ECEN 5053-002

Developing the Industrial Internet of Things

Week 1

Definitions, Influencing Factors, Market Overview, Key Skills

Dave Sluiter - Spring 2018

Credits

- If not otherwise indicated, market data by Markets and Markets, "*IOT Technology Market Forecast till 2022*"
- Used with permission
- http://www.marketsandmarkets.com

Learning Outcomes

- Definition of Industry 4.0
- Understanding precursors / enabling factors
- Understanding business considerations
- Understanding benefits
- Understanding influencing factors, market dynamics, drivers, restraints, opportunities and challenges
- Understanding the technical proposition
- Understanding the growth potentials
- Understanding the application areas
- Learning who the top players are

Highlights

- Cisco: Only 1% of the worlds devices are connected. Opportunity for new business to be created that can help industries derive value from all the new data that will be available.
- Shell Oil: Smart Wells: Downhole sensors, monitors reservoir dynamics: water flow, gas movement, pressure changes and compaction. Realized substantial savings.
- GE: Utilities suffer more than $200B in annual electrical losses and theft. GE True Grid Provides situational awareness with actual line data, reduces financial risks by truing up conventional billing and Smart Meters data to actual consumption, pinpointing theft as well as meter/billing errors.

Source: McRock Capital

Highlights (Con't)

- Executives must:
  - Increase production
  - Create hybrid business models
  - Fuel innovation
  - Transform the workforce
    - Rio Tinto's operations center in Perth Australia, equipment operators sit in a remote command center and work with data analysts to orchestrate the actions of huge drills, excavators, earth movers and dump trucks.

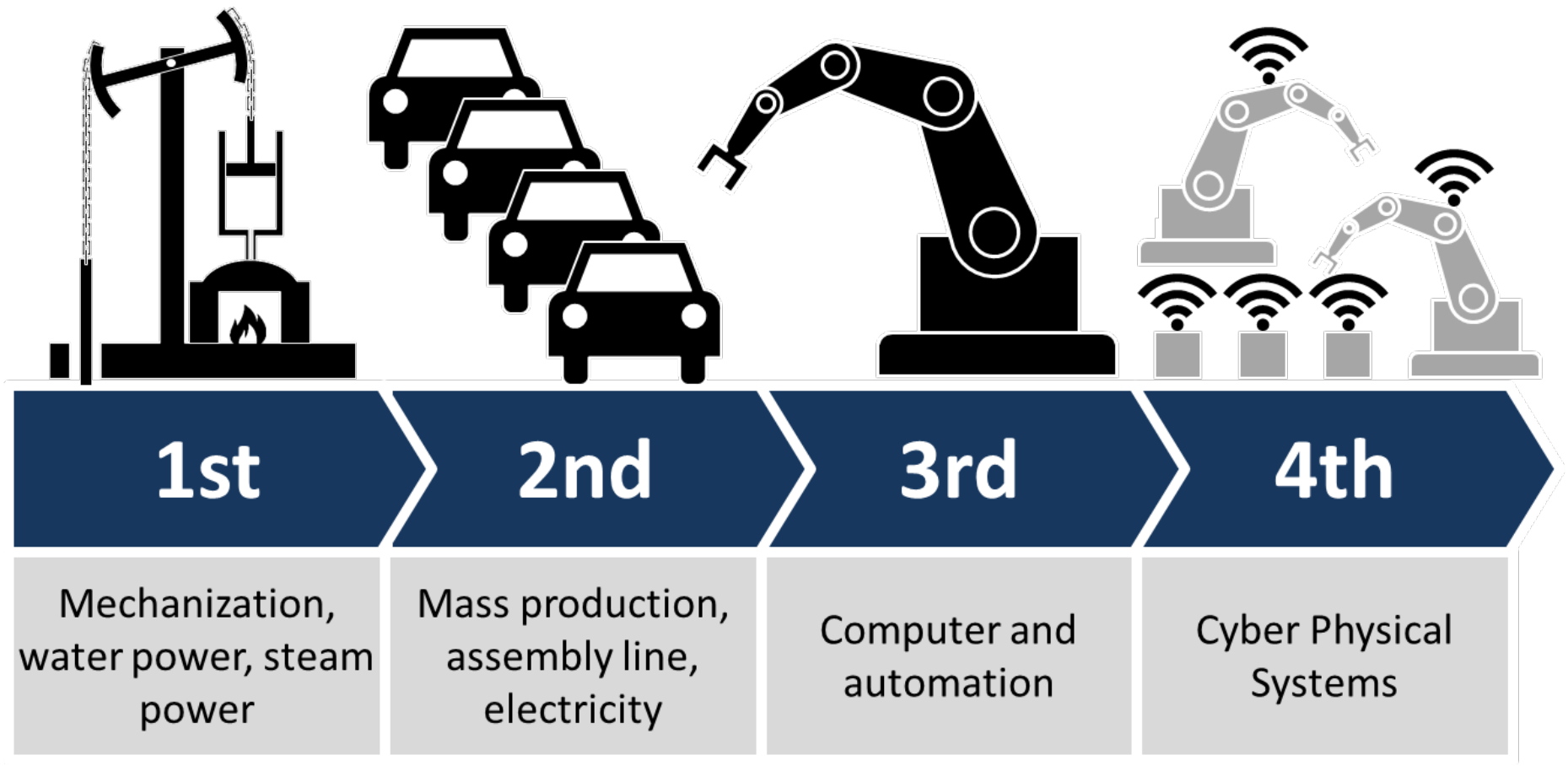
Source: Accenture

Highlights (Con't)

- Think unconventionally about what is valuable to customers
- ***Be the most valuable information provider***
- 3 capabilities to master:
  - Intelligent machine applications
  - Analytics
  - Sensor driven computing

Source: Accenture

Industry 4.0 - The 4th Industrial Revolution



Source: https://en.wikipedia.org/wiki/Industry_4.0

Industry 4.0 (con't)

- Industry 4.0 Workgroup
- 4 Design Principles
  - Interoperability: Connect and communicate via the Internet.
  - Information transparency: Ability to create a virtual copy of a physical system.
  - Technical assistance: Provide support to humans by aggregating information into visualizations, and perform operations that are unpleasant, too exhausting or unsafe.
  - Decentralized decisions: Ability of cyber physical systems (CPS) to make decisions on their own.

Industry 4.0 - A Brief History

Source: https://www.youtube.com/watch?v=JCswJIdVoXk

Precursors / Enabling Factors

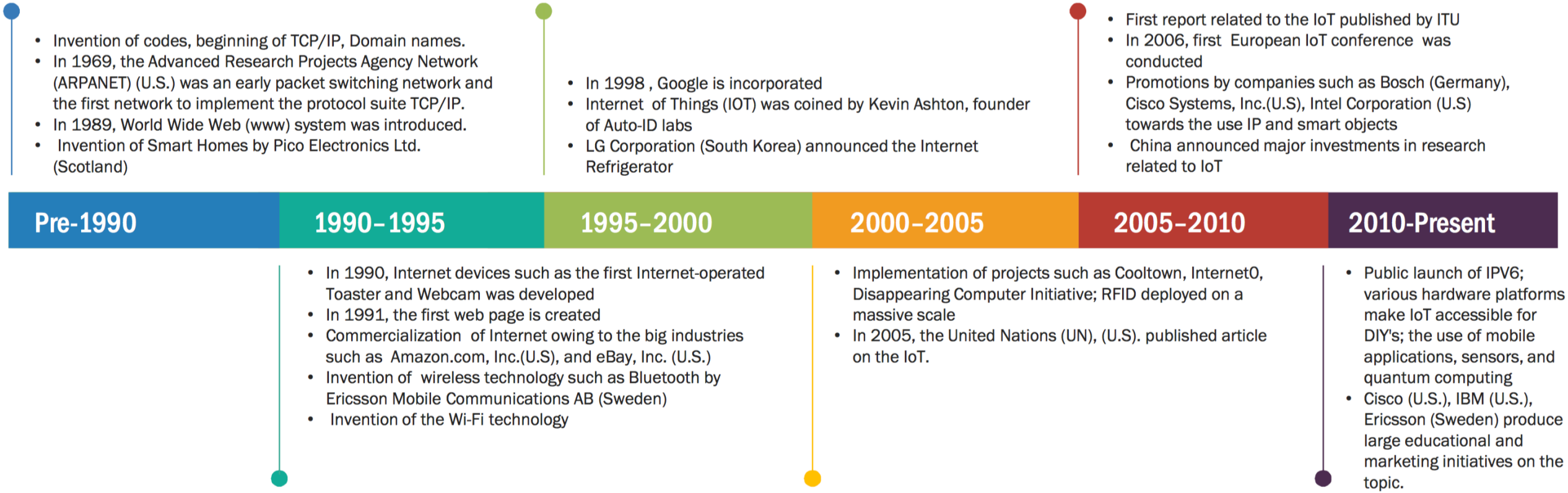
- IPv4 (2^32 addresses) vs. IPv6 (2^128 addresses = 340 x 10^36 addresses)
- Dramatic reduction in costs: sensors, compute, network bandwidth, storage
- Dramatic reduction in power consumption for compute and wireless communication
- Dramatic reduction is size
- M2M communication has been present in manufacturing for over a decade
  - IIoT joins Operational Technology (OT) with Information Technology (IT) as a new network structure
  - IIoT connects this new network structure to the internet

Precursors / Enabling Factors (con't)

- Confluence of:
  - Sensor data
  - Machine Learning
  - Big Data analytics

Evolution

FIGURE 17 IOT EVOLUTION



Business Considerations

- Business leaders witnessed the stability and maturity of the emerging solutions, tools and applications
  - => Reduces risk
- Solutions increase operational efficiencies
  - => Drives adoption
- Adopters want to see:
  - Increased profits
  - Increased revenue (sales)
  - Lower operational expenses

Influencing Factors Now

- Drivers
  - Increasing connectivity
  - Growing penetration of smart phones and other connected devices
  - Increasing adoption of wireless sensors
  - Mainstreaming of cloud computing
    - Machine Learning
    - Big Data Analytics
- Restraints
  - Lack of standards
  - Low power efficiency

Influencing Factors Now (con't)

- Opportunities
  - Significant gov't funding
  - Innovative cross domain applications, development of comprehensive system solutions
- Challenges
  - Security
- Acquisitions, Alliances, Collaborations and partnerships
  - More than 50 deals in the last 3 years
- New product launches
  - Dozens of product/service launches in the last 3 years

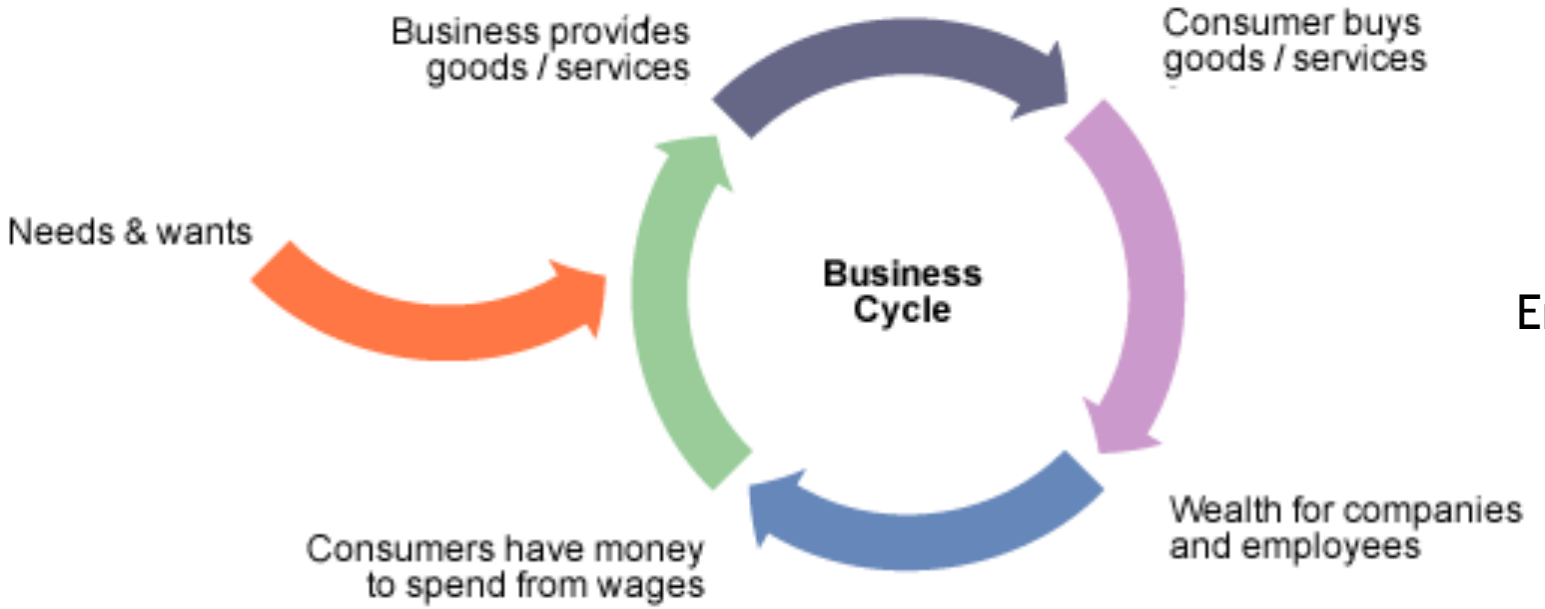
The power of 1%

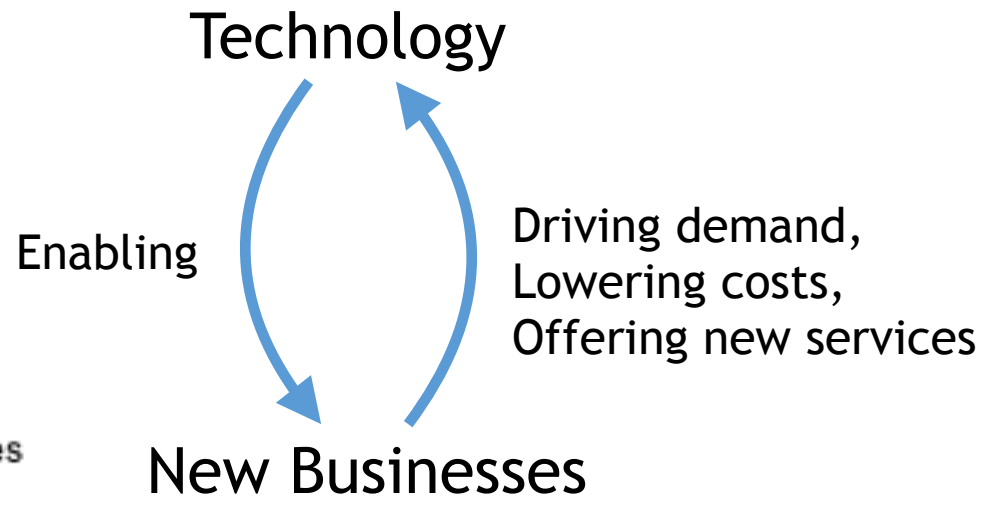
- A small amount of operational efficiency gain can lead to significant savings
  - Airline fuel savings : saves $30B
  - Gas-fired power generators : saves $66B
  - Oil & Gas: Improve pump efficiency, increases 500K barrels a day => earn an additional $19B
- => reduced costs
- => increased profit

The Technical Proposition

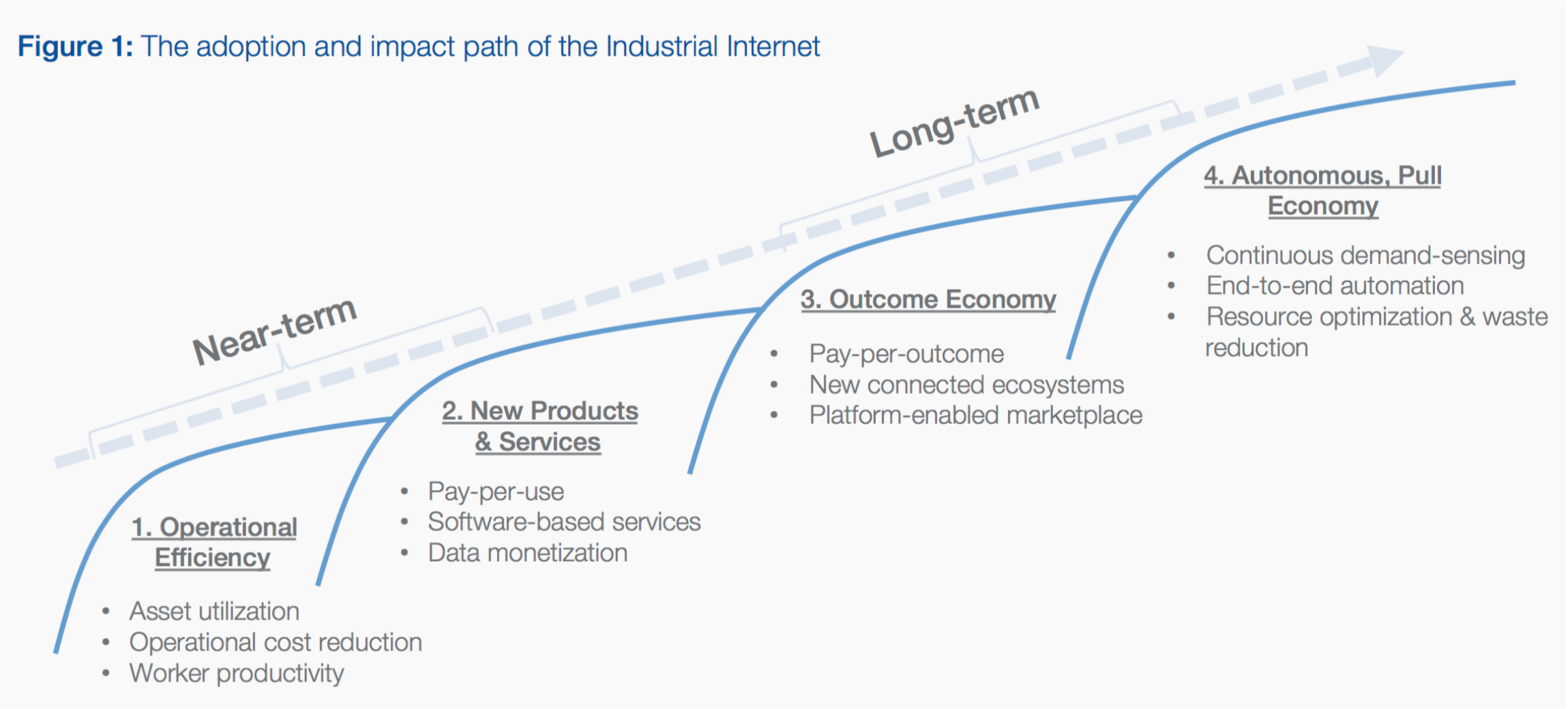
- Smart machines are better than humans at accurately, consistently capturing and communicating data. This data can enable companies to indentify inefficiencies and problems sooner, saving time and money and supporting business intelligence efforts.
- In manufacturing specifically, IIoT holds great potential for quality control, sustainable and green practices, supply chain traceability and overall supply chain efficiency.

Business Feedback Cycle





4 Phases of the Industrial Internet

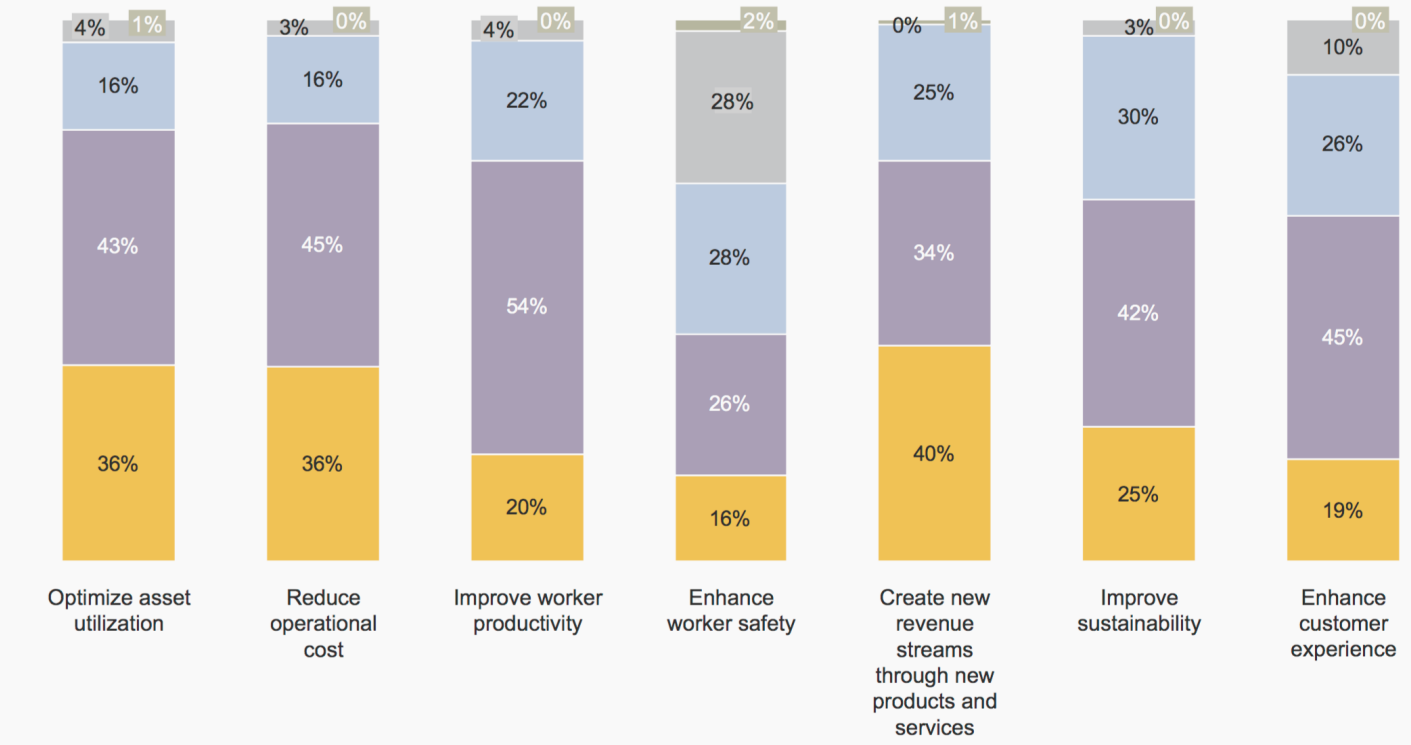


Source: https://www.rti.com/industries/iot-faq.html

Business Benefits

Figure 2: Business benefits for driving near-term adoption

Q: How important are the following benefits in driving businesses to adopt the Industrial Internet?



Source: https://www.rti.com/industries/iot-faq.html

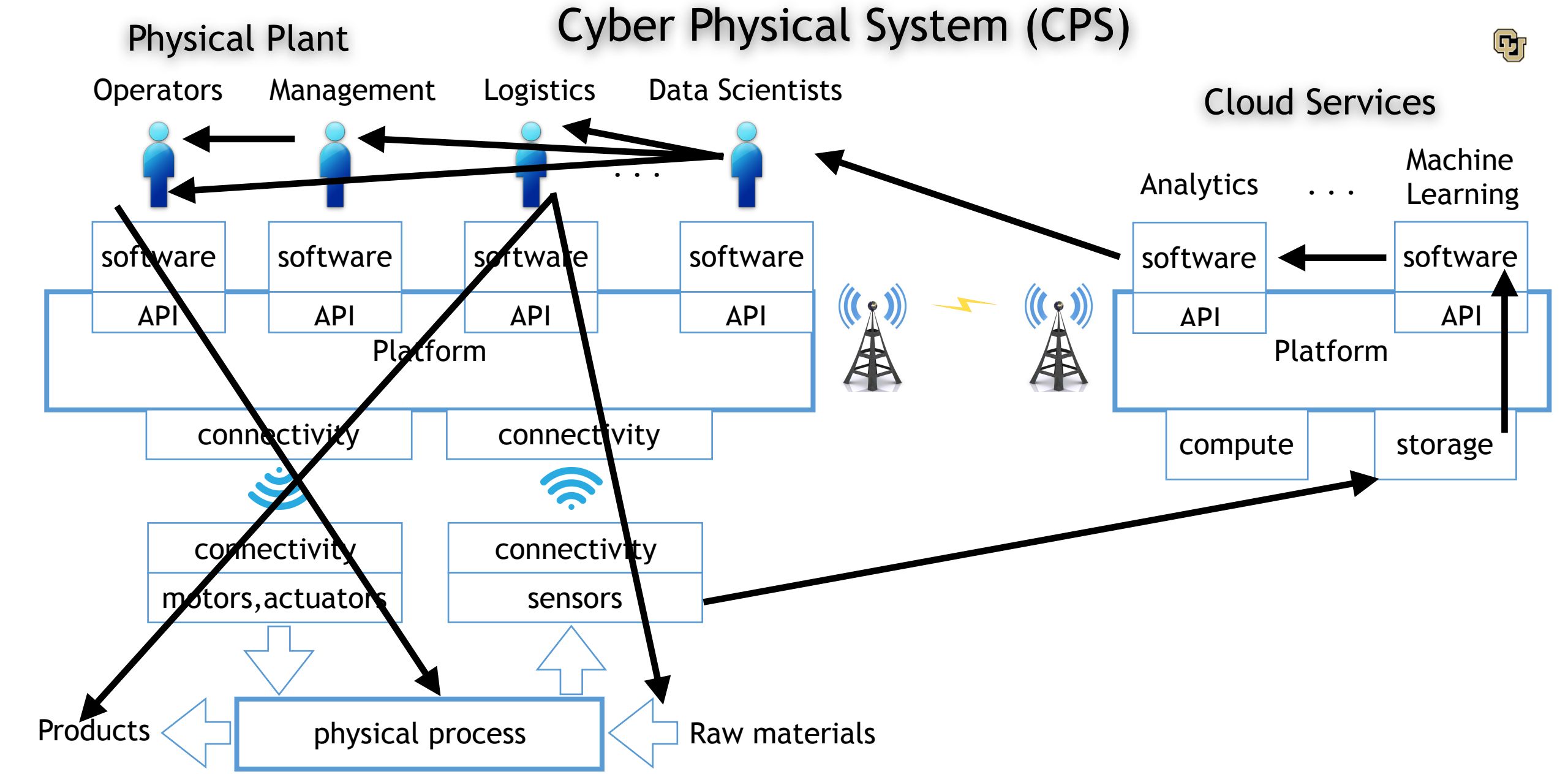
Market Overview: Terms & Definitions

- Hardware
  - Processors: CPU, MCU, FPGA, DSP and memory
  - Sensors
  - Connectivity: Bluetooth, WiFi, ethernet
- Software
  - Software solutions
  - Services
  - Platforms

Markets Overview: Terms & Definitions

- Platform
  - Allow central monitoring and control of each and every activity that takes place in an organization
  - Highly customizable software and API's that allow external developers to create specialized applications
  - Device management
  - Application management
    - In this context "Application" means Agriculture, Building Automation, Oil & Gas etc. - the business segment
  - Network management
- Purpose: Empowers system admins to monitor, control, visualize, simulate, schedule and analyze all organizational activities from a single location

Cyber Physical System (CPS)

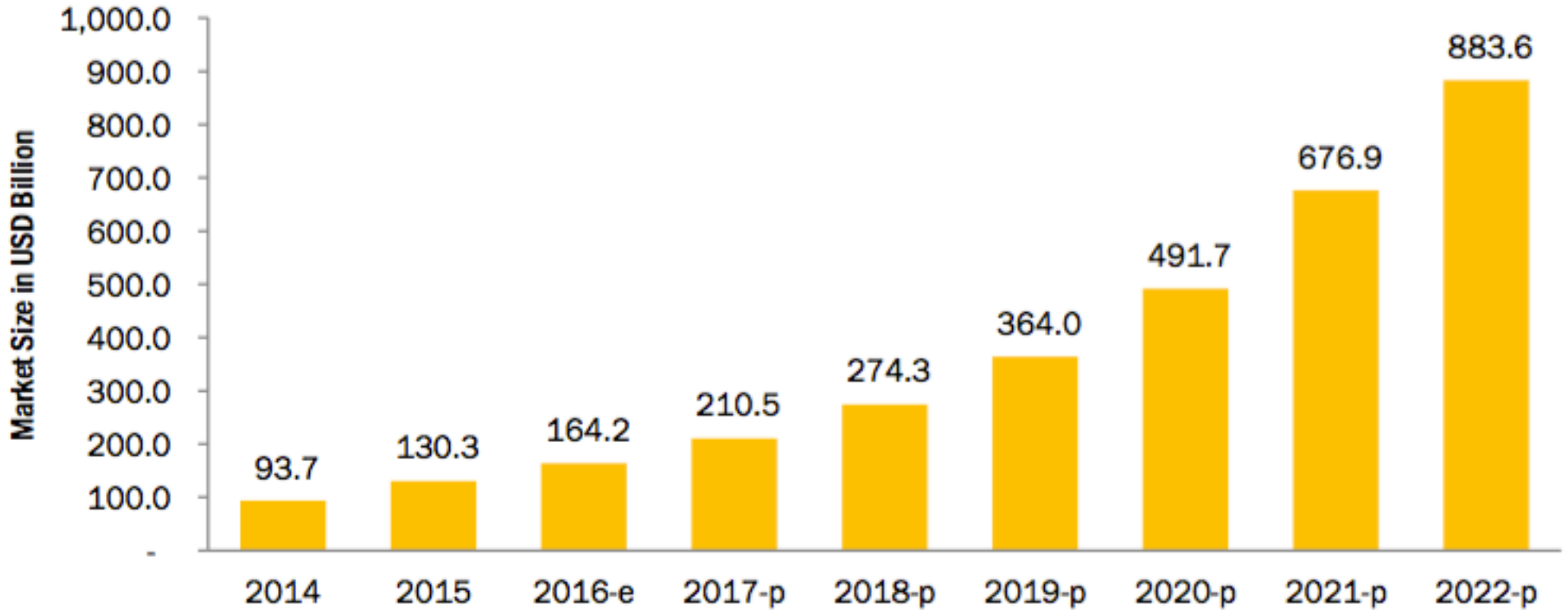


Market Coverage

- Hardware
- Platforms, Software, Services
- Applications:
  - Agriculture
  - Building automation
  - Manufacturing
  - Automotive & Transportation
  - Oil & Gas
  - Energy

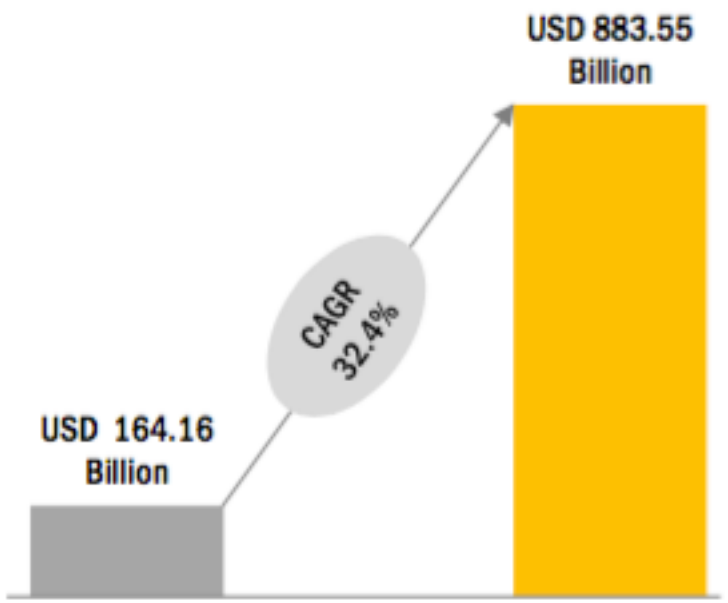
High Growth Ahead

FIGURE 6 **IOT TECHNOLOGY MARKET TO CROSS USD 880 BILLION BY 2022**



4.1 IOT TECHNOLOGY MARKET TO EXPERIENCE HIGH GROWTH

FIGURE 12 ATTRACTIVE GROWTH OPPORTUNITIES FOR THE IOT TECHNOLOGY MARKET

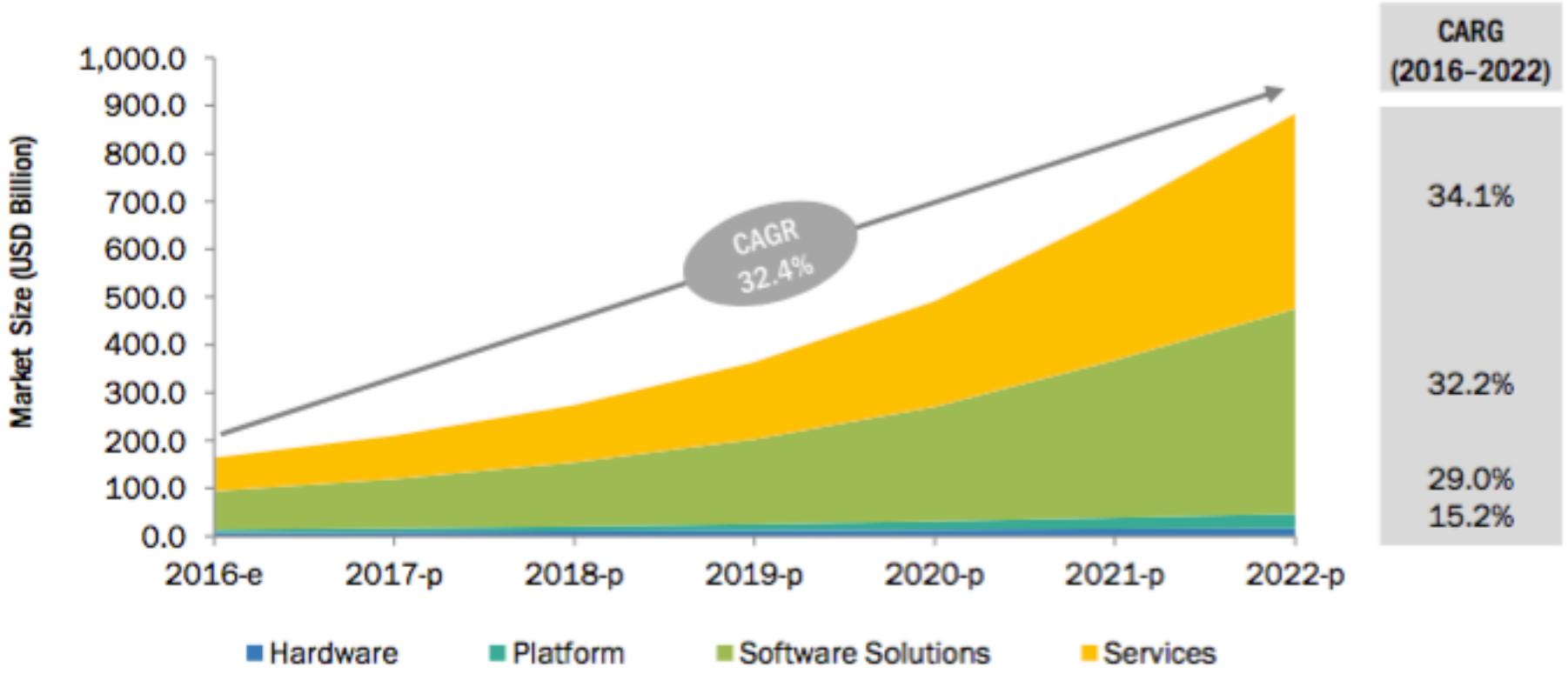


ATTRACTIVE MARKET OPPORTUNITIES

- The IoT technology market was valued at USD 130.33 billion in 2015 and is expected to grow at a CAGR of 32.4% between 2016 and 2022.
- The market growth is attributed to increasing Internet connectivity, increasing use of wireless sensors, and mainstreaming of cloud computing.
- Automotive & transportation, building automation, and industrial are some of the top application of the IoT technology market.

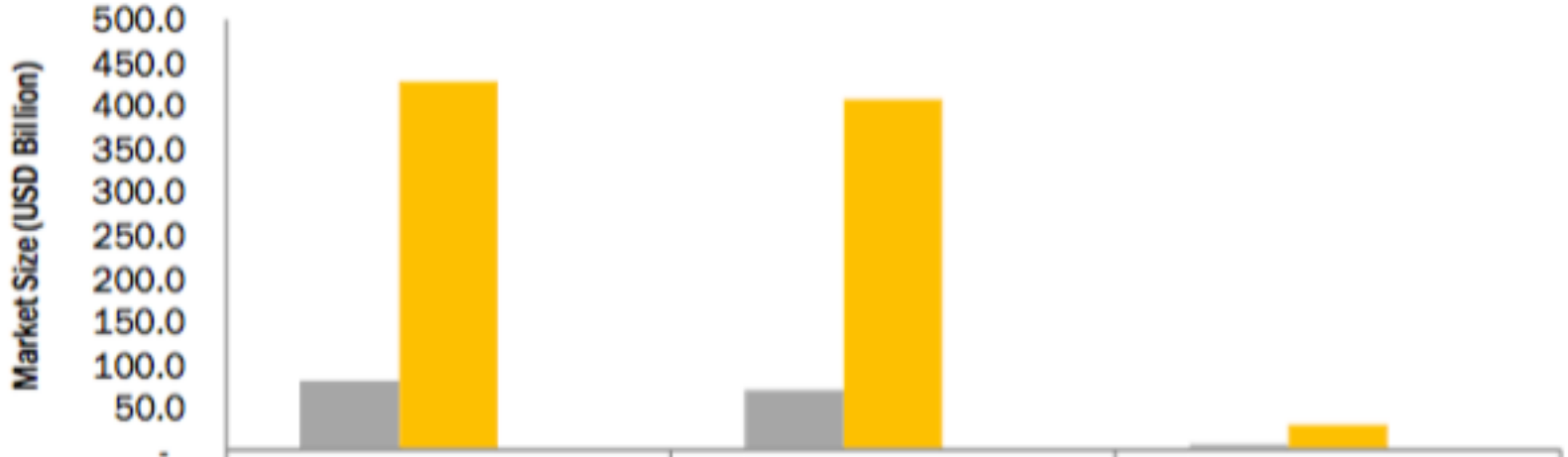
4.2 IOT TECHNOLOGY MARKET, BY APPLICATION(2016–2022)

FIGURE 13 IOT SOFTWARE SOLUTIONS TO HOLD THE LARGEST MARKET DURING THE FORECAST PERIOD



Software

FIGURE 8 **SOFTWARE SOLUTIONS TO HOLD THE LARGEST SHARE OF THE IOT TECHNOLOGY MARKET**



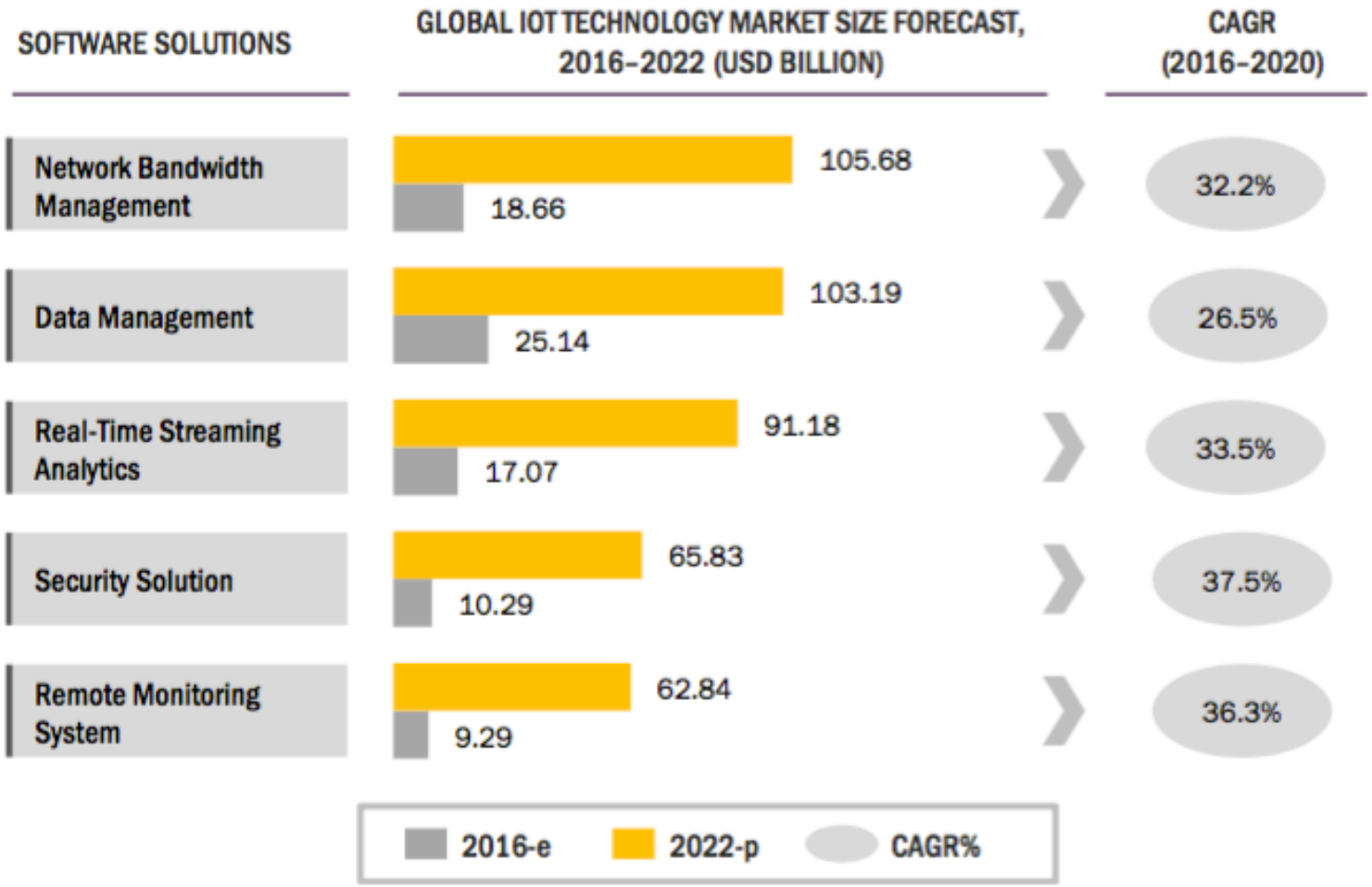
	Software Solutions	Services	Platform
2016-e	80.4	70.1	6.5
2022-p	428.7	408.3	29.8
CAGR (2016–2022)	32.2%	34.1%	29.0%

Software Market Breakdown

- Real-time steaming analytics
- Network bandwidth management
- Remote monitoring
- Security
- Data management (big data - how to store and analyze)

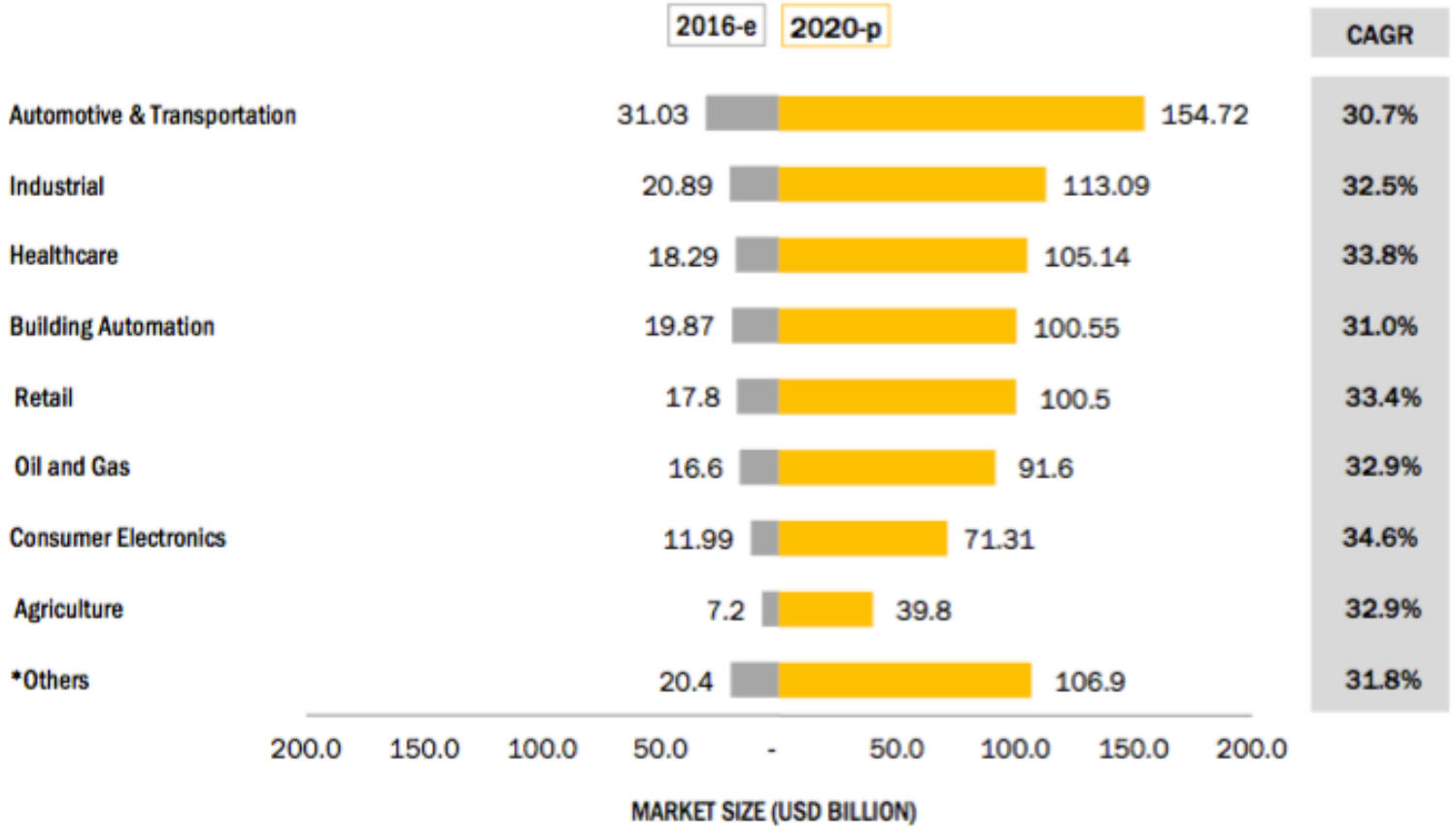
4.5 IOT TECHNOLOGY SOFTWARE SOLUTIONS MARKET, BY TYPE (2016–2022)

FIGURE 16 NETWORK BANDWIDTH MANAGEMENT SEGMENT TO DOMINATE THE SOFTWARE SOLUTIONS MARKET DURING THE FORECAST PERIOD



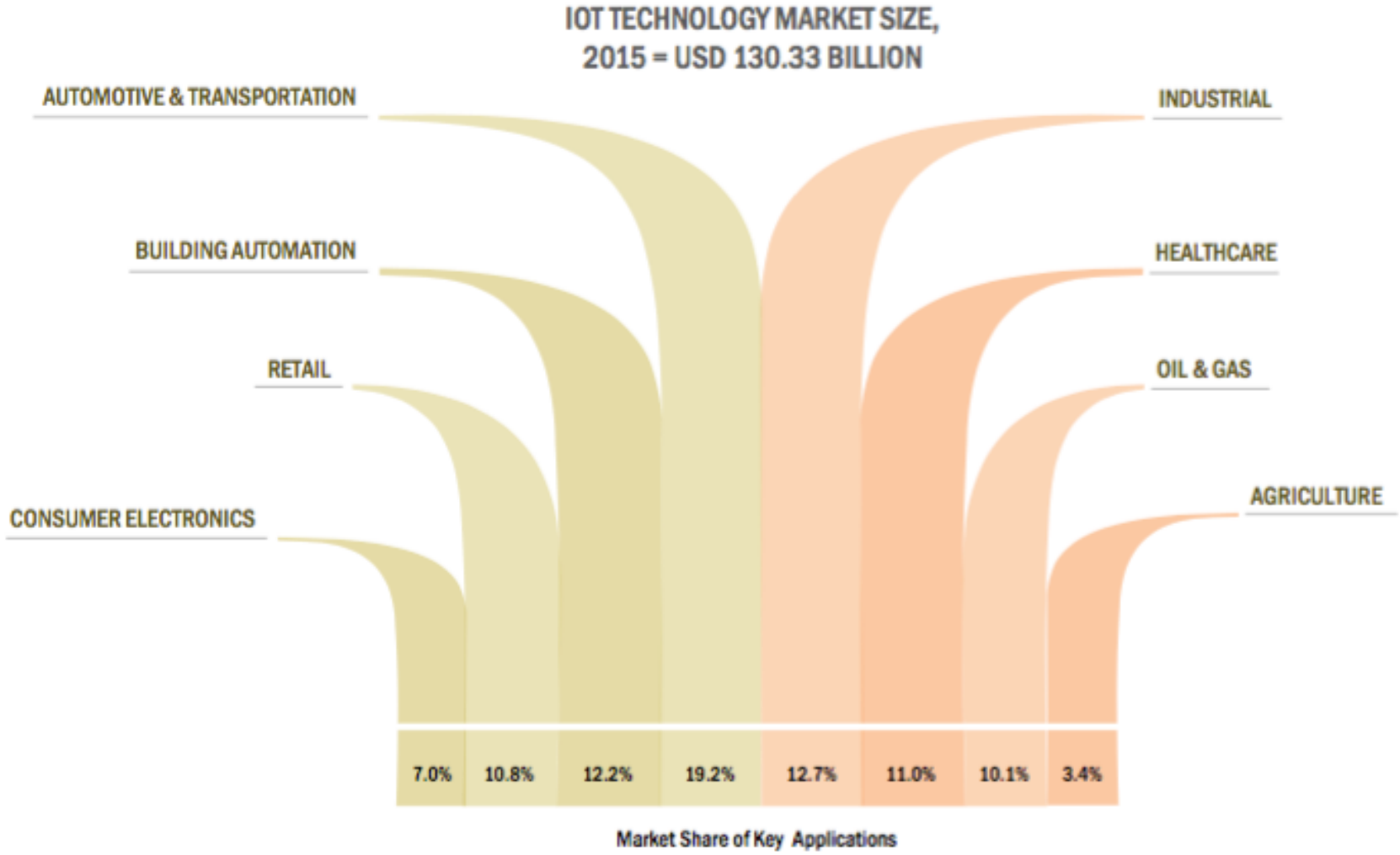
Automotive & Transportation

FIGURE 9 AUTOMOTIVE & TRANSPORTATION APPLICATION TO DOMINATE THE IOT TECHNOLOGY MARKET DURING THE FORECAST PERIOD



4.3 IOT TECHNOLOGY MARKET: KEY APPLICATIONS, 2015

FIGURE 14 AUTOMOTIVE & TRANSPORTATION HELD THE LARGEST SHARE OF THE IOT TECHNOLOGY MARKET IN 2015

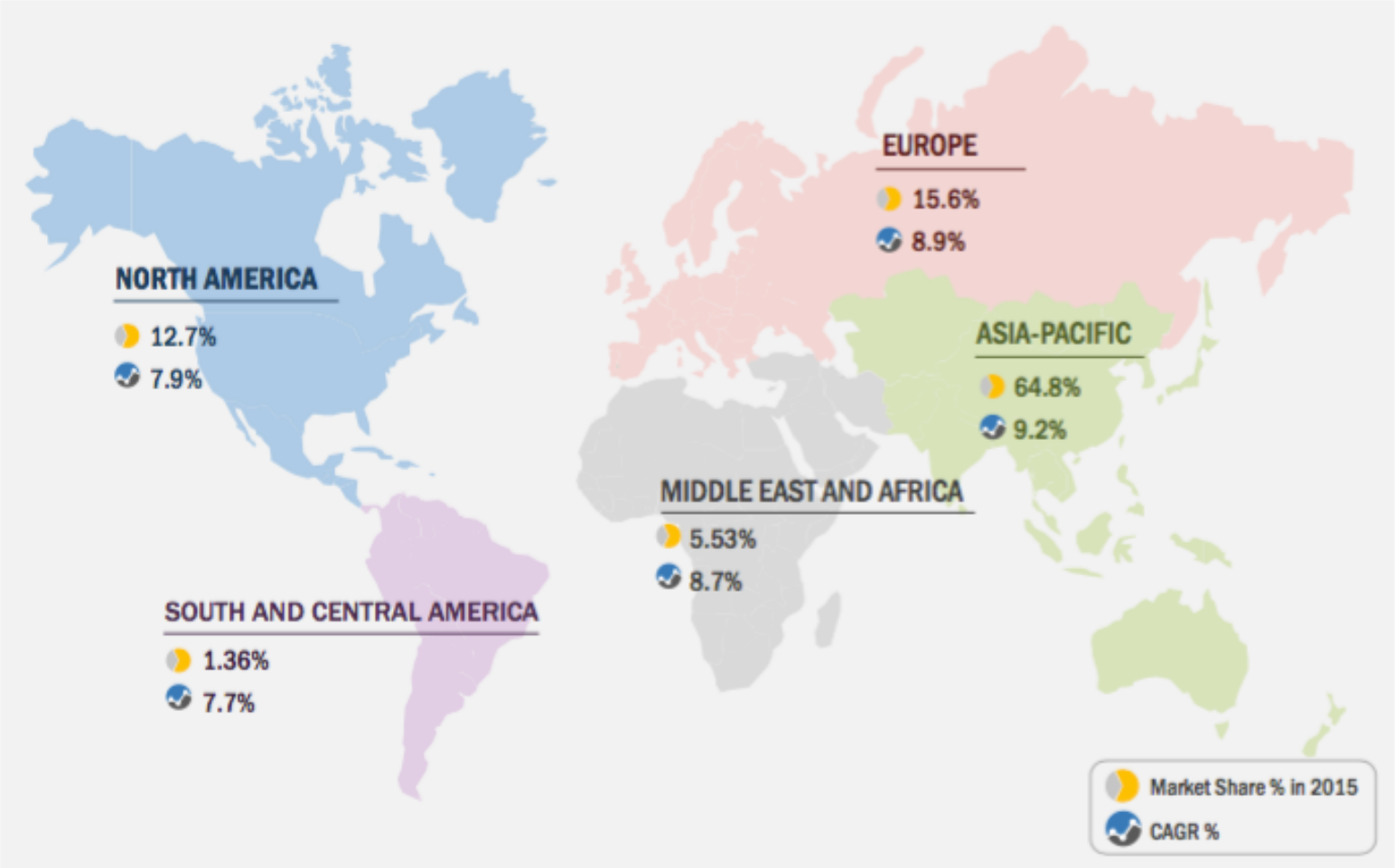


Partnerships

- “Strategies such as agreements, collaborations, joint ventures, and partnerships collectively accounted for 36% of the total strategic developments. This strategy was adopted by all major players in the market (2015-2016) as companies look beyond their core strengths to grow at a rapid rate in the IoT technology market.”
- What’s the trouble with partnerships?
  - Partners can become “Frienemies”, and later outright competitors

Geographical Market Share

FIGURE 10 ASIA PACIFIC HELD THE LARGEST MARKET SHARE, 2015



"The Asia-Pacific region is expected to grow at the highest CAGR of 38.3% from 2016 to 2022, followed by the Middle East & Africa"

"In China, there is a great deal of enthusiasm for Internet of Things, mainly owing to the heavy financial and strategic involvement of the government in IoT-based developments"

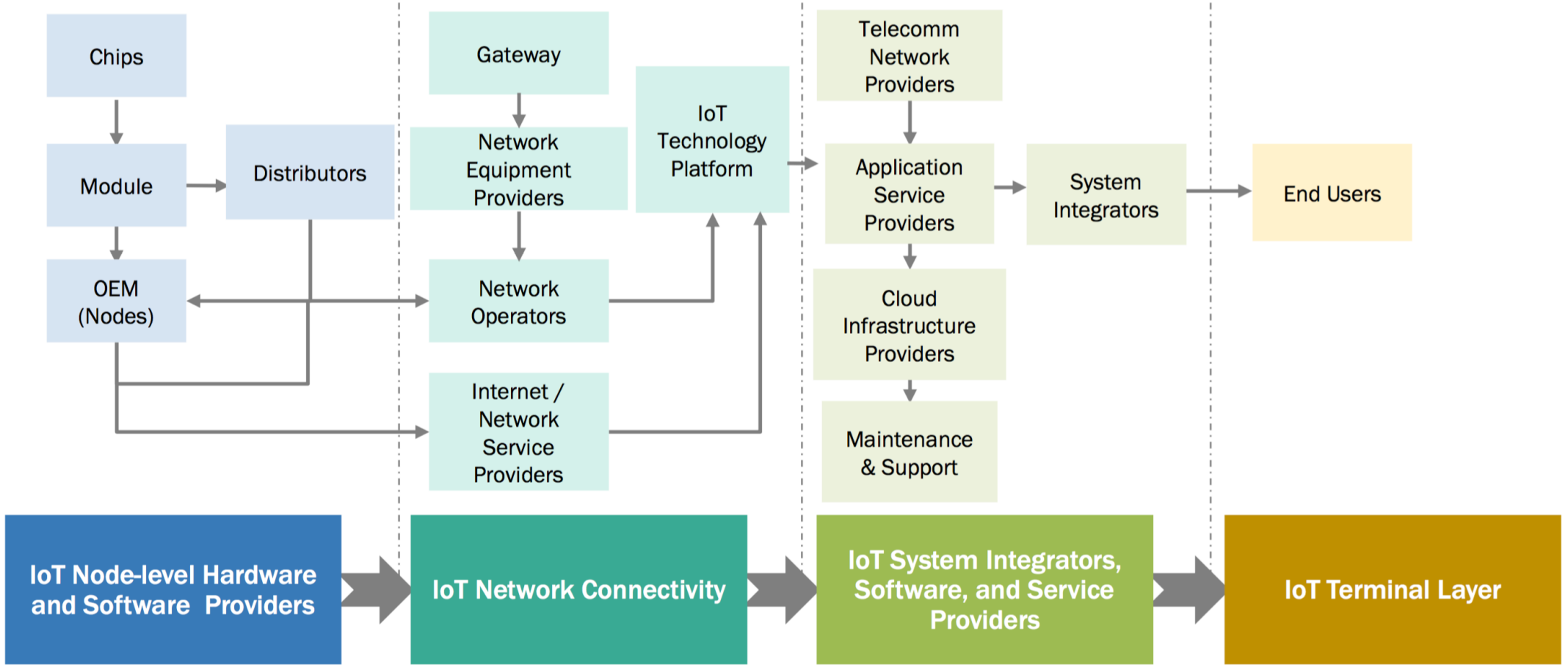
Top Players

Also: Cisco, Amazon, Microsoft, SAP

- Intel
  - Top player in the IoT technology market. It is involved in the design and manufacturing of integrated digital technology and development of IoT platforms which are helpful for the development of overall IoT market. The company's Internet of Things group segment offers platforms for customers to design products for the retail, transportation, industrial, buildings, and home market segments. The Internet of Things group (IoTG) further focuses on establishing an end-to-end architecture that captures actionable information for consumers
- IBM
  - Ranked second in the market. The company is actively investing on R&D and has more than 7,000 patents. The company collaborated with various IoT players to expand its IoT portfolio and offer innovative solutions
- GE
  - Ranked third. The company is focused on providing analytics platform and solutions to help data prediction through real-time analytics to assist organizations in forecasting better business outcomes and improving their operations.

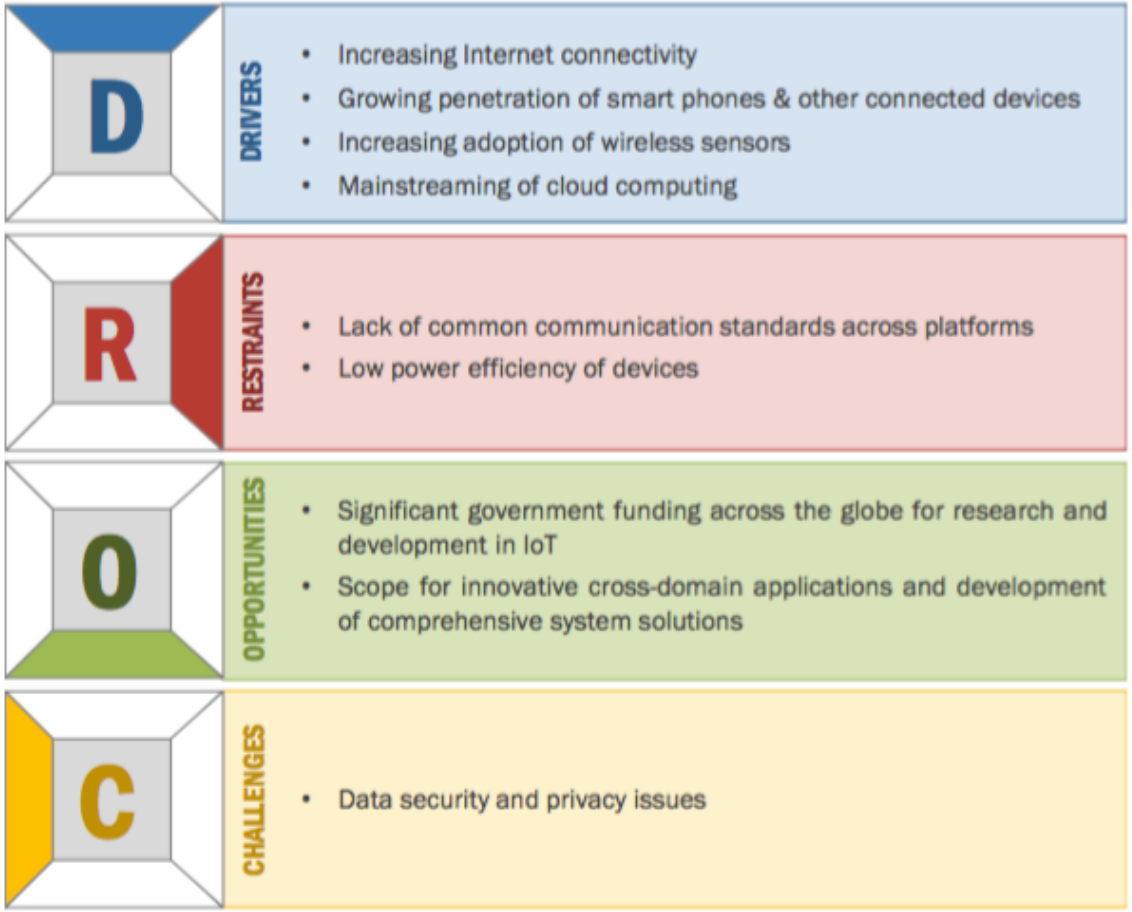
Value Chain

FIGURE 21 **VALUE CHAIN ANALYSIS: IOT TECHNOLOGY MARKET**

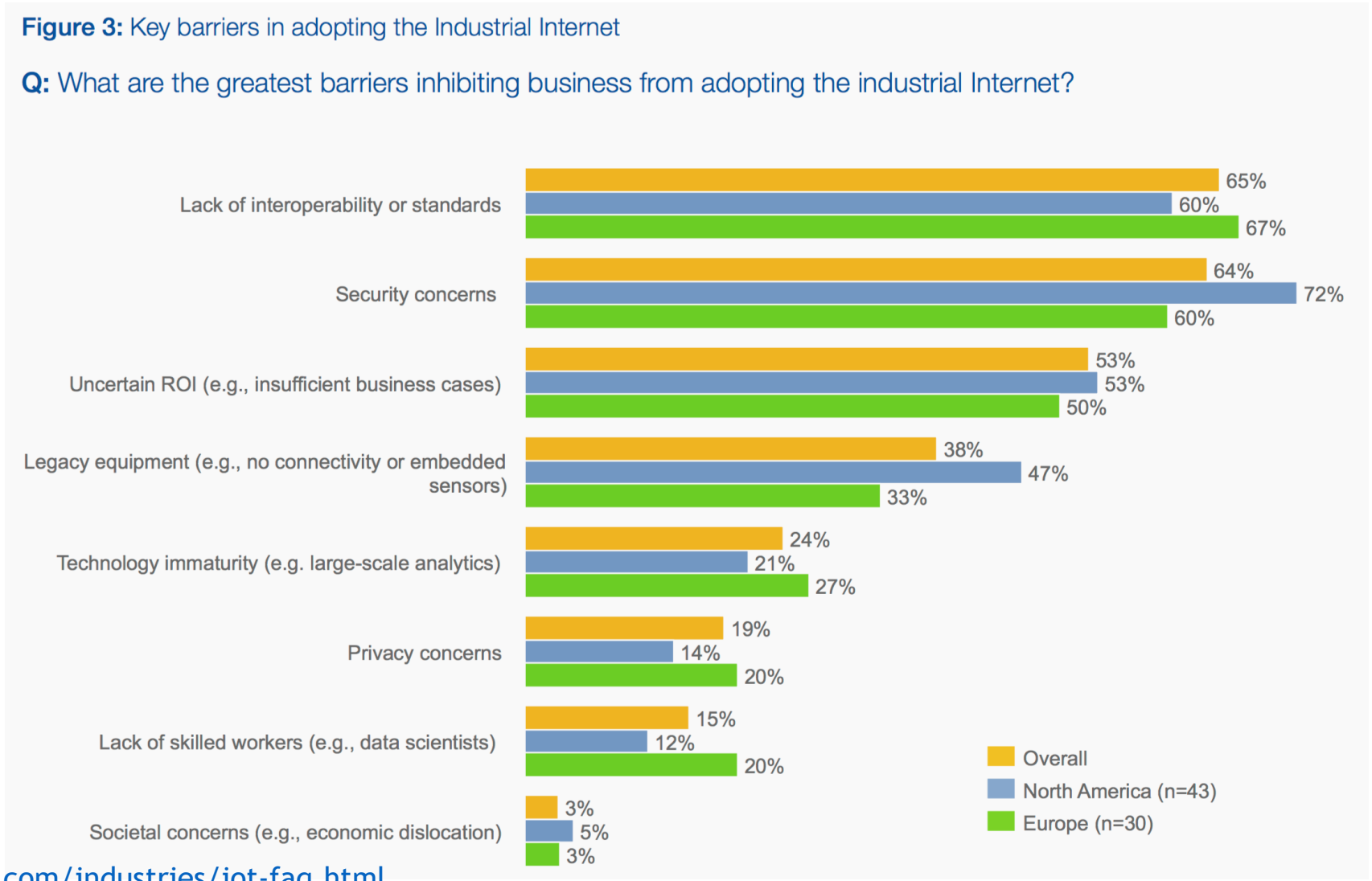


Market Dynamics

FIGURE 19 **INCREASING INTERNET CONNECTIVITY TO ENHANCE THE GROWTH OF IOT TECHNOLOGY MARKET**



Market Barriers

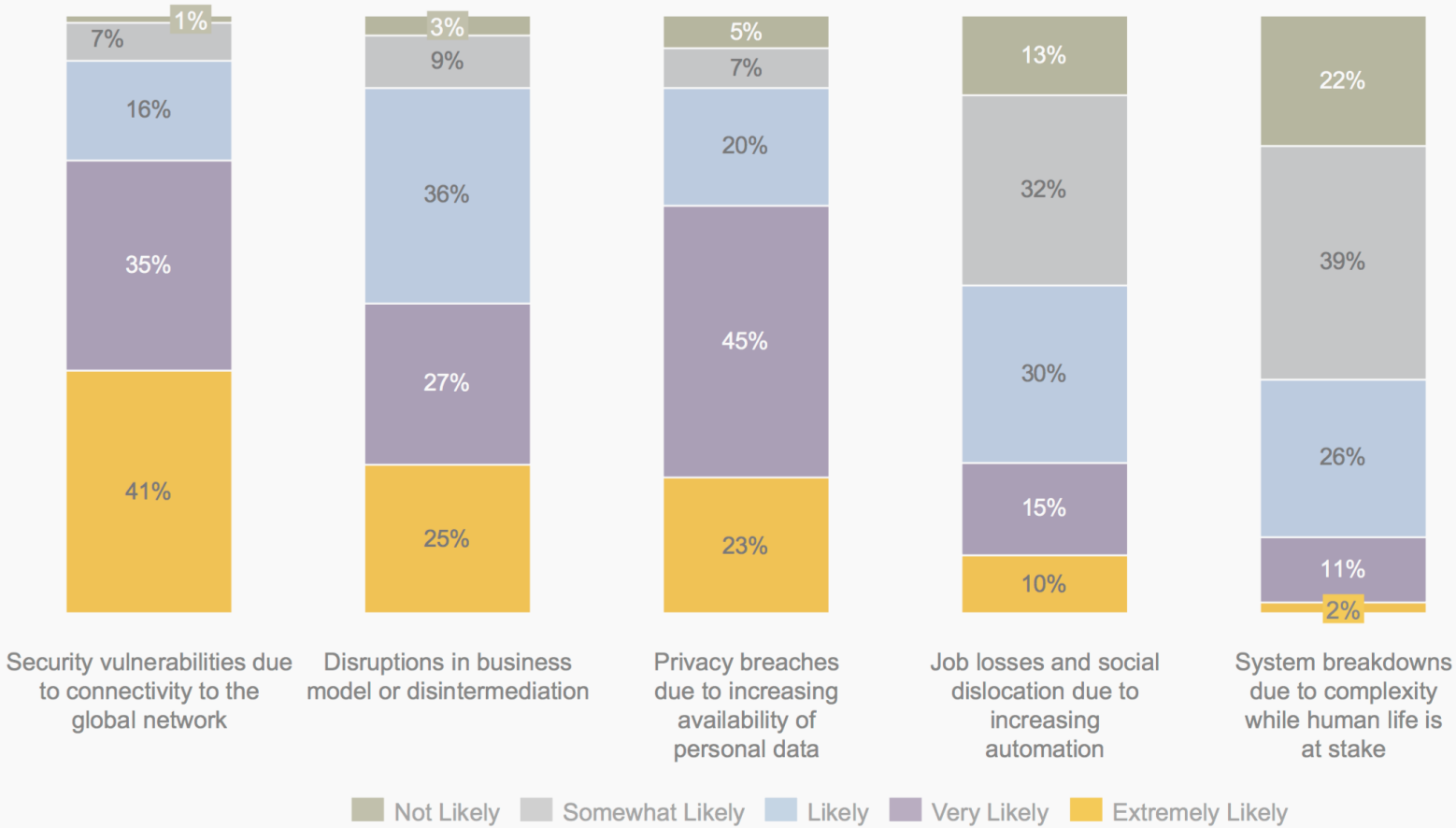


Source: https://www.rti.com/industries/iot-faq.html

Market Risks

Figure 4: Likely risks for adopting the Industrial Internet

Q: How likely are the following risks or negative consequences associated with the Industrial Internet?



Source: https://www.rti.com/industries/iot-faq.html

KEY FINDINGS

- IoT is changing the technological landscape across all verticals, and organizations are seeking ways to make improvements amidst the evolution.
- The market is expected to be driven by factors such as increasing Internet connectivity worldwide, increasing demand for the smart phones & other connected devices, increasing adoption of wireless sensors, and mainstreaming of cloud computing.
- Lack of common communication standards across platforms and low power efficiency of devices act as restraining factors for the growth of the market.
- Significant government funding across the globe for research and development in IoT presents a new growth opportunity for players in the market.
- Overcoming data security and privacy issues is important for the growth of the IoT technology market.

Source: Markets and Markets

Case study: Consumers Energy Co. JH Campbell Plant, Michigan

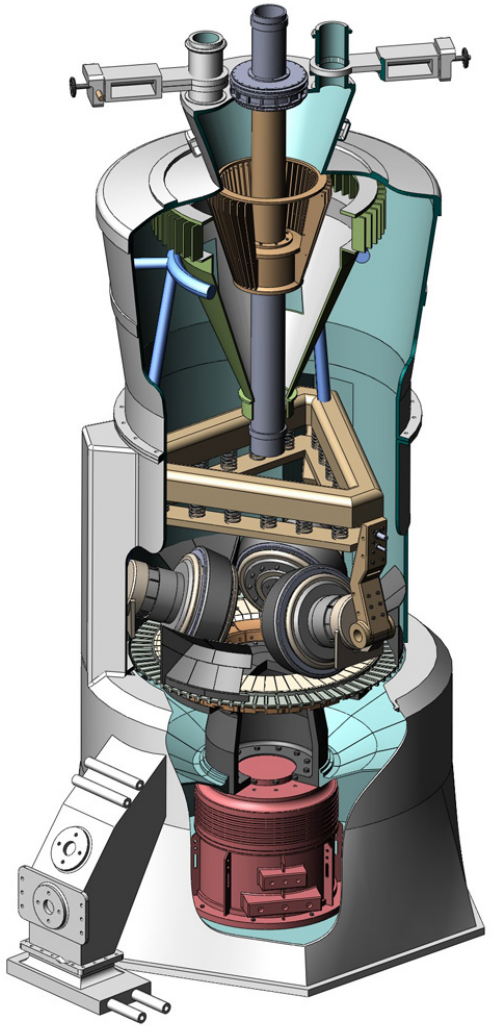
Case study: Consumers Energy Co.

Case study: Consumers Energy Co.

- Unit 3: (~830 MW), has over 15,000 "hard" I/O points (4,346 analog, 10,940 digital)
- The site (operations, engineering, maintenance) constantly reviews trend data, alarms, point excursions etc. to diagnose past failures and anticipate future failures.

Source: John Hiddema, PE, Consumers Energy Co.

Case study: Coal Pulverizers



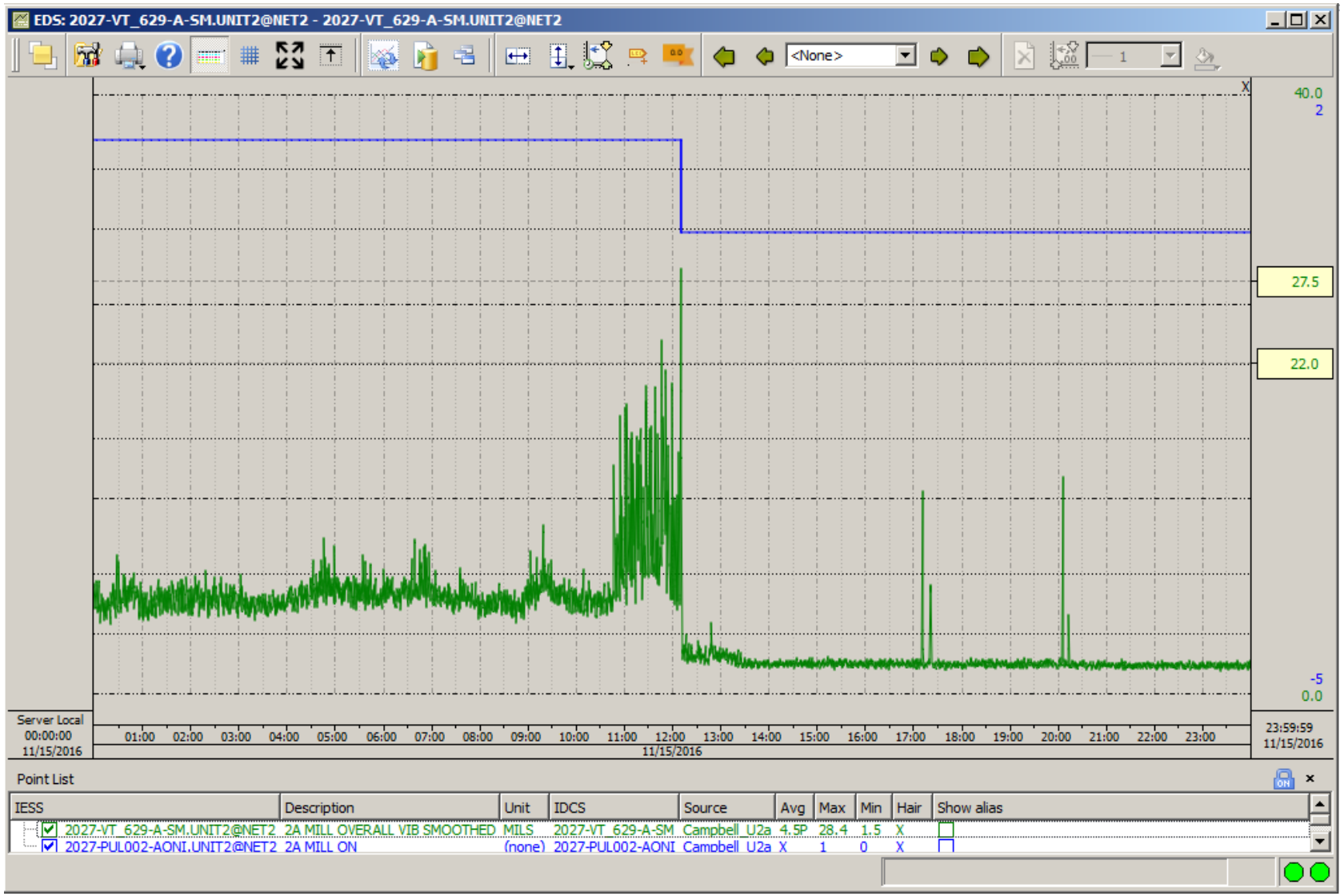
- https://www.youtube.com/watch?v=k_IG-tXihlU

Case study: Coal Pulverizer main shaft vibration

- Has had issues with the main shaft breaking on Unit 2 mills (due to various issues: change of fuel blend on the unit from 100% Eastern Coal to 100% Wester Coal, tramp iron, running the mill “lean” during startup/shutdown etc.)
- In attempt to remove the mill from service prior to failure, we have installed overall vibration probes on the mill housing. We have also setup alarm limits and an Alarm Response Procedure (ARP) to remove the mill from service if the overall vibration is above a prescribed limit.
- In the example below, 2A Mill went above 27.5 mils on 11/15 at ~12:00 and the operators removed the mill from service. We ended up finding tramp iron (foreign metal from the mine) in the mill.
- The ARP directs the operator to the trend and locally monitor the mill if in High Alarm Limit 1, remove the mill from service if in High Alarm Limit 2 for 2 minutes. The alarm has to go below 14 mils for 32 seconds to reset.

Source: John Hiddema, PE, Consumers Energy Co.

Case study: Coal Pulverizer housing vibration



Case study: Coal pulverizer main shaft vibration

	Mill Alarm Limits
Normal Operating	4.0 – 11.0 mils
High Alarm Limit 1	22.0 mils
High Alarm Limit 2	27.5 mils
Reset	< 14 mils (32 seconds)

Source: John Hiddema, PE, Consumers Energy Co.

Key Skills to Develop

- Manager at Accenture:
  - Network Security/ Security Infrastructure/ Data Security: This has always been on the top of the list, however after recent incidents, this has become an even more important skill that employers are looking for in people. The data is stored in cloud and cloud security is what they are focusing on currently.
  - There are also certain programmers who are trying to make patterns out of the sensor data outputs -> Data Analystics
  - Software Programming: C/C++/Python/Java/Node.js/Javascript/ RubyonRails are the major programming languages that they test candidates on depending on the requirement. They look for everything in a candidate including data structures and algorithms.
  - Firmware Programming: Many startups are doing interesting things with cloud computing, micro-controllers and embedded servers.

Key Skills to Develop

- Senior Engineer at Arrow deploying IIoT:
  - Wireless communications. Know the Pros/Cons of each.
  - Sensing systems
    - Sensor types
    - Calibration
    - Digital filtering methods
  - Embedded processing platforms
    - OS/RTOS
  - Cloud platforms and services
  - Security

End