Internet of Things (IoT)

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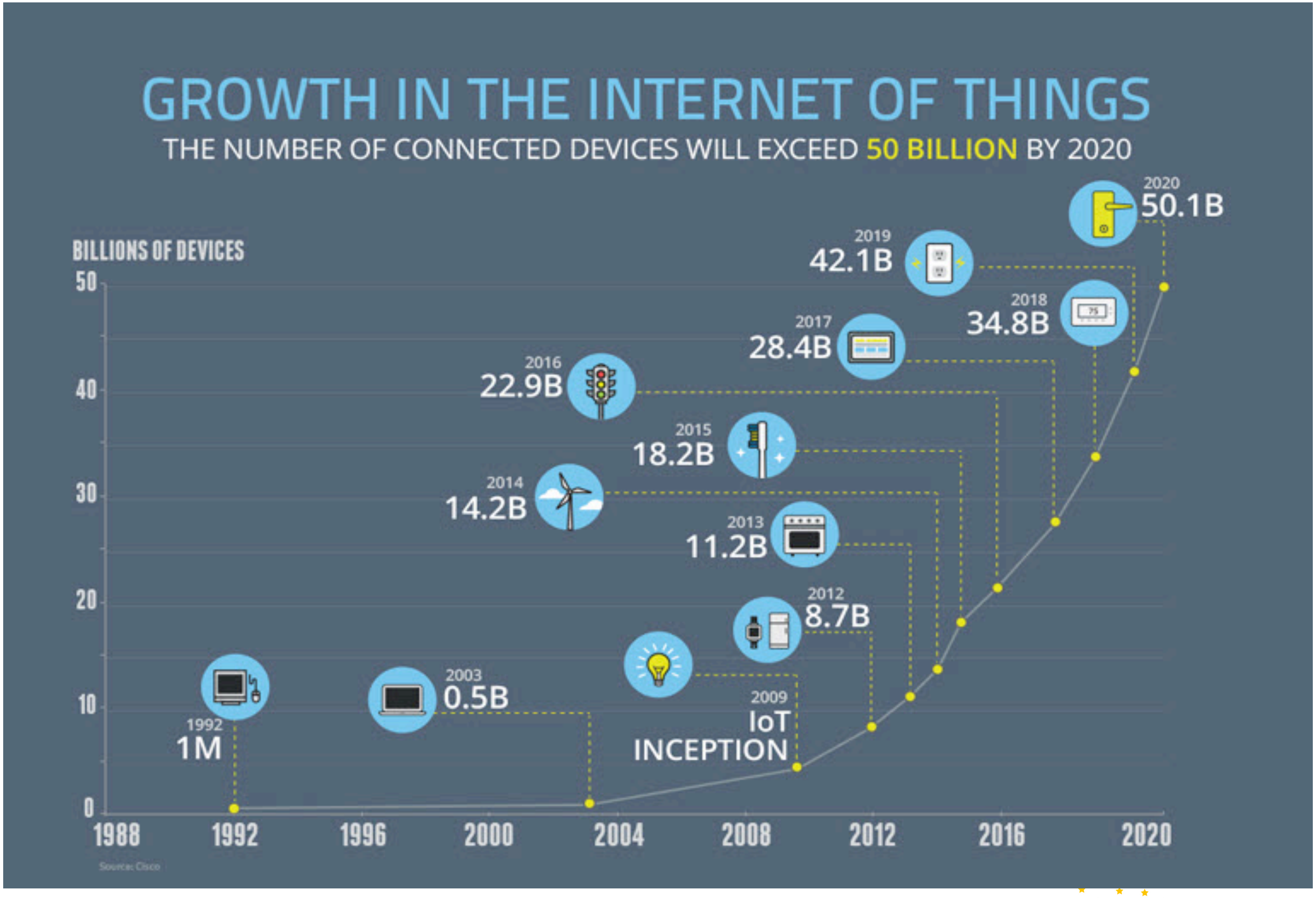
- The story of IoT
- Definition
- Diffusion
- Digital Twins
- Value Added
- Technologies
- Implementation steps
- Today
- Tomorrow
- Conclusion

IoT diffusion by industry



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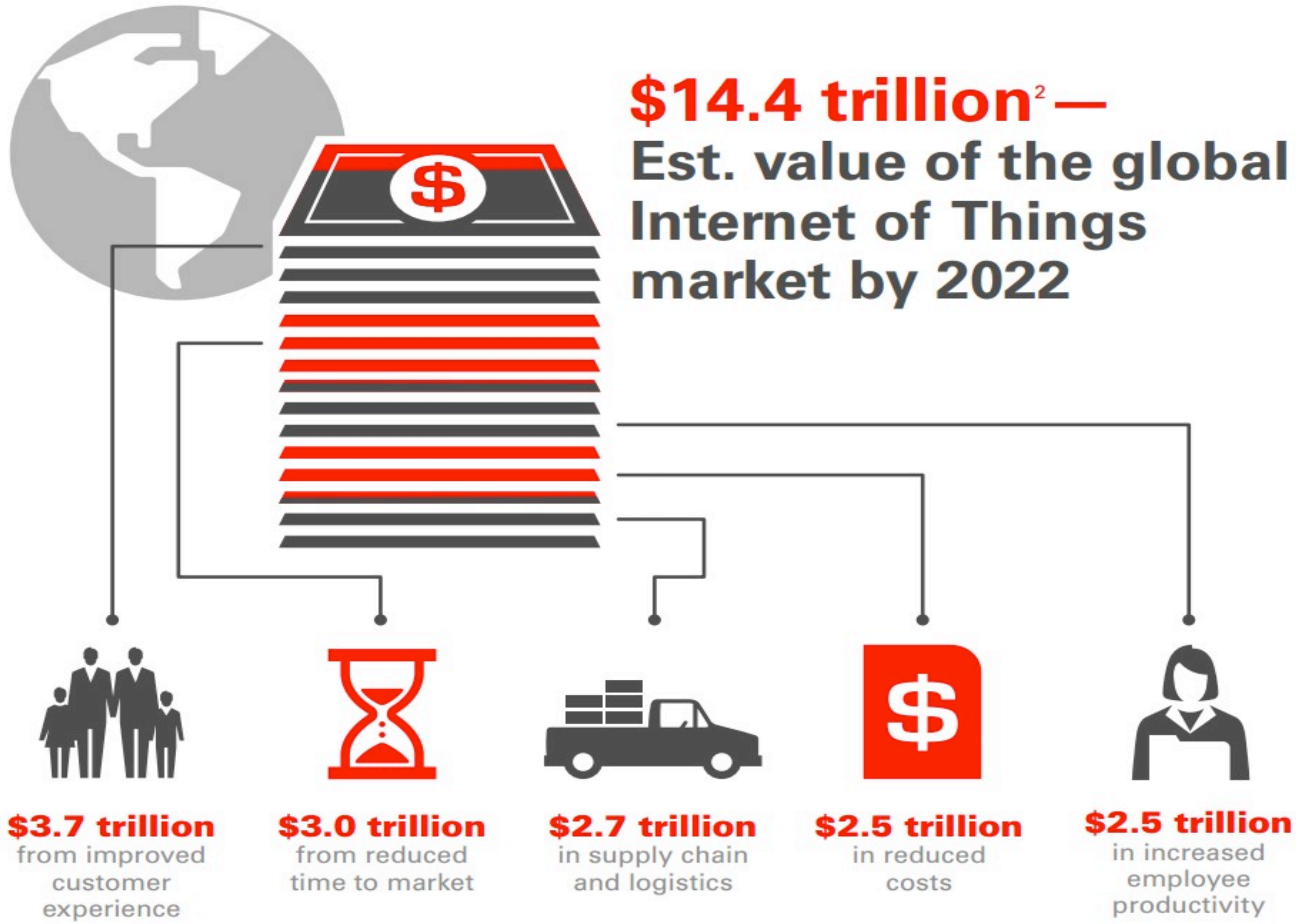
IoT diffusion by impact on value chain



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Digital Twin Definition

- Digital twins refer to computerized companions of physical assets that can be used for various purposes.
- Digital twins use data from sensors installed on physical objects to up date the representation of reality based on a mathematical and statistical model.
- The digital twin is meant to be an up-to-date and accurate copy of the physical object's properties and states, including shape, position, gesture, status and motion.

Digital Twins Examples

- One example of digital twins can be the use of 3D modeling to create a digital companion for the physical object.
- It can be used to view the status of the actual physical object, which provides a way to project physical objects into the digital world
- For example, when sensors collect data from a connected device, the sensor data can be used to update a "digital twin" copy of the device's state in real time.
- The term "device shadow" is also used for the concept of a digital twin.

Digital Twins Applications

- In another context, Digital twin can be also used for monitoring, diagnostics and prognostics.
- In this field, sensory data is sufficient for building digital twins.
- These models help to improve the outcome of prognostics by using and archiving historical information of physical assets and perform comparison between fleet of geographically distributed machines.
- Therefore, complex prognostics and Intelligent Maintenance System platforms can leverage the use of digital twins in finding the root cause of issues and improve productivity

Examples of industry applications

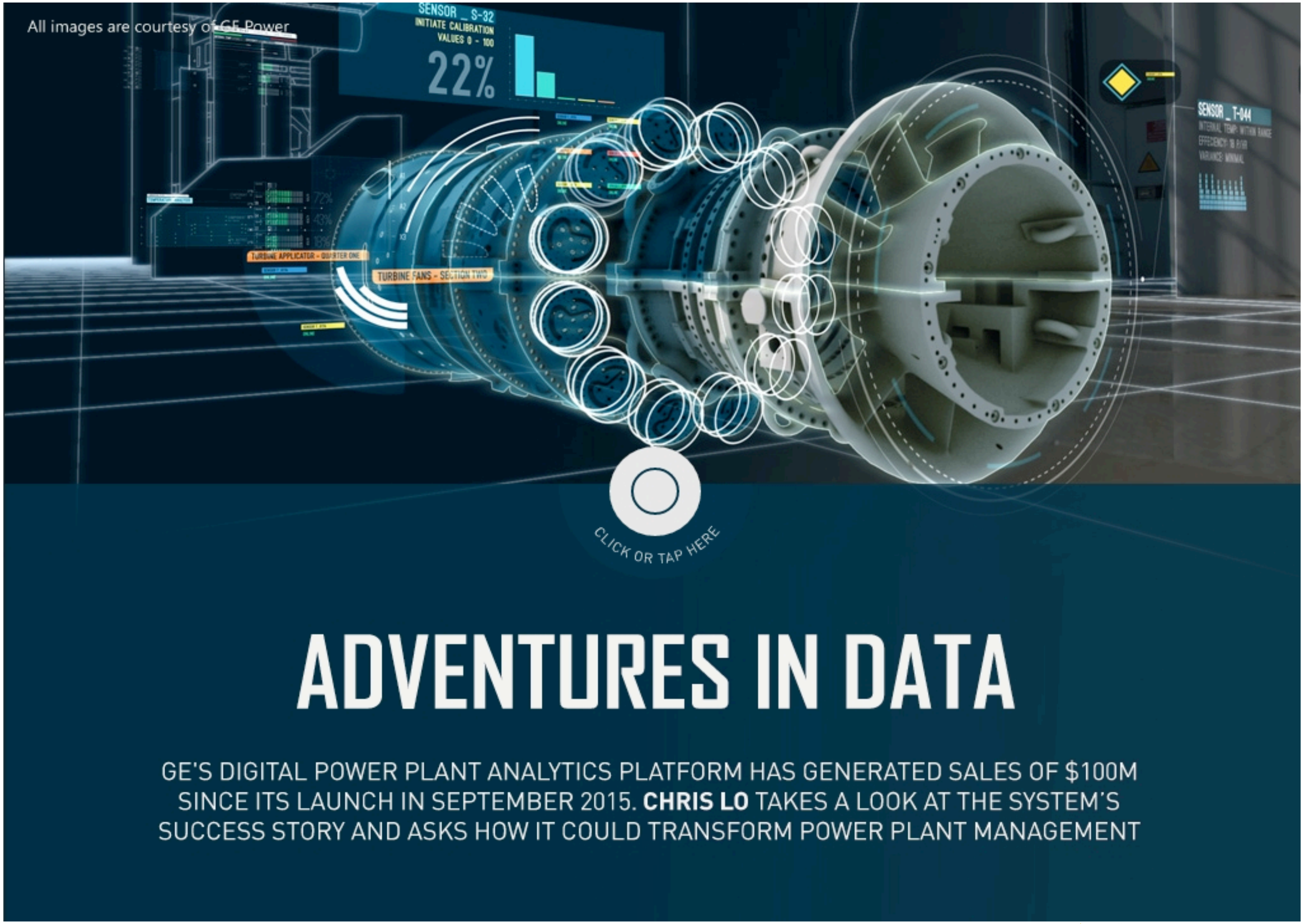
- Aircraft Engines: GE

https://www.infosys.com/insights/services-being-digital/Documents/future-industrial-digital.pdf

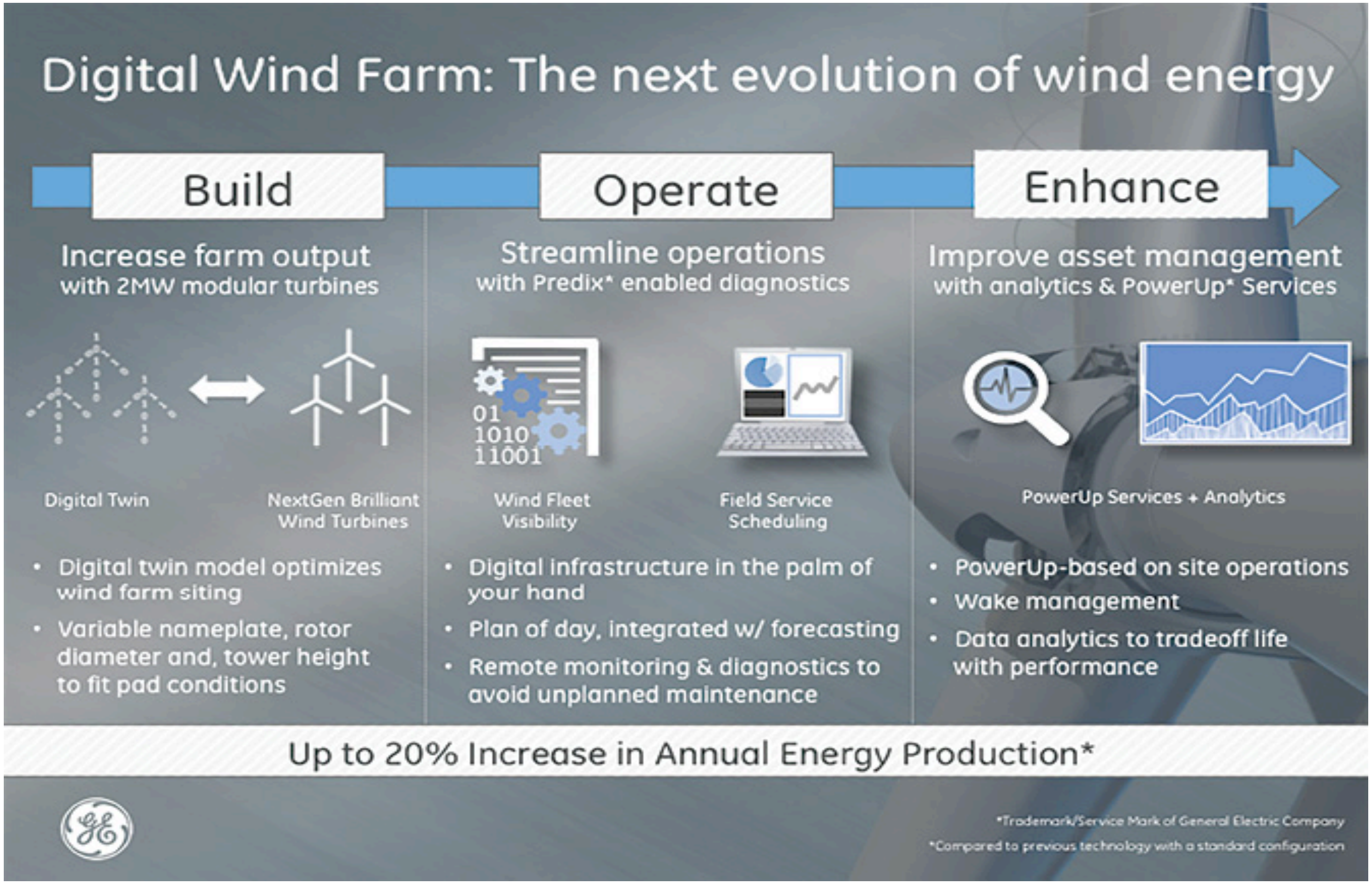
- Wind Turbines

http://www.twi-global.com/news-events/news/2017-03-twi-embarks-on-lifecycle-engineering-asset-management-through-digital-twin-technology/

Aircraft Engines



Wind Turbines



Video of industry applications

Aircraft Engines: **Minds + Machines: Meet the Digital Twin**

https://www.youtube.com/watch?v=2dCz3oL2rTw (15 min)

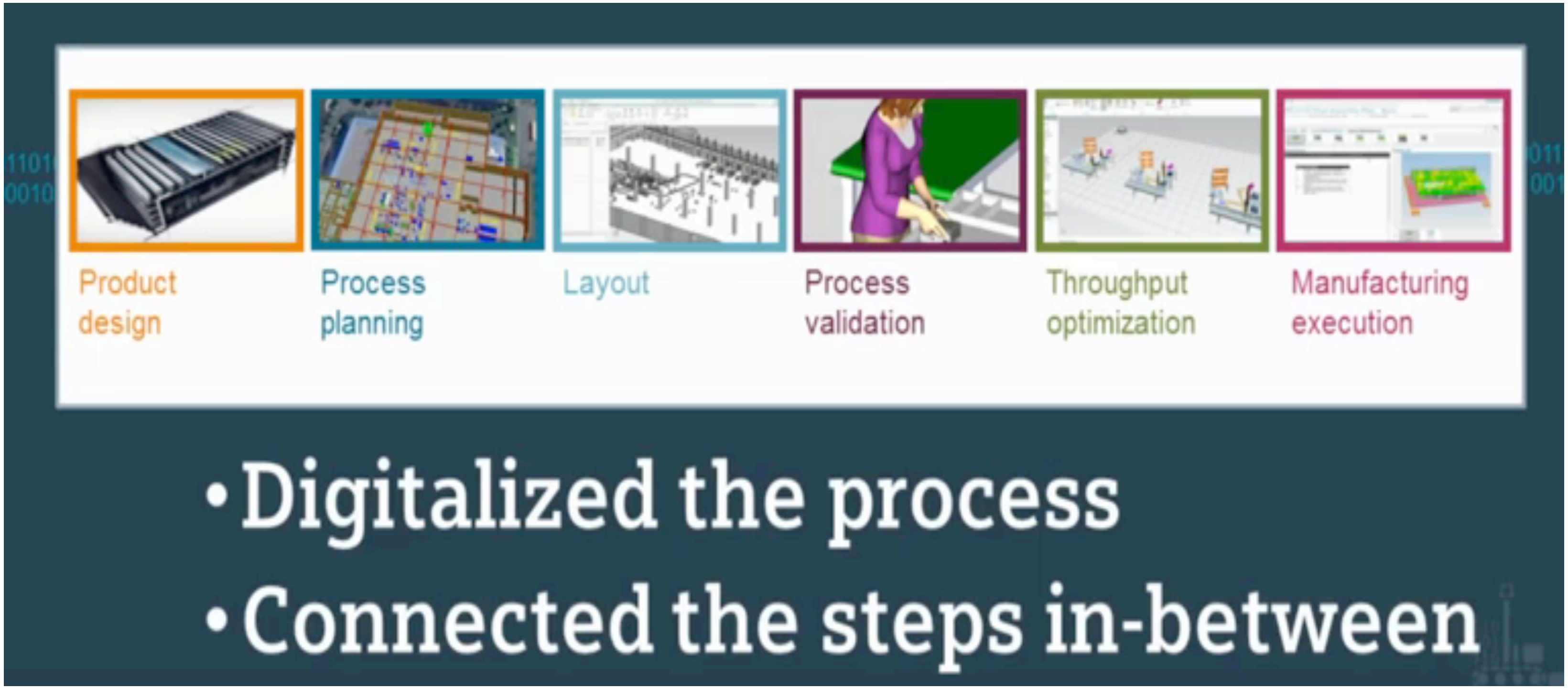
Wind Turbines

https://www.youtube.com/watch?v=OZ-N3h40lPc

An holistic vision of Digital Twins

Siemens PLM - The Real Value of the Digital Twin (24v min)

https://www.youtube.com/watch?v=gK5sHDfBMP4



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Potential impact of IoT on business processes

- Re-orders, replenishment, Kanbans, through the use of internet-connected sensors and devices, could be immediately communicated to a business's ERP, without the need for human intervention (besides the occasional moderation of processes).

- Lean manufacturing would get a little bit leaner by cutting out a lot of the need for human interaction with machinery and data.

- IoT allows for manufacturers to receive warnings and notifications when products need attention or repairing;

- However, businesses will need to be able to successfully adapt their processes to this new model, as well as respond accordingly.

Potential impact of IoT on business processes

- Understanding customer behavior within your business's CRM may get a little more sophisticated.
-
- By being able to communicate directly with products, manufacturers are better able to assess how and when products are being utilized, as well as if and when they malfunction.

- For manufacturing companies that are intrigued by the prospect of IoT, they'll need to do a lot of preparatory work and consider many factors, including the size of their current ERP and CRM, how these software tools will connect with IoT, if everyone in the company is on board with IoT, how it will affect current manufacturing and sales/customer service processes, and more.
-

Potential IoT Challenges

- Data security will likely be the biggest pressure point when it comes to the IoT.
- While IoT welcomes more data to the use of manufacturers, it also opens the door for more data to be breached, specifically with mobile devices or wearable tech.
- As a newer technology solution, IoT users will need to be able to find a way to secure large amounts of data from sources such as mobile
- The cost of adding IoT will probably be a major initial investment, something that many small to mid-size manufacturers just won't be able to do.
- Analysis of data from IoT is still relatively weak, meaning that manufacturers still have to manually parse through large amounts of information.

Potential IoT Challenges

- While there's a lot at stake with the Internet of Things, it's clear that it's not going away anytime soon.
- New advancements in technology are common in the manufacturing industry, and you can expect software companies to begin considering how to tap into the potential of IoT and begin crafting new ways of processing and understanding technology and communication from all kinds of sources.
- Sometimes additional IoT is not necessary because the sensors and data are available but not stored and used

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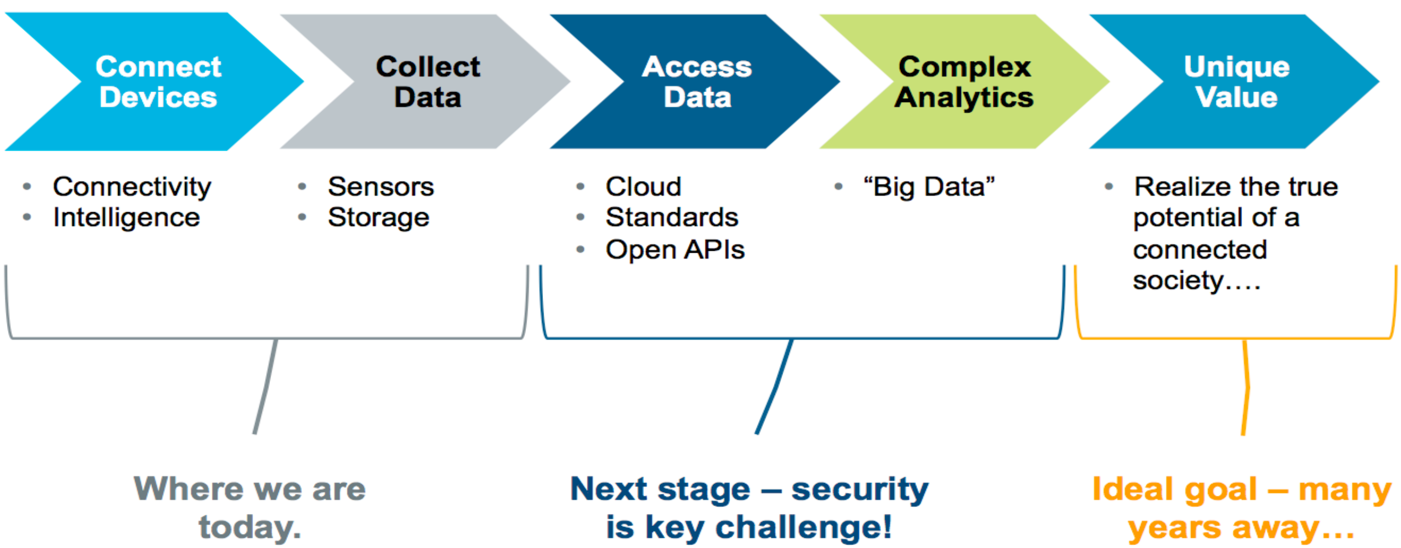
IoT Technologies

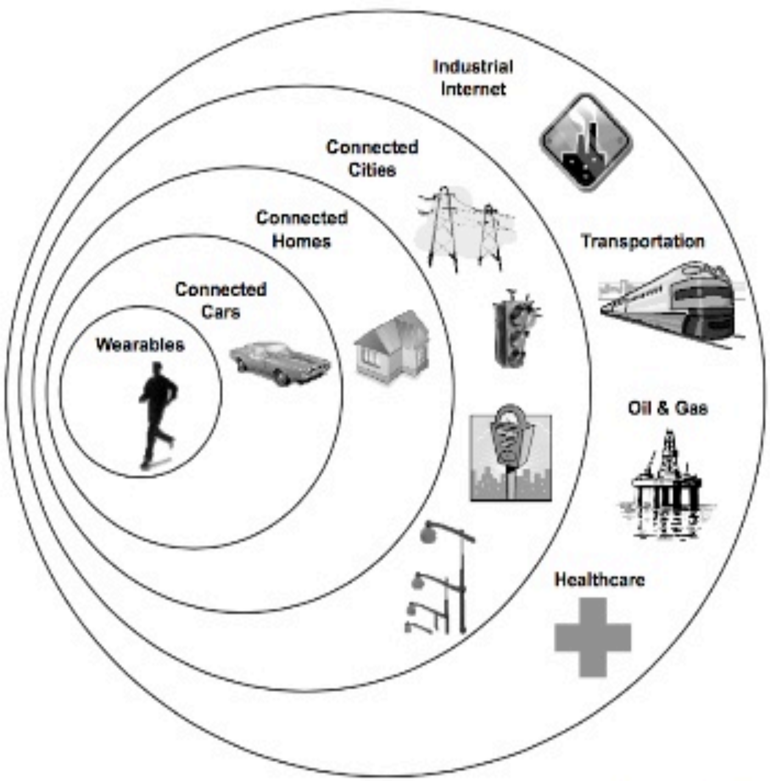
Internet of Things Evolution

Internet of Everything (IoE): represents the open access to data from one or more monitoring and control systems by third-party applications to provide unique, additional value to stakeholders.



IoT Technologies

The IoT landscape - One size doesn't fit all



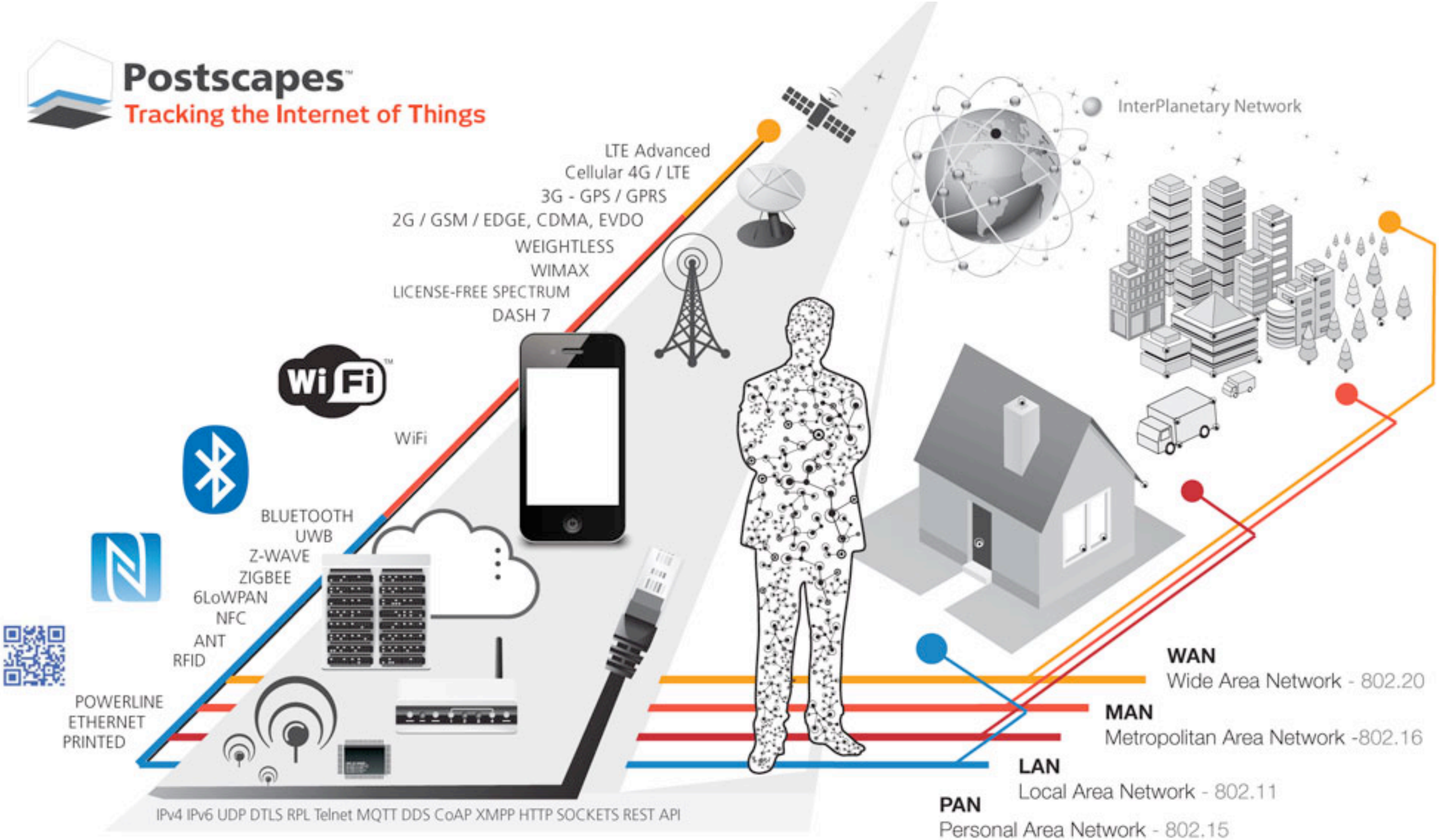
Broad variety of wireless standards, industry bodies, technologies for different types of networks:

- Body Area Network (BAN)
- Body Sensor Network (BSN)
- Medical Body Area Network (MBAN)
- Personal Area Network (PAN)
- Home Area Network (HAN)
- Nearby Area Network (NAN)
- Local Area Network (LAN)
- Wide Area Network (WAN)
- Global Area Network (GAN)

Source: Goldman Sachs, IoT Primer, September 3, 2014; 'Internet of Things: Making sense of the next mega-trend'

CONNECT SYSTEMS

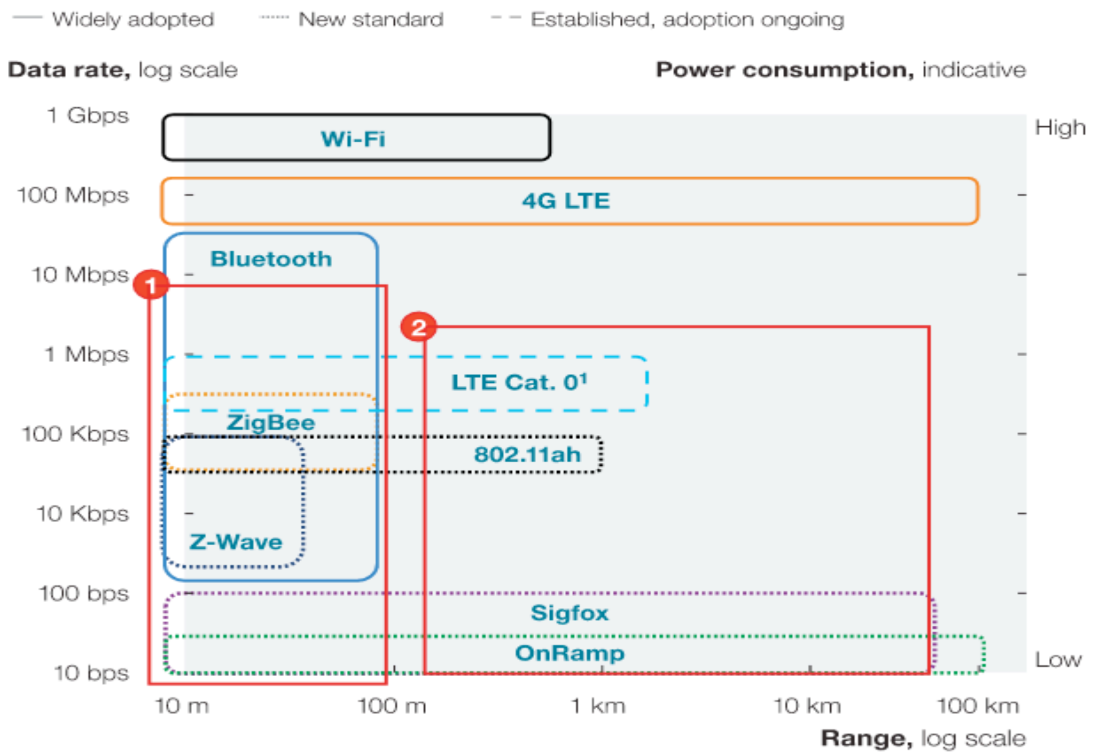
IoT Technologies overview



IoT Technologies key features

	TCP/IP Support	Gateway Needed?	Power	Data Rate	Topology	Wireless Spectrum	Alliance	Module Costs (5K EAU)	Other
Ethernet	Over 802.3	No, directly wired to Internet	High / Power-over-Ethernet (PoE) 802.3af	Up to 1 Gbps	Varies	None	None	$10 +	RJ45
Wi-Fi	Over 802.11	No, connects to Internet through Wi-Fi access points and routers	High (low-power modules available for battery applications)	1-135 Mbps	None	2.4 GHz, 5 GHz	Wi-Fi Alliance	< $10 +	Internal or external antenna
6LoWPAN	Over 802.15.4	Yes	Low	0.04-0.25 Mbps	Varies	868-921 MHz, 2.4 GHz	Internet Engineering Task Force (IETF)	$5 +	Internal or external antenna
ZigBee	Lacks native TCP/IP support, based on 802.15.4	Yes, ZigBee Coordinator	Low	0.04-0.25 Mbps	Mesh	868-921 MHz, 2.4 GHz	ZigBee Alliance	< $4 +	Internal or external antenna
Z-Wave	Lacks native TCP/IP support, based on Z-Wave standard	Yes	Low	0.1 Mbps, primarily for remote control	Mesh	868-921 MHz	Z-Wave Alliance	$5 +	Internal or external antenna, managed by Sigma Designs
Bluetooth	Lacks native TCP/IP support, based on Bluetooth standard	Yes	Moderate	0.7-2.1 Mbps	Point-to-point	2.4 GHz	Bluetooth Special Interest Group (SIG)	$5 +	Pairing can be complicated, max 8 devices in piconet, ~100 ms latency
Bluetooth Smart (such as BLE, BT 4.0)	Lacks native TCP/IP support, based on Bluetooth LE standard	Yes	Low to moderate	0.27 Mbps maximum	Point-to-point	2.4 GHz	Bluetooth Special Interest Group (SIG)	$5 +	Simpler to pair devices, new version 4.2 connects directly with Internet
Cellular	TCP/IP over cellular network	No, connects to Internet/cloud through cellular service provider network	High	Varies based on technology	Point-to-point	Varies	None	Monthly service charges, modules, carrier certification fees	External Antenna Only, Monthly Service

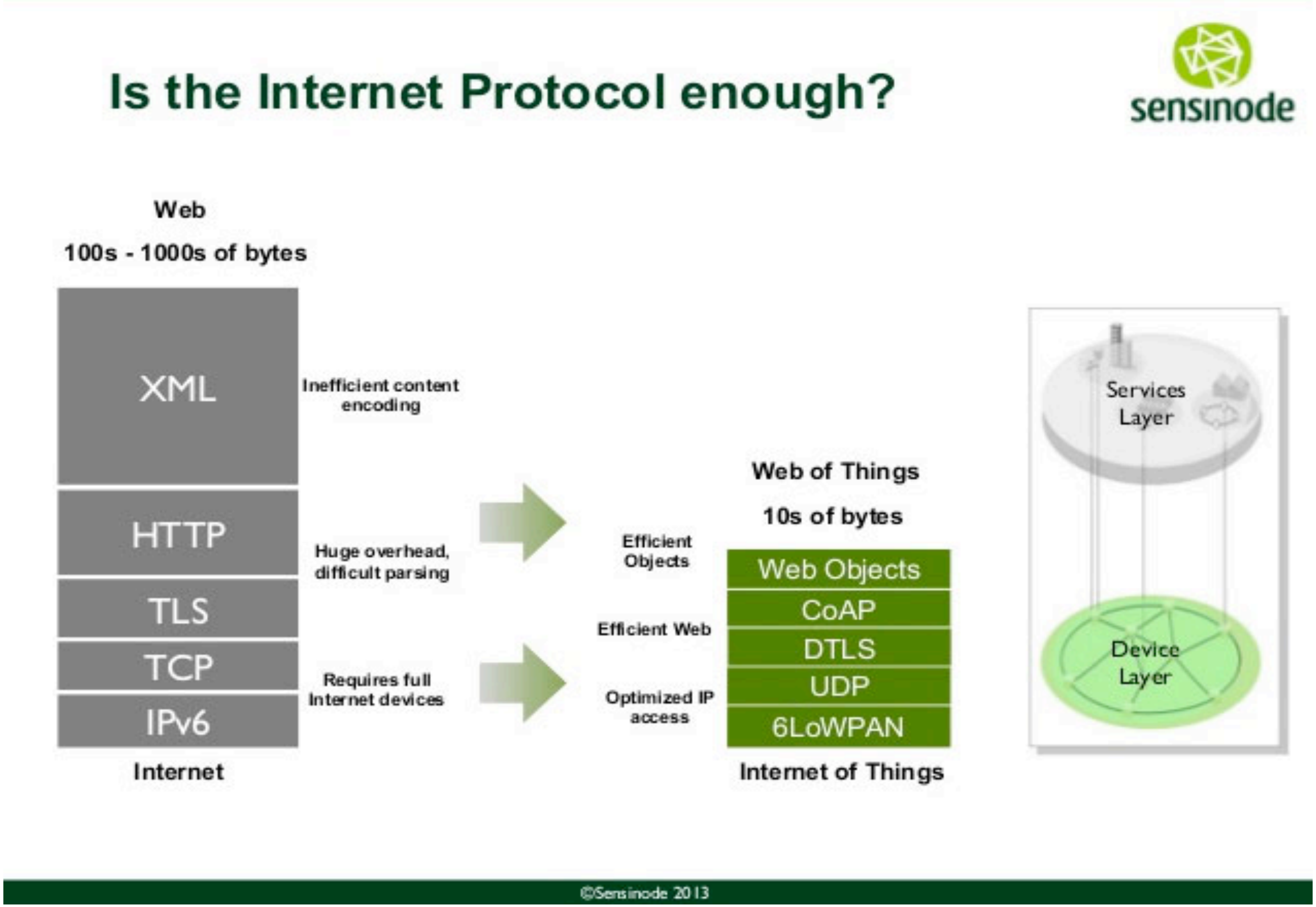
IoT Technologies data rate/power consumption



1. Many competing standards for low-range, medium-low data rate hinder growth for many IoT applications
   - Interoperability missing
   - Consortia wars might be emerging
   - Additional incompatibilities in higher communication layers, eg, 6LoWPAN vs ZigBee

2. Standard white space for low-data-rate, low-power, high-range applications such as smart grid
   - Wi-Fi and LTE have high power consumption
   - Alternatives with low power and wide range (eg, LTE Cat. 0, 802.11ah, Sigfox, and OnRamp) are in very early stages and compete against each other

IoT Technologies protocol efficiency



IoT Technological Developments

IoT Technological Developments

Development Areas	Before 2010	2010-2015	>2015
Identification Technologies	•Different Schemes •Domain specific IDs •ISO, GS1, u-code, IPv6, etc	•Unified framework for unique identifiers •Open framework for IoT •URIs	•Identity Management •Semantics •Privacy-awareness •"Things DNA" identifier
IoT Architecture Technology	•IoT architecture specification •Context-sensitive middleware •Intelligent reasoning platforms	•IoT architecture developments •Network of networks architecture •IoT architecture in the FI •F-O-T platforms interoperability	•Adaptive, context based architectures •Self-* properties •Cognitive architectures •Experiential architecture
Communication Technology	•RFID, UWB, Wi-Fi, WiMax, Bluetooth, ZigBee, ISA100, 6LoWPAN	•Ultra low power chipsets, system on chip •On chip antennas •Millimeter wave single chips •Ultra low power single chip radios •Ultra low power system on chip •Mobility •Heterogeneity	•Wide spectrum and spectrum aware protocol •Unified protocol over wide spectrum
Network Technology	•Sensor networks	•Self aware & self organizing network •Delay tolerance networks •Storage networks and power networks •Hybrid networking technologies •Sensor network location transparency	•Network context awareness •Network cognition •Self learning, self repairing network

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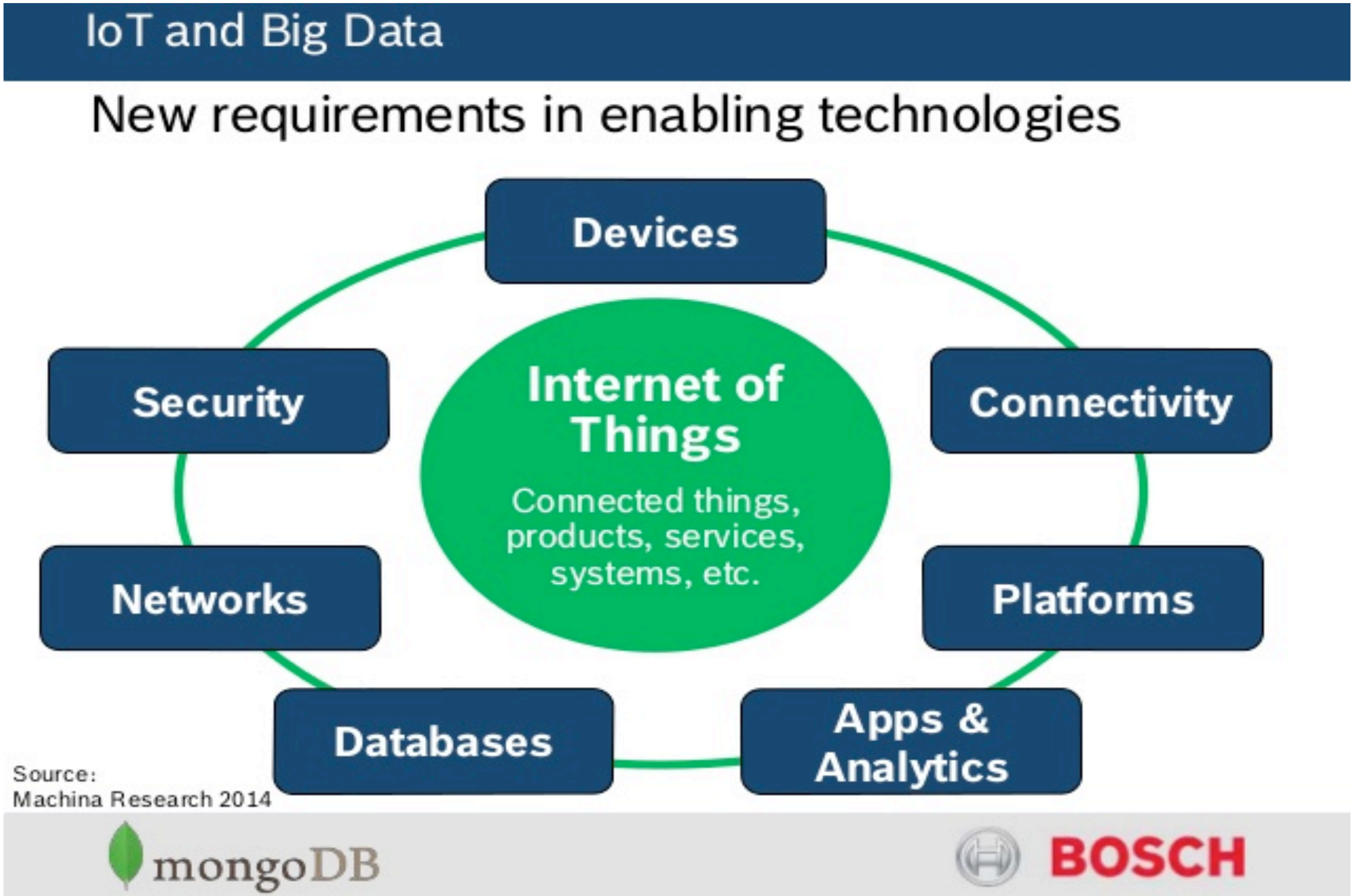
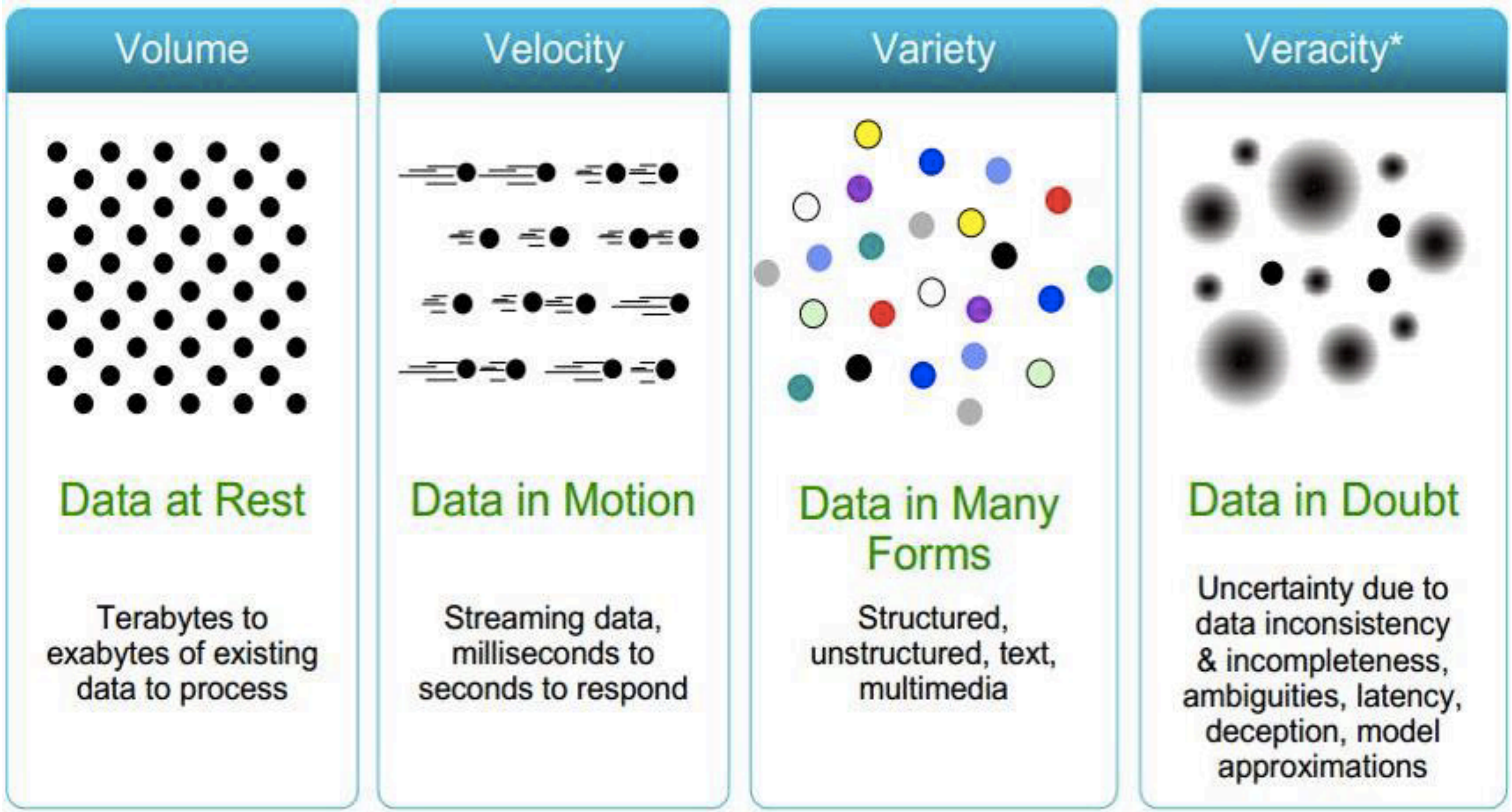
IoT Technologies



Big Data and IoT



IoT Technologies

S-E-N-S-E	What the Internet of Things does	How it differs from the Internet
Sensing	Leverages sensors attached to things (e.g. temperature, pressure, acceleration)	More data is generated by things with sensors than by people
Efficient	Adds intelligence to manual processes (e.g. reduce power usage on hot days)	Extends the Internet's productivity gains to things, not just people
Networked	Connects objects to the network (e.g. thermostats, cars, watches)	Some of the intelligence shifts from the cloud to the network's edge ("fog" computing)
Specialized	Customizes technology and process to specific verticals (e.g. healthcare, retail, oil)	Unlike the broad horizontal reach of PCs and smartphones, the IoT is very fragmented
Everywhere	Deployed pervasively (e.g. on the human body, in cars, homes, cities, factories)	Ubiquitous presence, resulting in an order of magnitude more devices and even greater security concerns

Source: Goldman Sachs Global Investment Research.

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Implementation steps of IoT

- How do we achieve success in this journey and become innovative?
- What are the critical success factors?
- What are the risks?
- The processing of Internet of Things data requires a step-by-step approach

5 steps to IoT implementation

1. **Acquire data from all sources**.

These sources include automobiles, devices, machines, mobile devices, networks, sensors, wearable devices and anything that produces data.

2. **Ingest all the acquired data into a data swamp**.

The key to the ingestion process is to tag the source of the data. Streaming data that needs to be ingested can be processed as streaming data and can also be saved as files. Ingestion also includes sensor and machine data.

3. **Discover data and perform initial analysis**.

This process requires tagging and classifying the data based on its source, attributes, significance and need for analytics and visualization.

5 steps to IoT implementation

4. Create a data lake after data discovery is complete.

This process involves extracting the data from the swamp and enriching it with metadata, semantic data and taxonomy and adding more quality to it as is feasible. This data is then ready to be used for operational analytics

5. Create data hubs for analytics.

This step can enrich the data with master data and other reference data, creating an ecosystem to integrate this data into the database, enterprise data warehouse and analytical systems. The data at this stage is ready for deep analytics and visualization.

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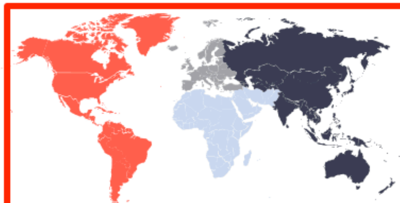
The top 10 IoT application areas – based on real IoT projects

IOT ANALYTICS **Q3/2016** *Insights that empower you to understand IoT markets*

#	IoT Segment	Global share of IoT projects[1]	Americas	Europe	APAC	Trend[2]
1	Connected Industry	22%	43%	30%	20%	
2	Smart City	20%	31%	47%	15%	
3	Smart Energy	13%	49%	24%	25%	
4	Connected Car	13%	43%	33%	17%	
5	Other	8%	46%	33%	13%	
6	Smart Agriculture	6%	48%	31%	17%	
7	Connected Building[3]	5%	48%	33%	12%	
8	Connected Health	5%	61%	30%	6%	
9	Smart Retail	4%	52%	30%	13%	
10	Smart Supply Chain	4%	57%	35%	4%	



N = 640 global, publicly announced IoT projects

Americas · Europe · APAC · MEA · N/A

1. Based on 640+ publicly known enterprise IoT projects.(Not including consumer IoT projects e.g., Wearables, Smart Home) 2. Trend based on IoT Analytics's Q2/2016 IoT Employment Statistics Tracker 3. Not including Consumer Smart Home Solutions Source: IoT Analytics 2016 Global overview of 640 enterprise IoT use cases (August 2016)

1-Connected Industry: Strong IoT project footprint in oil & gas and in factory environments

- Connected industry is the largest IoT segment in terms of number of IoT projects.
- This segment covers a wide range of connected “things” such as printing equipment, shop floor machinery, cranes or entire mines.
- One of the largest sub-industries is Oil & Gas.
- The ability to remotely monitor and optimize heavy assets has resulted in a number of projects.
- An example is RasGas´ LNG equipment monitoring in Ras Laffan, Qatar, allowing the LNG producer to perform predictive maintenance on its assets.
- Manufacturing shop floors are another area of major importance for IoT.
- For example, German food producer Seeberger knows exactly where specific goods are at any stage of the production process allowing for complete food traceability.

2-Smart City: Traffic management and utilities driving Smart City IoT use cases

- 20% of all identified IoT projects are Smart City related.
- On top of that, the IoT Employment Statistics Tracker shows a strong upward trend on the back of hundreds of recent Smart City initiatives started by governments around the world.
- Prominent examples include the City of Barcelona and the City of London.
- The most popular Smart City application is **Smart Traffic** (e.g. Intel and Siemens´ Smart Parking solution in the City of Berlin) followed by **Smart Utilities** (e.g. Dublin´s smart bins).
- Other Smart City initiatives evolve around **city safety**. A notable (European) safety monitoring IoT project is the CityPulse IoT project in Eindhoven where the information on noise levels is matched with social media messages in order to detect and manage incidents and adjust the street lighting accordingly.

3-Smart Energy: Strong push in the US and other parts of the Americas

- Both North and South America appear to be strong adopters of Smart Energy projects with nearly half of all identified Smart Energy IoT projects taking place there.
- The majority of Smart Energy projects can be classified as **Smart Grid** initiatives, an example being the American City of Fort Collins Utilities´ Smart Grid initiative.
- Another extensive Smart Energy project is the smart grid demonstration project on Jeju Island, South Korea, which incorporates both distributed renewable generation and advanced metering infrastructure.
- While typically these projects focus on increasing the efficiency and reliability of the grid, IoT technology can also be used to avoid energy theft as showcased in a project in Tucumán, Argentina.

4-Connected Cars: Largest segment making use of M2M technology

- Connected cars is one of the more mature IoT segments in which M2M/Cellular type of IoT connectivity has been employed for quite some time.
- Most Connected Car IoT Projects focus on **vehicle diagnostics and monitoring**.
- Two out of three projects can be classified as **Fleet Management** initiatives, an example being Telefonica´s fleet management solution for ISS.
- On top of that, there are a number of **usage-based car insurance projects**, e.g. Unipol Sai´s black box solution.
- Other types of projects include real time decision support for Honda´s racing team or Daimler´s Car2Go car sharing service.

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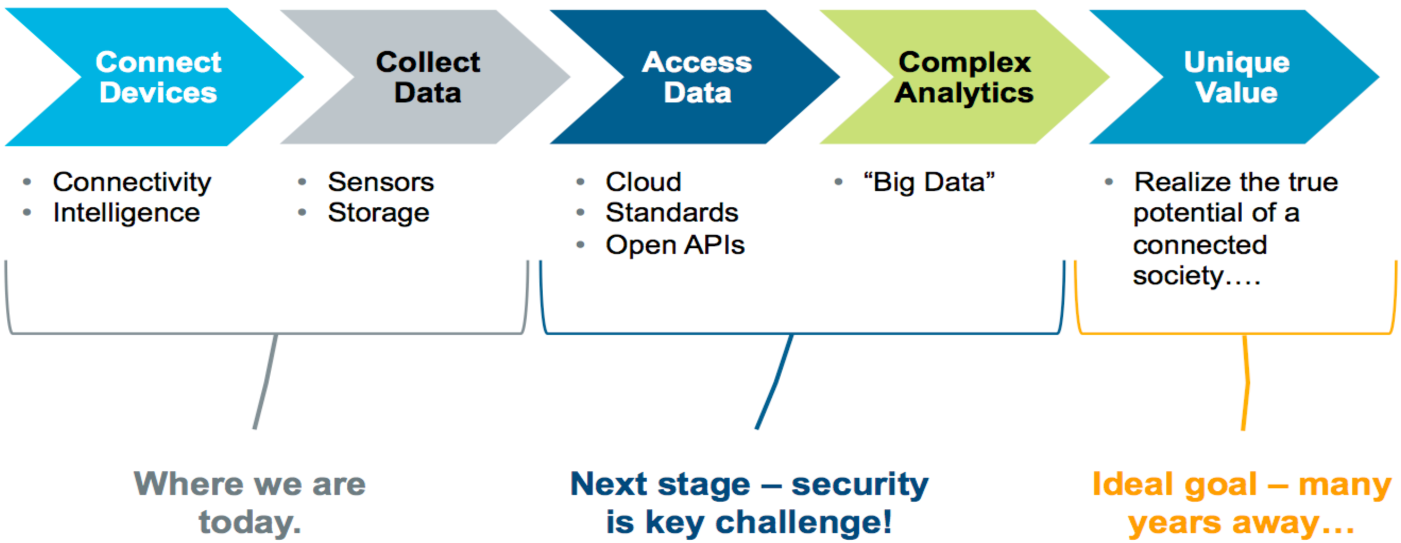
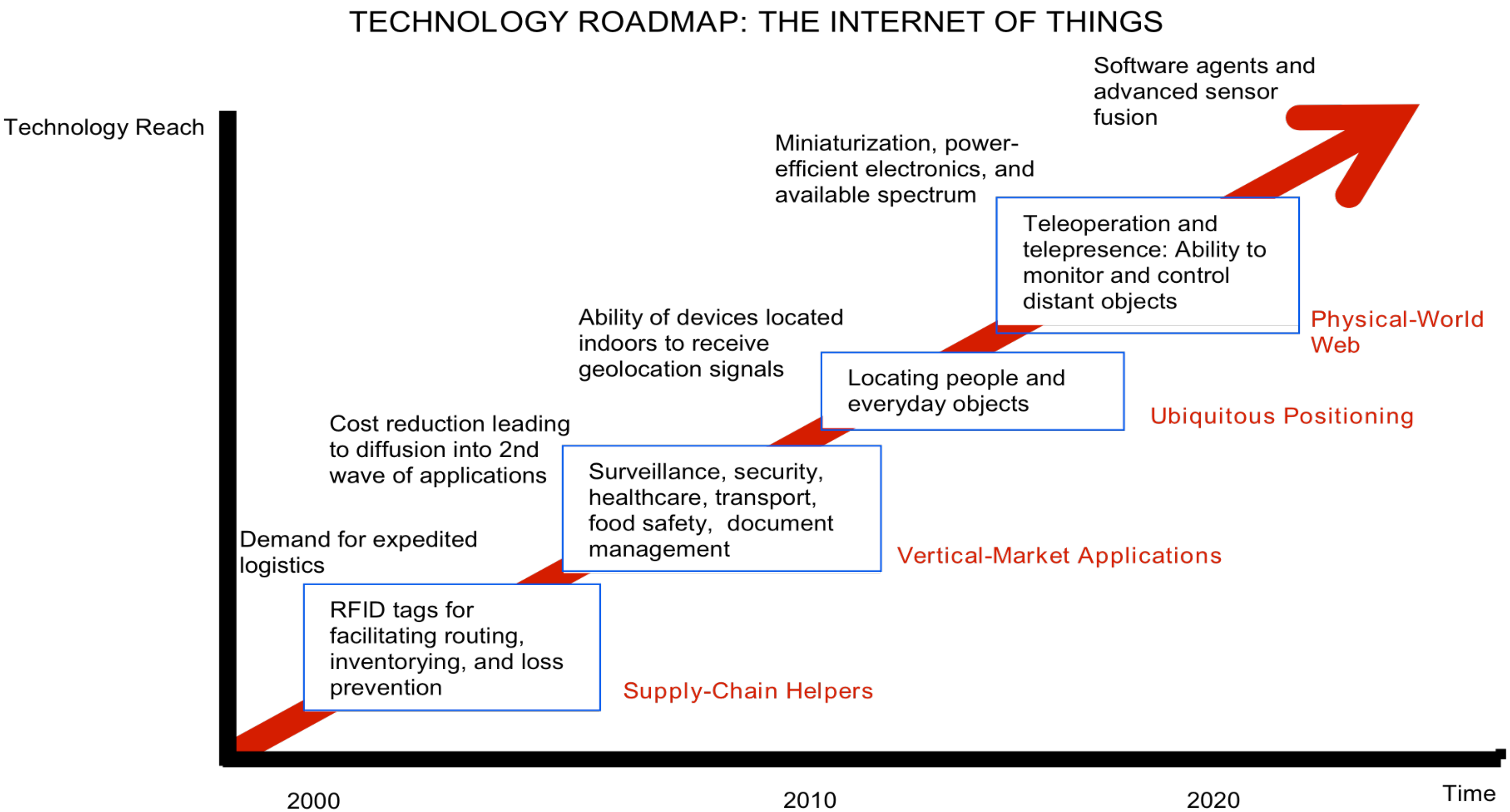
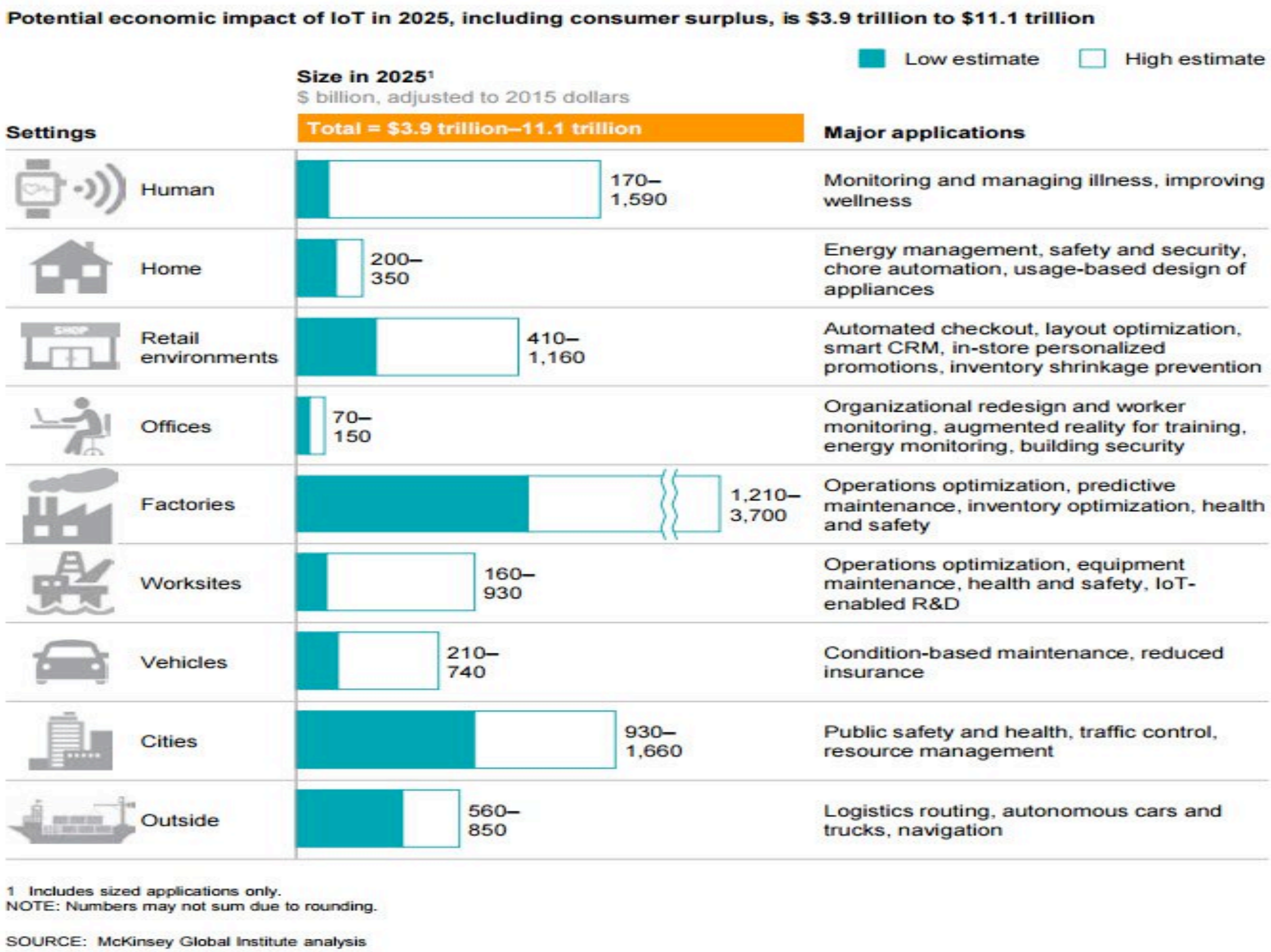


IoT Technologies road map



Source: SRI Consulting Business Intelligence

Potential economical impacts of IoT



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Conclusions

- Key issue: Digital Twin
- Potential impact of IoT and trust
- Adaption level of IoT and maturity of industrial sectors
- IoT, Cyber security, Cloud….