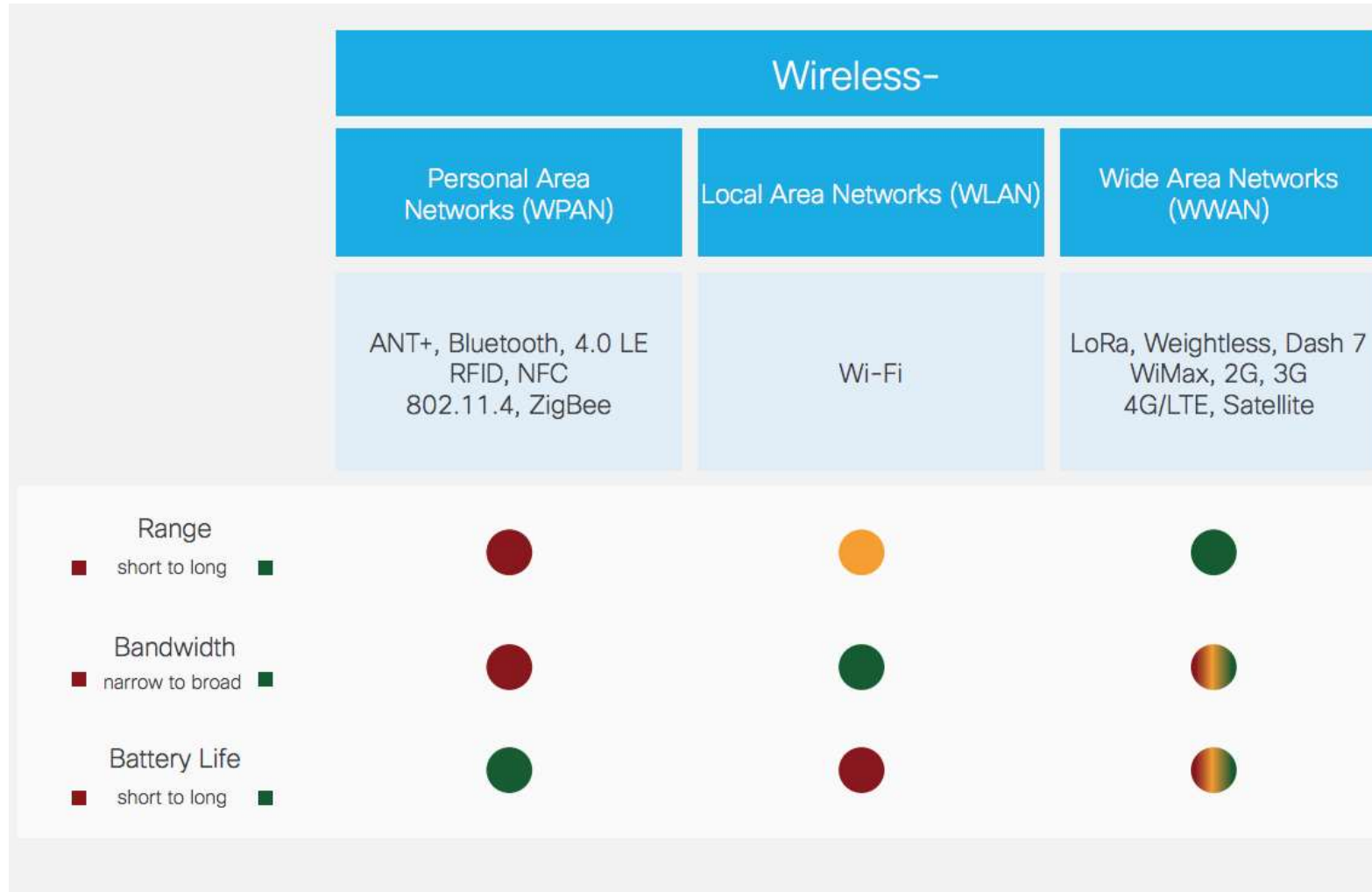
Stateless Auto-configuration thanks to Neighbor Discovery Protocol

Each embedded node can be individually addressed/accessed



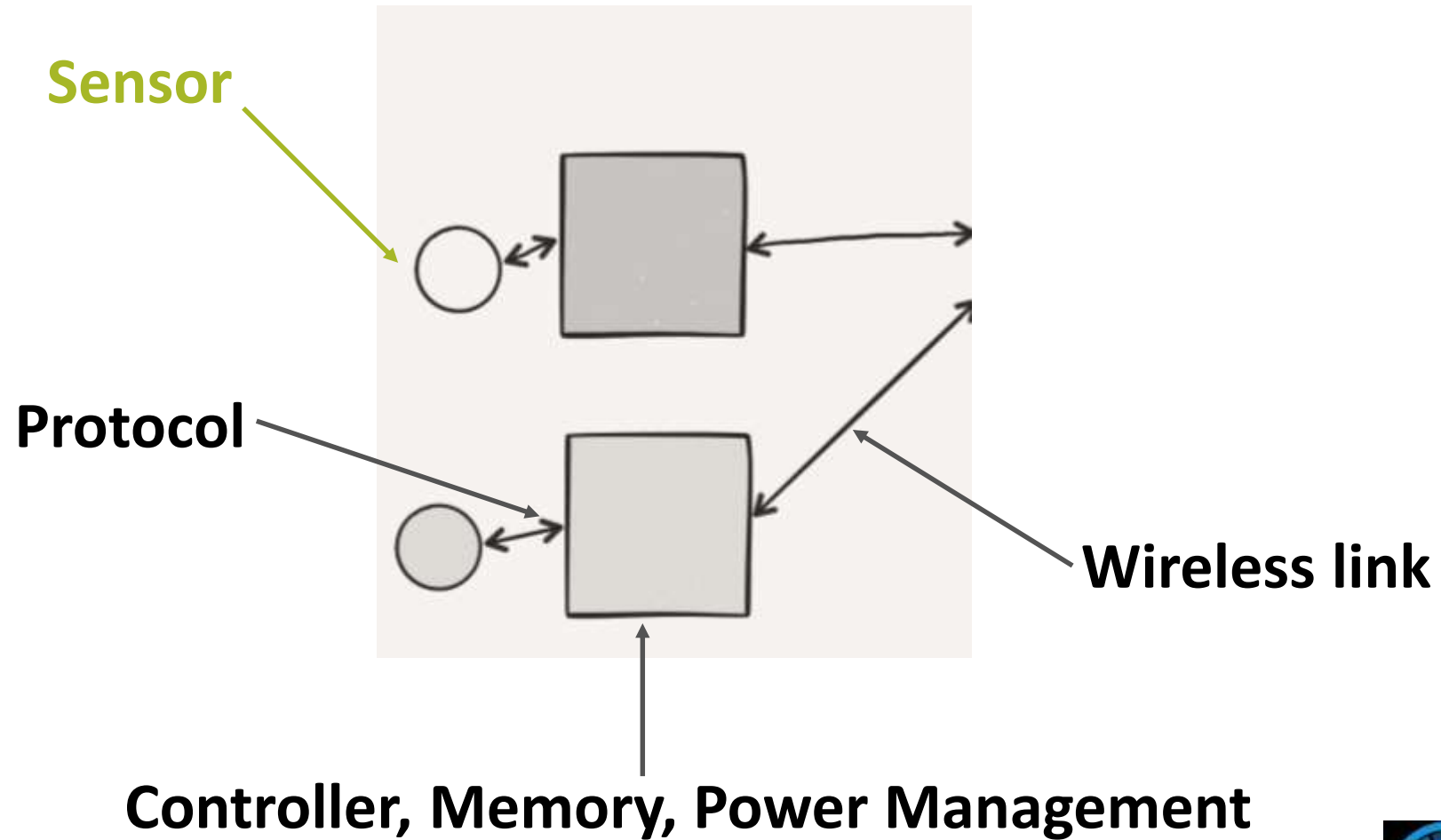


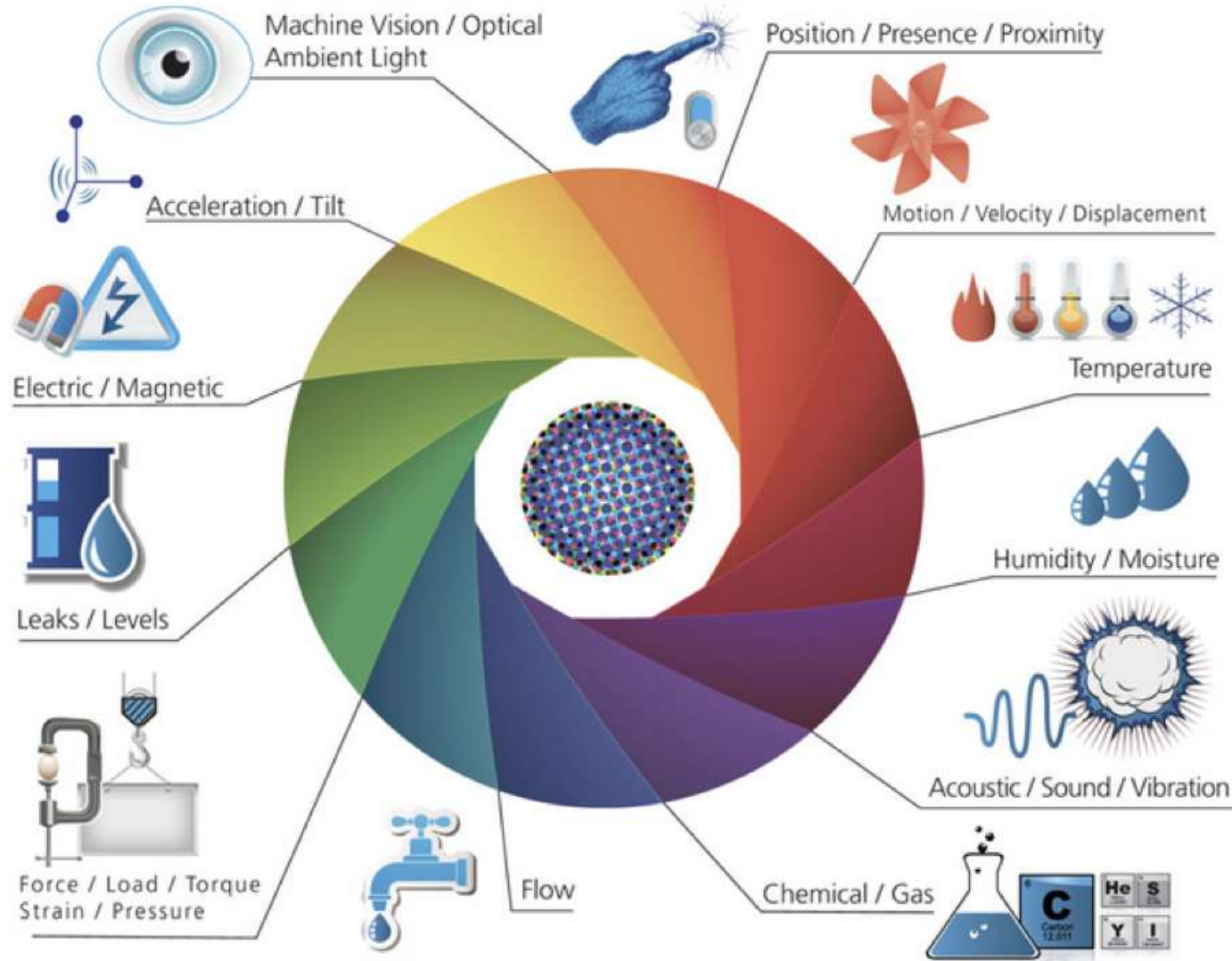
Connectivity Landscape

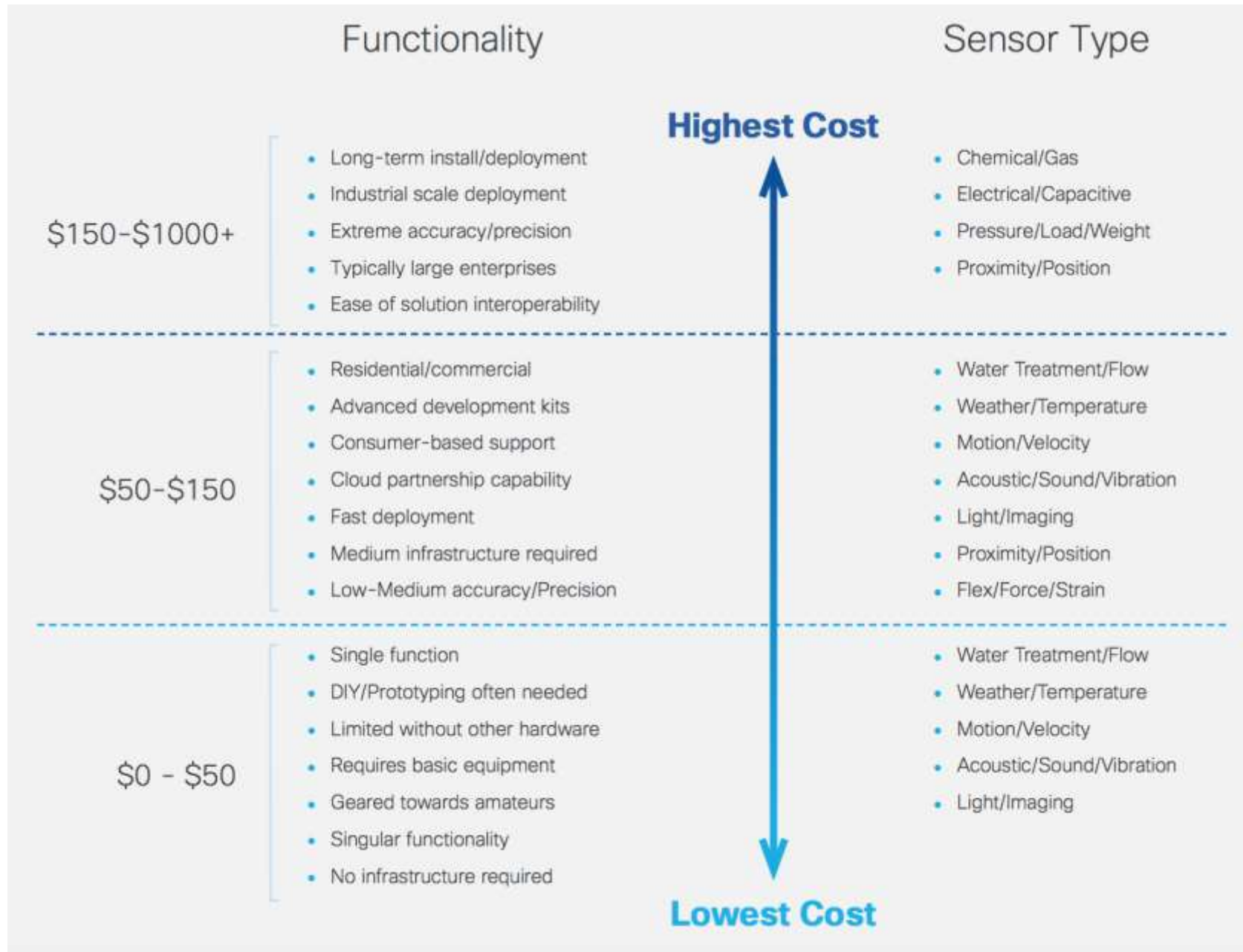




IoT Architecture: node









Applications

ambient™

Ambient Umbrella

Glowing intelligence
lets you know that there's
rain in today's forecast.

A black umbrella is shown against a light blue sky. The handle of the umbrella is glowing with a blue light, indicating its smart functionality. The umbrella is tilted to the right.



Applications





MyVessyl Cup

It can hold 13 ounces of liquid.
The battery takes 60 minutes to
fully charge and will last for 5-7
days. Also has wire-free charging.

<http://www.myvessyl.com/>



Egg Minder

THE SMART EGG TRAY



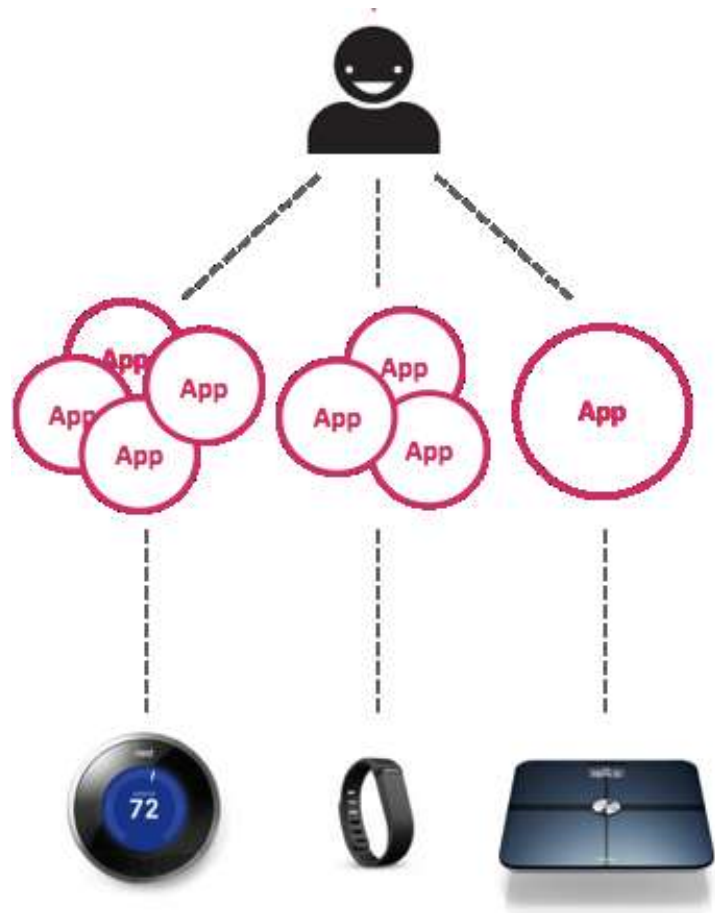


Introduction to IoT



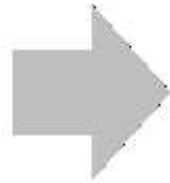






Today: **Intranets of Things**

Connected devices



Tomorrow: **Internet of Things**

Interconnected devices





These **things** are starting to talk to each other and develop their own intelligence. Imagine a scenario where.....

This is communicated to your **alarm clock**, which allows you 5 extra minutes of sleep.



...your **meeting** was pushed back 45 minutes.



...your **car** knows it will need gas to make it to the train station. Fill-ups usually take 5 minutes.



...there was an accident on your **driving route** causing a 15 minute detour.



...your **train** is running 20 minutes behind schedule.



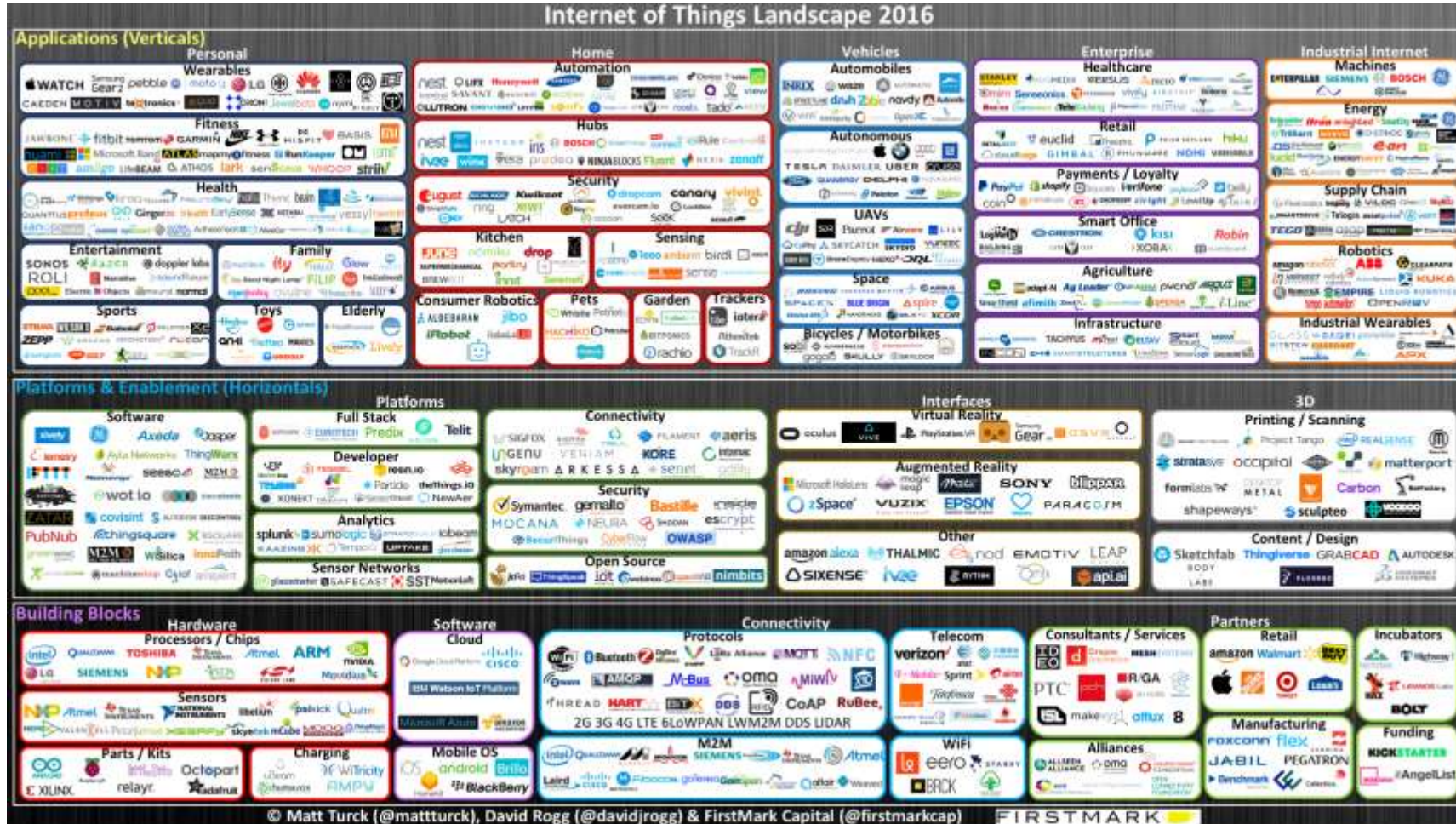
And signals your **car** to start in 5 minutes to melt the ice accumulated in overnight snow storms.



And signals your **coffee maker** to turn on 5 minutes late as well.



IoT Landscape





Thank You

