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CPS Market Trends

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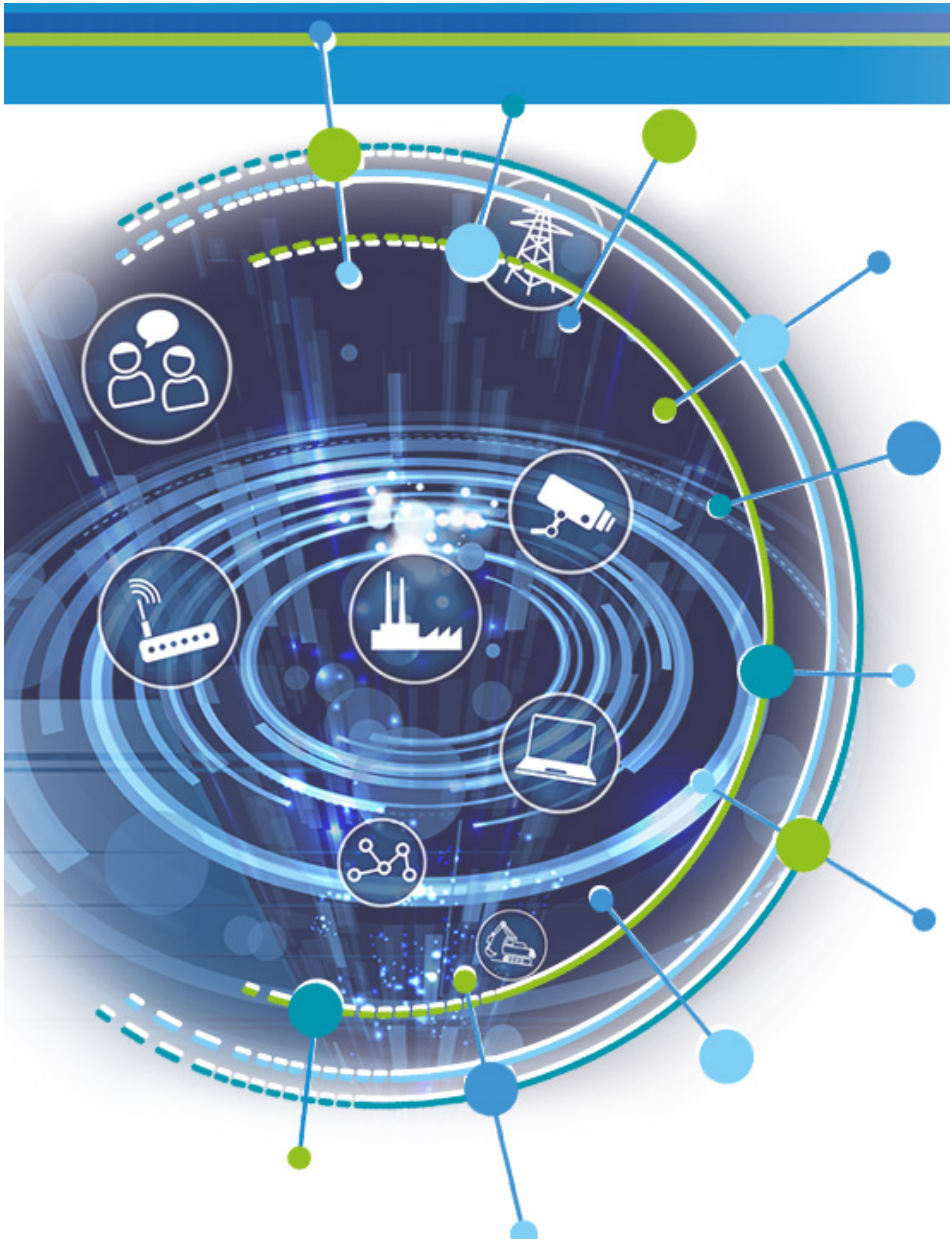
Summary

- Introduction
- Market expectations
- Dimensions of the market
- Research and innovation
- The value network
- CPS evolution
- CPS market obstacles
- Conclusions



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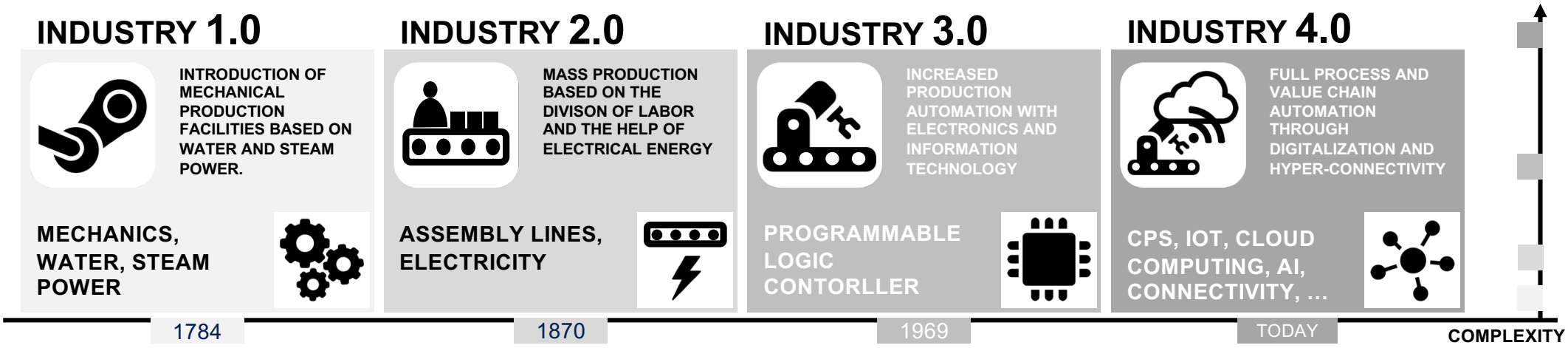
Introduction

Introduction

Digitalization and **ubiquitous/hyper connectivity** are already shaping and will shape our economy and our society in an unprecedented way.

The advances in technologies such as the **Internet of Things** (IoT), **Cyber Physical Systems**, **embedded systems**, **M2M communication**, **cloud computing**, **artificial intelligence** (AI) provide all the enabling elements for the starting point of the **fourth industrial revolution**.



Introduction

DIGITALISATION is the baseline: everything in the process must have a **DIGITAL representation**.

HYPER-CONNECTIVITY is the key factor for **ubiquity**: it allows entities to cooperate, exchanging huge amount of data.

HISTORICAL CHANGE IN THE STRUCTURE OF THE CURRENT ECONOMIC SYSTEM:

LINEAR VALUE CHAIN → NON-LINEAR VALUE NETWORK

CPS, IoT, cloud computing, AI lie at the core of this radical transformation to a network-based economy.

→

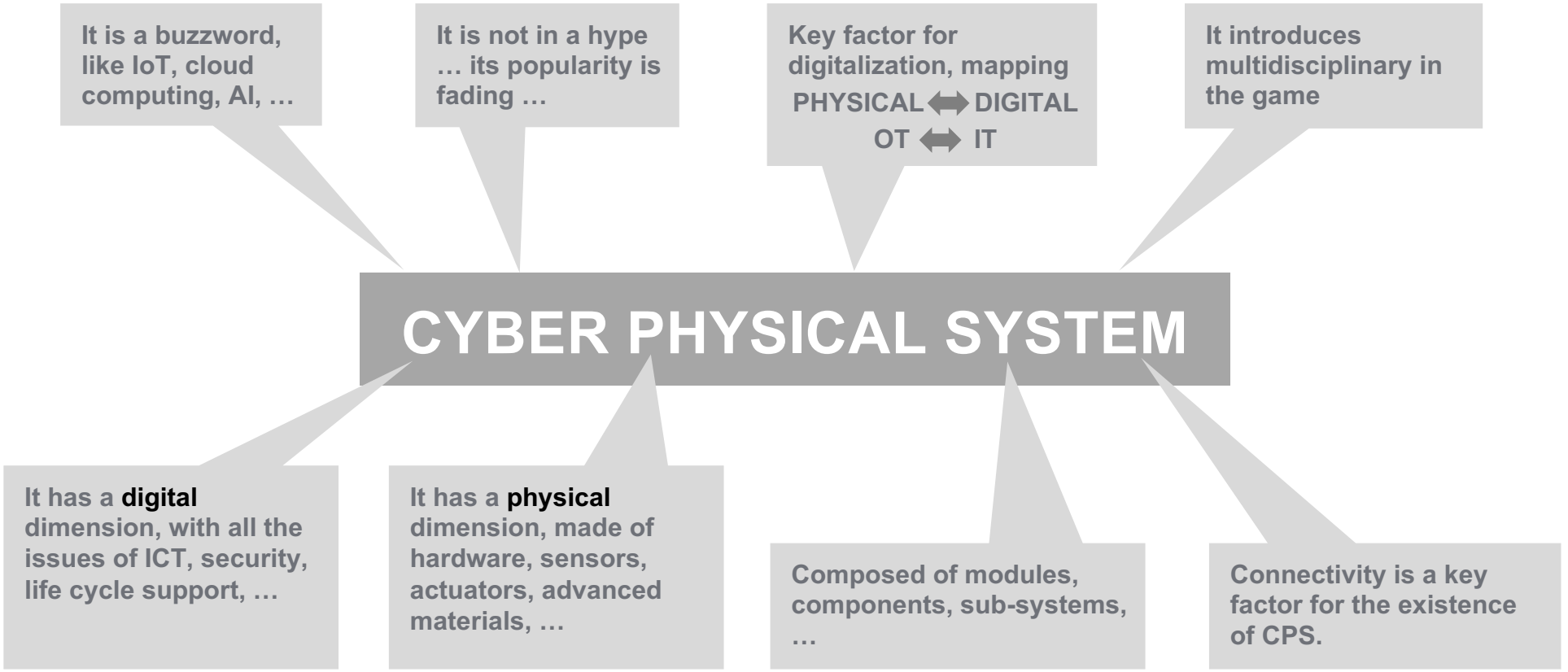
They are the enabling technologies for the "**integration of computation with physical processes**", i.e. they allow to map the **PHYSICAL WORLD** with the **DIGITAL WORLD**.

→

They allow the creation of an integrated and self-regulating **system of systems** (SoS), beyond firms, industries, vertical domains boundaries.

The potential market is huge. However, the take-up of these technologies, as envisioned by Industry 4.0 or similar concepts, is far from being a reality.

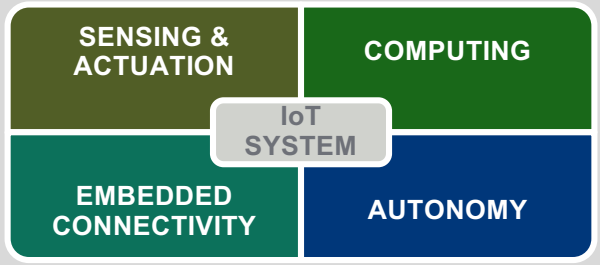
CPS main concepts



CPS vs IoT

The concept of CPS is controversial … and it is not always fully recognized. Analysts very frequently consider CPS as a synonymous of IoT, or a subset of IoT, or just a layer of an end-to-end stack, …

When we consider an IoT system, the similarity appears evident:



As IoT, the concept that gave life to CPS is the idea to map the **physical world** with the **digital world**.

Today, the active and dynamic interaction between these two worlds is one of the **strongest driving force** that will shape the digital innovation and **will influence** the evolution of future markets, potentially in every vertical domain.

CPS vs IoT

The original concept of IoT was to connect “Things” to the internet and eventually to each other.

Cyber Physical Systems focus on the integration of computation, networking and physical processes.

Today, IoT represents a **wider conceptual approach** adopted to solve classical problems with a new recipe based on smart objects, connectivity, interoperability, embedded intelligence, actionable data streams, delocalized computation, and agile business models.

The evolution of the IoT concept is market driven.

IoT enables heterogeneous and distributed objects to physically and/or virtually connect and cooperate to achieve common goals. The ability to collect vast amounts of data in near-real time from these objects is the foundation of the IoT.

CPS is an acronym more used:

- in the US;
- by engineering communities;
- for large scale real-time control (e.g., time critical problems), combining organizational and physical processes.

IoT is an acronym more used:

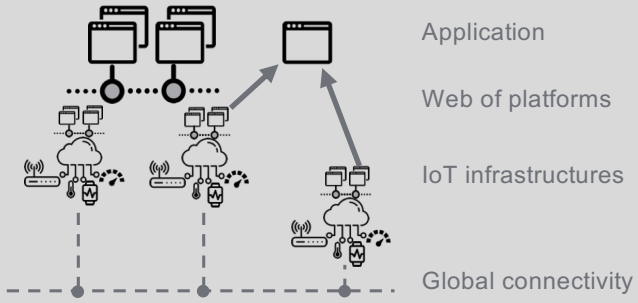
- in Europe;
- by telecommunications and networking communities;
- collect and process data from the physical world, without essentially involving real-time control.

Towards system of systems (SoS)

IoT/CPS: the physical entities are connected together and exchange information, following a predefined business logic. The infrastructure is typically focused on a single application, factory, manufacturing line…or an entire vertical domain, bringing to life new digital complex ecosystems (SoS).

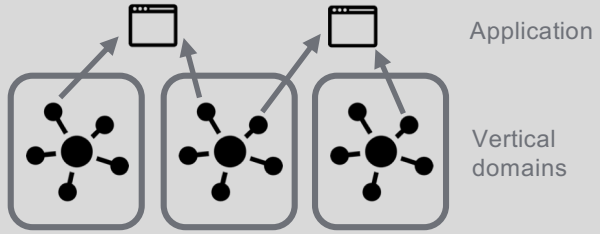
SoS are large-scale integrated systems which are independently operable on their own, but are networked together for a period of time to achieve a higher goal, e.g. costs, performance, robustness, etc. (Jamshidi,2009):

- they are operational and managerial independent.
- SoS evolve, changing their behavior, but trying to stay interoperable.
- SoS are collaborative and can be virtual.

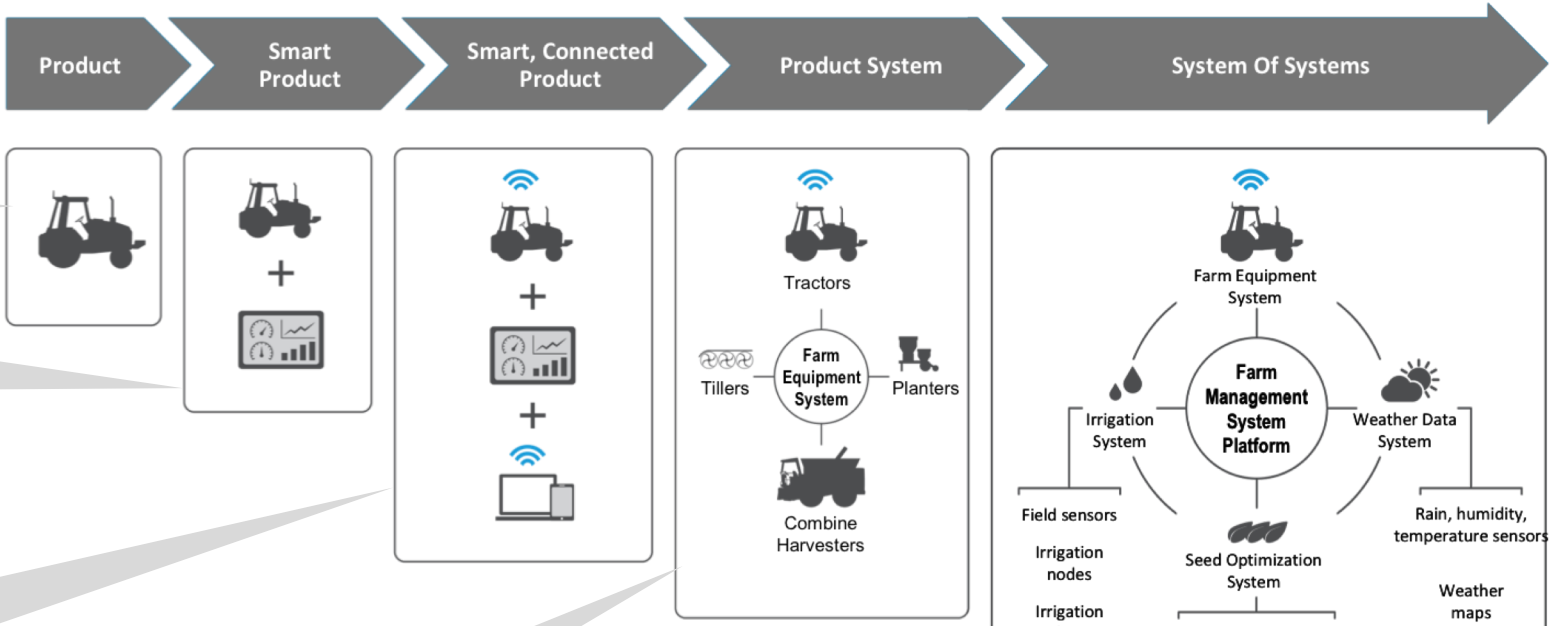


Connected domains represent a cross dimension of SoS, with a wider shared understanding of the context and situation, more useful services, richer functionalities, better user experience and value proposition:

- application and services run on top of connected vertical domains.
- Domains can be physical or virtual.



Towards SoS: an example



Just mechanical and electrical components.

Electronics, controls, sensors, software and an enhanced UI.

Connectivity enables remote capabilities and features.

Smart connected products integrate in a product line, to optimize product and system performance.

Subsystems, made of smart objects and belonging to different stakeholders, are integrated in a SoS, to optimize product and system performance.

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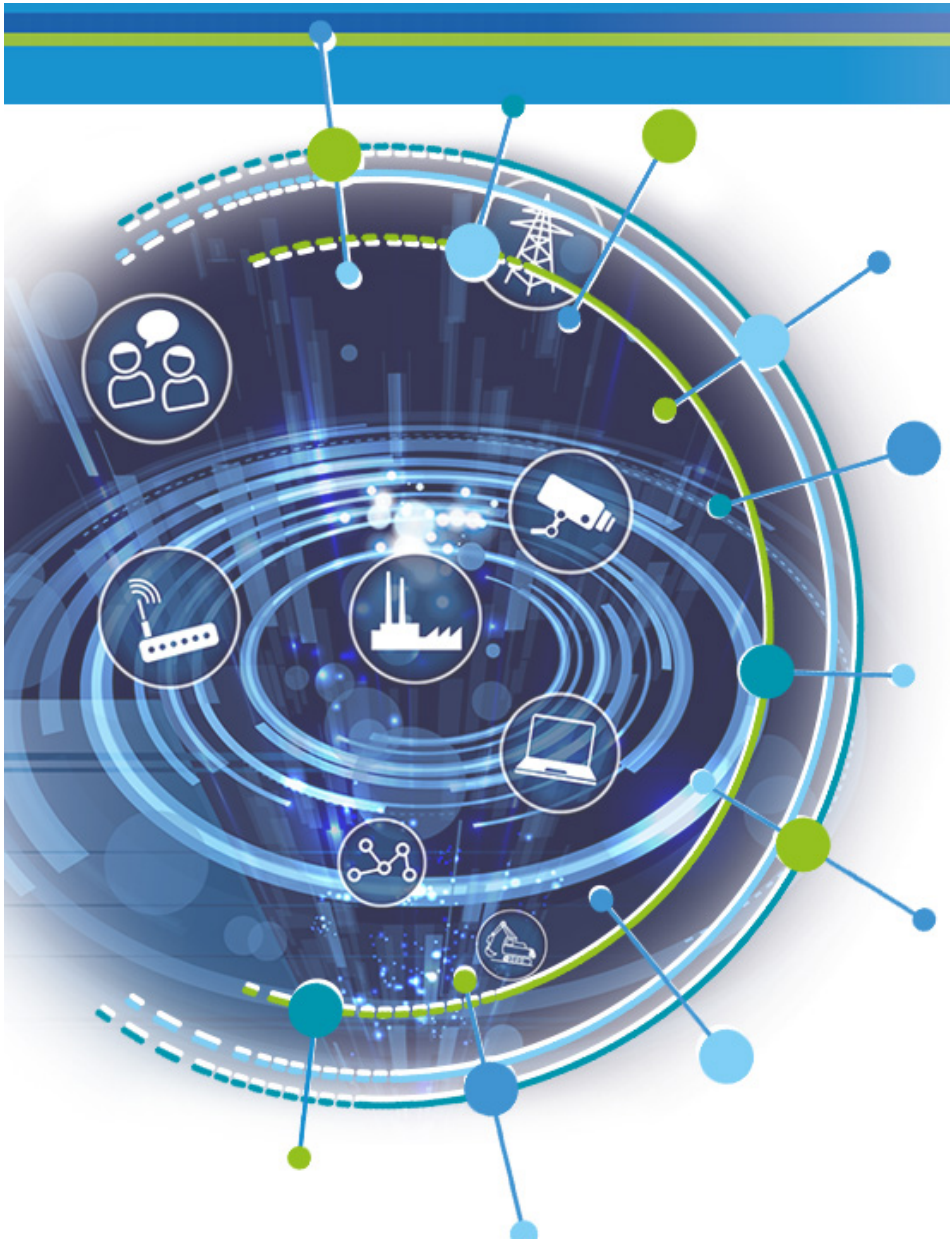

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Overestimated expectations

The market in 2017/2018

The last two years have been very difficult and often frustrating for the CPS/IoT:

- prediction **overestimated** and sometimes fully missed.
- Many **company failures**: a recent study states that almost 75% of IoT projects fail (source, CISCO).
- There are new **buzzwords**: AI, blockchain, bit coin, …

The CPS/IoT market was supposed to be huge, already today … but it isn't … **at least not for all the potential stakeholders**.

The CPS/IoT is continuously growing to a **massive scale**.

Growth rates have been overestimated but they are a **constant**.

It seems that in 2017 the total number of IoT devices (wearables, connected cars, machines, etc.) surpassed mobile phones.

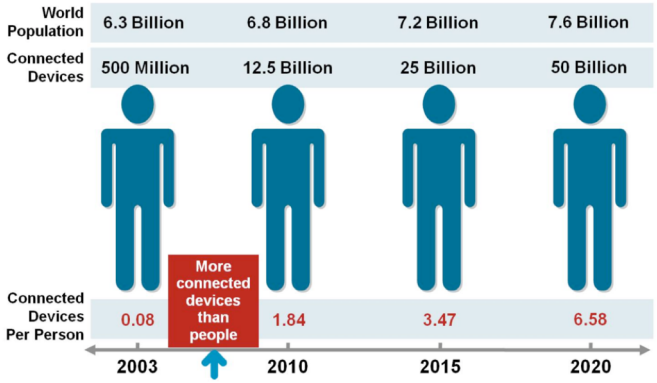
IDC estimated for 2017 a global spending of $800 Billion in the IoT domain, with an increase of 16.7% over previous years.

CPS/IoT market is currently still in an early stage of development, a significant progress must be recognized, some solutions are available, not all satisfy the expectations, but the CPS/IoT foundations are being laid and an undeniable growth is happening.

An overestimated market

Several stunning predictions tried to envision the CPS/IoT evolution:

- 2010, *IBM*: "*A world of 1 trillion connected devices" by 2015.*
- In 2010 Hans Vestburg (Ericsson's former CEO) in a presentation to shareholders envisioned 50 billion of connected devices by 2020.
- In 2011 Dave Evans (futurist from CISCO) confirmed this forecast.

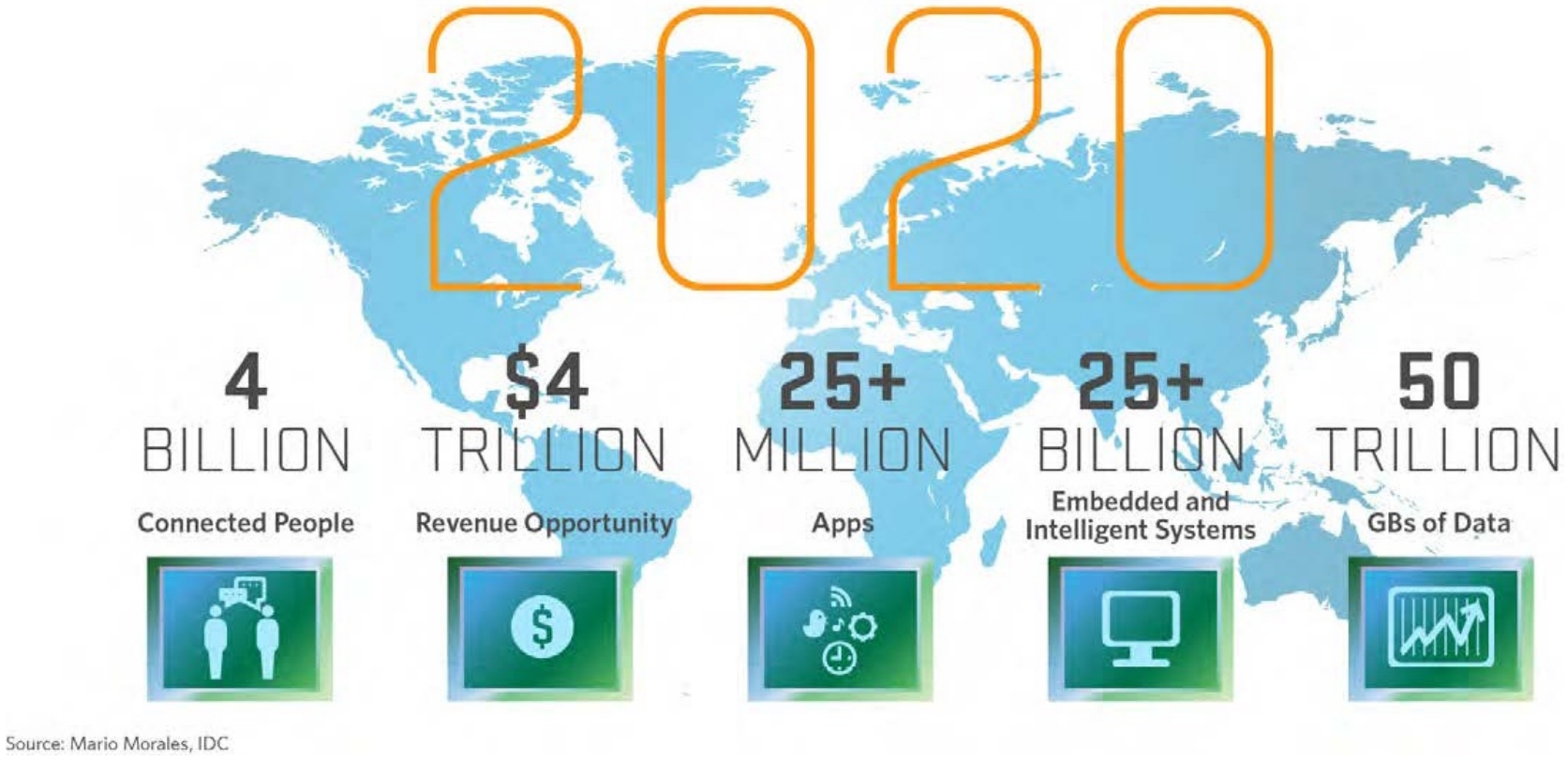


Source: Cisco IBSG, April 2011

Expectations were a shot in the dark in 2010, and they completely missed the target, resulting largely overestimated.

In 2016 the estimation of existing connected devices was **6.5-9 billion** (up to 17.5 billion including smartphones) (Source Gartner). Vestburg and Evans have corrected their prediction and, currently, IDC, Gartner, McKinsey and HIS Markit are converging to **20-30 billion** of connected IoT devices (excluding smartphones, tablet and computers) … but the 50 billion figure is still very popular.

A new estimation …



Source: Mario Morales, IDC

… the market is in any case enormous.

A new estimation …

The commercial, industrial and consumer sectors, will account for nearly 50% of new connected devices between 2018 and 2030.

Commercial and industrial electronics
5.4 billion devices
24.4% CAGR 2013-30

Consumer
5.9 billion devices
13.8% CAGR 2013-30

Communications
16.8 billion devices
8.0% CAGR 2013-30

31 B
CONNECTED
DEVICES

Medical
406 million devices
20.8% CAGR 2013-30

Computers
1.7 billion devices
-2% CAGR 2013-30

Automotive and transportation
928 million devices
21.4% CAGR 2013-30

Compound Annual Growth Rate is the mean annual growth rate of an investment over a specified period of time longer than one year. The compound annual growth rate (CAGR) is a useful measure of growth over multiple time periods.

Source HIS Markit

The reasons of the overestimation

1

The analysis are based on annual sales data:

- sales data just on the number of connected devices or of components (such as semiconductors), giving a partial perspective on market trends.
- And, frequently, companies haven't any idea of how many of the devices sold are really connected. 90% of connected devices are turned on, but less then the 50% are connected.
  (Source IHS Markit)

2

Technology issues:

- The forecasts try to anticipate the demand of devices that have largely not yet been invented or commercialized.
- The various parts of the IoT ecosystem are not evolving at the same speed.
- Evans' prediction was based on Moore's Law and Metcalfe's Law, that are no more actual.

3

Vertical domain issues:

- A large number of senseless application and devices has been considered. Technology needs to solve real problems. If it is used as a gimmick to create new problems and solve them, it dies…
- IoT evolution is characterized by completely different dynamics depending on the vertical domain.
- Industrial IoT has a steady growth, while consumer trends are more fluctuating.

The reasons of the overestimation

4

«Boosterism»: frequently too much enthusiasm at technology or product launch. The famous “WoW” effect … very frequently technology enthusiasts misread reality.

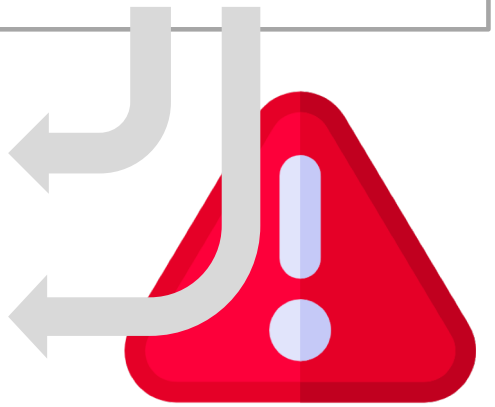
5

Market studies contain unfortunately serious errors, due to the extreme complexity of the CPS/IoT and to the lack of extensive expertise in these domain.

The point is to think of the estimates as a **general indicator**, rather than focus on the specific numbers.

There is a **gap** between the customers requirements and the technology & solutions developed by research.

Significant **obstacles** are preventing the disruptive evolution of CPS/IoT.



But … what if the numbers are real?

If 18 billion devices are connected today (Gartner estimation), **we have 3-5 years to double the number**.

How will this work? What do business, government and standards organizations need to prepare for this growth?

Devices don't just connect themselves and the impact of that many connected devices is not so trivial to understand.

Connectivity is the key factor, but it is not yet uniformly available at the world level.

To get more things online, we need to **expand the cellular network** across vast and mostly rural spaces.

The U.N. reports more than 90% of rural areas are not yet connected: getting these areas covered by connectivity will be a challenge for business and governments.

The **inherent nature** of solutions based on CPS and IoT ensure support and simplifies the diffusion in these distant areas.

But these solutions must be capable to **scale up** to the enormous numbers in Gartner's or Cisco's predictions.

Can we scale up to 30 billion devices?

Scalability is at the heart of this problem. The number of connected devices will generate massive amounts of data.

- 5 megabytes per month,
- 30 billion devices by 2020,
- 150 hundred of terabytes.

How will all this data be **transported**? How will it be **stored**? How will it be **analyzed**? How do you search through it? How will it be kept **secure** and **private**?

Each of these issues must be addressed.

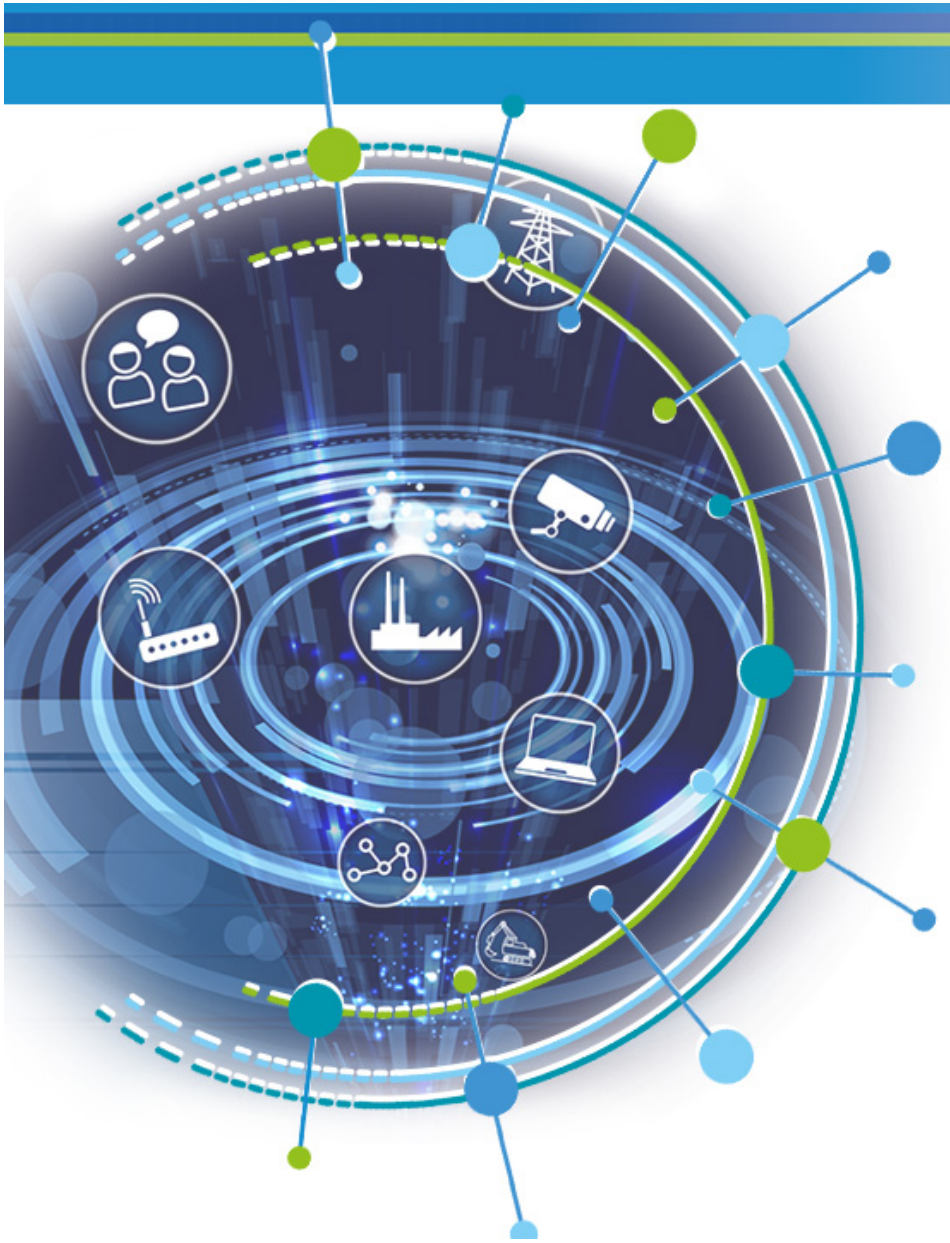
Because finding promptly, actionable information within these vast data stores could be difficult and **expensive**.

Because the **costs** of telemetry, storage and analytics could become unsustainable, and must be considered to identify the **adequate business models**.

Because with a similar **amount** of data **security** and privacy become an enormous issue.

Security measures have to be **built into the process,** from the beginning.

If 30 billion devices are connected by 2020, certainly a large part of the data they generate will need to be carefully secured, whether it's financial, industrial, health, personal, …



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The dimensions of CPS phenomenon

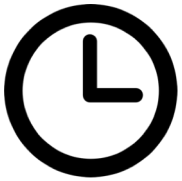
The dimensions of the game

- How quickly CPS will be adopted? Are they a KEY technology?
- What is the readiness level?
- How many companies are involved?
- How connectivity is changing?
- Which vertical markets could be influenced? And the potential revenues?
- What is the impact of security?
- What is the role of semiconductor companies?
- And finance?

Although not all strictly related to CPS, some snapshots help dimensioning the domain and the potential evolution of the market.

Reaching 50 million users

Clock
200 yrs



Airlines
68 yrs

Cars
62 yrs

Telephone
50 yrs

Electricity
46 yrs

Credit card
28 yrs

Television
22 yrs

ATM
18 yrs

Computer
14 yrs

Cell phone
12 yrs

Internet
7 yrs

Ipod
4 yrs

You Tube
4 yrs

Facebook
3 yrs

Twitter
2 yrs

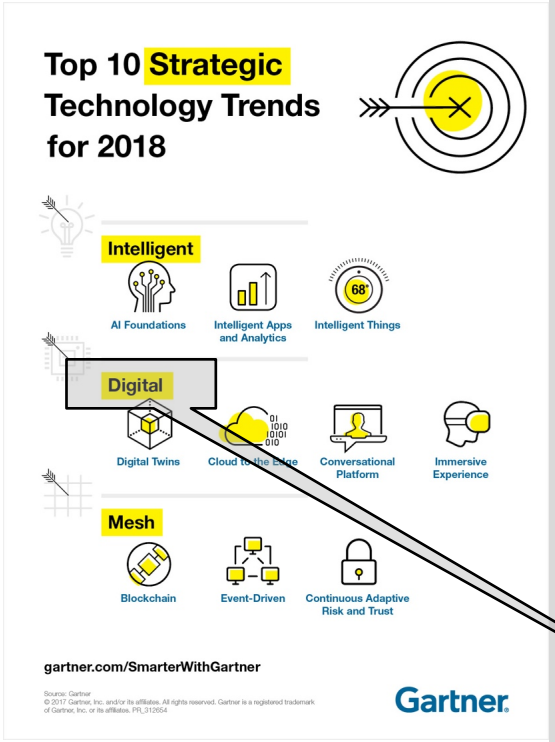
Pokémon Go
19 days

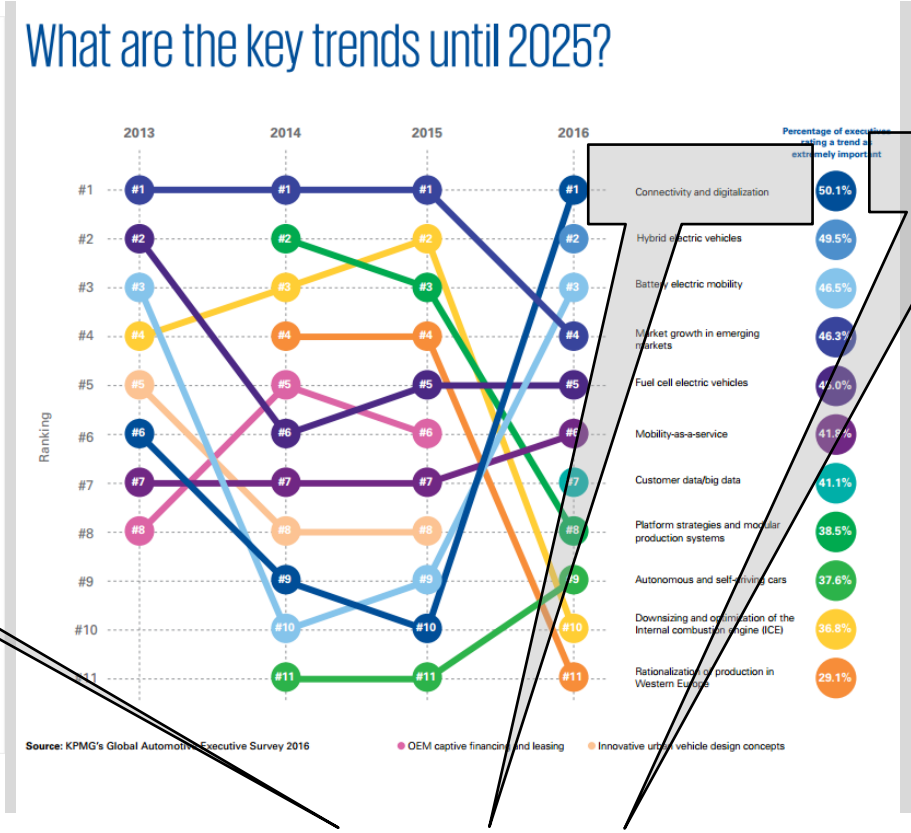
How fast the CPS phenomenon could grow? After the technology readiness break point: less than a year…

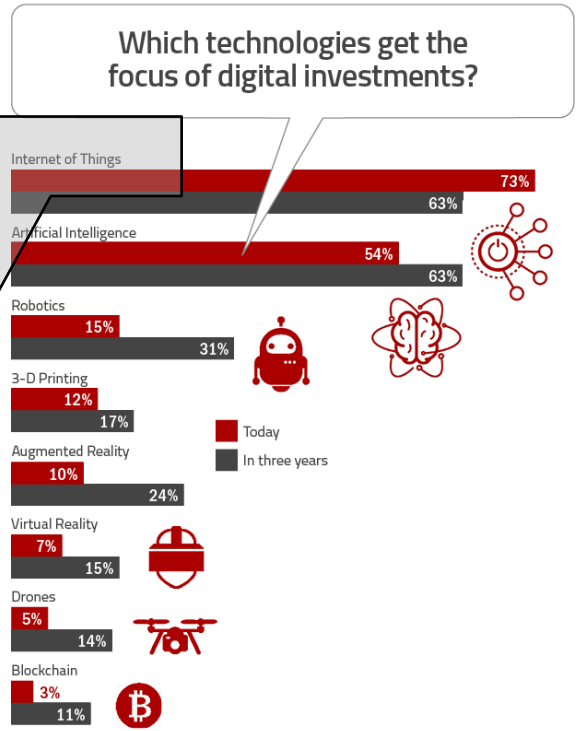
Bitcoin
10 yrs ?

EOS
1 night ?

Is CPS/IoT a key technology?

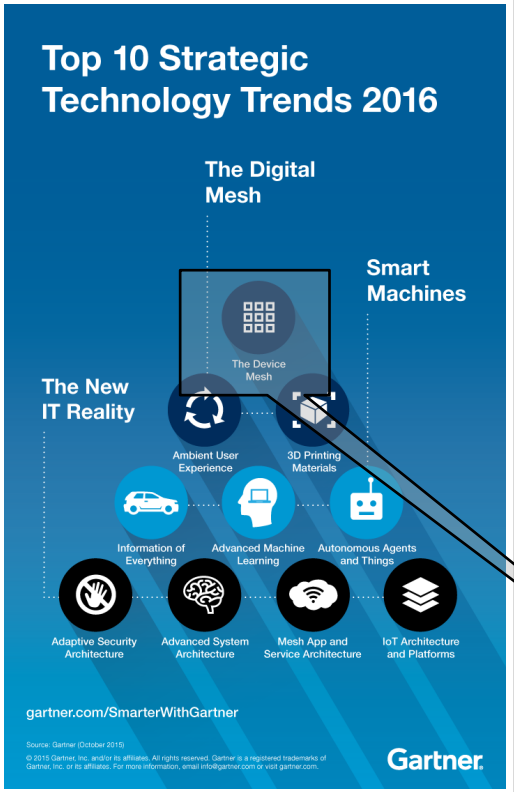


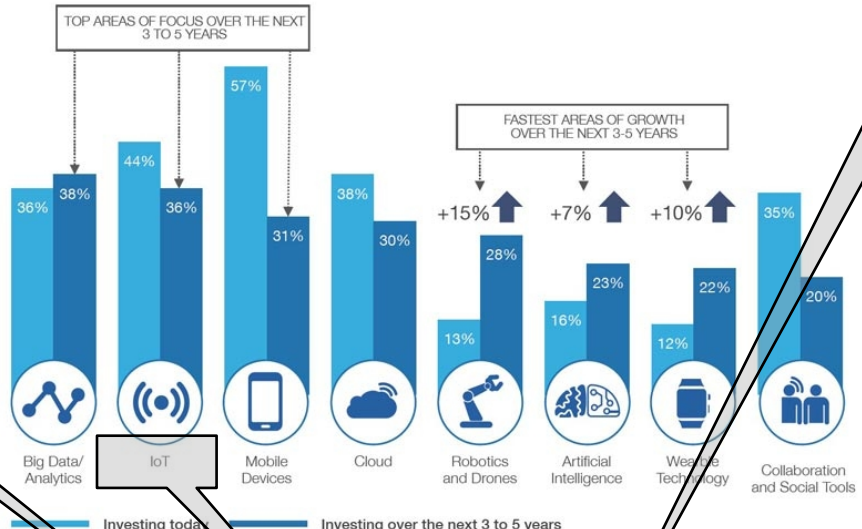




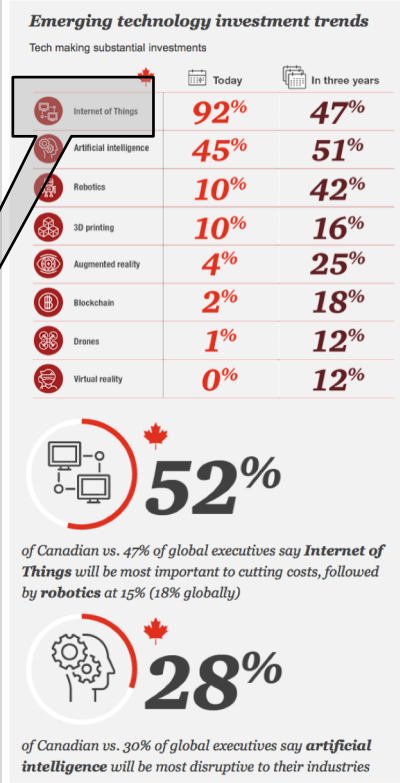
DEFINITELY YES!

Is CPS/IoT a key technology?





Source: Accenture, The 2016 Upstream Oil and Gas Digital Trends Survey

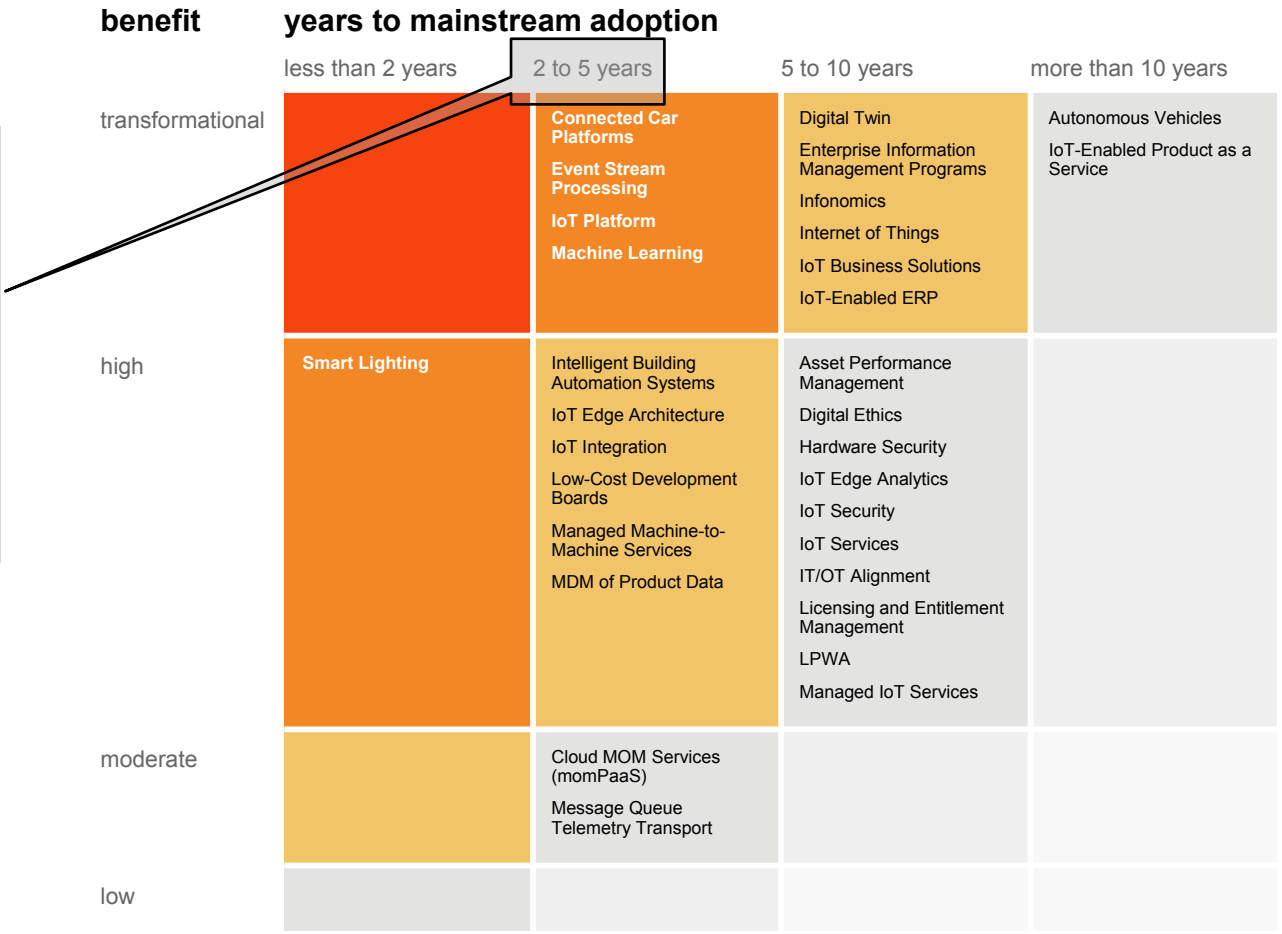


DEFINITELY YES!

Readiness level

According to Gartner, CPS/IoT technologies are still in an early stage of development.

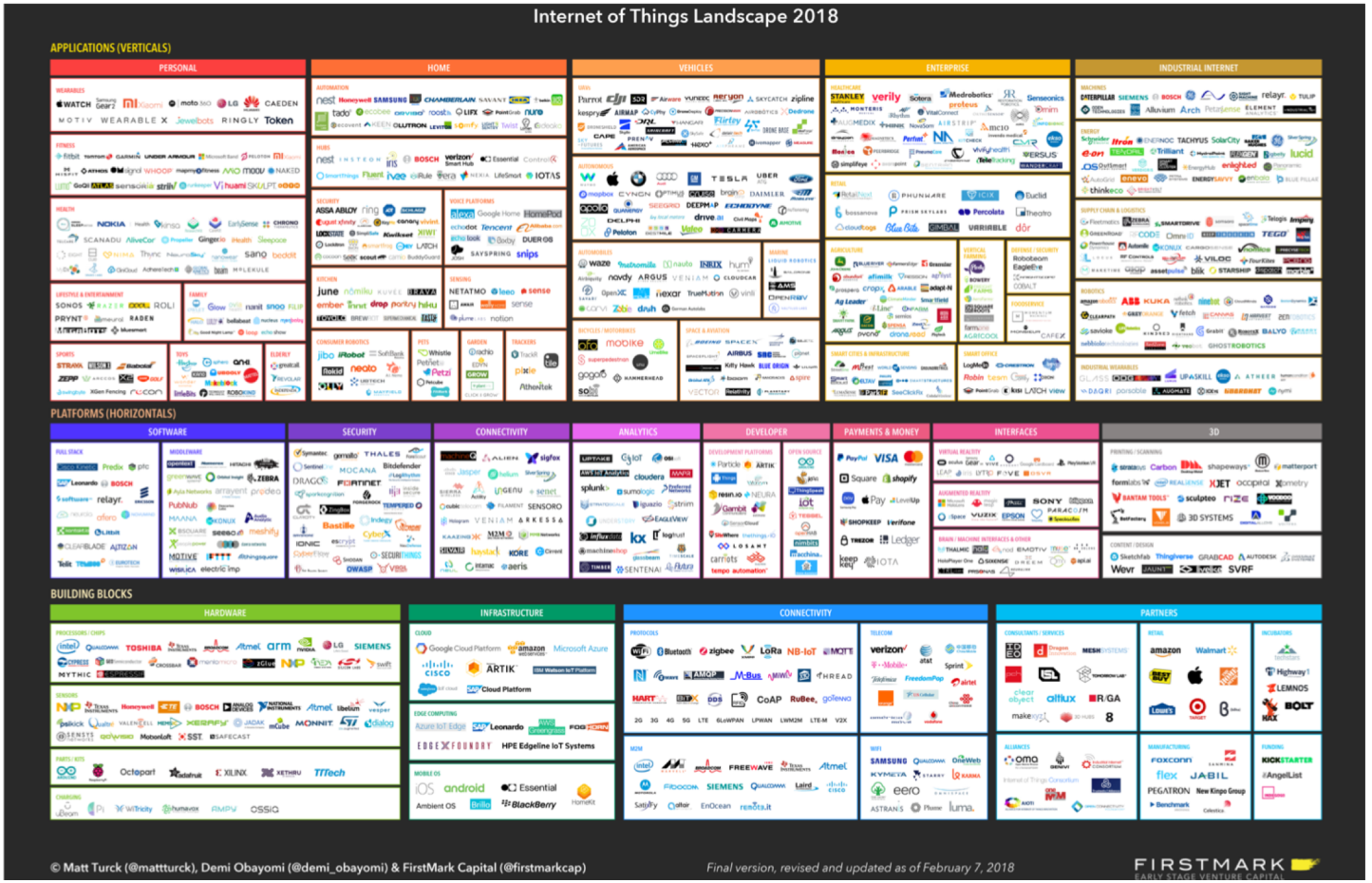
At least 2-5 years will be required for their adoption in the market main stream.



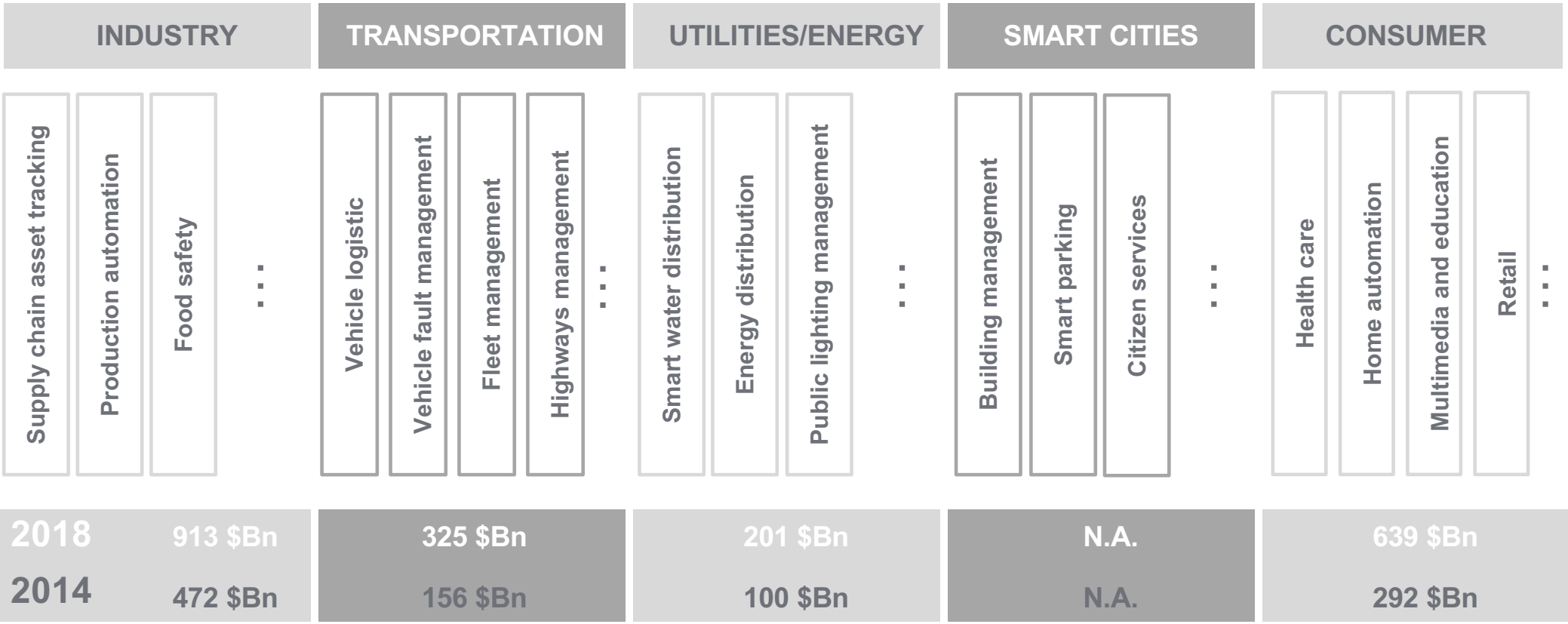
IoT Landscape 2018

Hundreds of companies are already strongly involved in IoT and CPS markets:

- building blocks: hardware, materials, infrastructure, connectivity, third parties, …
- platforms: software, security, connectivity, analytics, development, payment systems, 3D, …
- verticals: personal, home, automotive, enterprise, industrial, …



Vertical markets



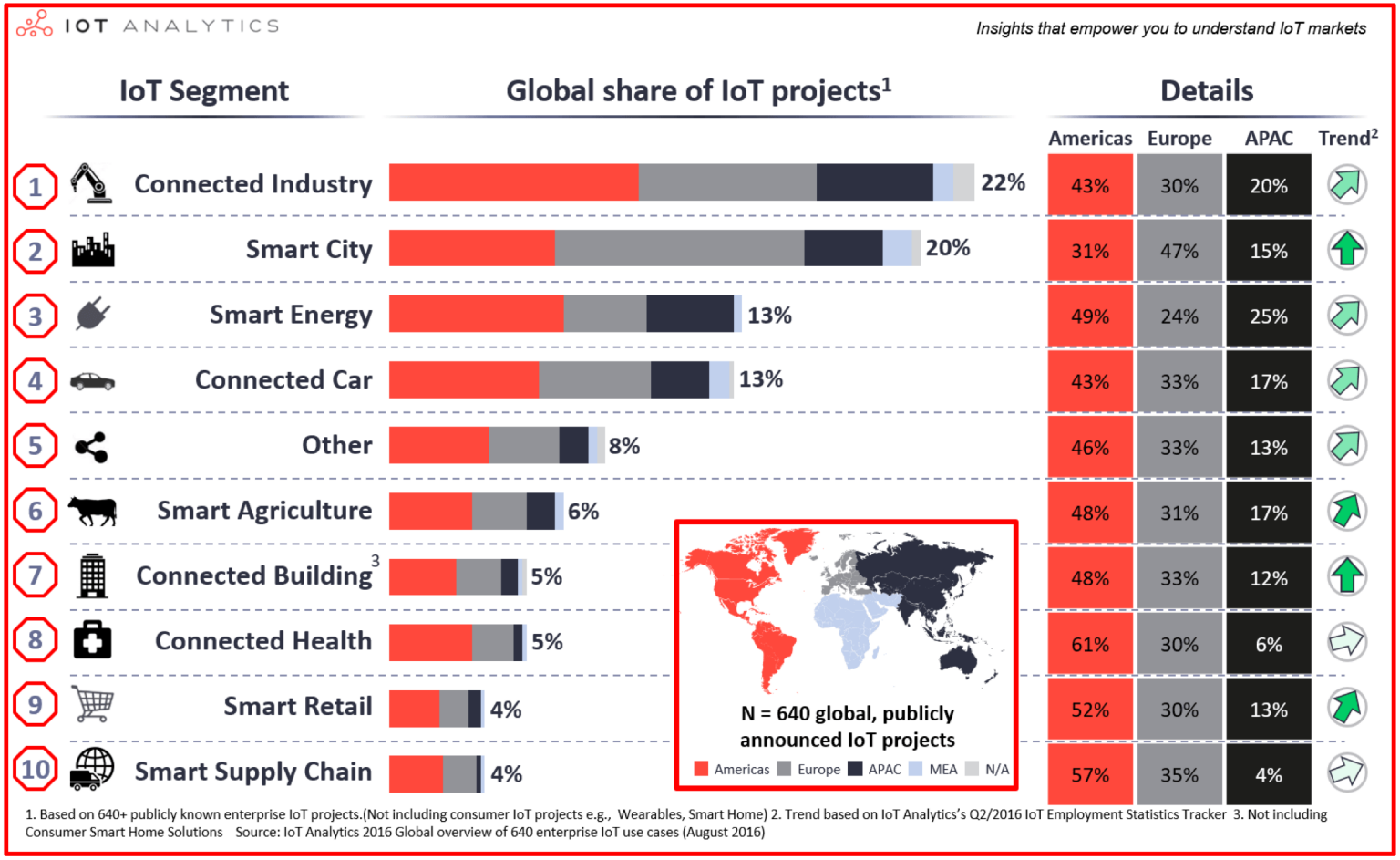
Agriculture (N.A.), banking (92-154$B), government (301-570$B) and others (877$B-1.79$T)

Source IDC

IoT market segmentation

More than 50% of the market share is on industry, smart city, smart energy and automotive.

The growth rate ranges from 25% to 40%.



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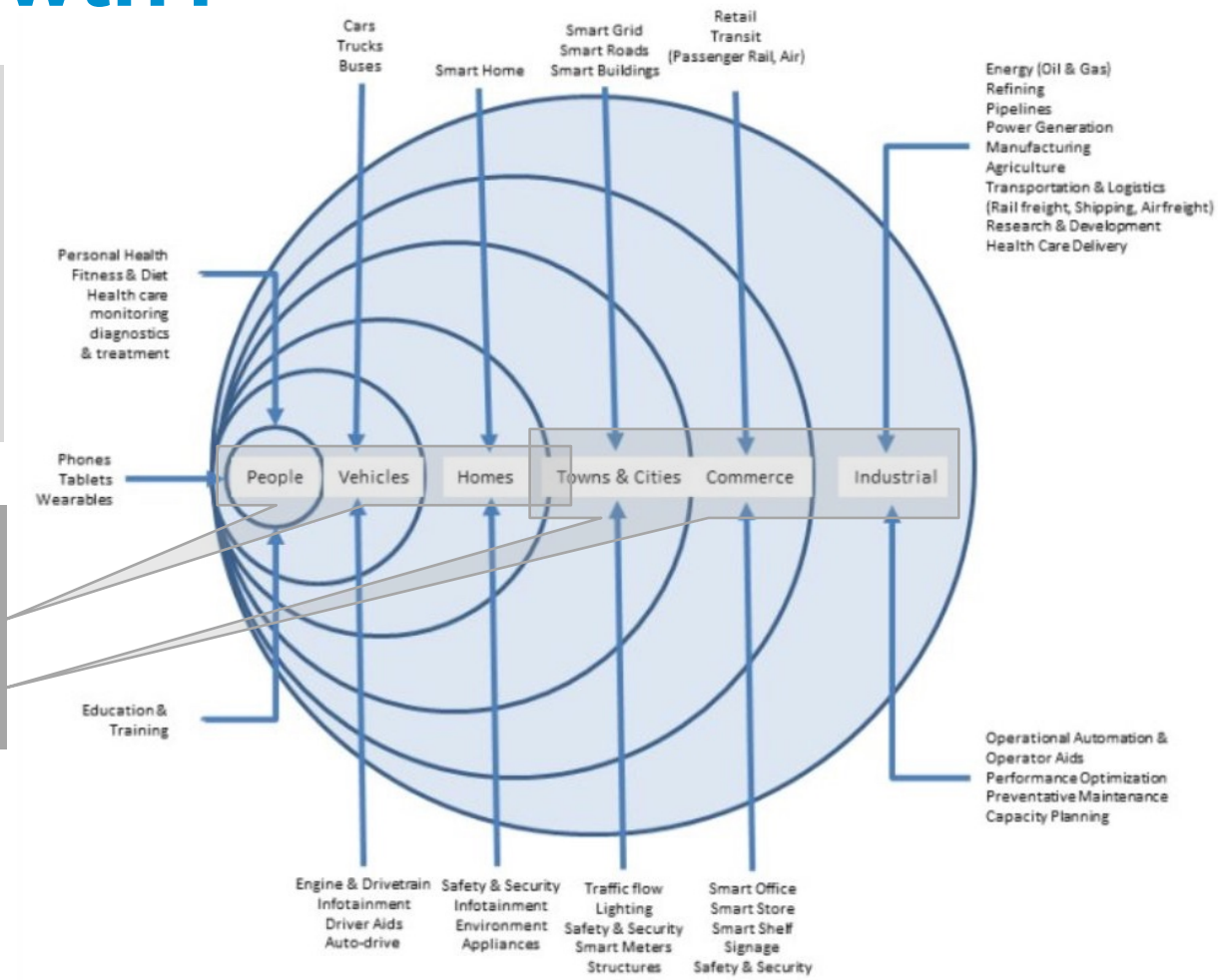
A sequential growth?

A diffused opinion identifies the origin of IoT/CPS technologies in the “personal” domain. The growth follows the sequential improvement of technologies conceived for people.

But consumer requirements deeply differ from industrial requirements, and also the related solutions differ…



Source: Based on Goldman Sachs Global Investment Research. Additional analysis by WMG

Industrial vs consumer

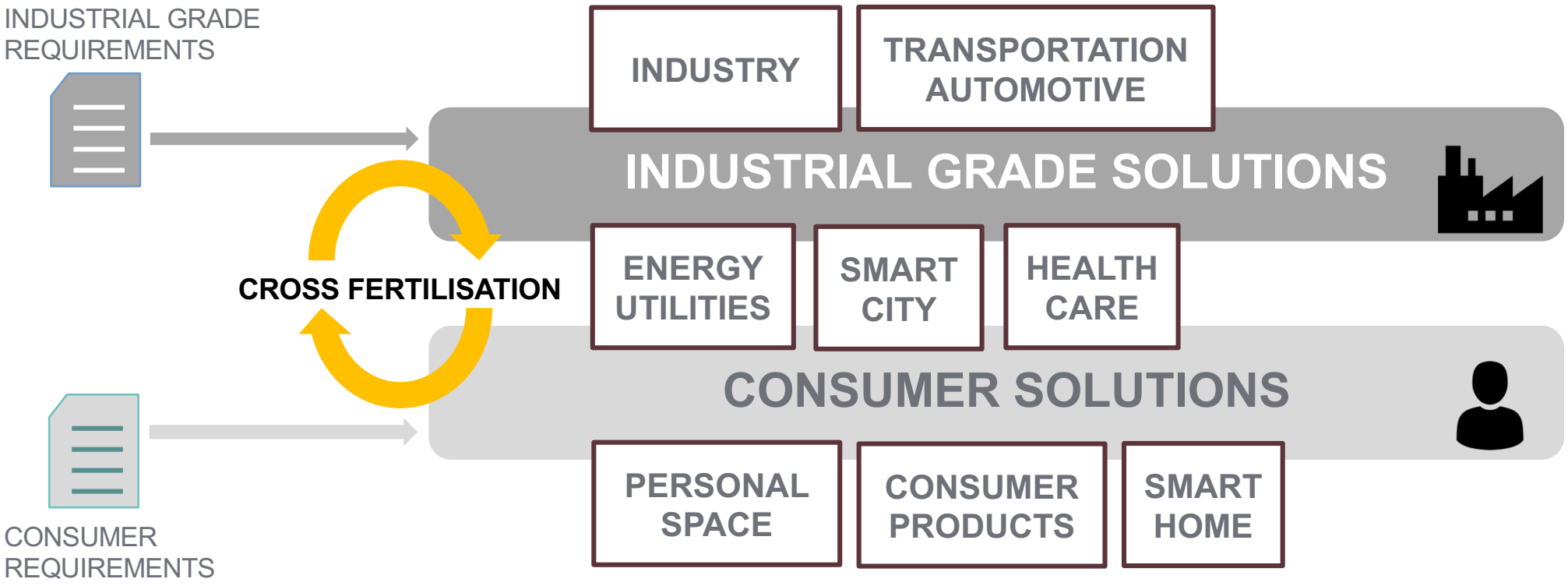
Industrial domain

- Focus on the return of investment by improving efficiency, safety and productivity.
- A system failure could be critical. Resilience, fail in place.
- Driven by machine productivity.
- High reliability, harsh environments, long lifecycles.
- High security levels.
- Requires full control, high availability and uptime.
- Data volume very high.
- Structured connectivity. Industrial standard based and proprietary protocols.
- Legacy and new devices/standards.
- Brownfield, devices/solutions uptake must be phase-in and planned.

Consumer domain

- Focus on the convenience for individual consumers.
- A system failure is not critical. Retry, replace.
- Driven by human productivity.
- Moderate reliability, easy of use, short lifecycles.
- Security focused on identity and privacy.
- Updates, charges, user apps download & random reboot are tolerated.
- Data volume medium to high.
- Ad-hoc connectivity. Mainly IP-based protocols.
- New devices and standards.
- Greenfield, devices/solutions fast market uptake.

A growth based on cross-fertilization



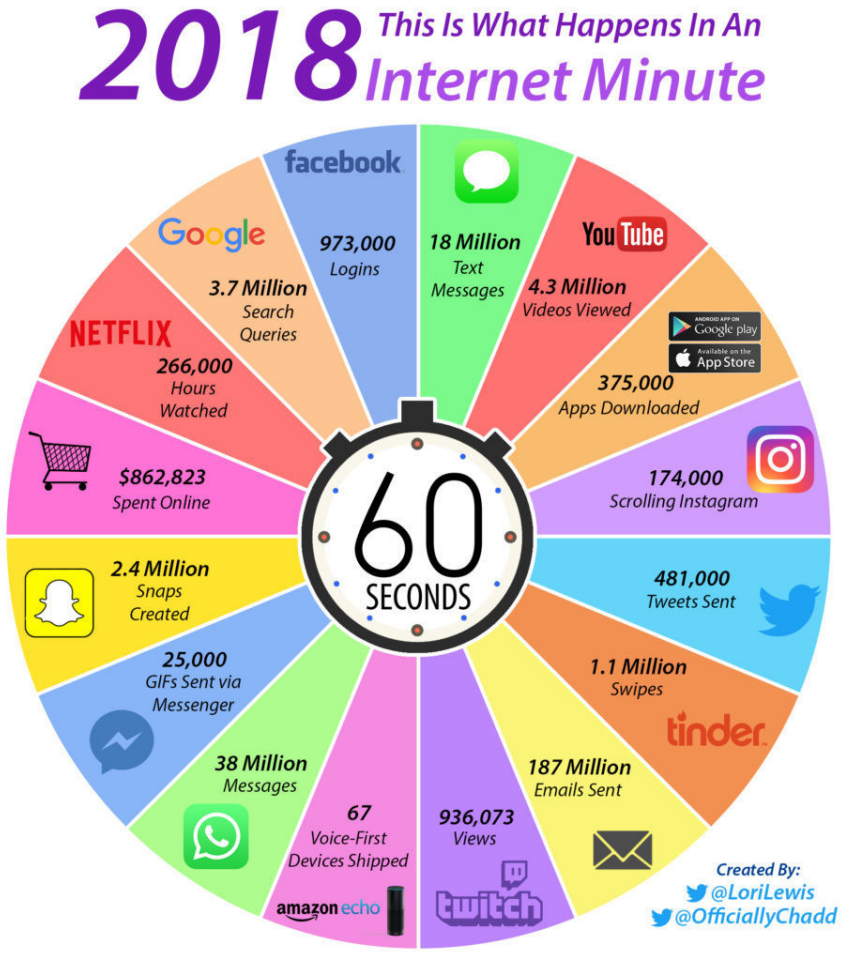
The scale of “operations”

”Internet in a minute” is not just a curiosity!

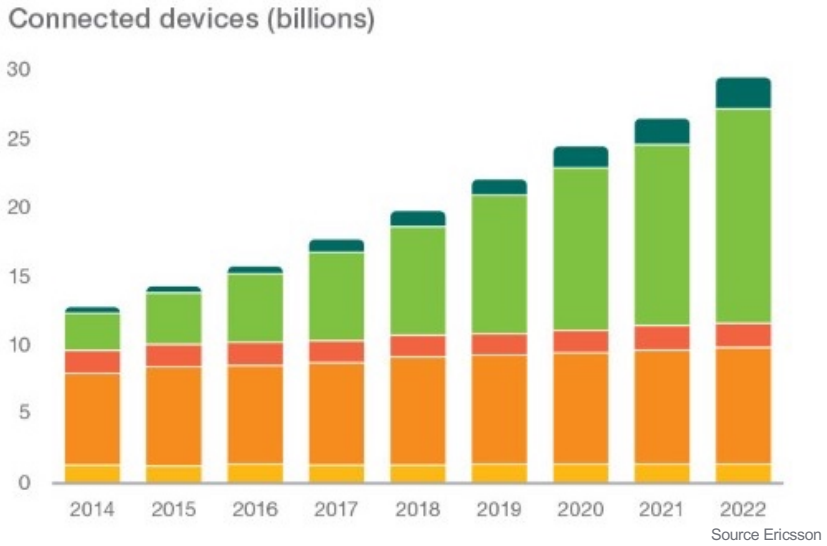
It gives a clear overview of the Internet load required to support consumer applications.

And, proportionally, allow to imagine the dimensions of the “throughput” potentially required in CPS/IoT based systems.

Many consumer applications considered by the analysis are IoT application at the end …



Connectivity and connected devices



Source Ericsson

Around 30 billion of connected devices are forecast by 2025-30, of which around 18 billion will be related to IoT.

A connected device is a physical object that has an IP stack, enabling two-way communication over a network interface.

- 70% of wide-area IoT devices will use cellular technology in 2022;
- In 2018, mobile phones are expected to be surpassed in numbers by IoT devices;
- In 2017 around 400 million of IoT devices already use cellular connections.

IoT devices: connected cars, machines, meters, wearables, consumer electronics, etc.

	2016	2022	CAGR
Wide-area IoT	0.4	2.1	30%
Short-range IoT	5.2	16	20%
PC/laptop/tablet	1.6	1.7	0%
Mobile phones	7.3	8.6	3%
Fixed phones	1.4	1.3	0%
	16 billion	29 billion	10%

Source Ericsson

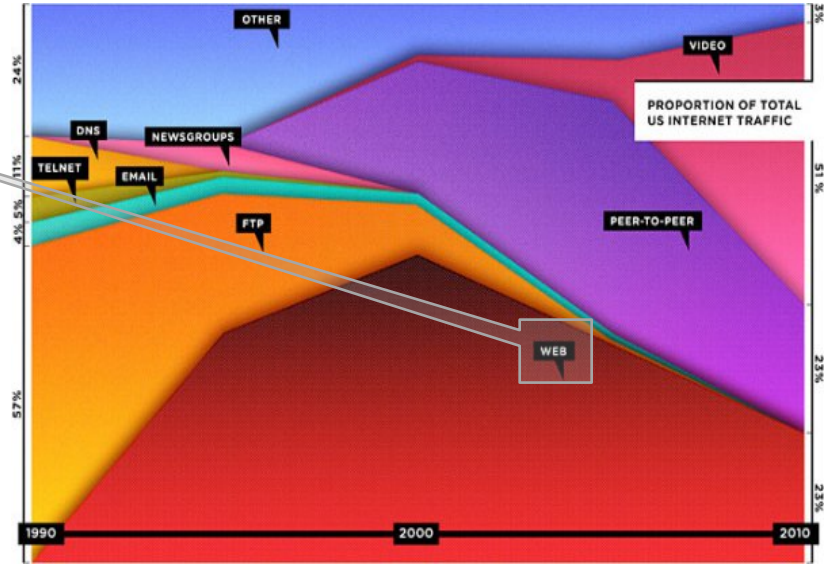
Connectivity evolution

Since 2010 the traffic generated by WEB navigation has been drastically decreasing. A large part of the traffic today is generated by **mobile entities**: 15 billion IoT devices with cellular connections by 2022.

This significant growth is due to:

- increased industry interest in CPS/IoT;
- 3GPP standardization of cellular IoT technologies;
- new IoT-inspired functionalities available on cellular connections, like provisioning, device management, service enablement and security.

The 3rd Generation Partnership Project (3GPP) unites [Seven] telecommunications standard development organizations (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC), and provides their members with a stable environment to produce the Reports and Specifications that define 3GPP technologies in cellular communications.



Source CISCO

Massive IoT application requires high speed connections and small data traffic volumes, low cost devices, with low power consumption.

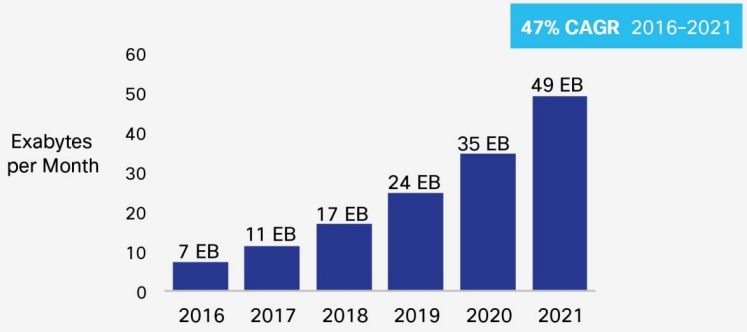
Critical application requires ultra-reliability, availability, low latency and high data throughput.

The reduction of modem costs and the evolution of LTE functionality and 5G capabilities could support both massive and critical IoT deployments.

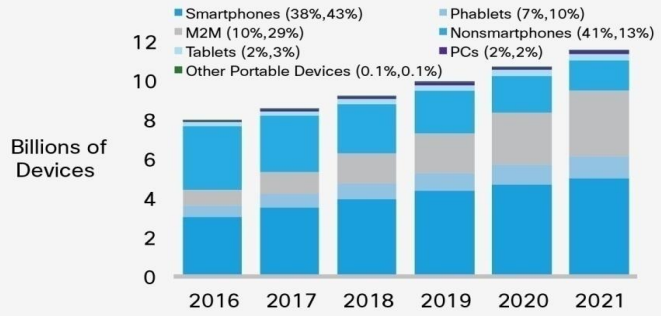
Mobile connectivity forecast

Source CISCO

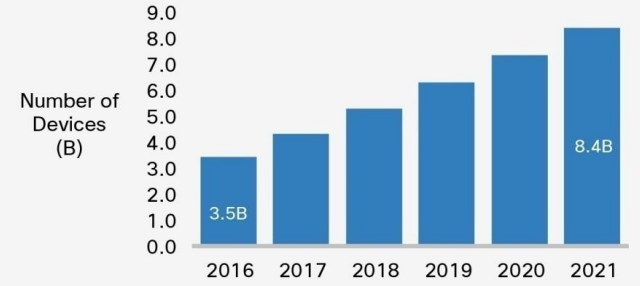
Exabytes x month



Devices and Connections Growth - 8% CAGR 16-21

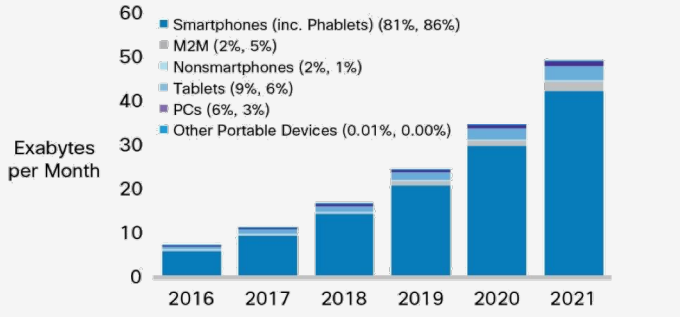


IPv6-Capable Mobile Devices – 20% CAGR 16-21

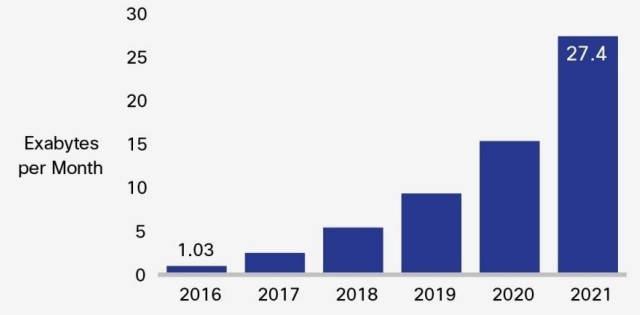


Traffic forecast by region

Traffic Growth by Device Type – 47% CAGR 16-21



IPv6 Mobile Data Traffic – 92% CAGR 16-21



CPS/IoT security

The ubiquity and pervasiveness of CPS/IoT, the heterogeneity of devices and their capabilities expose both industrial and consumer domains to a huge set of security risks.

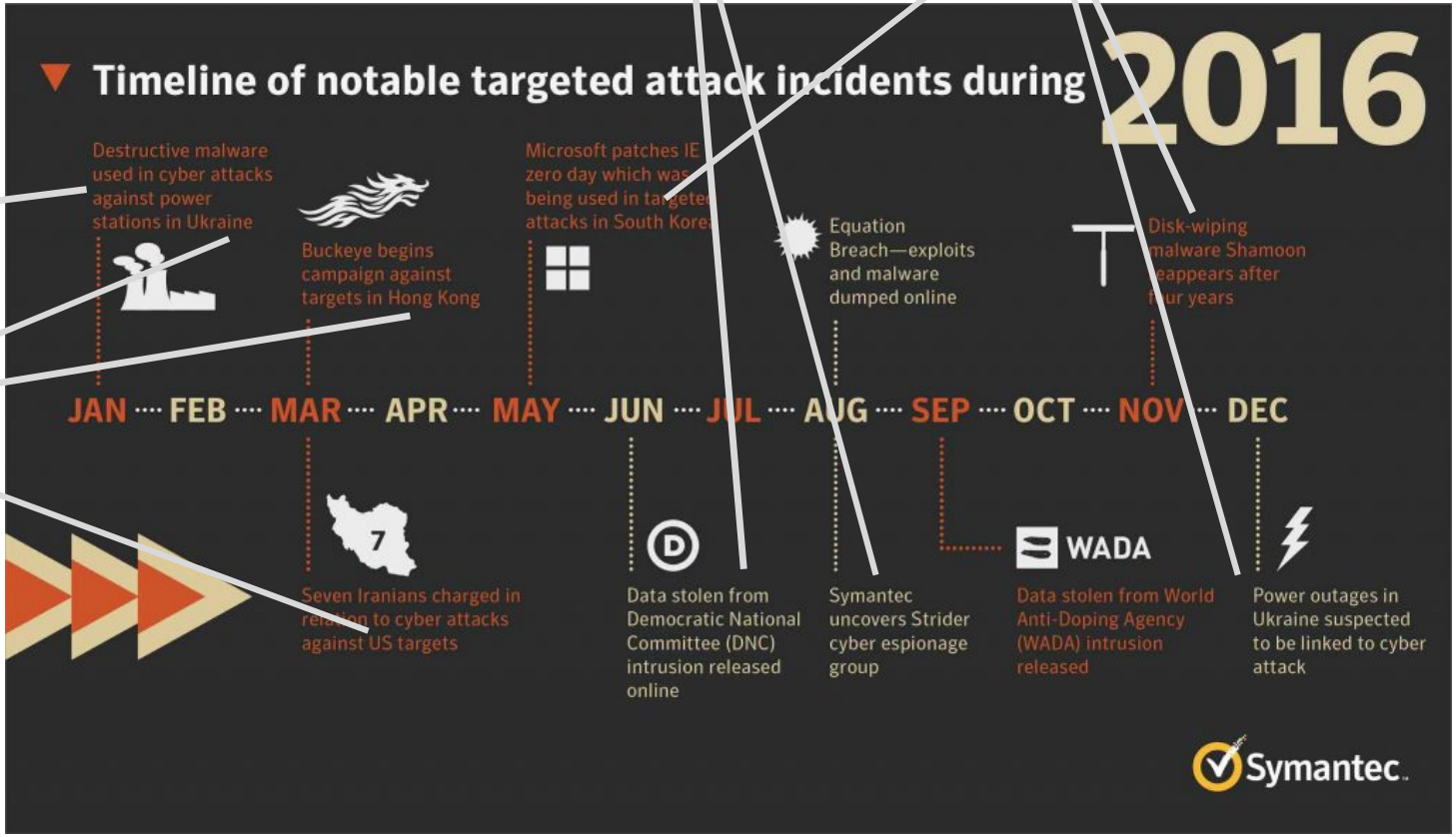
A security risk in the digital world affects also the physical world.

Security has a global geographical impact.

Security threats must be tackled on a daily basis. Every month the digital world is affected by hundres of significant attacks.

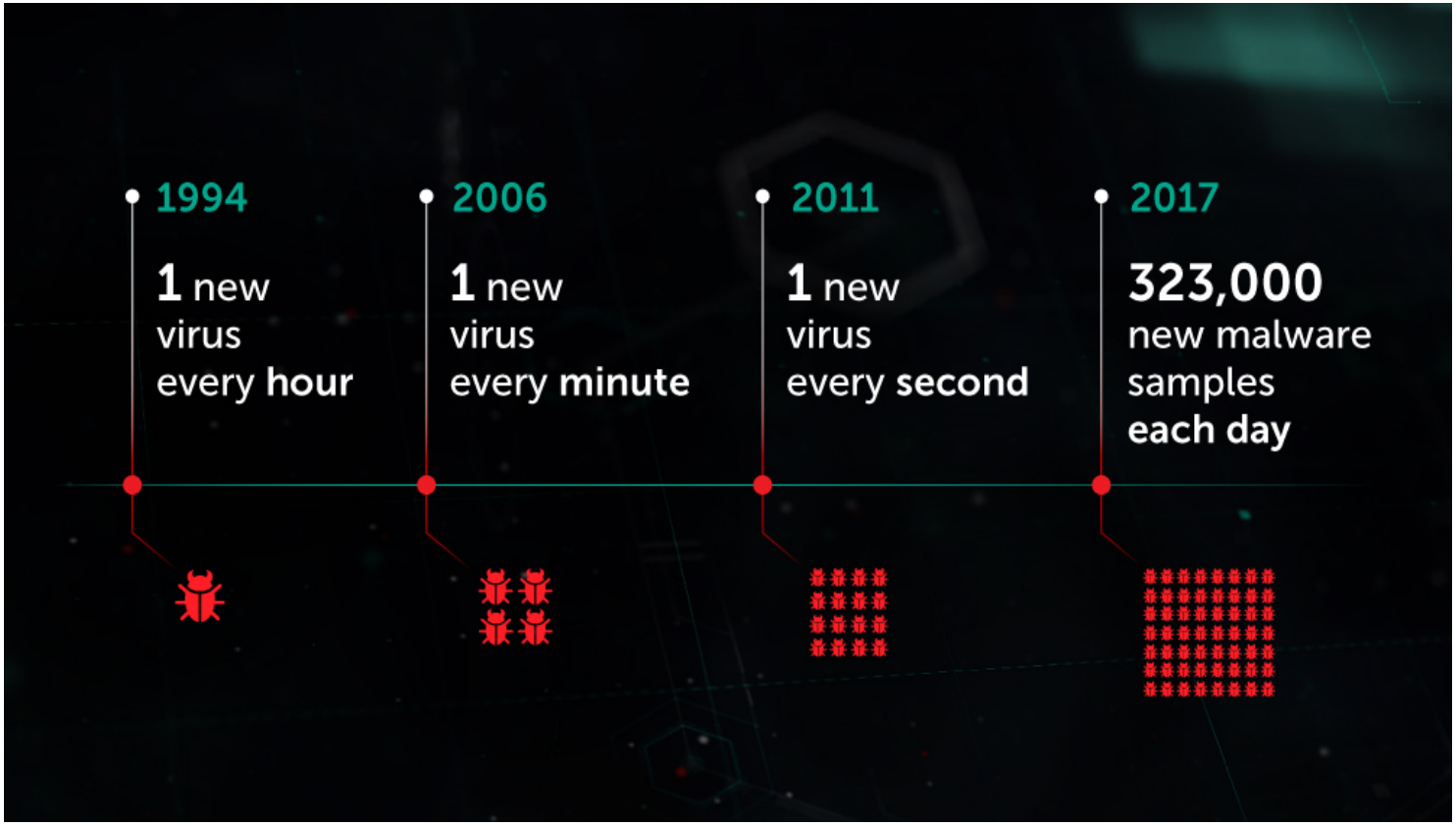
Risks on user privacy, industrial and governmental sensible information, …

Security has a global technology impact.



Attacks evolution

The growth of CPS/IoT ecosystem is unprecedented, but also the criticality of security will be unprecedented.



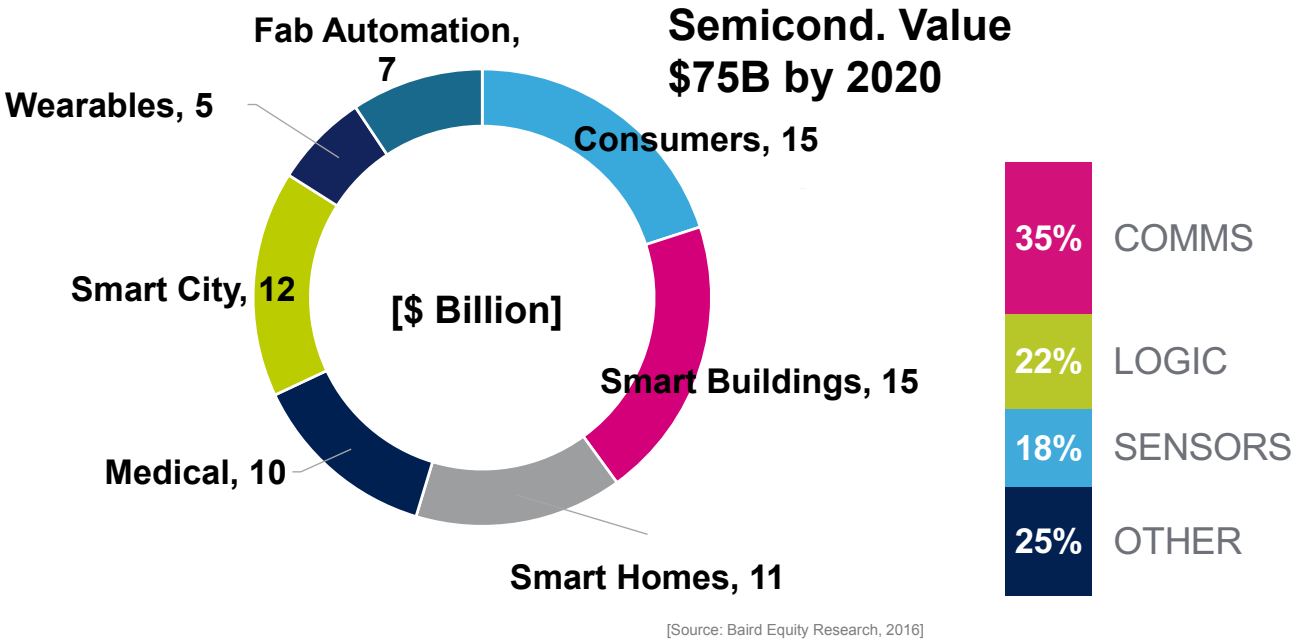
The role of semiconductors

Semiconductors are the foundation of CPS/IoT:

- increase the capabilities of devices,
- enable processing on the edge,
- enable connectivity,
- represent the contact point between the physical and digital world.

Semiconductors are fundamental both for DIGITALISATION and HYPER CONNECTIVTY.

Note: smartphones, tablets and PCs are not included.



[Source: Baird Equity Research, 2016]

Key end-markets:

- Industrial: smart meters, smart buildings, farm, city, and smart fab
- Consumer: smart appliances, smart homes and cars
- Wearables: fitness bands, smart watches

Investments in CPS/IoT

From explosive growth, the investments in CPS/IoT are moving to a much more cautious approach. The investment remains very high in the aggregate.

Larger, more concentrated investments in a smaller number of companies, typically at the growth stage.

Most IoT startups were Seed or Series A companies. In 2016, about 73% of VC deals were at the Seed and Series A level; in 2017, this number dropped to 53%.

The most active investors have been **huge corporate venture arms**, that played a primary role to support the CPS/IoT domain:

- Intel Capital
- GE Ventures
- Qualcomm Ventures

The **big exits of 2017** involved companies that were **already public, e.g.:**

- Intel purchased AI/computer vision company Mobileye for $15 B.
- Samsung acquired connected car solutions specialist Harman for $8 B.
- In IoT security, Thales acquired Gemalto $5.6 B.
- Itron acquired mesh connectivity specialist Silver Spring Networks for $830 M.
- Sierra Wireless acquired full stack managed platform Numerex for $107M
- OpenText bought IoT middleware platform Covisint for $103M.

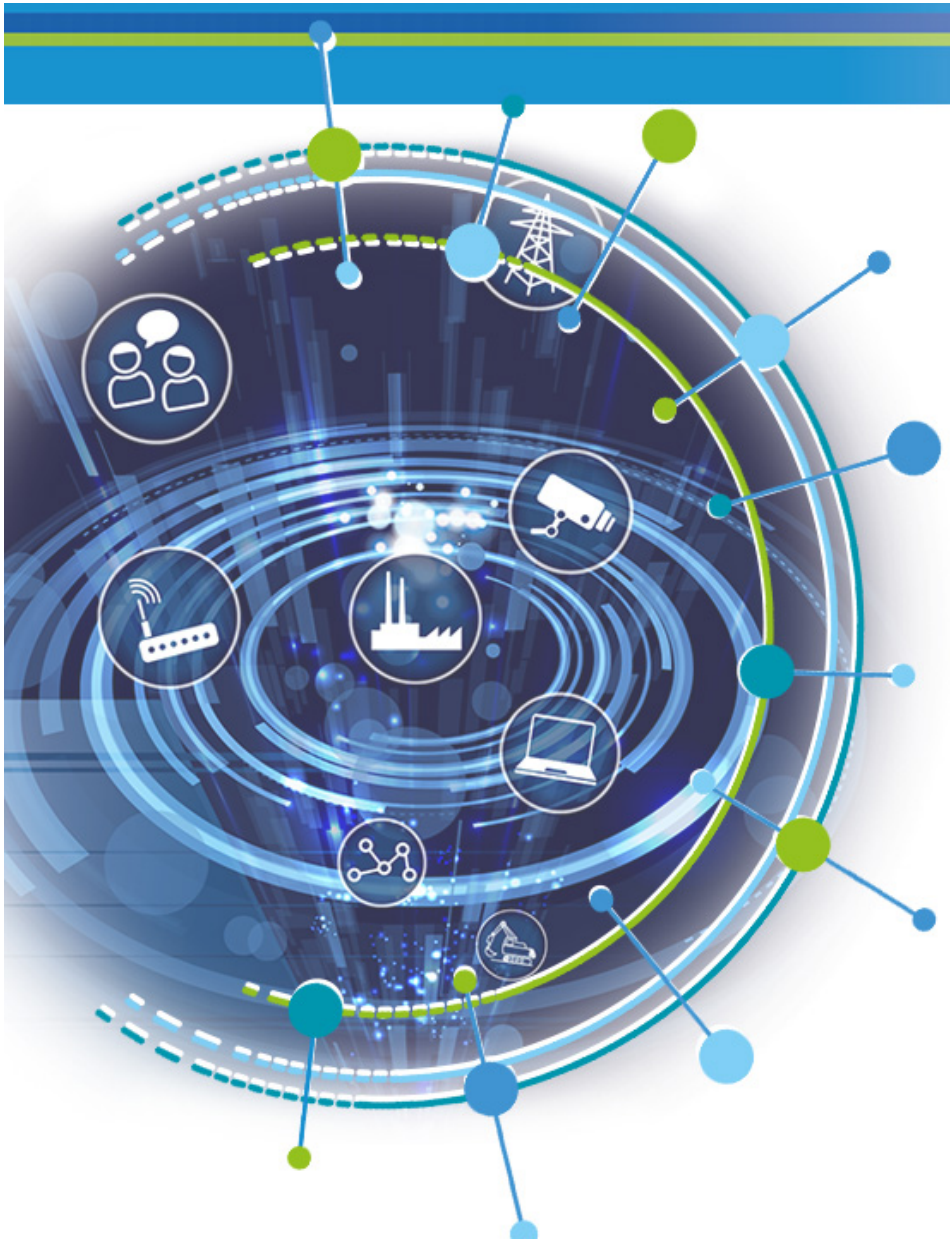
IoT startup exits in 2017 has been very poor, with acquisitions not over $500 M**:**

- Continental purchased automotive cyber security startup Argus, $450 M.
- Delphi acquired autonomous vehicle startup nuTomy for $400 M
- John Deere bought agriculture machine learning company Blue River for $305 M

Pretty meager year in terms of **IPOs**:

- Switch Inc., a data center infrastructure company.
- ForeScout Technologies, cybersecurity company.

Note: information focused only on the US market



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Research and innovation

CPS/IoT research

Is research providing answers to the CPS/IoT challenges?

Is it capable to find **concrete solutions** to the practical issues that engineers face building CPS/IoT?

There is a gap between the CPS/IoT market and CPS/IoT industrial/scientific research (a gap[2] for SoS):

Companies are still far from the CPS/IoT state of the art.

Research has left too many open issues behind.

For SoS, research is in a very early stage, or completely missing.

A more pragmatic research

CPS/IoT market is far from being a stable reality: huge revenues in some domains, few revenues in others, customers don't know what CPS/IoT is, what are the advantages, they are scared and don't trust technology, platforms are not mature, there is no interoperability, …

The reality is very different from what we usually depict and foresee in our research projects. Just some examples that illustrates the gap:

Market readiness: many customers still discuss if their future will be with microcontrollers or microprocessors … and research talks about microservices, digital twins, AI, …

Lack of TRUST: the customers don't trust the distributed nature of IoT, the security and the protection of data …

RESEARCH & INNOVATION

Business un-awareness: the customers still focus on the cost of the device, not on operative and maintenance costs…

Inadequate solutions for **connectivity:** LTE adoption had a stop (AT&T and Verizon already stopped further sim activation for IoT devices), the future of 5G is very uncertain…and the actual 4G network is overloaded…M1 and Narrowband IoT don't take off.

Some research priorities

Predictive and preventive self-learning systems:

- increase productivity on continuous product manufacturing,
- and process change manufacturing;
- improve efficiency of preventive/predictive maintenance …

Data collecting and analysis:

- real time analytics along the whole lifecycle and value chain/network;
- integration and interoperability of all stakeholders …

Humans in CPS/IoT:

- improve well-being, human engagement and productivity;
- increase the use of humans' technology awareness;
- optimize working conditions …

Professional training:

- faster development of competencies;
- more efficient recruitment processes;
- Return On Training (ROT), improvement of manufacturing and business processes with proper professional training.

Manufacturing automated reconfiguration:

- shorten the time to market;
- reduced planning effort and improved scheduling activities;
- production flexibility and improve up-time of machinery.

Manufacturing as a Service:

- improve production, reduce distribution costs and time to market;
- increase flexibility (product variants) and elasticity (production capacity);
- SMEs inclusion …

Some research priorities

Production management tools and models:

- better use of machines through distributed and real-time control;
- promote plug-and-produce;
- better production system lifecycle management;
- production mix management …

Focus on customer:

- increase of market shares;
- customer satisfaction;
- decrease of design and engineering costs …

Cyber Native Factories:

- integration of IoT compliant machine;
- legacy machines/lines support;
- implementation of shorter ROI;
- reduction of the environmental impact …

CPS/IoT Open Platform:

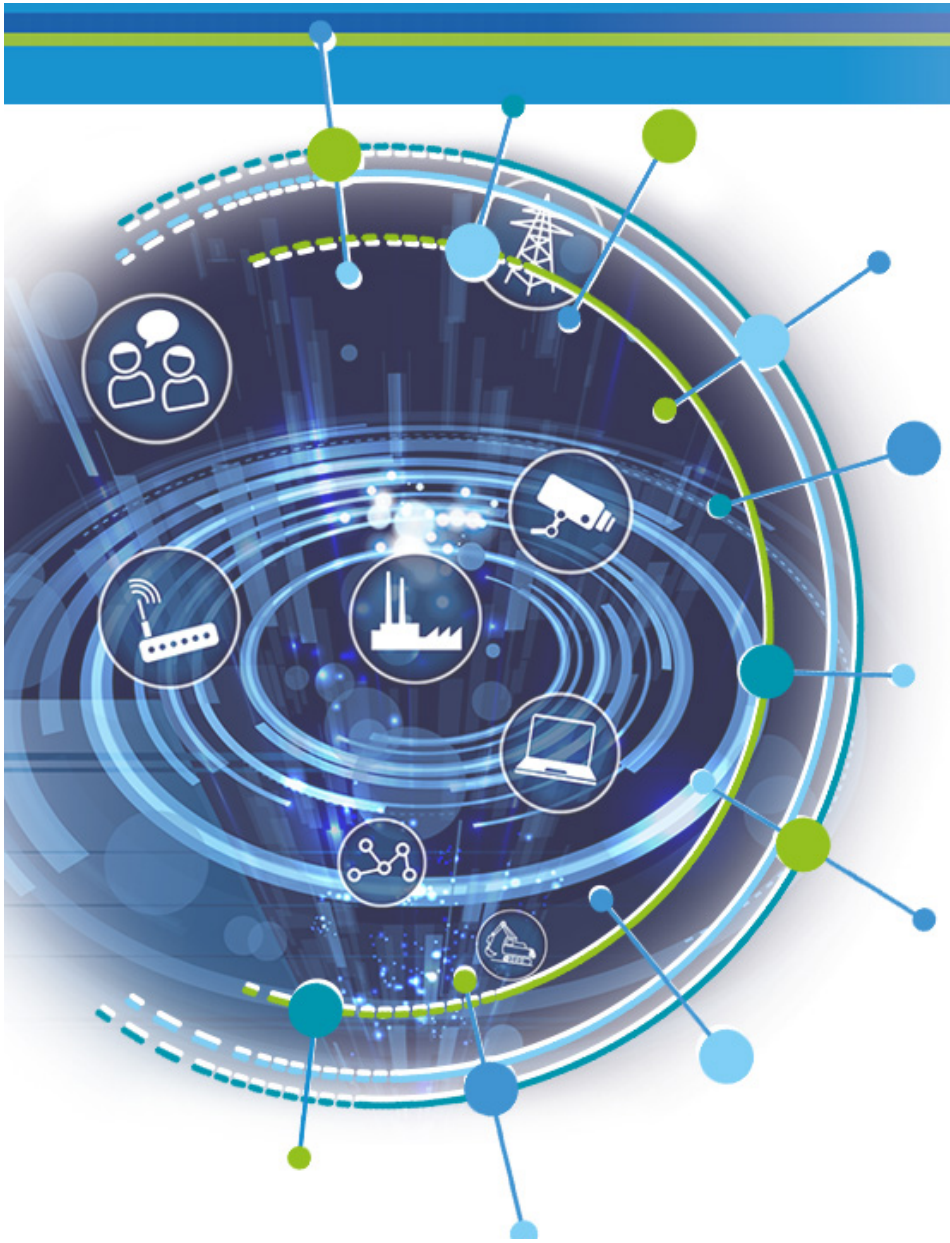
- optimize manufacturing processes in a seamless, easy and friendly way, with existing platforms;
- innovation ecosystems for a EU Circular Economy;
- improve knowledge circulation.

Digitalization of value networks:

- increase supply network visibility;
- risk reduction along the supply network;
- reduce production total cost;
- reduce carbon footprint;
- improve customer service …

Materials and resources efficient use:

- improve sustainability, reducing energy use, CO_2 emissions, pollutants, waste of resources and materials …



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From value chain to value network

From value chain to value network

CPS GENERATE A RADICAL CHANGE IN THE STRUCTURE OF THE CURRENT ECONOMIC SYSTEM:

LINEAR VALUE CHAIN ➡ NON-LINEAR VALUE NETWORK

CPS/IoT have a **deep networked** nature that generates a value network, which requires an appropriate **ecosystem**.

A single company is not capable to offer an **all-inclusive solution**, addressing the entire value network.

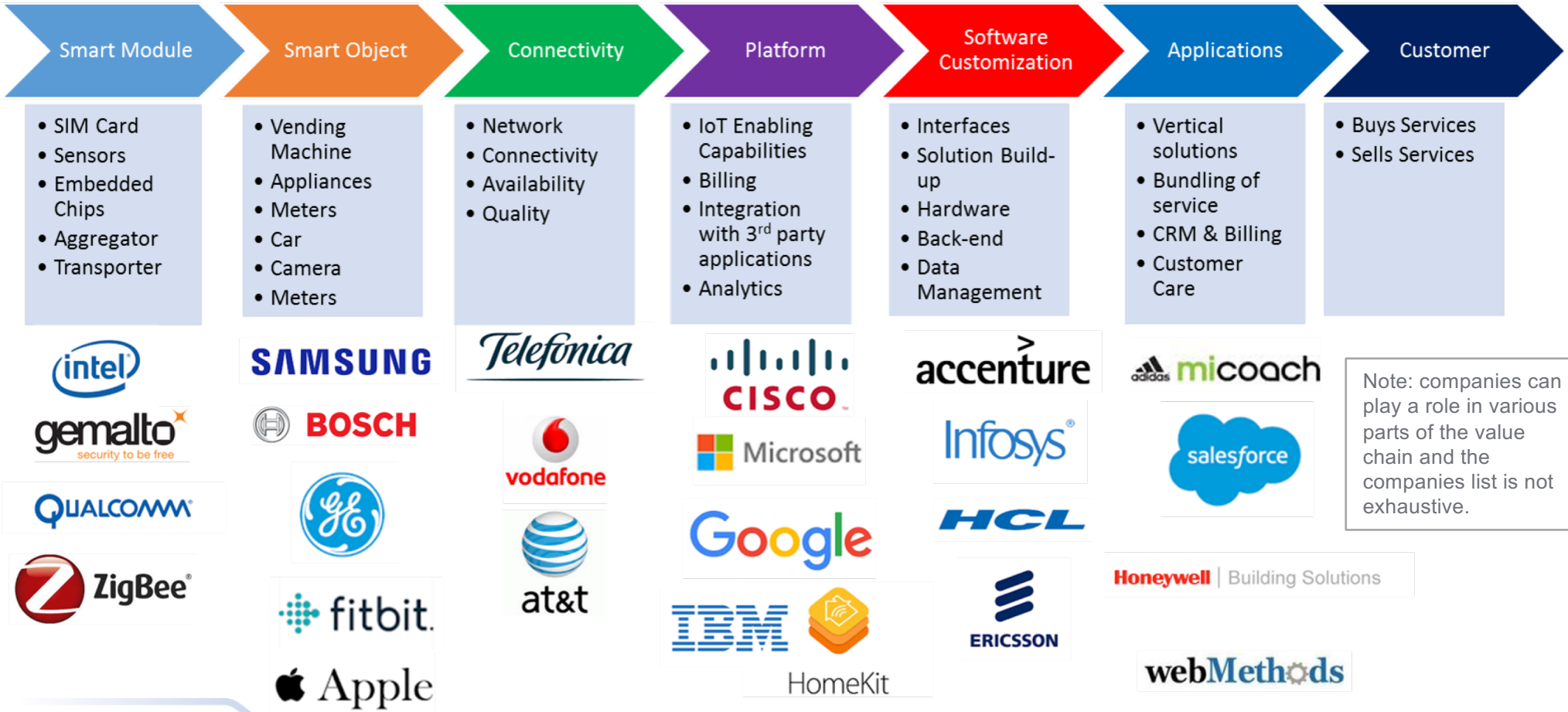
An ecosystem of companies, with **complementary** competences and business is the appropriate answer.

New and existing actors will be able to **integrate** both vertically and horizontally encompassing all the stages of production.

In a value network, software providers, service providers, brokers and end-users may **collaborate** in a flexible manner for the creation of a product.

The conventional boundaries between industries, technologies and vertical domains will fade away.

Example of value chain



Note: companies can play a role in various parts of the value chain and the companies list is not exhaustive.

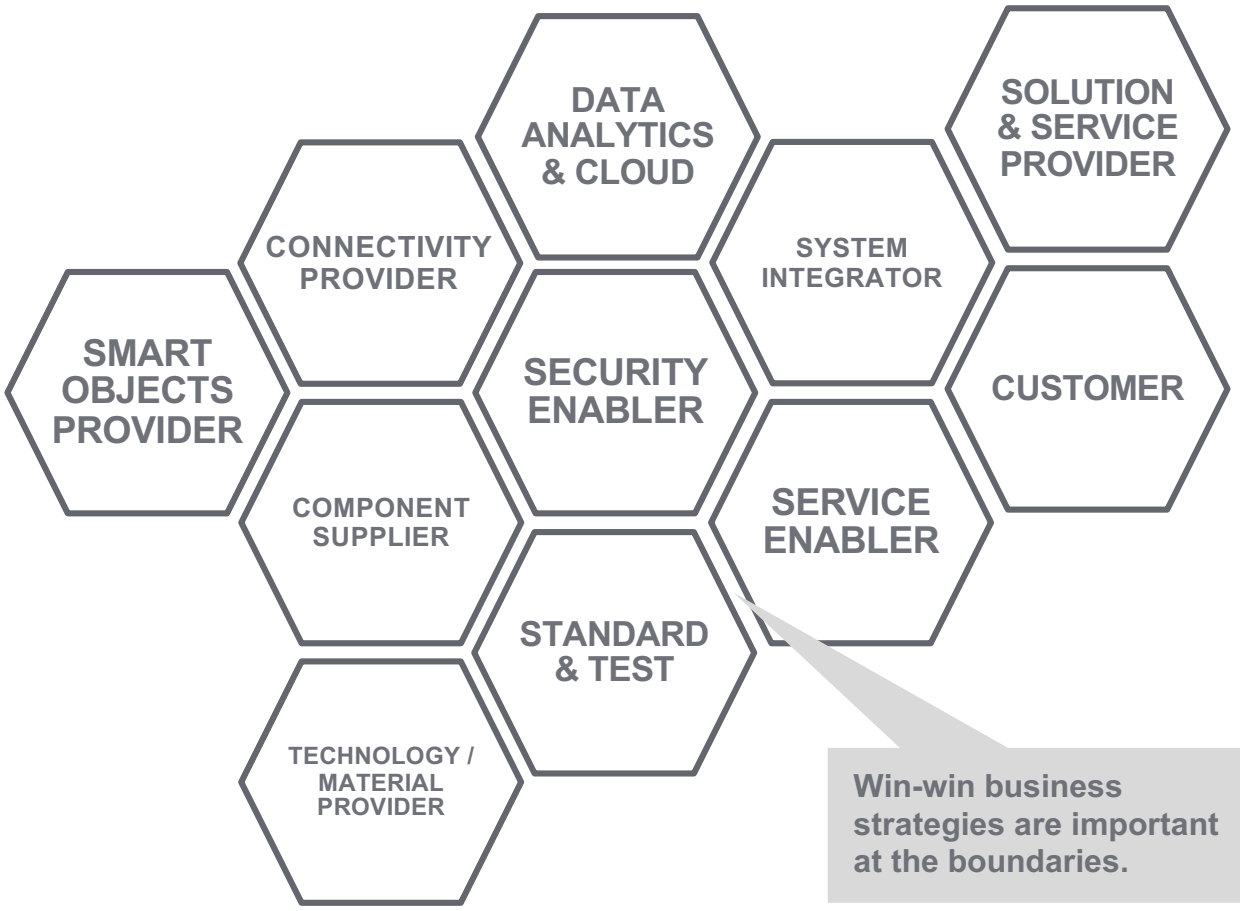
(Source Telecomcircle.com)

CPS/IoT value network

Company should design their business model starting from their closer environment (direct suppliers, clients, etc.) but also considering the entire ecosystem of their products or services.

Additional value propositions and potentially new revenues streams could be created – i.e. new business model combinations.

Any business combination in the network could potentially work.



CPS/IoT value network

1st step - **vertical integration**: the IT systems of all companies in a vertical, from logistics, resource planning & usage to production and sales, can interact seamlessly through a standardized architecture.

2nd step - **horizontal integration**: multiple verticals are integrated and processes are now connected beyond the boundaries of one single entity, spanning the entire ecosystem.

Value network has an impact on **competitivity**. The complexity of CPS/IoT pushes companies to bring all competencies under a single umbrella.

In the value network, a multitude of actors, with their own peculiarities, could forge alliances and partnerships, which in turn will compete against each other.

In a value network the traditional roles and responsibility can mix, shift and change:

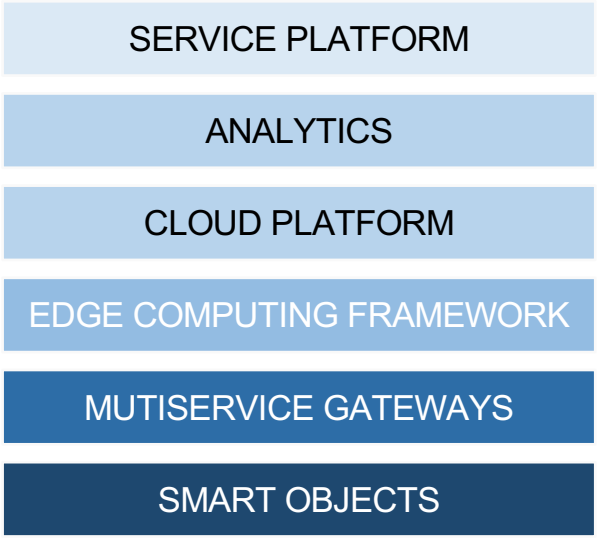
- customers can act as designers for their products;
- machine manufacturers can become service providers, selling both machine and aftersales;
- new service providers will emerge;
- …

From devices to services

CPS/IoT technologies, connectivity, edge computing and cloud computing enable the creation of high-level services: a device, even a single sensor, could become a high-level service. Services become the components of new added value application, potentially multibrand and cross-vertical. Devices-to-service could reinvent business and find new sources of revenues.

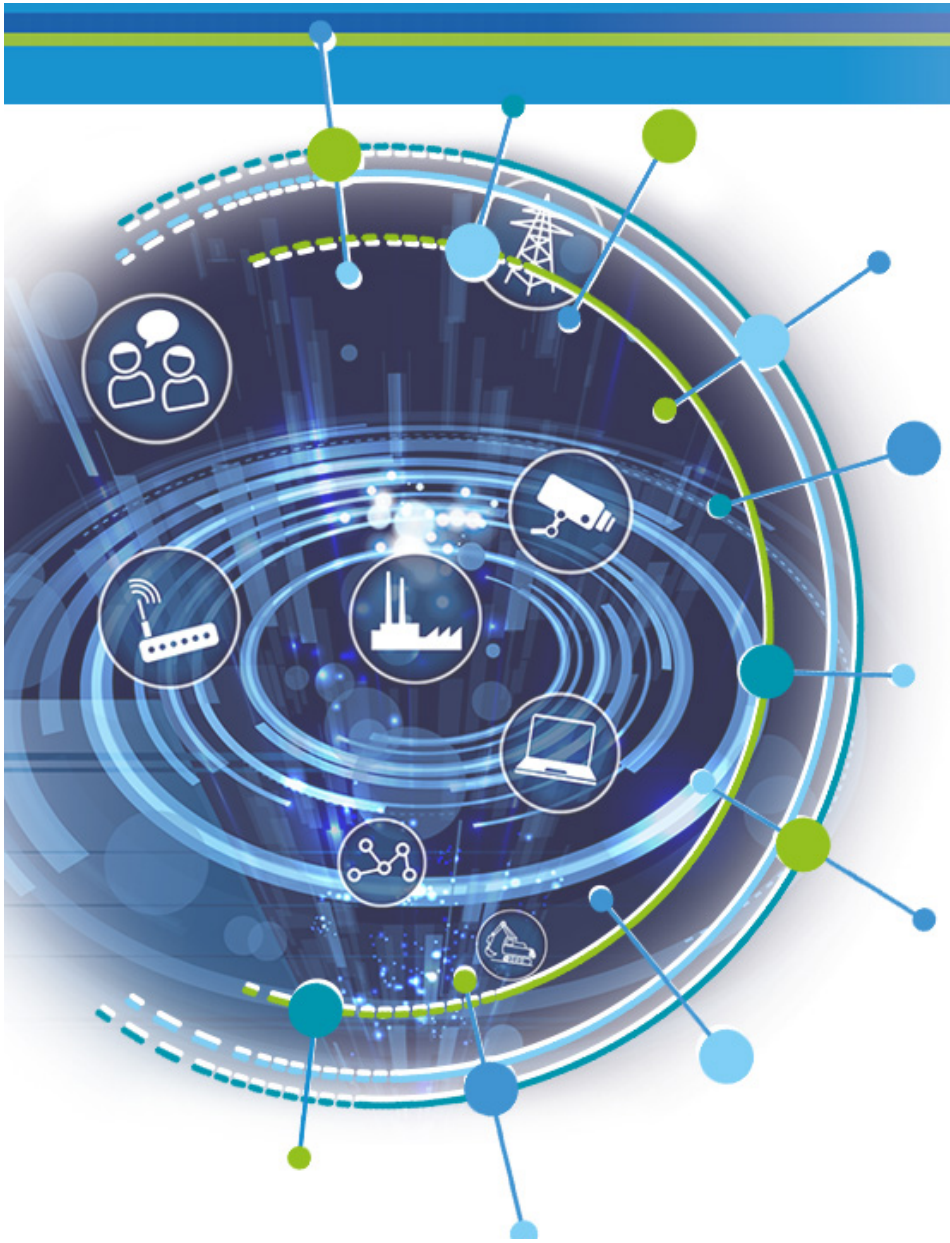
Elements for device-to-service:

- sensors, smart devices and multiservice gateways depending on the architecture;
- IoT oriented edge framework;
- IoT oriented cloud integration platform;
- a service platform;
- a business logic.



Services:

- increase interoperability
- simplify application development
- allow to focus on vertical business logic
- abstract the complexity of the underlaying system
- open new business opportunities
- improve after-sales
- improve the end user experience



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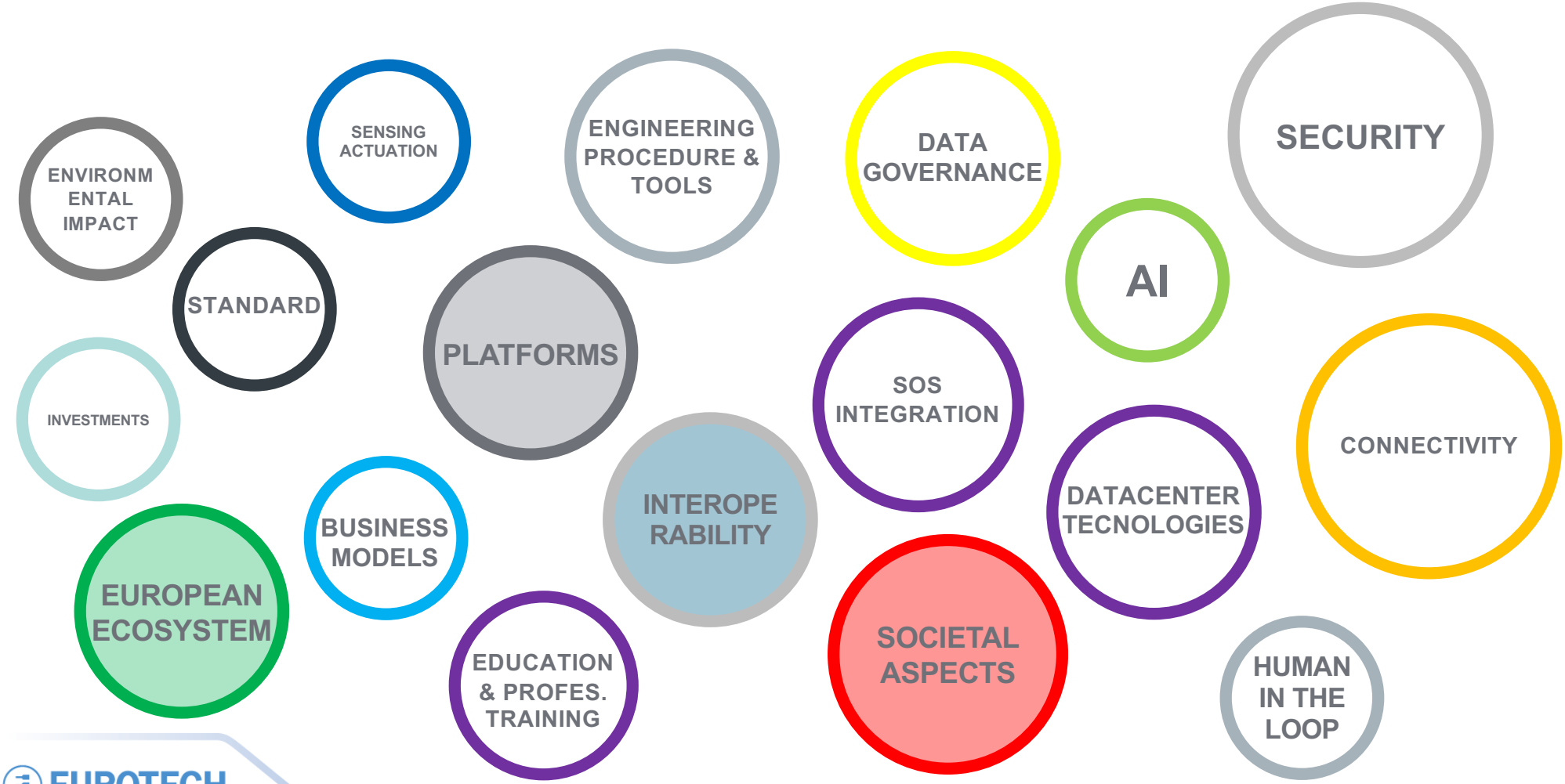
CPS Evolution

What are the CPS drivers?

What are the barriers to be urgently removed?

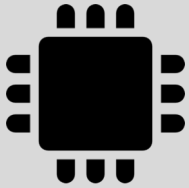
CPS/IoT drivers



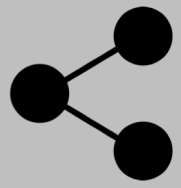
CPS/IoT drivers

4 PRIMARY DRIVERS

SENSING



COMPUTING



CONNECTIVITY

VALUE CREATION

Physical to digital

SENSING

Adding sensing capabilities to CPS/IoT allows for unprecedented collection of data from the environment. We are assisting to the first wave of IoT data monetization.

40 Billion semiconductors

- IoT sensors 18B, 5.5%
- IoT connectivity 12.5B, 11,5%
- Processors 7B, 14.5%

Privacy, safety, information security, standardization, trust

MEMs, TPM, TNC, Crypto technologies, SoC, Radio Chipset, …

Processing on the edge & big data

COMPUTING

The analysis of huge amount of data generated by CPS and IoT devices requires both edge processing, aggregation, analytics and cloud-based big data solutions.

30% Cloud services

- Infrastructure aaS 21%
- Platform aaS 28%
- Could asS 39%
- Other service 12%

Security, data sensitivity, real-time issues, energy efficiency

Cloud tecs, Big Data tecs, Edge & fog computing, Blockchain

Communicate to exist

CONNECTIVITY

Connectivity represents a huge opportunity for telecom operators to expand their addressable markets. But how to move beyond connectivity is a challenge for operators (<5% revenues Telefonica Verizon Vodafone).

Communication is the foundational component of CPS/IoT. The IoT is about embedding connectivity and processing capabilities into devices all around us.

30 Billion devices

- Industrial 5.5B, 25%
- Consumer 6B, 14%
- Comms. 17B, 8%
- Computers 2B, -2%
- Transportation 1B, 21%
- Health care 0.5B, 20%

Cyber-security, standardization, interoperability, energy efficiency, ...

5G, NB-IoT, Private LTE, LoRa, Sigfox, Zwave, …

Value from technology

€ VALUE CREATION

Identify the emerging opportunities created by CPS/IoT and develop new solutions, services and business models, capable to generate value from the infrastructure & collected data.

Impact 2025 ($)

- Home/Office 270-500B
- Health 170B-1.6T
- Factories 1,2T-3,7T
- Transportation 788B-1.6T
- Cities 930B-1.6T
- Retail env. 410B-1.2T

Investments, scalability, trust, interoperability, …

Mature and reusable techs, knowledge management/AI

Other driving factors

Security is a top concern, but it tends to be underestimated because of more pressing challenges involved in just shipping an IoT product. Security is a complicated topic that is outside the area of expertise of the average CPS/IoT developer.

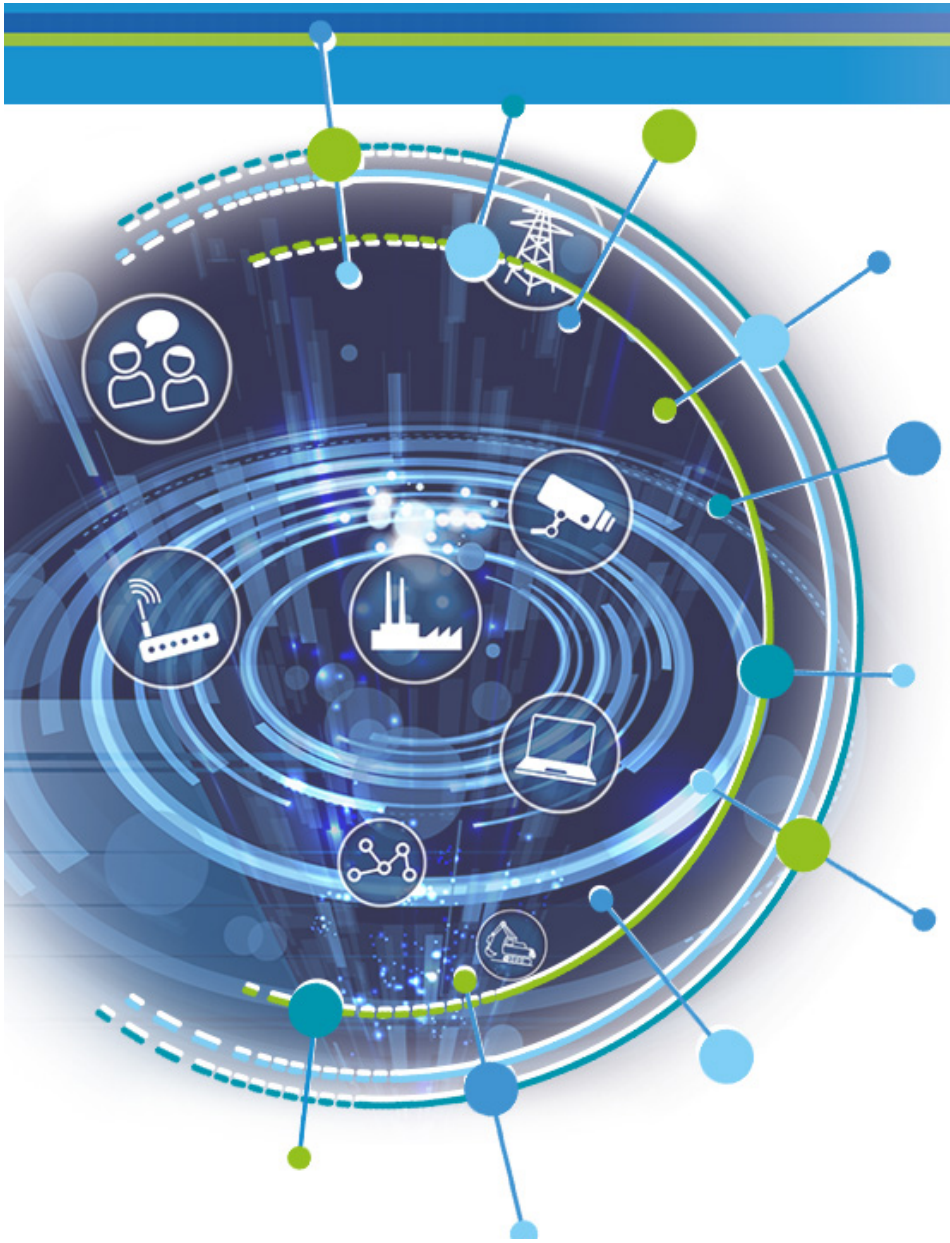
Acceptance barriers can be overcome through effective marketing, professional training and consumer education.

AI enables the possibility to gain more insights on collected data, in an automated, real-time and intelligent way. This is exactly the promise to create "smart" objects.

Policy can help pushing technology and, the proper use of the eco, generated by policy, can contribute to the uptake of CPS/IoT market.

EU-level initiatives required.

Distributed systems has been driven by a "technology pendulum", cyclically oscillating between centralized and distributed solutions, datacenter technologies and edge technologies. In the last 3 years the pendulum seems to lean toward datacenter technologies: JAVA, containers, enterprise security…



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CPS Market Obstacles

What are the barriers to be urgently removed?

CPS/IoT market obstacles

The analysis of the CPS drivers allows to understand:

- the technology challenges that the industry will face,
- the societal impact,
- the business opportunities.

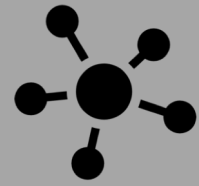
The analysis allows also to identify the main obstacles that could hamper CPS/IoT evolution:

Absence of a European IoT ecosystem

Lack of trust

Lack of interoperability

Unavailability of solid platforms



European ecosystem

A European ecosystem where the stakeholders cooperate to CPS/IoT innovation and market development.

An ecosystem supported by private initiative of companies, with complementary expertise and assets, teaming up.

A private initiative also supported by policymaking in terms of infrastructure, funding and involved authorities ...

An ecosystem capable to create industrial and academic networks, across horizontals & verticals: ECSEL, ARTEMIS, AIOTI, …

Create the value network.
Define European policies, common strategies, roadmaps.
Define standards, architectures and platforms.

Building a similar ecosystem is a strategic step to ensure a competitive advantage in the upcoming developments of CPS market. THIS IS A TOP PRIORITY.

European ecosystem

A European ecosystem where the stakeholders cooperate to CPS/IoT innovation and market development.

Simplify the market entry:

- specifically for **start-ups** that have to tackle the conservative behavior of the industry and the IoT security challenges,
- overcome the **"death valley"** with a EU Platform like the Trilateral Cooperation for Smart Manufacturing.

CPS/IoT ecosystems will be based on **networked platforms** that will generate a value network: in a similar economy the competition must be regulated by policy. The risk of the creation of a commercial **monopoly** must be avoided, giving to all the competitors equal access to the value network.

A European legal environment that regulate the business and the use of information is mandatory.

Without these elements the market cannot flourish.

Trust: in IoT we trust

Customers, end users, and the entire society must trust the security, safety, integrity and privacy of the massive transformation that CPS/IoT is generating and will generate.

Fight diffidence:

- clarify the meaning of buzzwords,
- customers and end-users “education”,
- effective marketing,
- professional training,
- clarify the commercial offer,
- evidence the price reduction,
- evidence the quick return on investment,
- target financial decision-makers,
- identify enthusiastic early adopters and involve them.

Trust: privacy

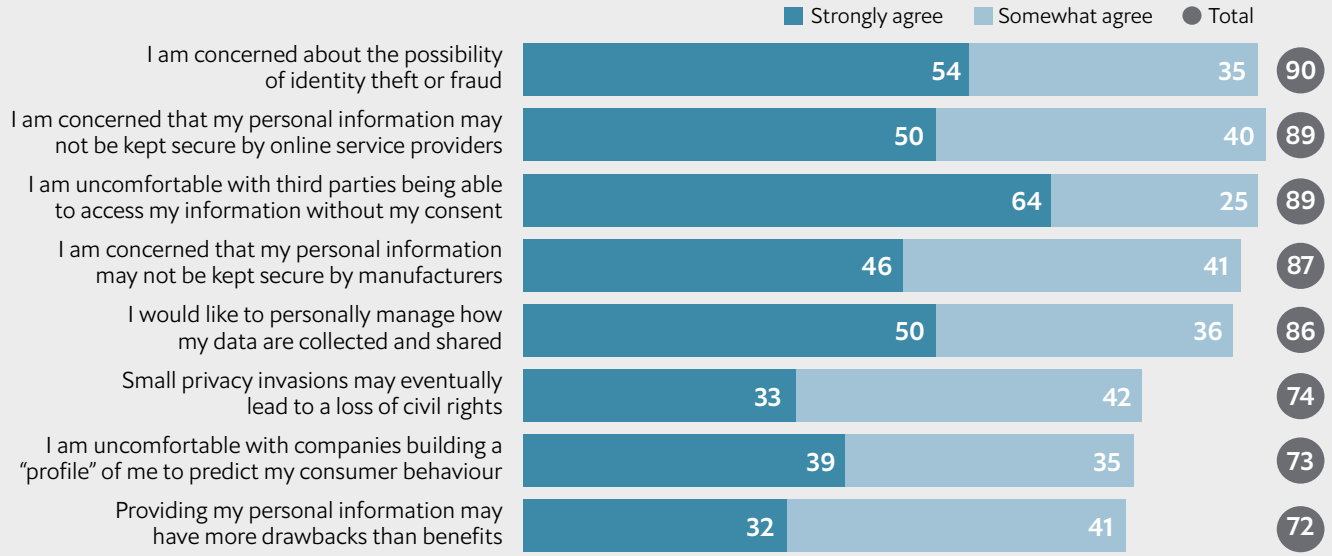
Trust, is a key acceptance barrier. Are we aware of technology risks? Do we trust it?

Europe has recently focused the attention to data privacy and data ownership (see GDPR), but CPS and IoT open up a series of questions that GDPR only partially solves.

The consciousness of privacy related issues generates more diffidence … and privacy is just one aspect of trust.

To what extent do you agree or disagree with the following statements?

(% of respondents)



Note: Percentages may not add to total due to rounding.

Source: Economist Intelligence Unit survey, 2018.

Trust: information security

Trust, is a key acceptance barrier. Are we aware of technology risks? Do we trust it?

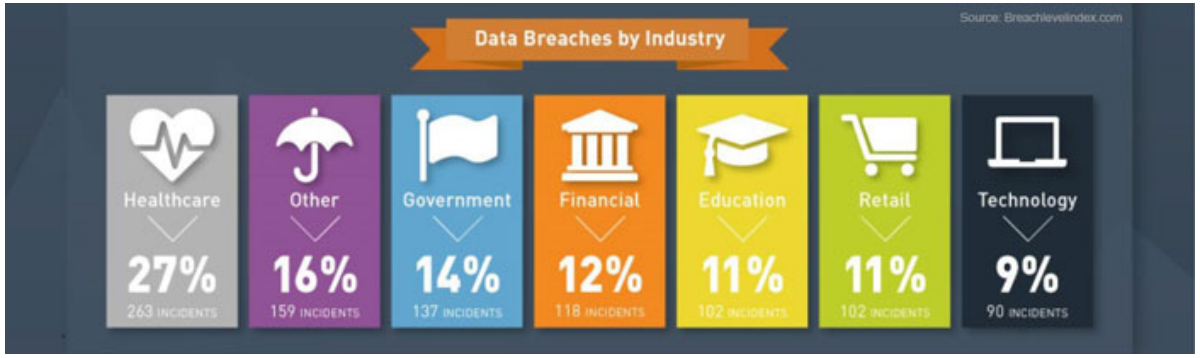
Information security consists in guaranteeing that data is protected from unauthorized access and/or usage.

Information security is addressed:

- **establishing a secure communication path,**
- **encrypting data,**
- **securing authentication.**

Information must continue to flow:

- **a very simple attack could simply consists in interrupting the information flow,**
- **similar to DDoS for data.**



Trust: security

Concerns about security represent the biggest barrier to the uptake of CPS/IoT market and are considered a top priority.

The cybersecurity industry is the key enabling element for the creation of an environment of digital trust.

Security in CPS/IoT is the result of their inherent nature and involves many aspects:

- physical security,
- environmental security,
- communications security,
- single data security,
- data flows security,
- software security,
- IPR security,
- process security,
- lifecycle security,
- human factor, …

The panorama of attack is as much diversified:

- identity spoofing,
- denial of service,
- phishing,
- worms, trojans, viruses,
- physical tampering,
- users misusage, …

Trust: security

The complexity of CPS and IoT provides a rich and inspiring playground for hackers: CPS/IoT introduce unprecedented opportunities.

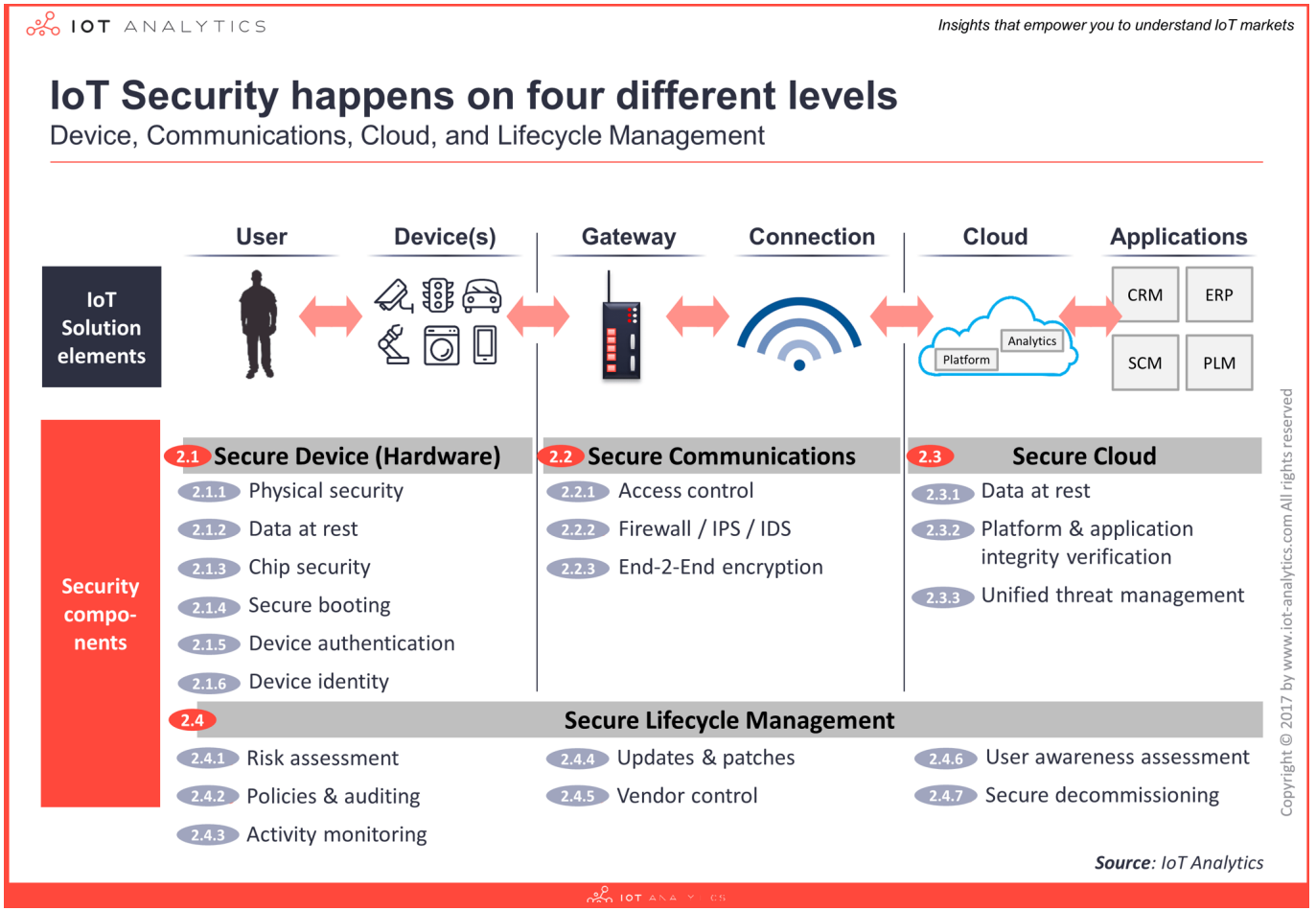
Ability to remotely manipulate physical assets

↓

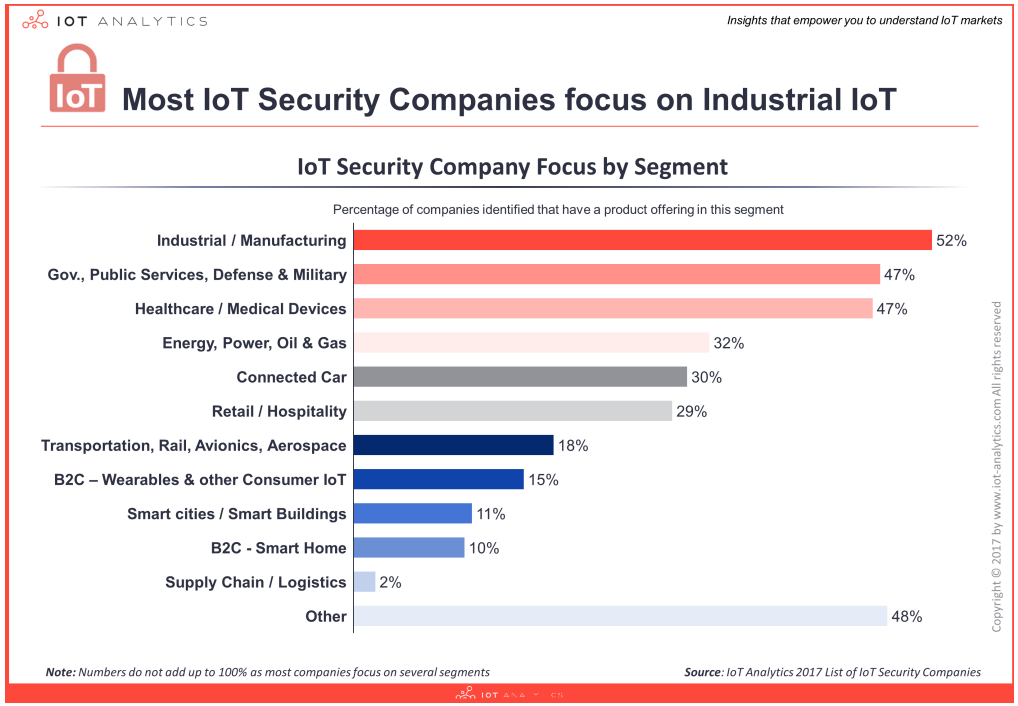
Privacy violations, security breaches, safety issues

↓

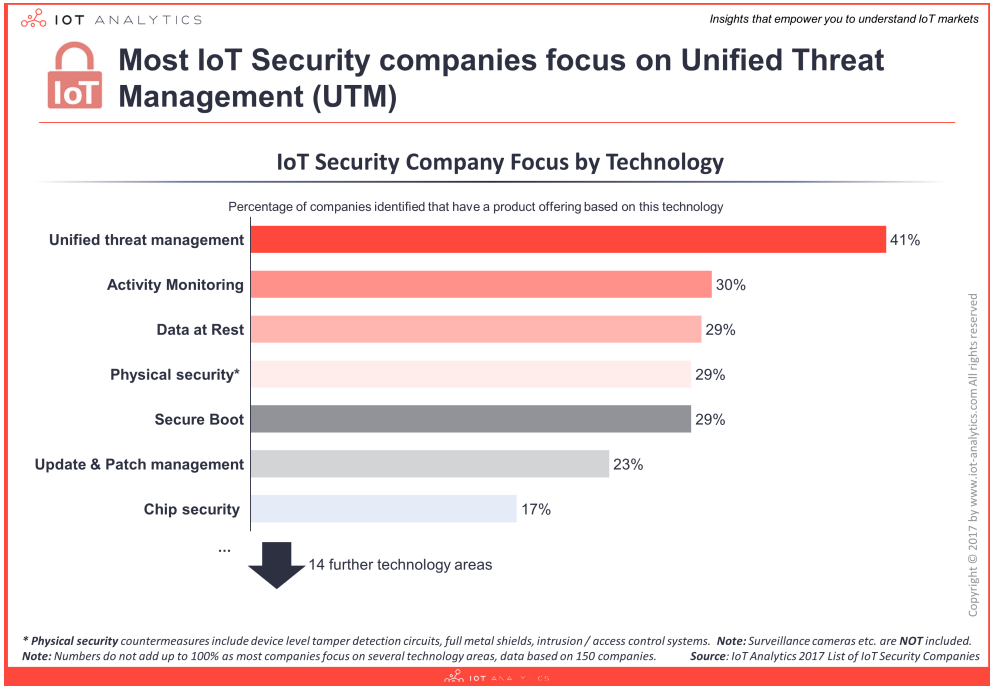
Security concern increases TRUST decreases



Trust: security



Recent market analysis on CPS/IoT security shows that none of the global security vendors offer a holistic end-to-end solution.

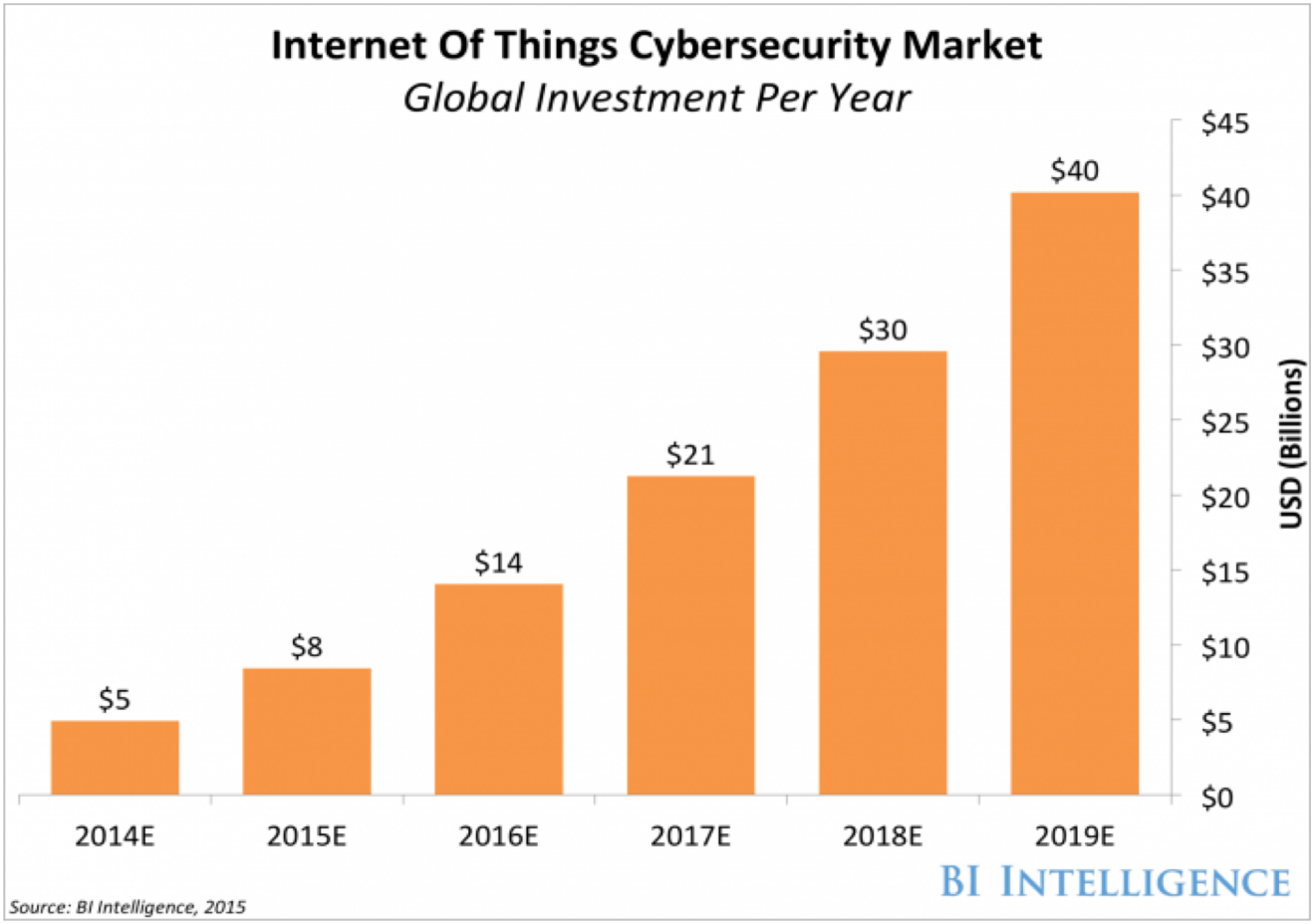


Trust: security

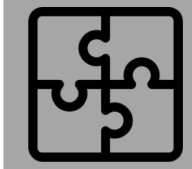
Cyber-security requires huge private investments that must be complemented with governmental initiatives: companies will be primarily involved in the creation of a security framework but cannot fully control it.

Europe should define a common powerful cybersecurity strategy and a strong coordinated policy, in all member states.

US is already moving in this direction.



Interoperability



Interoperability is the key element to inherently control diversity and avoid fragmentation.

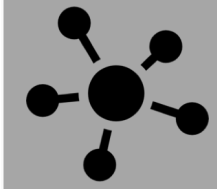
Diversity in SoS is not **something to be solved**, but an aspect that must be **embraced and managed**:

- diversity means richness and added-value,
- diversity is an indicator of innovation,
- but fragmentation is a CPS/IoT enemy.

Some standards are available (e.g. in automation industry) but the lack of interoperability is still a huge obstacle.

Interoperability is a key factor for CPS cooperation and SoS existence … but companies don't want to be interoperable.

SoS platforms

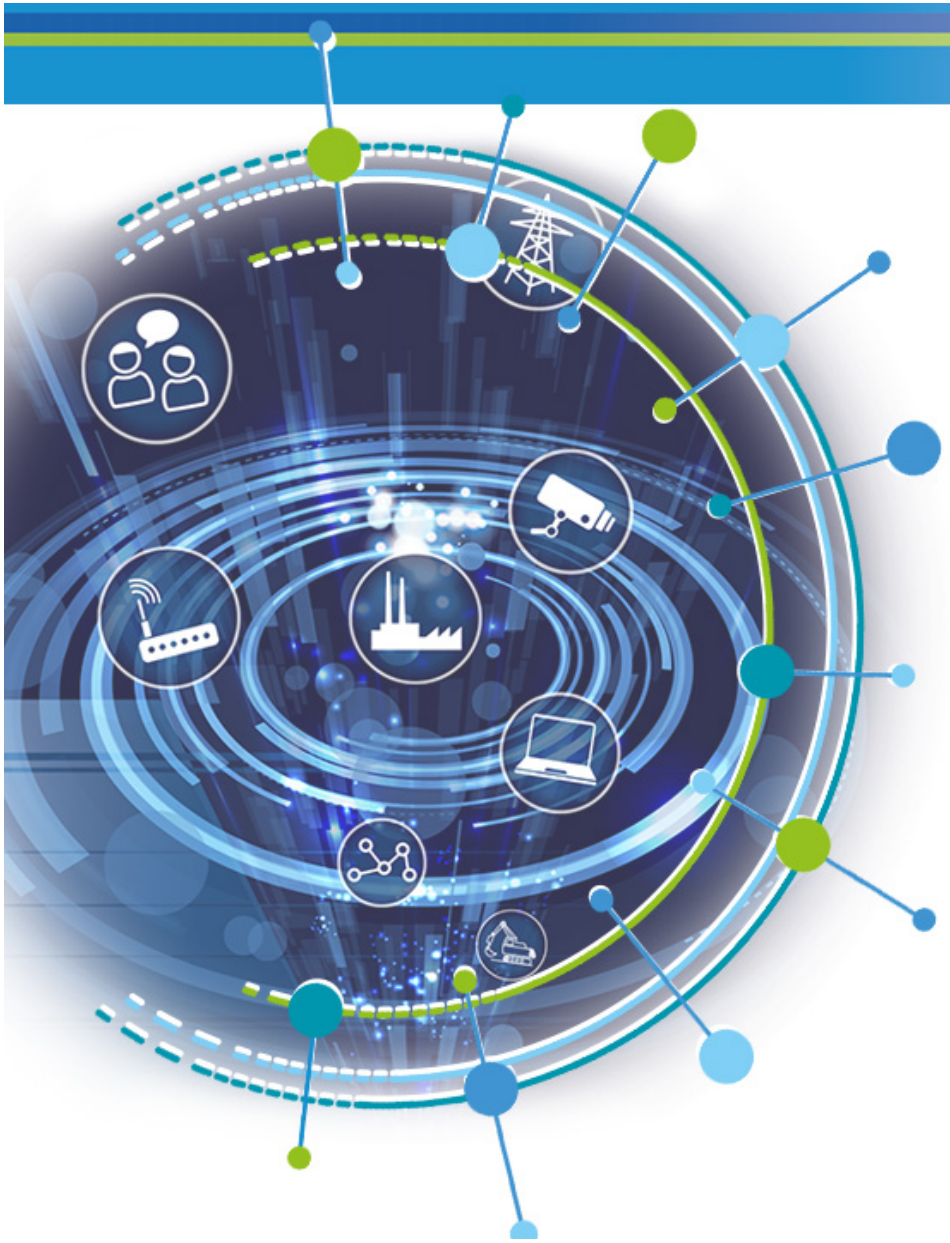


A CPS/IoT ecosystem requires a secure and efficient platform capable to orchestrate and manage it for the entire lifecycle.

The platform “competition” will probably require a long convergence process, without a single winner, because a unified platform is unrealistic and senseless. But at least the capability to securely and efficiently orchestrate the SoS infrastructure across the entire lifecycle is a must.

- Platforms must provide a core set of functionalities: remote man., fleet man., provisioning, device abstraction, APIs
- Platforms create the value network, being a reference architecture that allows the integration of SoS, across multiple companies, firms, technologies, standards, vertical domains, …
- Platforms promote CPS/IoT adoption, specifically for starters.

To date, no software application can manage the data generated by billions of connected devices in a CPS/IoT ecosystem.



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Conclusions

Conclusions

CPS/IoT market is still far from being a stable reality, at least for all the potential stakeholders.

It is growing constantly, to a massive scale, with unprecedented opportunities.

Technology is ready for the first wave of revenues, but a huge effort in research and innovation is required to let the market scale to the estimated dimensions.

The evolution of the market requires:

- to demolish the existing barriers,
- a significant investment on the market drivers,
- a strong commitment of both companies and policy.

A European ecosystem is a high priority.

Thank You!

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