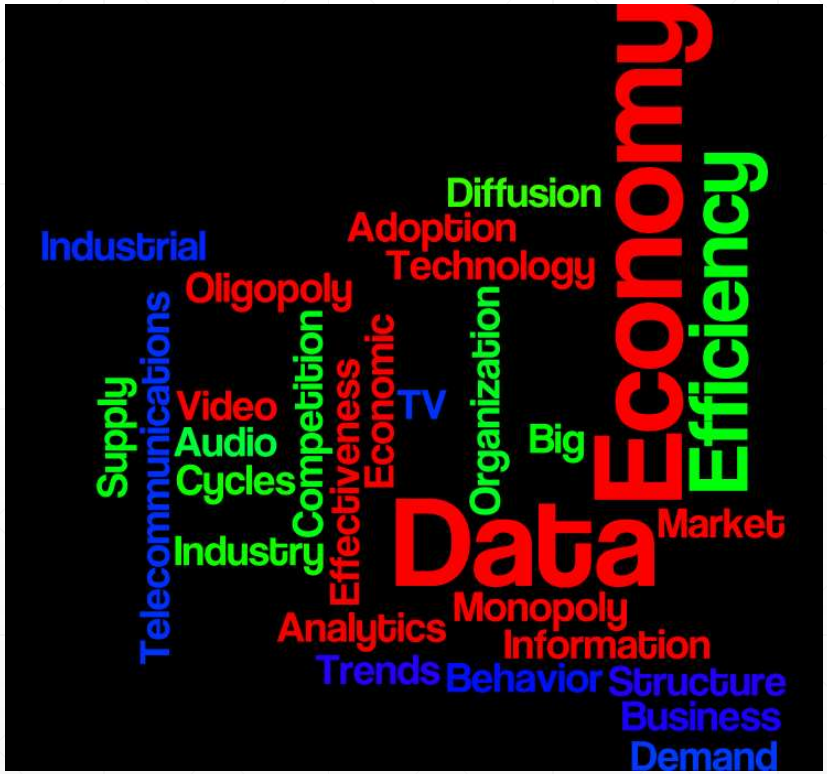
Digital Transformation

Class # 2: Technology Trends # 1 – Internet of Things (IoT), Blockchain

EPITA | Spring 2022

Valeriu Petrulian

Digital Transformation Class 2



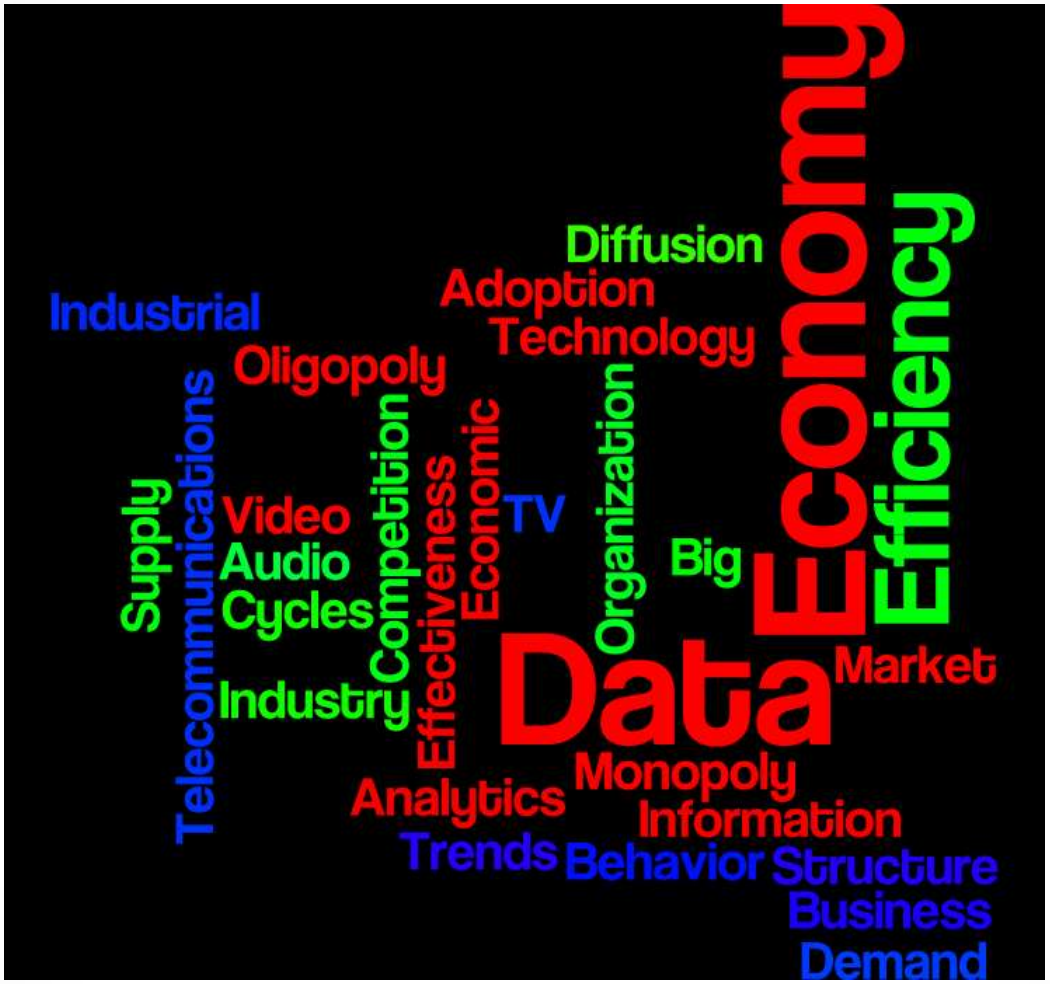
- Admin
- Recap
- Thoughts for the day

Course Breakdown
EPITA Spring 2022

Class	Date & Time | Topics
Class # 1	Welcome to the Digital Economy!
Class # 2	Technology Trends # 1: Internet of Things (IoT), Blockchain
Class # 3	Technology Trends # 2: Big Data & Artificial Intelligence (AI)
Class # 4	Digital Platforms
Class # 5	Final Presentations and Course wrap-up

Today's Readings:

- **Michael E. Porter and James E. Heppelmann.** *How Smart, Connected Products Are Transforming Competition.* Harvard Business Review, November 2014 Issue
- **Marco Iansiti, Karim R. Lakhani.** *The truth about blockchain*. Harvard Business Review, January-February 2017



Class # 2
Internet of Things (IoT), Blockchain

The Internet of Things (IoT): Fundamentals

Blockchain

Class assignment & discussion: The distinctive natures of IoT and Blockchain

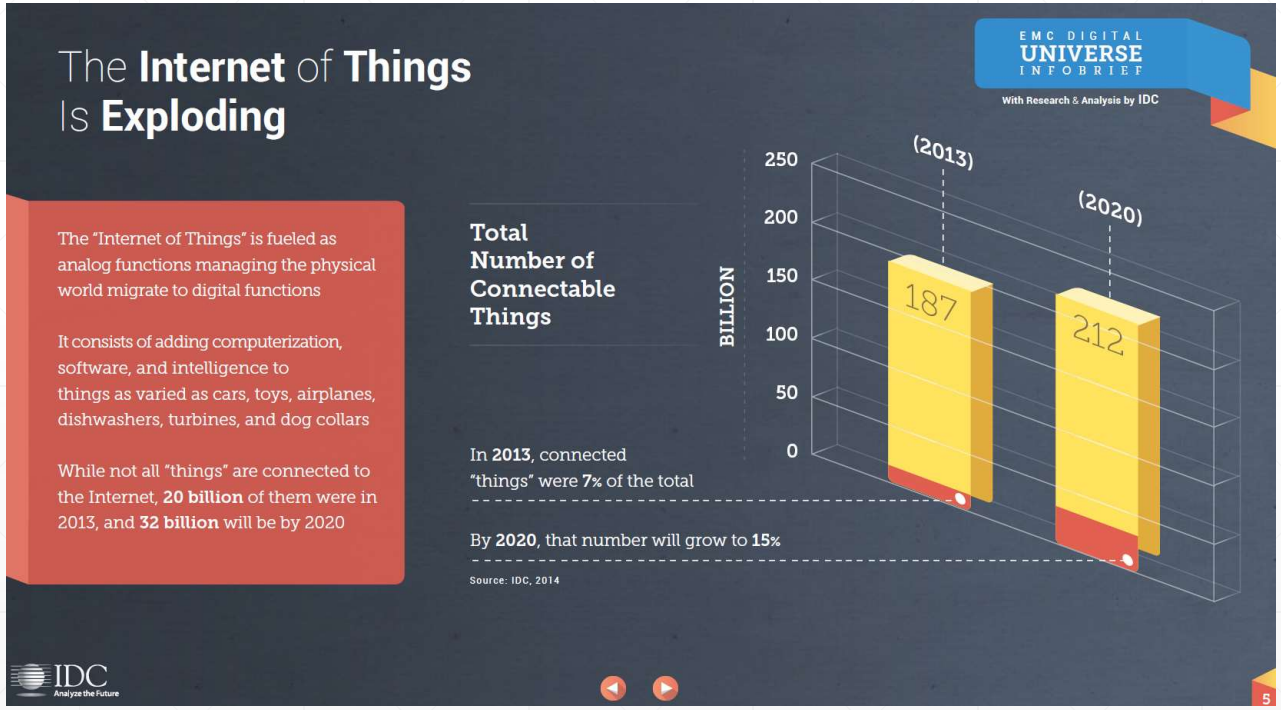
Technology trends
Starting point

- Imagine the following situation:
  - A professor comes to class with a set of carefully selected references for his/her course
  - He/she wishes
    - That each student uses 1 reference at a time for the class assignments
    - That the students interexchange the references (between themselves)
    - That the students return the references at the end of each class
    - That for the next class, the process starts again, until the end of the course
    - At the end of the course, he/she wants trustworthy statistics and recommendations on who used what, when and why

What does the professor need?

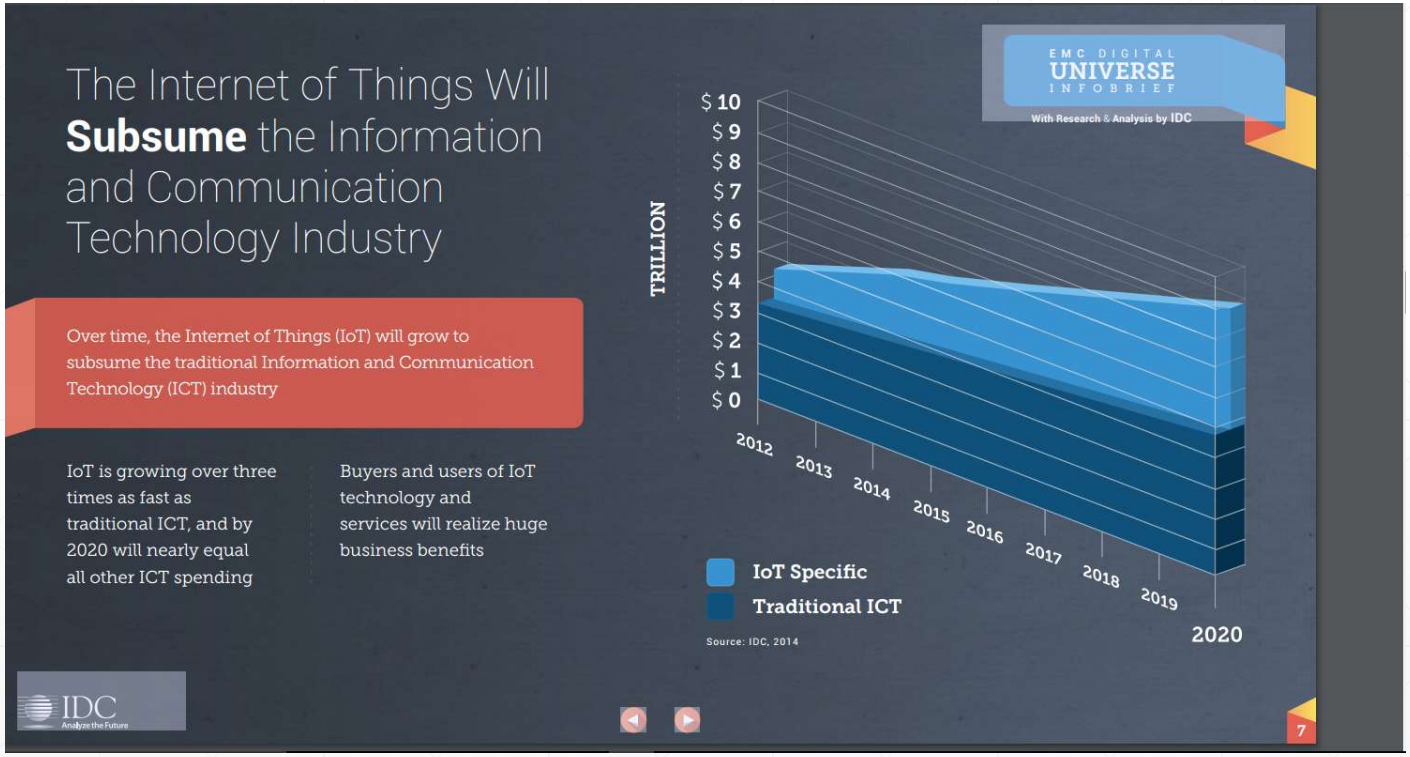
- Each reference to hold a tag
- Each student to hold a student ID
- A reading mechanism for tags and IDs
- A computer program:
  - To store references and student IDs
  - To link reference movements to class/context/time
  - A set of rules

Why IoT ?
Predictions came true? | Growth Potential



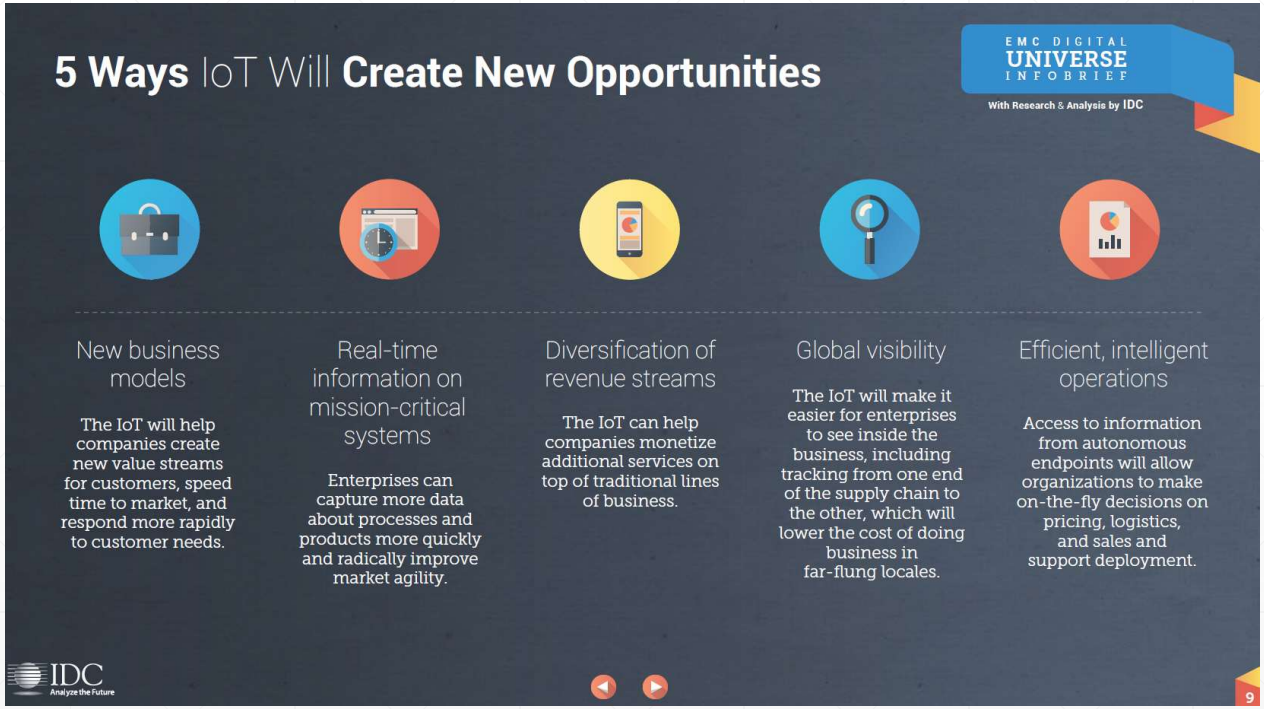
Source: EMC, IDC Digital Universe 2014 Report.
http://www.emc.com/collateral/analyst-reports/idc-digital-universe-2014.pdf

Why IoT ?
Predictions came true? | Challenging traditional ICT



Source: EMC, IDC Digital Universe 2014 Report.
http://www.emc.com/collateral/analyst-reports/idc-digital-universe-2014.pdf

Why IoT ?
Predictions came true? | New Opportunities



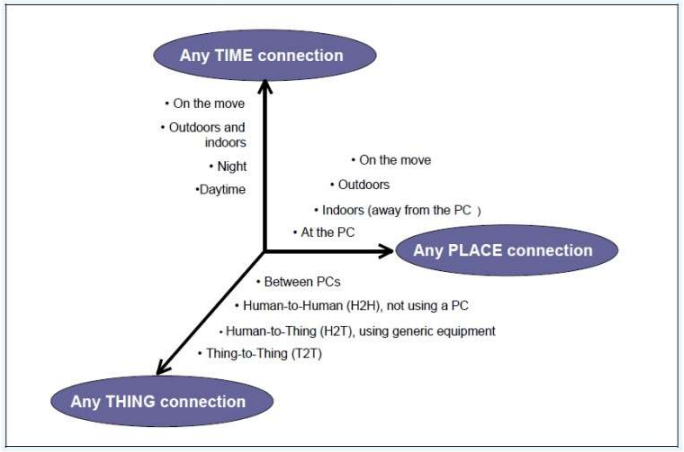
Source: EMC, IDC Digital Universe 2014 Report.
http://www.emc.com/collateral/analyst-reports/idc-digital-universe-2014.pdf

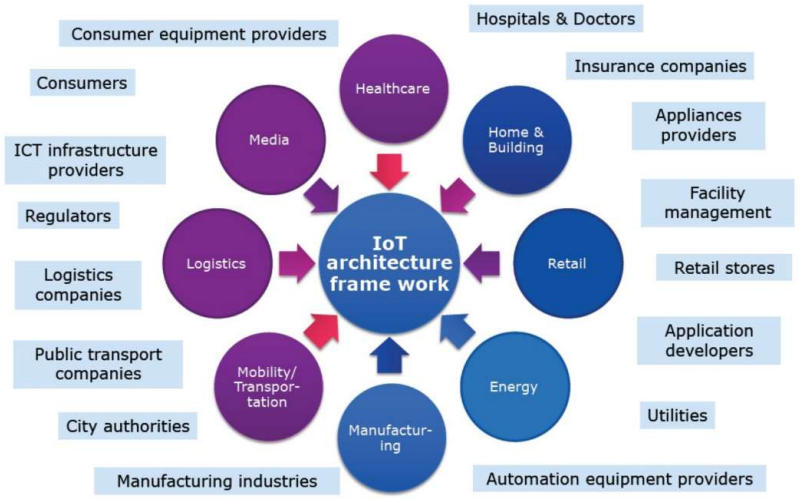
IoT Fundamentals

Definitions

- **Wikipedia** – “The **Internet of things** (**IoT**) is a system of interrelated computing devices, mechanical and digital machines are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.”
- **IEEE** – « A network of items – each embedded with sensors – which are connected to the Internet.”
- **ETSI** – “Machine-to-Machine (M2M) communications is the communication between two or more entities that do not necessarily need any direct human intervention. M2M services intend to automate decision and communication processes.”
- **ITU** – “A network that is available anywhere, anytime, by anything and anyone.”

IoT Fundamentals
Potential reach and usages at a glance





Source: IEEE Internet Initiative. *"Towards a definition of the Internet of Things (IoT)."* **IEEE**, May 27th 2015.

IoT Fundamentals
Few technical aspects: Operating Systems

OS	IPv6	TCP	6LoWPAN	RPL	CoAP
Contiki	Y	P	Y	Y	Y
Tiny OS	N	P	Y	Y	Y
Linux	Y	Y	Y	P	P
RIOT	Y	Y	Y	Y	N

	IPv6	EPC
Objects to identify	Network interfaces	Physical objects
Primary application	Routing address	Pointer to information
Address allocated by	Network manager	Item manufacturer
Unique identifier	Yes	Yes
Identifier length (bits)	128	64, 96, other
Can identifier change?	Yes	No
Area of difficulty	Mobility	No location information

Source: IEEE Internet Initiative. *"Towards a definition of the Internet of Things (IoT)."* **IEEE**, May 27th 2015.

IoT Fundamentals
Few technical aspects: Protocols

Protocol	Type of application
Bluetooth	Specific to IoT/General Purpose
Zigbee	Specific to IoT
Z-Wave	Specific to IoT
6LoWPAN	General Purpose
Thread	General Purpose
Wi-Fi	General Purpose
GSM/GPRS/EDGE (2G), UMTS/HSPA (3G), LTE (4G)	General Purpose
NFC	General Purpose
Sigfox	Specific to IoT
Neul	Specific to IoT
LoRaWAN	Specific to IoT

IoT and 5G Example

	1st G	2nd G	3rd G	4th G	5th G
Technology type	Analog	Digital	Digital	Digital	Digital
Norms (examples)	NMT, Radiocom 2000	GSM, TDMA, CDMA	UMTS	LTE	3GPP 5G NR
Bandwidth	1,9 kbps	14,4 kb/s to 384 kb/s	144 kb/s to 2 Mb/s	2 Mb/s to 1 Gb/s	1 Gb/s to 10 Gb/s
Main application	Voice calls	Data messages (SMS, MMS)	Mobile internet	Video streaming	Internet of Things

Lock-In types	Associated switching costs
Contracts	Cancellation costs
Durable equipment	Costs of replacing equipment
Specific skill set	Learning costs
Information and data-bases	Costs of conversion of data to new formats
Specialized suppliers	Costs of changing suppliers
Research costs	Costs associated with researching alternative products
Loyalty programs	Loss of acquired advantages

Source: SHAPIRO C., VARIAN H. *Economie de l'information*. Trad. Française, De Boeck Université. Paris, Bruxelles, 1999

Cost of change (lock-in and switching costs)

The cost of change is very often an important decision element and, consequently, a potential barrier to change.

Shapiro and Varian propose a classification of the costs associated with switching from one technology to another.

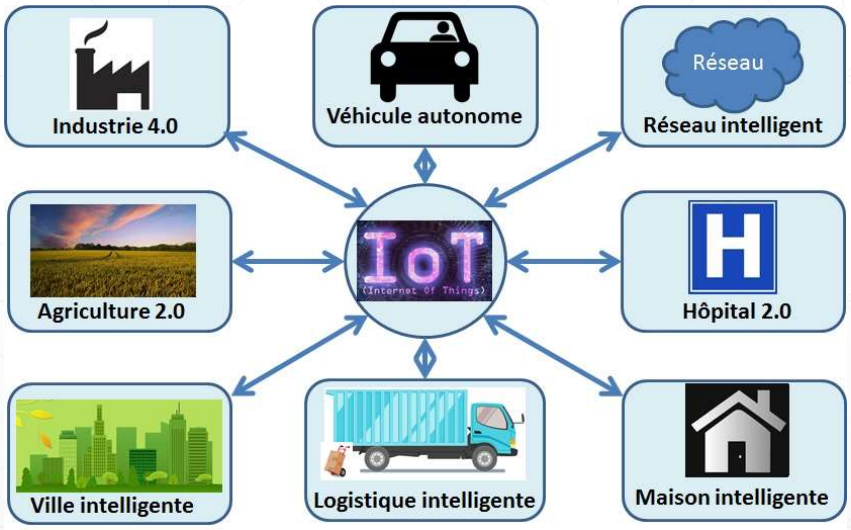
IoT Fundamentals
Enabling Technologies (according to the ITU)

- For tagging things
  - **RFID**
- For “feeling” things
  - **sensor technologies**,
- For making things “think“
  - **smart technologies**
- For shrinking things
  - **nanotechnology**

- RFID has advantage over barcode technologies
- Sensor technologies are being used for « **sensing** » and « **actuating** ». The former in input devices (« eyes » that collect information) the latter in output units (« hands » that implement decisions »)
- Smart materials incorporate both sensors and actuators and they can be passive, active or autonomous

Source: IEEE Internet Initiative. *“Towards a definition of the Internet of Things (IoT).”* **IEEE**, May 27th 2015.

IoT Fundamentals
The Interoperability challenge



https://fr.wikipedia.org/wiki/5G_pour_l%27Internet_des_objets

Examples of consortia working on the IoT Interoperability challenge:

- AllSeen Alliance
- Open Connectivity Foundation
- oneM2M
- Thread Group
- Wi-Fi Alliance, Bluetooth 5
- …

	Control	Openness
Compatibility	Controlled migration	Open migration
Performance	Performance choice	Discontinuity

Generic strategies when launching a new technology in network economics
Source: SHAPIRO C., VARIAN H. *Economie de l'information*. Trad. Française, De Boeck Université. Paris, Bruxelles, 1999

		Choice of the weak	
		Conflict	Standard
Choice of the strong	Conflict	« Standard war »	Weak tends to block strong
	Standard		Agreement on a standard

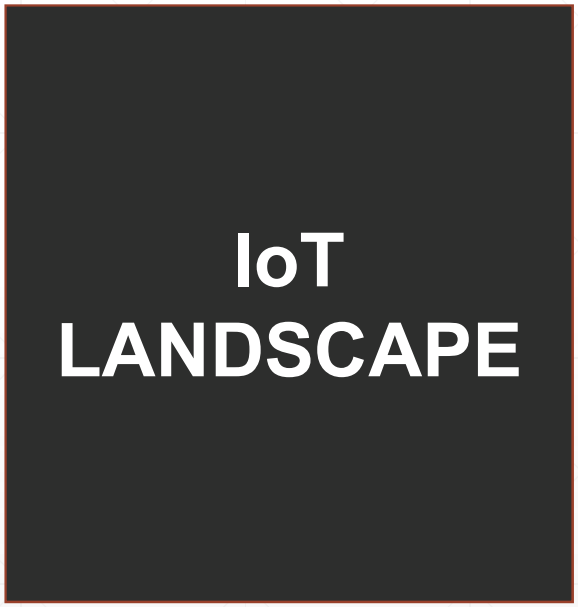
Strategies in standard-setting
Source: SHAPIRO C., VARIAN H. *Economie de l'information*. Trad. Française, De Boeck Université. Paris, Bruxelles, 1999

Strategies & Standard-setting tactics

Shapiro and Varian quote 7 factors that are important in standard setting strategies:

1. Installed base
2. IP rights
3. Capacity to innovate
4. Pioneer's advantage
5. Production capacity
6. Product complementarity
7. Brand reputation

IoT | Supply-side considerations
Complexity is obvious …

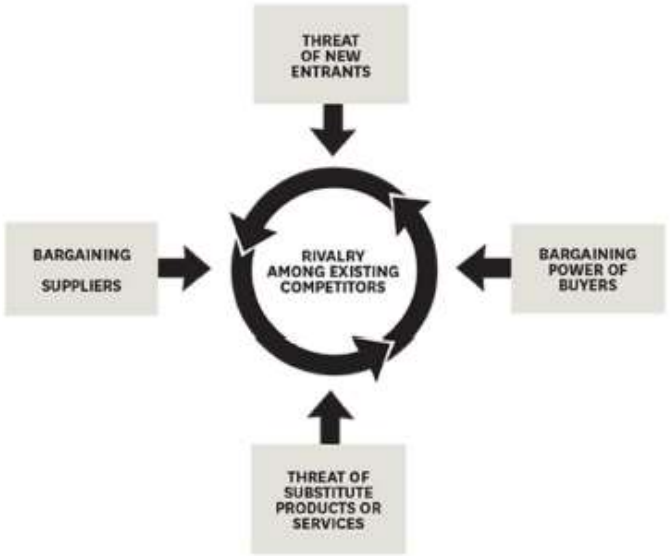


Discussion:

- A large variety of frameworks, architectures, technologies, applications, ..
- OS, Protocols
- Tagging
- Sensors
- Industry-specific versus general purpose solutions
- Open vs proprietary standards, …

The Five Forces That Shape Industry Competition

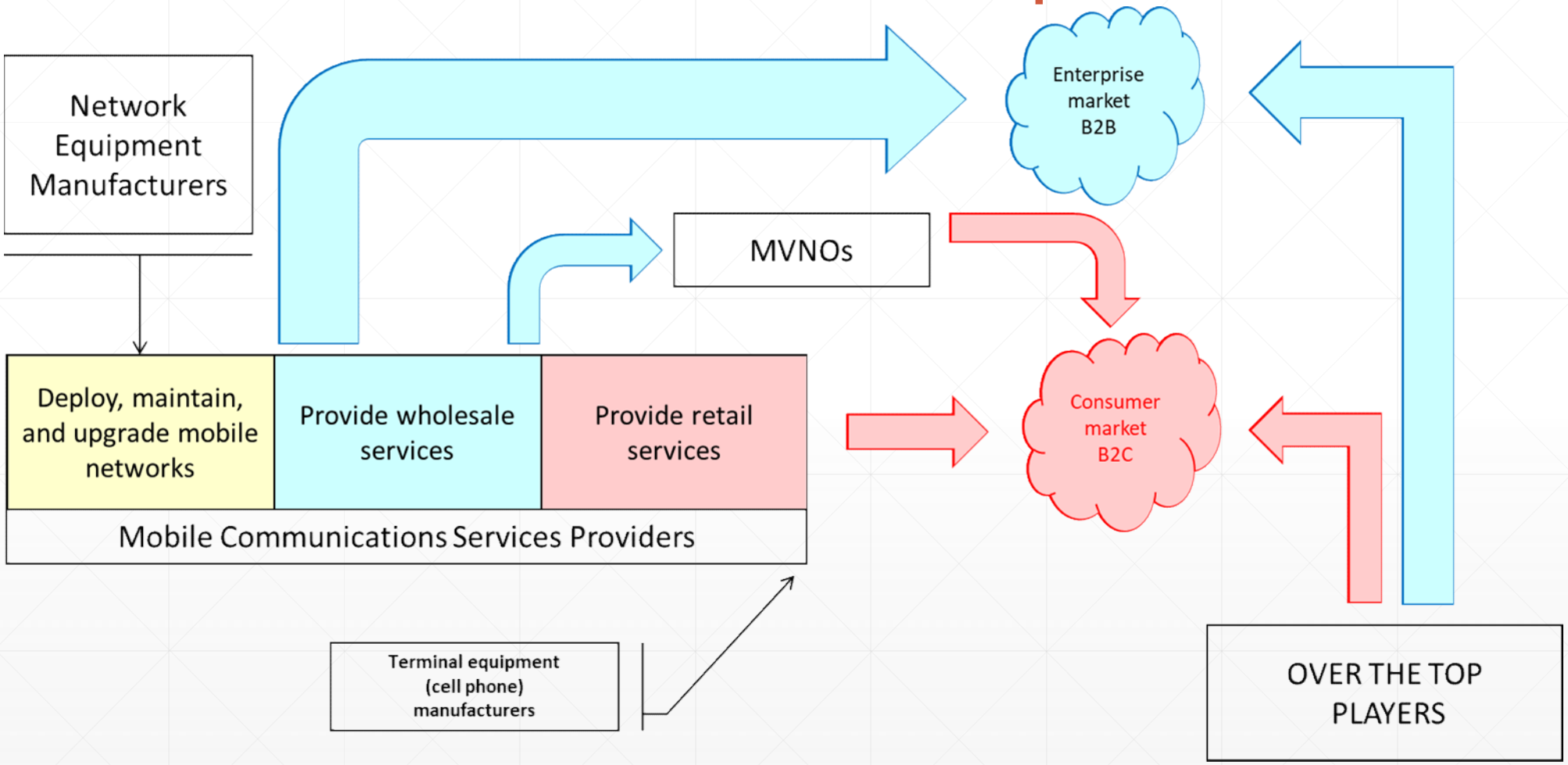
Smart, connected products will have a transformative effect on industry structure. The five forces that shape competition provide the framework necessary for understanding the significance of these changes.



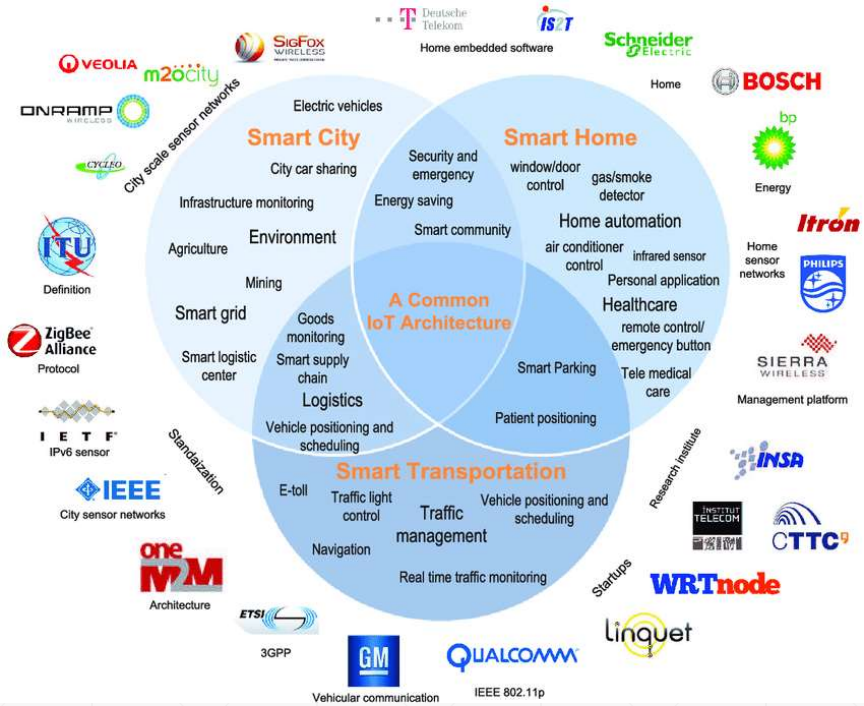
Reminder: The competitive framework

Source : **Michael E. Porter, James E. Heppelmann**. *How Smart, Connected Products Are Transforming Competition*. Harvard Business Review, November 2014

IoT and Telecommunications – Example



IoT Applications and Players
An illustration



https://www.researchgate.net/figure/Industrial-IoT-ecosystem-including-major-applications-and-players-3_fig8_277562344/download

IoT Case Studies Discussion

B2B

Industrial IoT applications

- Manufacturing
- Machinery
- Self-healing networks

B2C

Consumer IoT applications:

- Retail shopping
- Health
- ..

H2M/M2H

Human to machine:

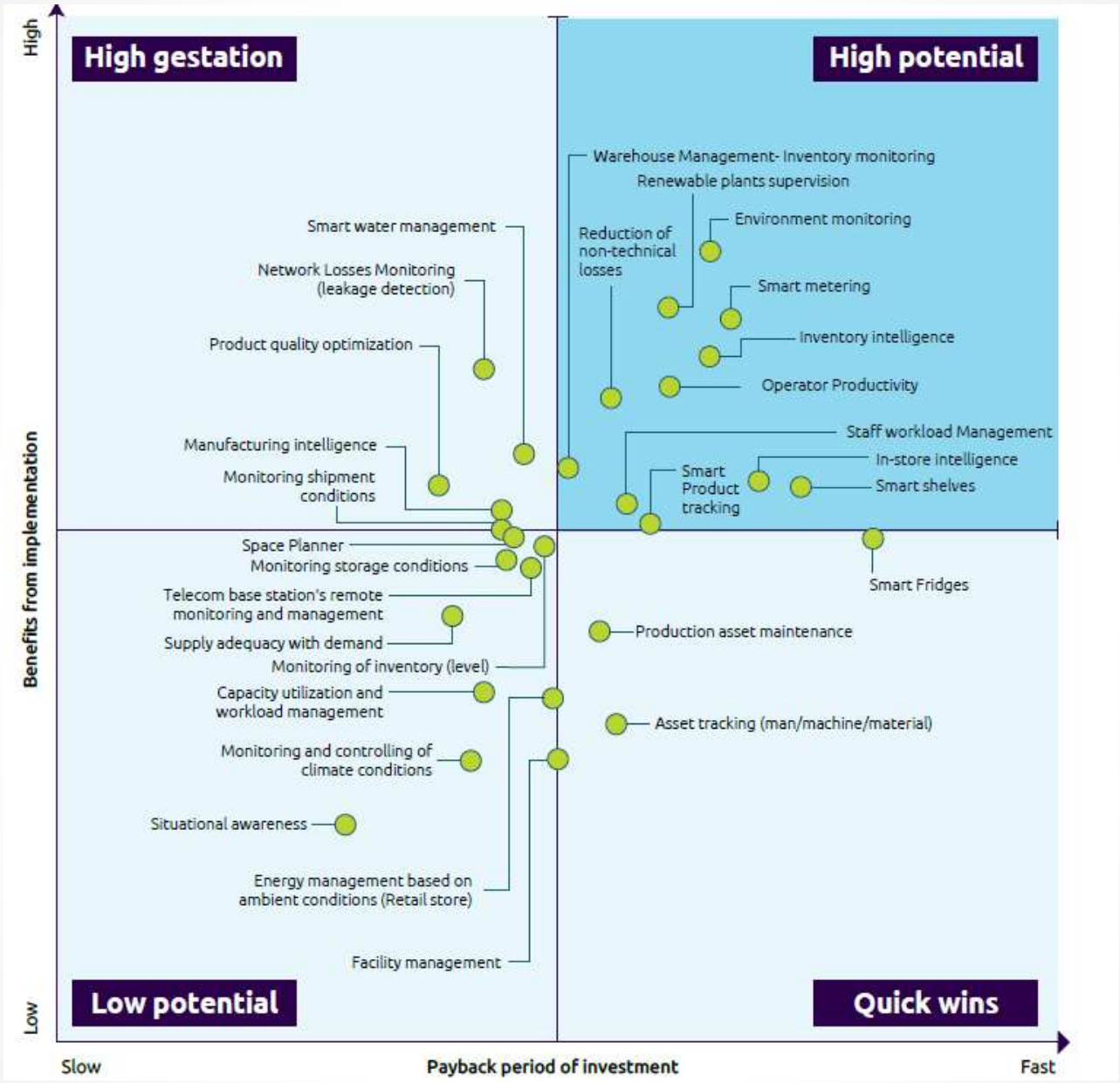
- Quantified self

Machine to Human

- Remote health services

M2M

- Warehouse management
- Inventory management



IoT Use Cases Overview

Source: Capgemini Digital Transformation Institute. *Unlocking the business value of IoT in operations*. **Capgemini**, 2018

Selected IoT Applications
Smart Metering

Smart metering

- “Smart meters record electricity consumption in intervals of one hour or less and communicate this data to the utility company.”

Examples:

- France – Linky by Enedis
- Germany - Sonderweg

Discussion points:

- Roll-out – adoption rate
- Data Collection and Privacy – regulation aspects
- Data usage – value creation aspects
- … common to several European countries

Selected IoT Applications
Smart Home

Monitor home appliances

- “Adapt, in real-time, several home appliances (blinds, lights, cooling, lighting) depending on several parameters (humidity, homme occupancy, natural light, …)”

Examples:

- Multiple projects

Discussion points:

- Ownership of data
- Ownership of IoT system

Selected IoT Applications
Smart Mobility

Smart mobility

- “Smart mobility are P2P applications allowing carpooling and on-demand car sharing services. These are services similar to Uber and Lyft, the major distinction being that the relationship are 1-2-1 and there is no need for intermediation platform.”

Examples:

- Norway – Sharepool
- Europe – Sunset project

Discussion points:

- IoT as enabler for P2P interaction
- No need for platform in the middle
- Still early stage

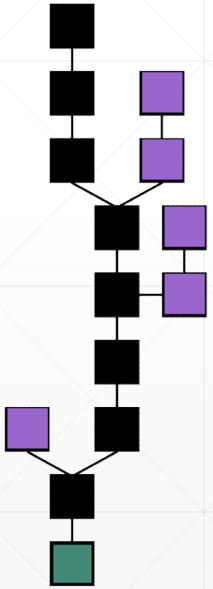
Blockchain

What is it?

« A **blockchain**, originally **block chain**, is a growing list of records, called *blocks*, that are linked using cryptography. Each block contains a cryptographic hash of the previous block, a timestamp, and transaction data (generally represented as a Merkle tree). By design, a blockchain is resistant to modification of its data.”

Source: Wikipedia

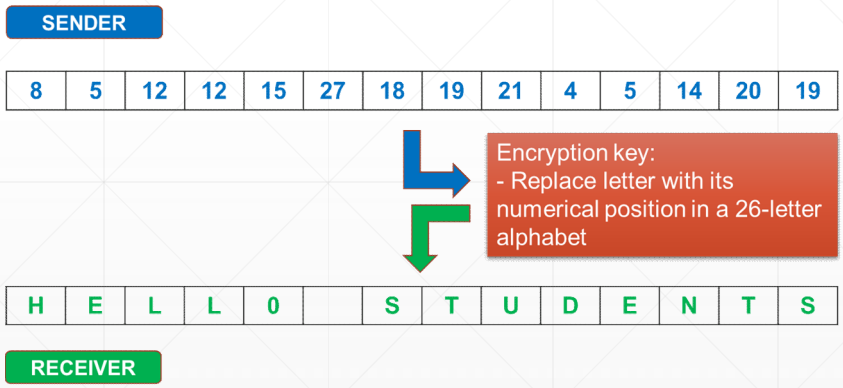
What does it look like?



Source: Theymos from Bitcoin wikiVector : Razorbliss — Bitcoin Wiki: https://en.bitcoin.it/wiki/File:Blockchain.png, CC BY 3.0, https://commons.wikimedia.org/w/index.php?curid=16043262

Blockchain Ingredients

CHRYPTOGRAPHY



DISTRIBUTED LEDGER

A **distributed ledger** (also called a **shared ledger** or **distributed ledger technology** or **DLT**) is a consensus of replicated, shared, and synchronized digital data geographically spread across multiple sites, countries, or institutions. Unlike with a centralized database, **there is no central administrator**.

Source: Wikipedia

Blockchain Ingredients (continued)

P2P RELATIONSHIP

Peer-to-peer (**P2P**) computing or networking is a distributed application architecture that partitions tasks or workloads between peers. Peers are equally privileged, equipotent participants in the application. They are said to form a peer-to-peer network of nodes. **Example**: Napster (1999)

Source: Wikipedia

TRUSTED THIRD PARTY

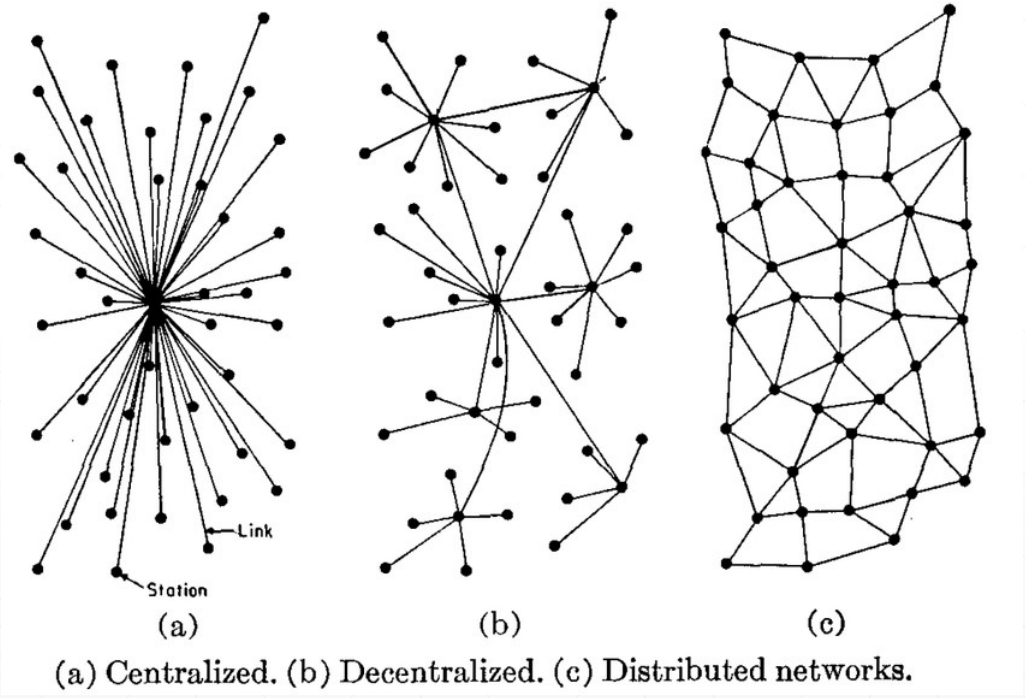
Definition(s): An entity other than the owner and verifier that is trusted by the owner, the verifier or both to provide certain services.

Source: https://csrc.nist.gov/glossary/term/trusted_third_party

With blockchain, the « trusted third party » becomes the system itself: each distributed element of the chain of blocks contains the necessary information that guarantees the integrity of the exchanged data (through a cryptographic algorithm).

Source: Wikipedia (French)

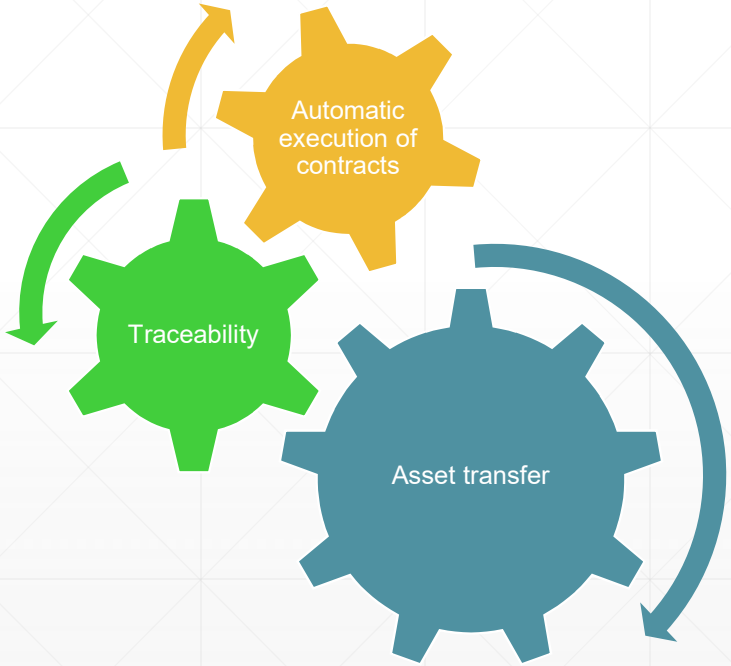
Blockchain
Architecture principles



(a) Centralized. (b) Decentralized. (c) Distributed networks.

Source: https://www.researchgate.net/figure/Distinction-between-centralized-decentralized-and-distributed-systems-according-to-Baran_fig2_334170377/download

Blockchain
Application domains



Blockchain
Main Applications - Overview

Main Application Types

- Cryptocurrencies (ex: Bitcoin, Libra, Ethereum, …)
- Smart contracts
- Distributed ledgers
- Anti-counterfeiting => NFT
- Energy trading
- …

More concretely

- Liquid stock exchange (security tokens)
- Immediate refund if plane is delayed (insurance)
- Product traceability (food markets)
- “tokenized” art work
- Digitalized and distributed gaming assets

Selected Blockchain Applications
Energy Trading (P2P)

Energy trading

- Energy trading, enabled by blockchain, is the possibility to trade energy (coming, in most cases, from renewable sources) between individual producers, without having to go through the central distribution network

Examples:

- France – ekWateur
- USA – Brooklyn MicroGrid project

Discussion points:

- Blockchain as enabler for P2P interaction
- Role in renewable energy production

Selected Blockchain Applications
Product Traceability (food markets)

Fresh product traceability

- Providing a unique source of information regarding food origin, main ingredients, transformation chain, including transport, intermediaries and distribution points

Examples:

- France – connecting-food
- USA – IBM Food Trust

Discussion points:

- Blockchain as a source of trust
- Transparency of supply chains

Selected Blockchain Applications
Non Fungible Tokens

Non Fungible Tokens

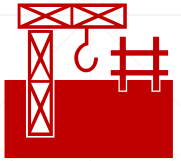
- Piece of code associated with a digital asset. It is usually associated to a license to use, copy or display the underlying asset. Unlike cryptocurrencies, NFTs are not mutually interchangeable, hence not fungible.

Examples:

- Art – digital artwork
- Games – allowing gamers to trade game artefacts

Discussion points:

- Anti-counterfeit measure
- Energy consumption (similar to cryptocurrencies)



Class Assignment

On the basis of today's reading material, and using concepts discussed in today's class, please elaborate on the potential for change of **IoT and/or Blockchain** in a company and in an industry of your choice. Please address, *ad minimum*, the following aspects:

1. What is your chosen company and industry today's structure (high-level, for example: in energy we have energy producers, energy transporters, energy distributors, energy commercial providers, energy consumers)?
2. Describe the 2 situations: the company without IoT/Blockchain and the company with IoT/Blockchain.
3. Compare the 2 situations

Company examples (to choose from the following industries): automotive, financial services (banking), telecommunications, energy (electricity), industrial manufacturing, clothing/fashion industry, healthcare, luxury goods, …

The strategic nature of IoT

“Smart, connected products raise a new set of strategic choices related to how value is created and captured, how the prodigious amount of new (and sensitive) data they generate is utilized and managed, how relationships with traditional business partners such as channels are redefined, and what role companies should play as industry boundaries are expanded.”

Source : **Michael E. Porter, James E. Heppelmann**. *How Smart, Connected Products Are Transforming Competition*. Harvard Business Review, November 2014

The strategic nature of Blockchain

« TCP/IP unlocked new economic value by dramatically lowering the cost of connections. Similarly, blockchain could dramatically reduce the cost of transactions. It has the potential to become the system of record for all transactions. If that happens, the economy will once again undergo a radical shift, as new, blockchain-based sources of influence and control emerge.”

Source: **Marco Iansiti, Karim R. Lakhani.** *The truth about Blockchain*. Harvard Business Review, January-February 2017

IoT and Blockchain
Factors influencing technology adoption

Internal (intrinsic) factors

- Standards (open vs proprietary, for example)
- Interoperability
- « Ease of use »
- Availability of adjacent technologies
- Specific technological constraints:
  - in IoT's case: authentication, ID management, …
  - In Blockchain's case: energy consumption, difficulty to embed existing contracts, …

External factors

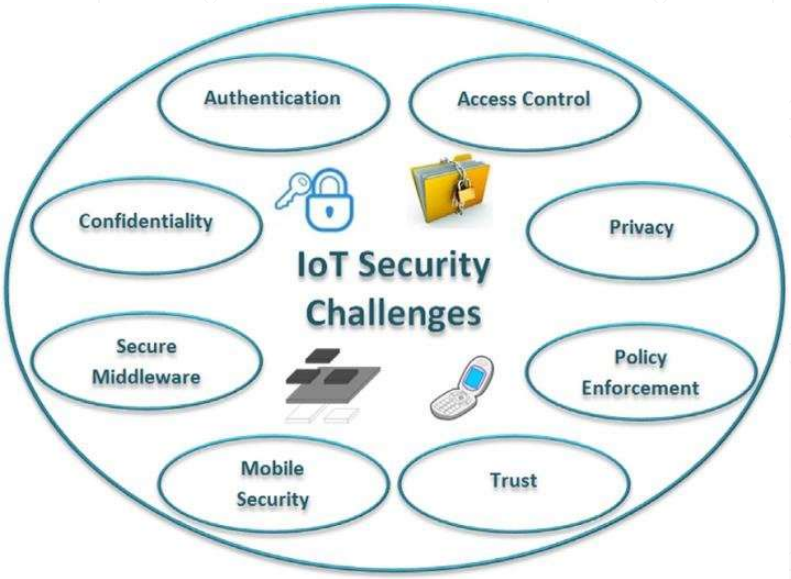
- Sector and industry
- Organizational factors (for example: digital maturity, technology « savviness », …)
- Availability of knowledgeable HR resources

Blockchain adoption challenges

- **Scalability**
  - A blockchain network enables a relatively lower number of transactions per second compared to traditional transactions networks
- **Interoperability**
  - Most of the blockchain networks are designed to work in silo mode
- **Energy consumption**
  - Transaction validation requires a lot of processing power
- **Talent**
  - Trained blockchain specialists and interdisciplinarity

Source: https://www.blockchain-council.org/blockchain/5-key-challenges-for-blockchain-adoption-in-2020/

IoT
The Security Challenge

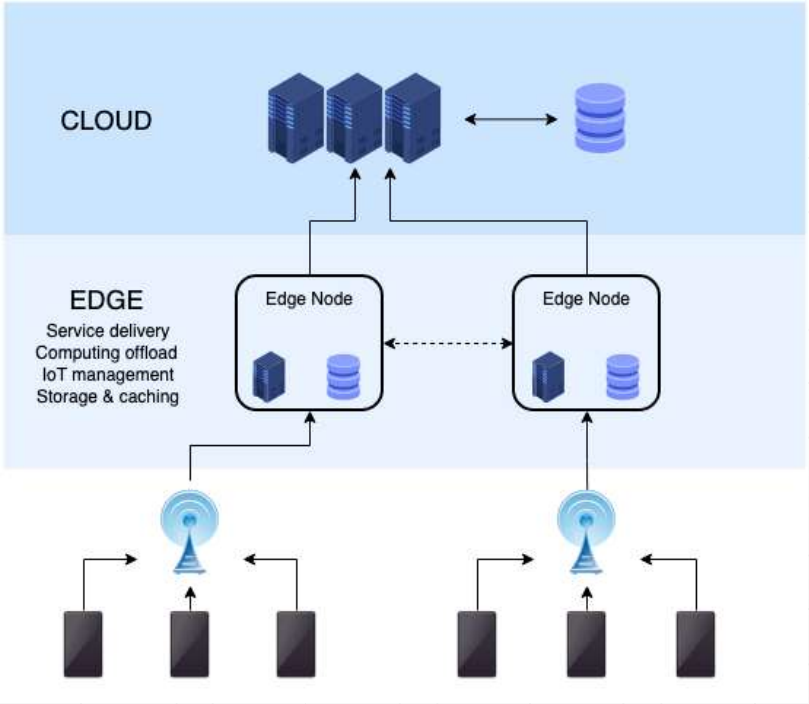


Main causes:

- Number of devices
- Number of transactions
- Complexity of networks
- « Anonimity » of devices
  - Access and authentication
  - Identity management

Source: Internet of Things: A Survey - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Security-Challenges-of-IoT-23_fig3_315460916 [accessed 8 Mar, 2020]

IoT Fundamentals
Architecture Challenges

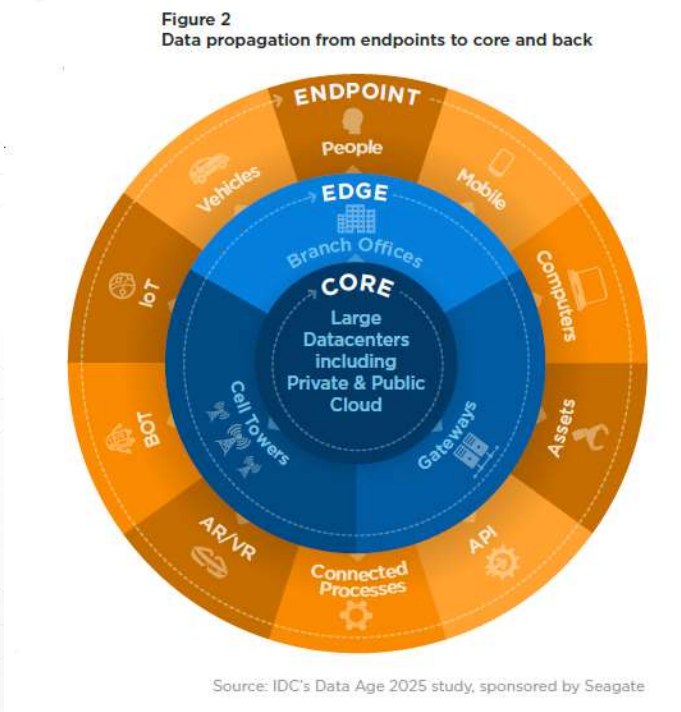


https://en.wikipedia.org/wiki/Edge_computing#/media/File:Edge_computing_infrastructure.png

According to the IEEE, the long-term technology challenge is that:

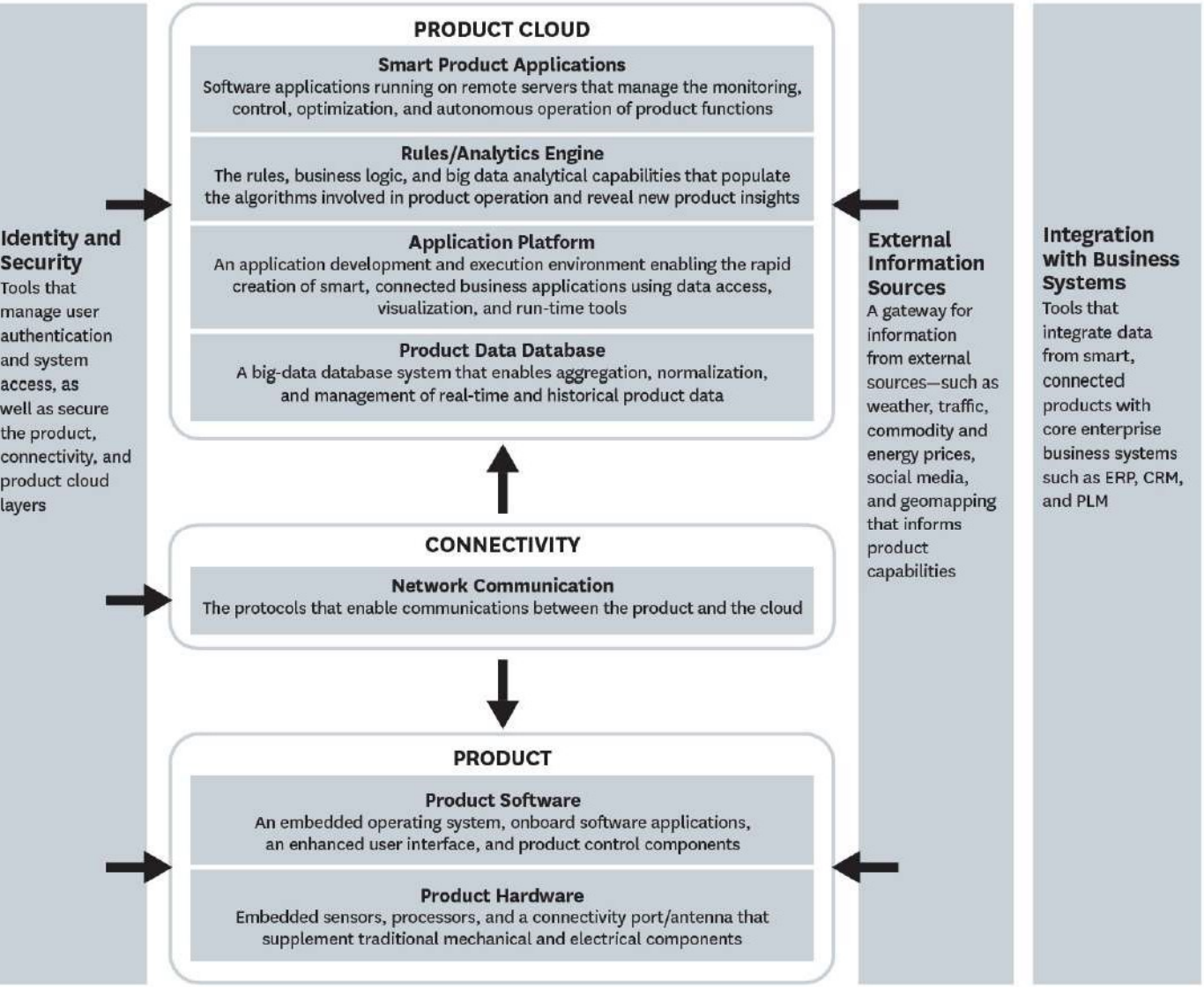
- "Embedded intelligence in the things themselves can further enhance the power of the network by devolving information processing capabilities to the edges of the network."

IoT Long Term Technology Challenge
Shifting Intelligence



1. **Edge** – Enterprise servers and appliances which are not in the datacenters
2. **Core** – Designated computing datacenters on premises and in the cloud. It covers all forms of cloud (private, public, hybrid)
3. **Endpoints** – terminal devices (PCs, smartphones, sensors and wearables)

Source: IDC, Seagate Whitepaper. *Data Age 2025 – The Digitization of the world: From Edge to Core.* 2018



urce "How Smart, Connected Products Are Transforming Competition," HBR, November 2014

Illustration: The IoT-Driven Technology Stack

Source : **Michael E. Porter, James E. Heppelmann**. *How Smart, Connected Products Are Transforming Competition*. Harvard Business Review, November 2014

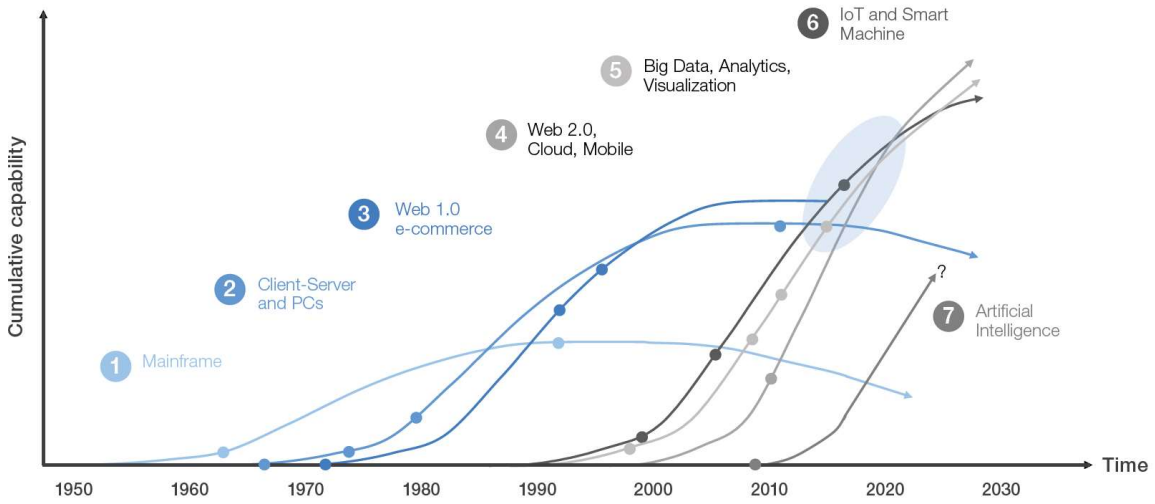
IoT and Blockchain
The Regulatory Perspective (Europe)

EXISTING REGULATIONS

- General Data Protection Regulation (GDPR)
  - May 25th 2018
- Directive of Security of Network and Information System (NIS Directive)
  - May 9th 2018
- Payment Services Directive 2 (PSD2)
  - January 13th 2018

PROPOSED REGULATIONS

- E-Privacy Regulation
  - Draft
- Free Flow of Data Regulation
  - Draft



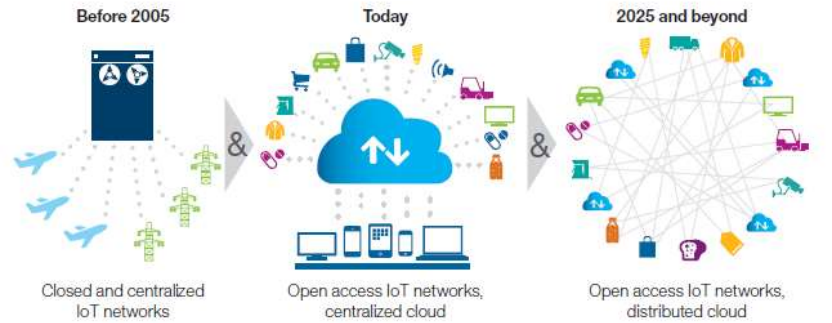
Combinatorial effects of technologies

Source: *Digital Transformation of Industries: Demystifying Digital and Securing $100 Trillion for Society and Industry by 2025*. **World Economic Forum, Accenture**. January 2016

Combining IoT and Blockchain
The « Device Democracy » approach

The challenge

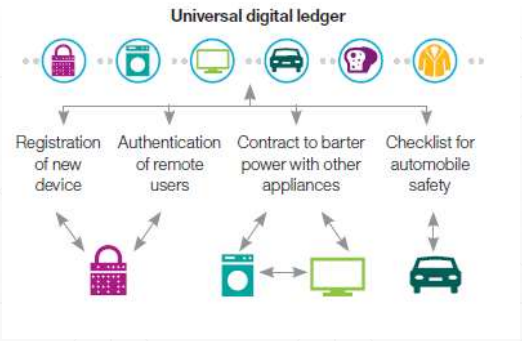
Figure 4. *To be safe, scalable and efficient, Internet of Things networks must be re-architected to gradually shift from managing billions of devices to hundreds of billions of devices*



What if … ?

Figure 5

The blockchain functions as a universal digital ledger facilitating various types of IoT transactions between devices



Source: IBM, 2015. Device democracy *Saving the future of the Internet of Things*

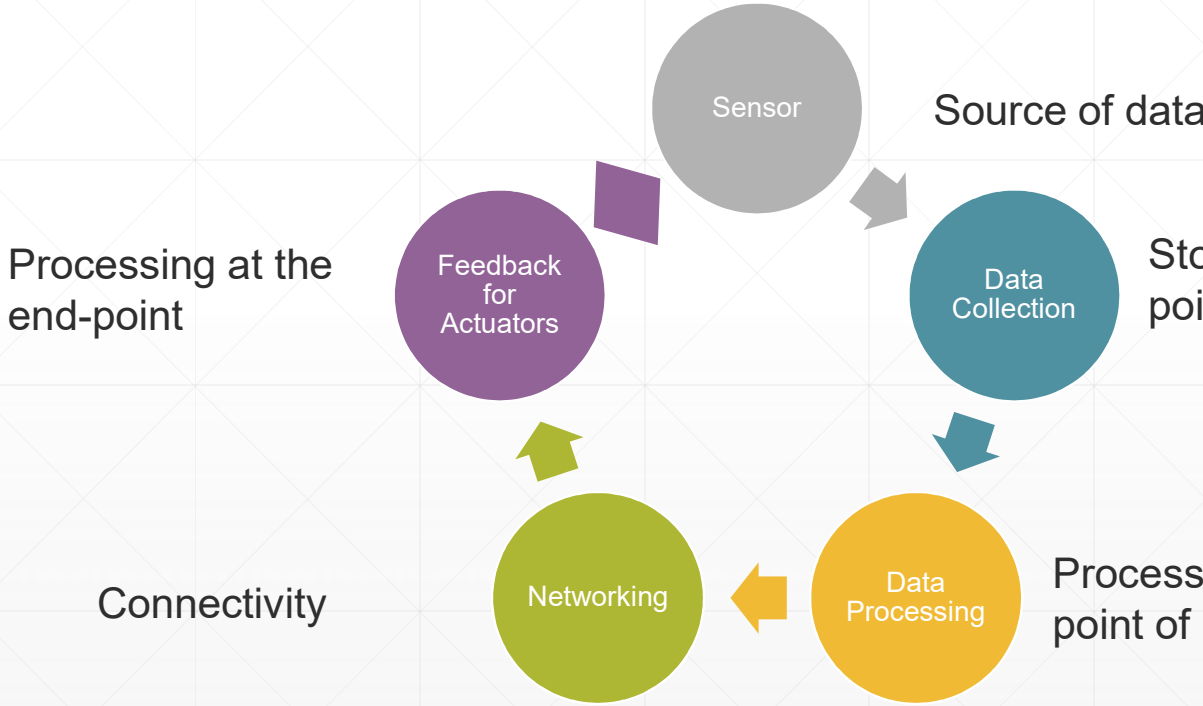
Blockchain Summary

- P2P services (as opposed to mediated services through a 3rd party intermediary)
- Infrastructural-type of technology
  - Example: Blockchain is to digital services what TCP/IP is for communication networks
- Adoption (outside cryptocurrencies) is relatively slow, because of:
  - Inherent complexity
  - Transparency (trust)
  - Difficulty to embed existing legal provisions at technology layer

The class/reference example IoT-Blockchain (so far)

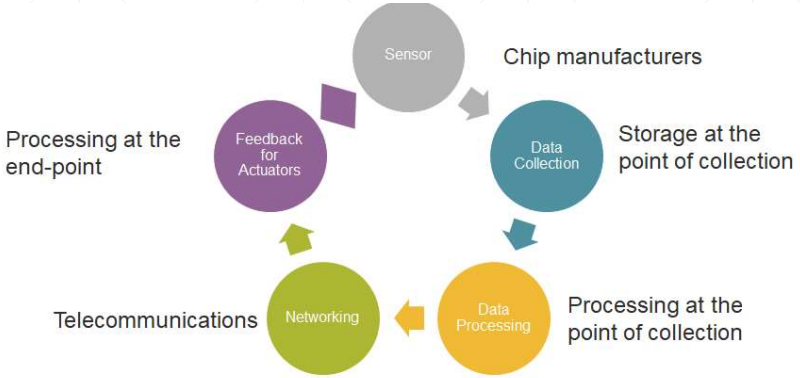
- **IoT** is the technology enabling objects to be connected to a network, either existing, or new
  - In our case, the reader of reference and student IDs and the portable ID for each “item” allowing unique identification of all assets and temporary associations between them
- **Blockchain** is the technology allowing trust to be embedded in the system
  - In our case, the rules that make sure that all references are returned at the end, and; the possibility that students exchange references between them without going through a central point (professor)
- …

IoT and Blockchain Value Chain
A simple model (for class discussion)



IoT and Blockchain Value Chain Further discussion (1)

SIMPLE MODEL STARTING POINT

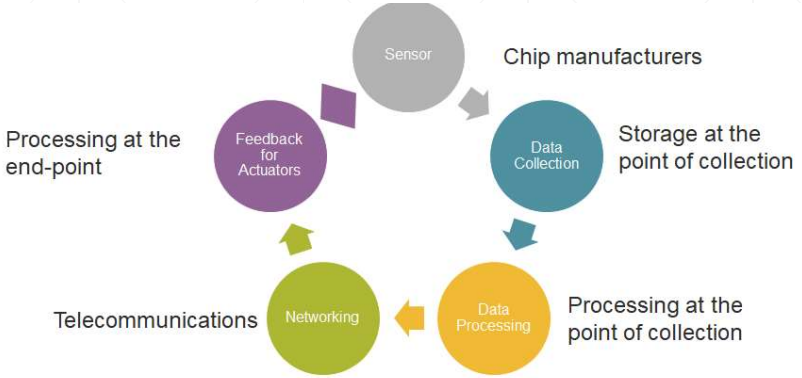


VERTICALS

- Health-care
- Smart Cities
- Home (Consumer)
- Automotive
- Public transportation (Mobility Services)

IoT and Blockchain Value Chain
Further discussion (2)

SIMPLE MODEL STARTING POINT

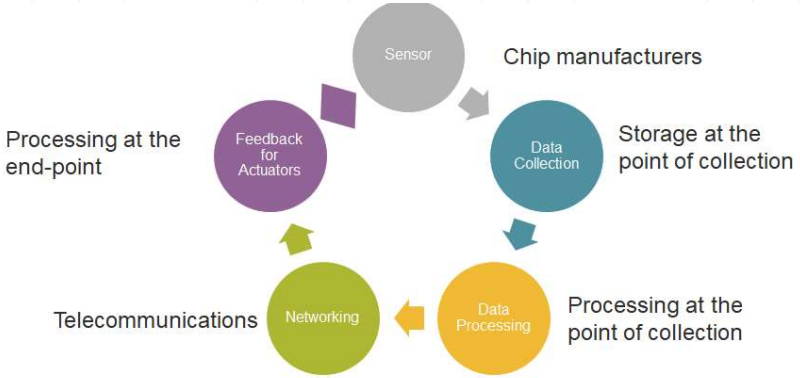


TYPES OF PLAYERS

- Telecom Operators
- Systems Integrators
- Large Internet Players
- Semiconductor Manufacturers
- Governmental Authorities

IoT and Blockchain Value Chain Further Discussion (3)

SIMPLE MODEL STARTING POINT



VALUE CREATION (THROUGH DATA)

- Data Collection
- Data Cleansing and Preparation
- Integration of Several Data Sources
- Data Analytics
- (Data Visualization)
- Insights & Recommendations

IoT and Blockchain - Wrap-Up
Adoption considerations (we'll come back to it)

- Combination of several technologies
- Adoption discussion:
  - Standards (ex: MS-DOS)
  - Installed base (ex: QWERTY keyboard)
  - Convergence between different types of knowledge
    - (ex: computer: binary arithmentic, symbolic logic, programming)
  - Co-existence of what initially was considered to be rival technologies (ex: DC and AC)

Digital Transformation
Class 2 – Summary (IoT and Blockchain)

- ☑ IoT is **one** of the enabling technologies of the Digital Economy
- ☑ It is a data generation technology set, which combines other various individual technologies, such as RFID, sensors, smart technologies, nano-technologies, etc … Its adoption is expected to instill significant change in existing industrial supply chains, as illustrated by its current use cases
- ☑ Examples of current IoT use cases include, at a macro-level: Smart Home, Smart City, Smart Transportation
- ☑ Blockchain is about trust (and control), it's a distributed ledger technology mostly utilized in P2P transactions (energy trading, traceability, NFT, …)
- ☑ Their combination might provide a promising infrastructure solution for our increasingly interconnected world

Thank You!

Valeriu Petrulian