

# Internet of Things: Introduction

By  
Sachin Pawaskar, Ph.D., MBA, MS.

## IoT: Current state of affairs

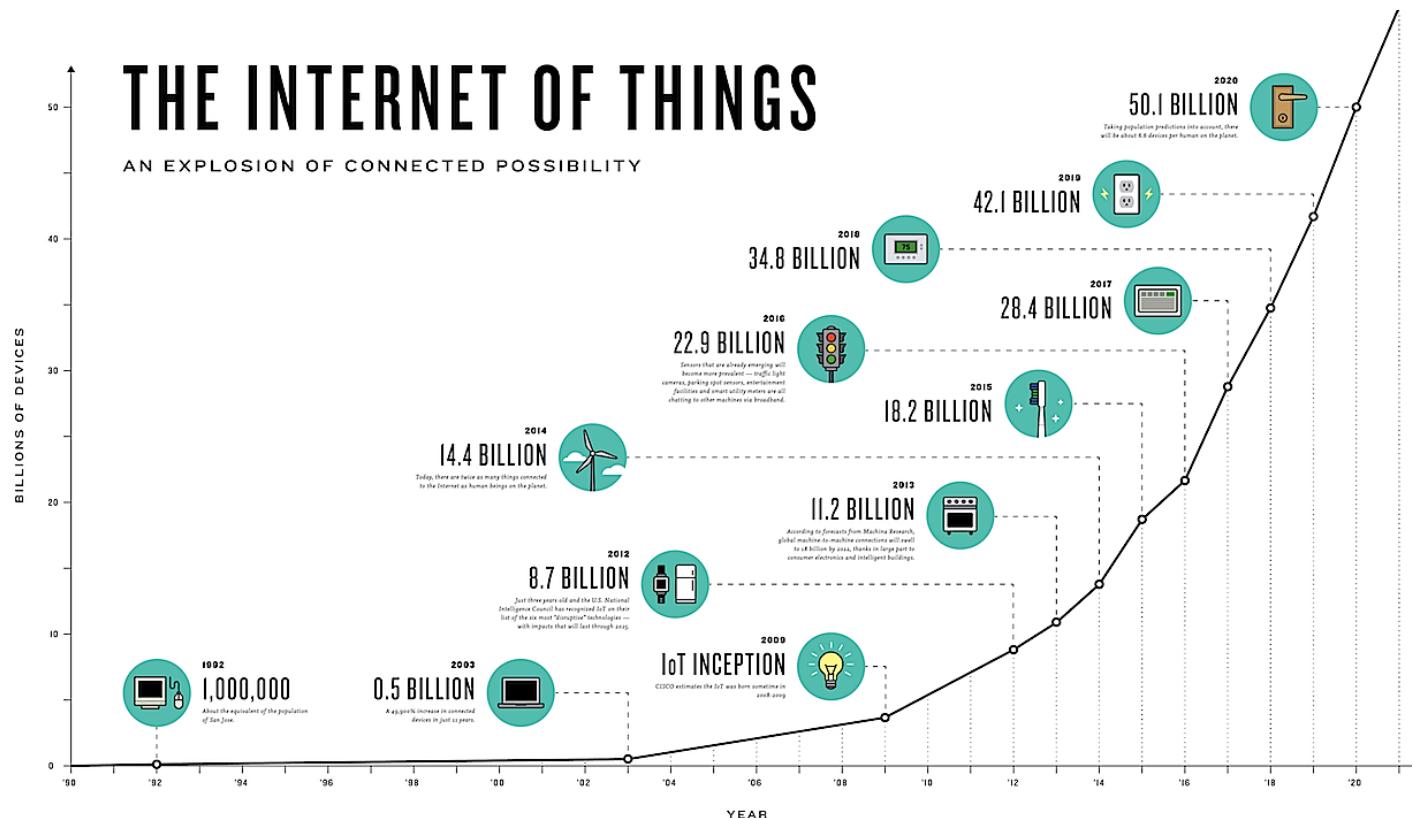
- We already have TV's, cars, homes, building & industrial equipment and other things **connected** to the internet.
- What can they do for us?
  - Automate systems for us
  - Allow us to communicate easier, and
  - Collect data for us.

So whether we've have known it or not, the  
**Internet of Things is already here.**



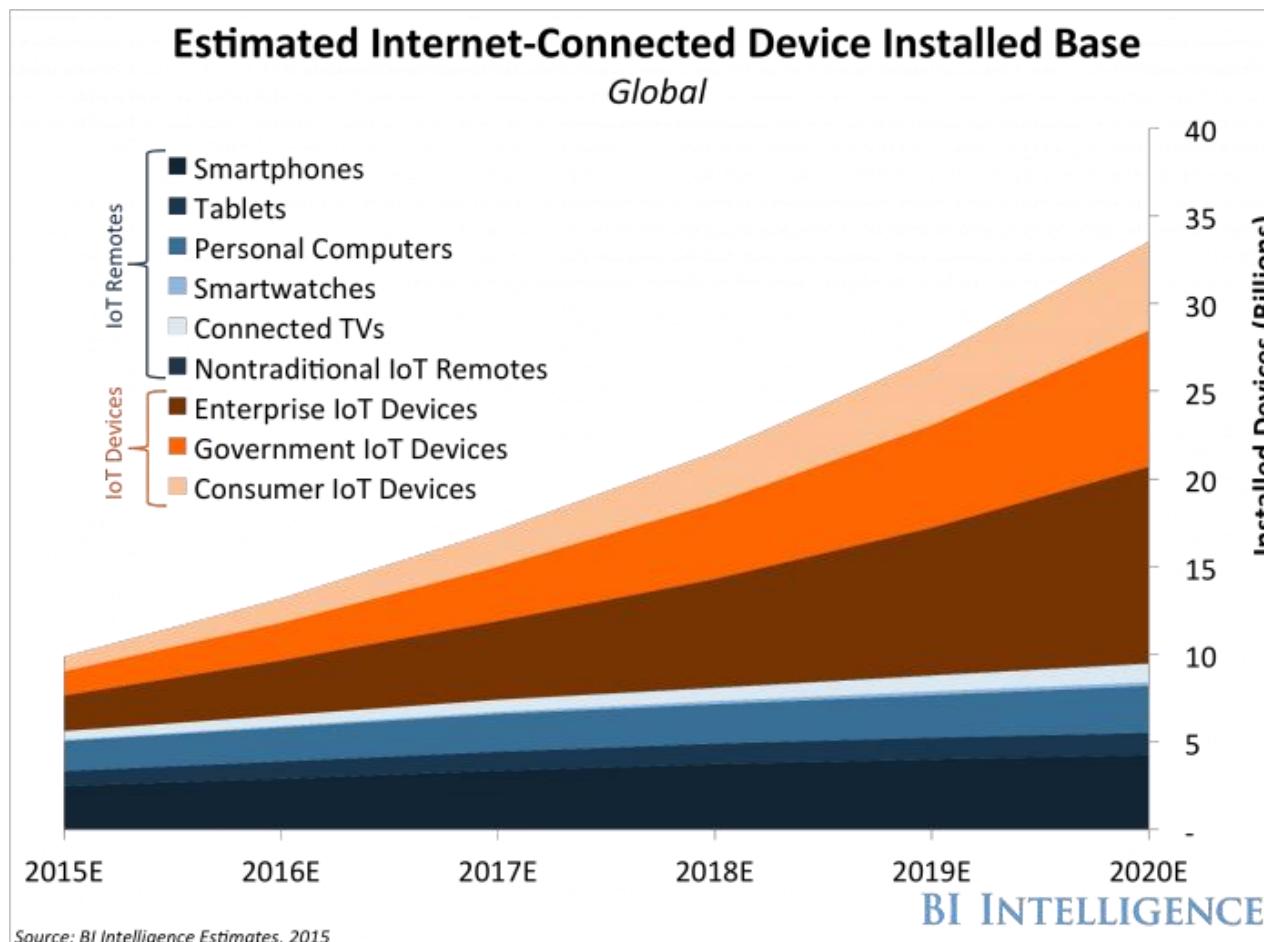
# So, What is the FUSS all about?

- Amount of IoT connections about to **explode**.



[https://www.reddit.com/r/dataisbeautiful/comments/2kdym6/forecast\\_of\\_the\\_number\\_of\\_connected\\_devices\\_until/](https://www.reddit.com/r/dataisbeautiful/comments/2kdym6/forecast_of_the_number_of_connected_devices_until/)

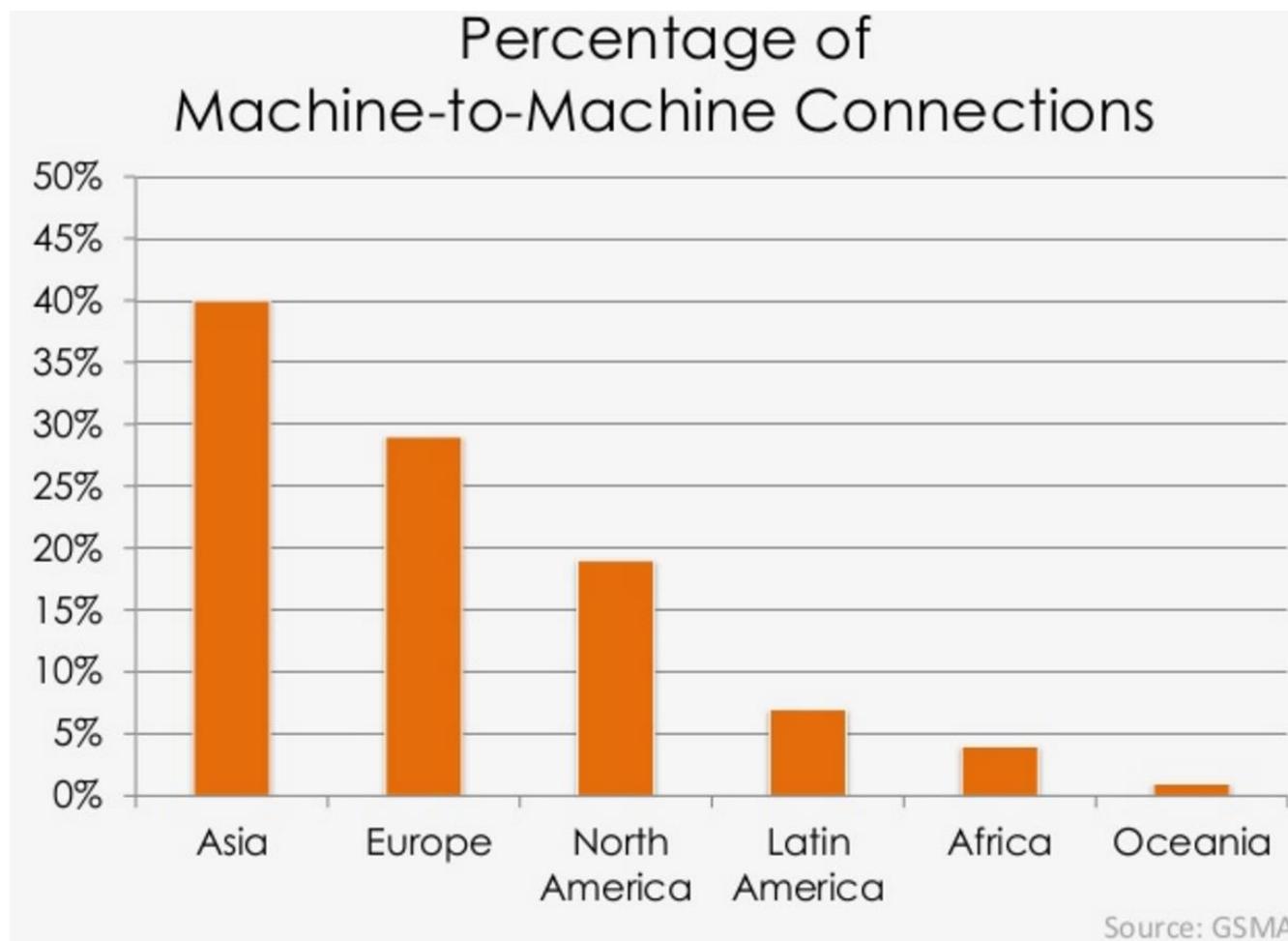
# So, What is the FUSS all about?



<http://www.businessinsider.com/bi-intelligence-34-billion-connected-devices-2020-2015-11>

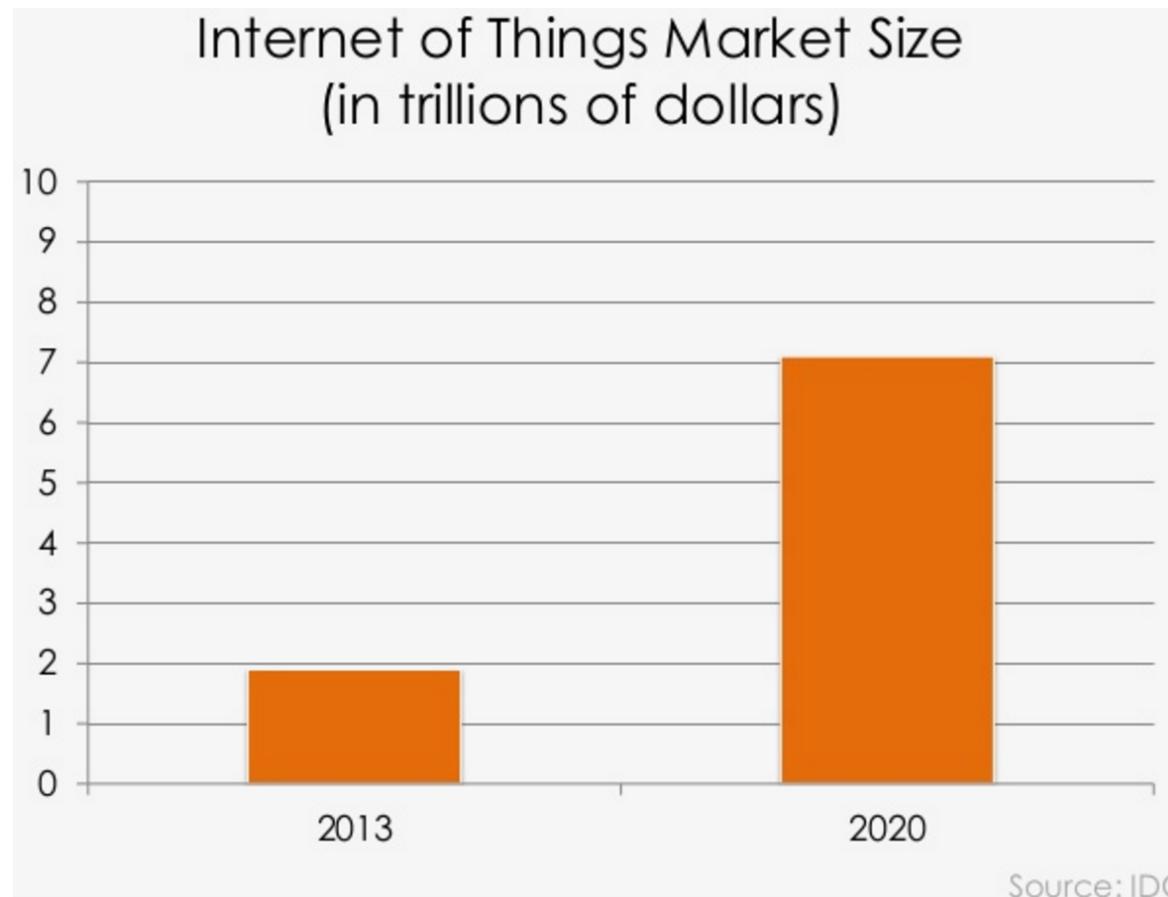
# Where is all the action?

- While American technology companies are making lots of IoT progress,
- **Asia** currently has the most connections.



# Asia – Really? – Why? What's it worth?

- China's government has committed to spend \$603 billion by 2020 for M2M connections.
- What's the worth of all these connected things?
- Probably much more than you think.



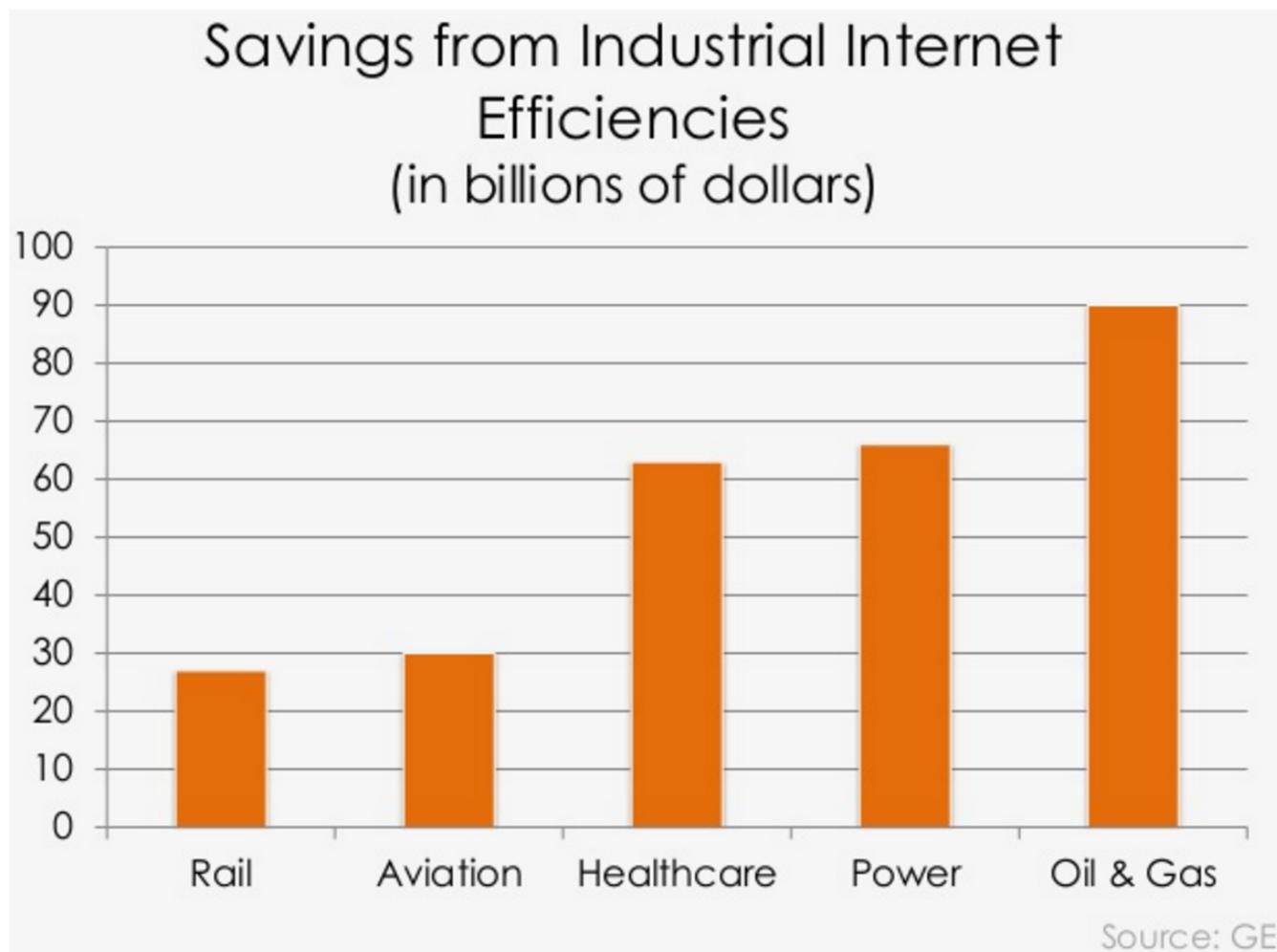
Not everyone agrees.

Cisco believes the market size will be \$19 trillion by 2025.

# What does it mean for Business and Me?

- The potential market size is so big because the IoT is about increasing **efficiency**, as well as creating new **profits**.
- These efficiencies will touch nearly **every** part of our lives: Healthcare, Transportation, Utilities, etc.
- General Electric says that a 1% increase in efficiencies from the Industrial Internet (part of the IoT) will have huge savings.

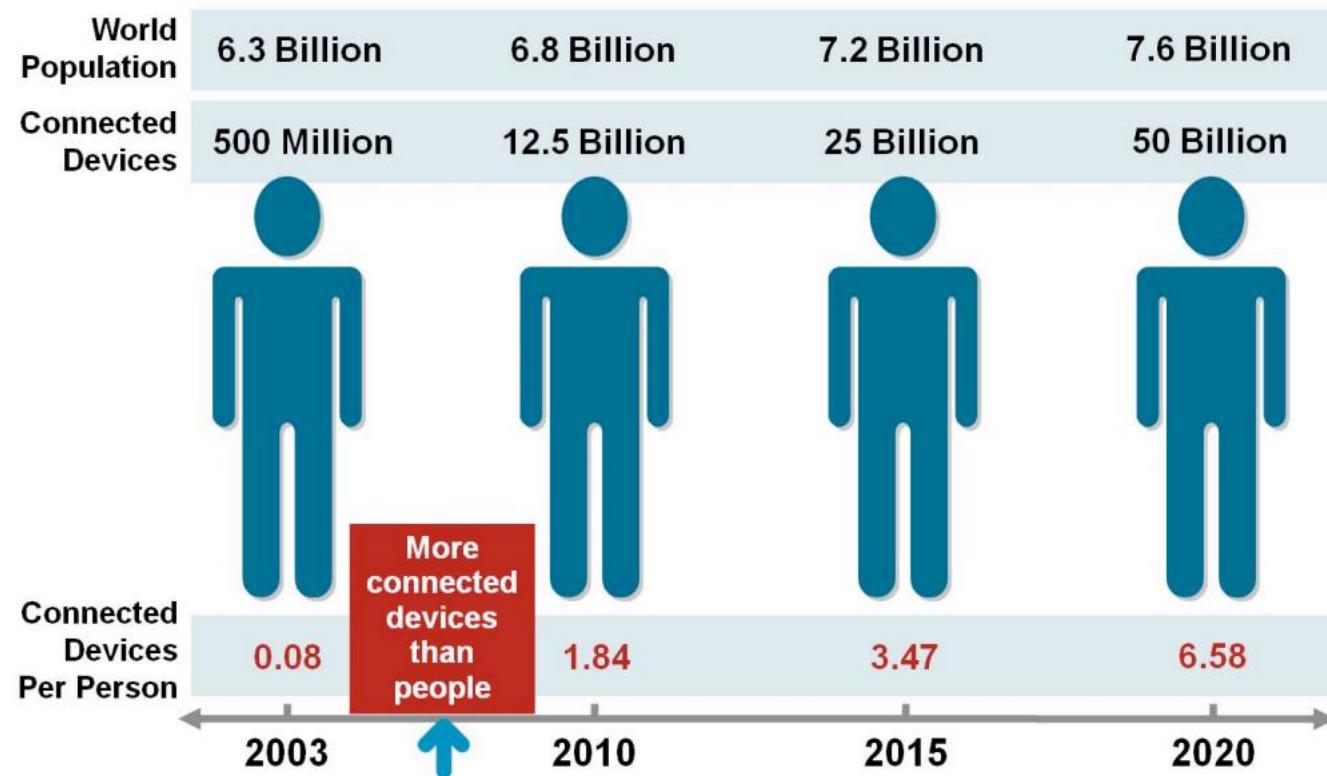
# Industrial Internet efficiencies



# Some Skepticism and Optimism

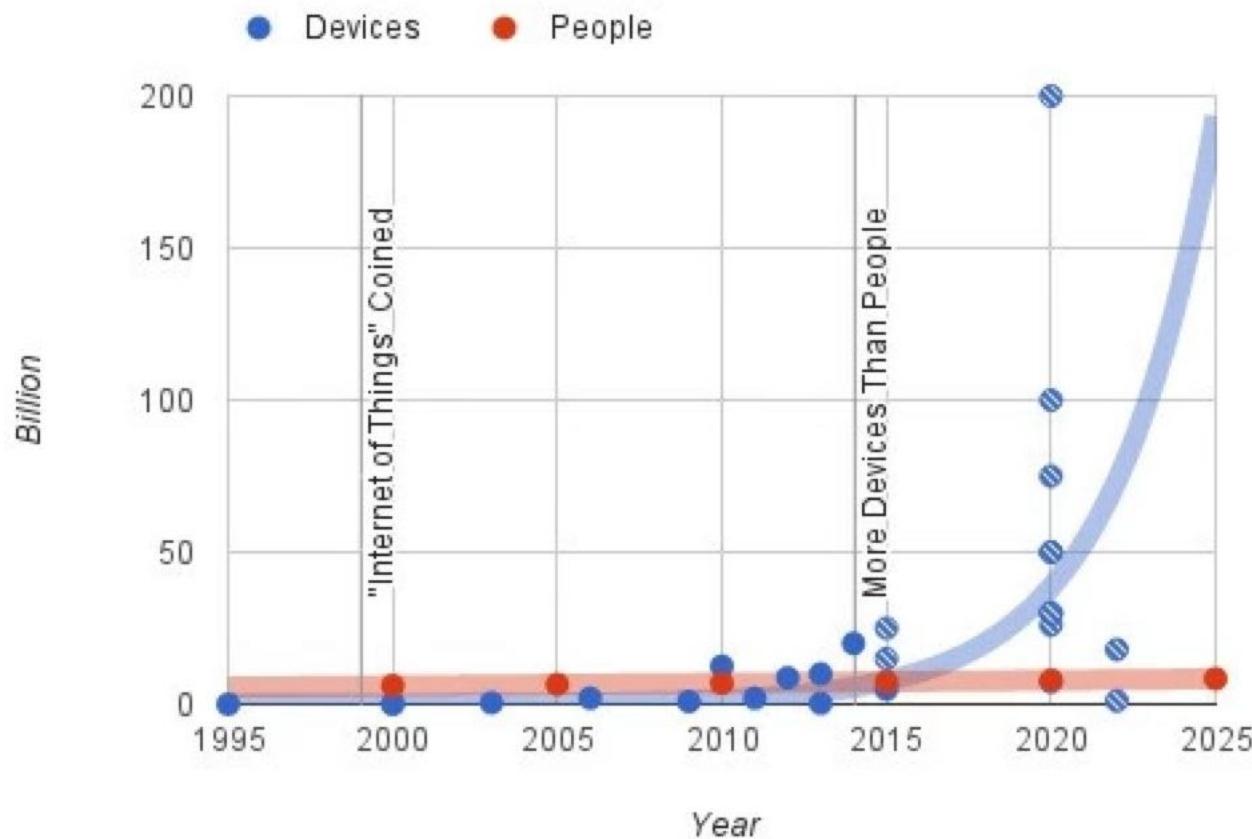
- There is a lot of room for **varying** IoT predictions.
- But even if we look at the low estimates, IoT will still have a huge impact on our **lives**.
- And we've only just **begun**.

# Internet Usage and Population Statistics



Source: Cisco IBSG, April 2011

# Internet Usage and Population Statistics

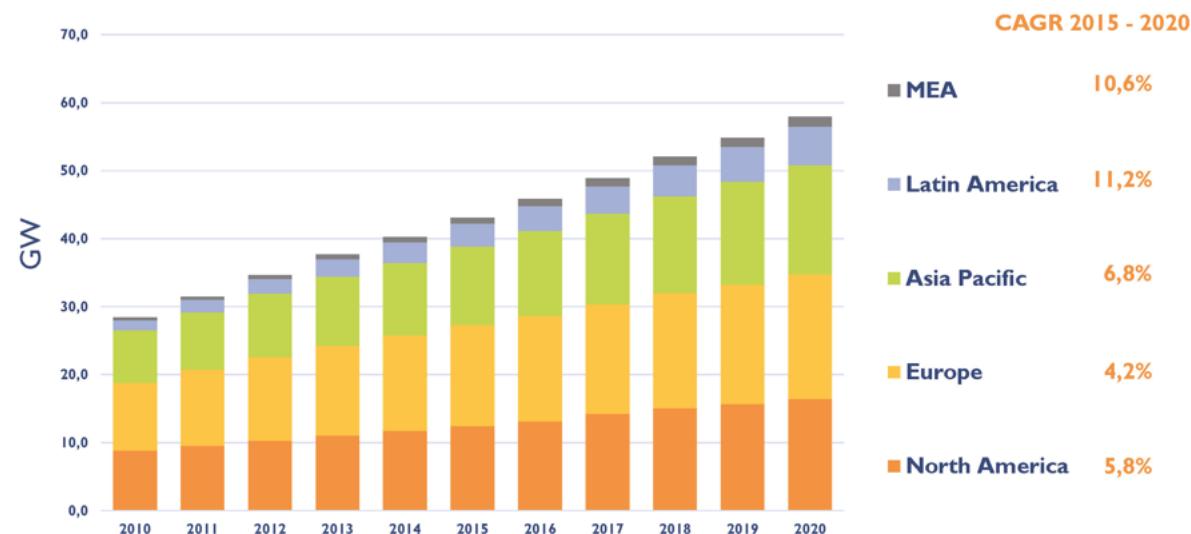


<https://www.brookings.edu/blog/techtank/2015/06/09/sketching-out-the-internet-of-things-trendline/>

# Rising Energy Requirements (Data Center + IoT)

## WORLDWIDE DATA CENTER FACILITIES – POWER NEEDS IN GW

(Source: New Technologies and Architectures for Efficient Data Center report, July 2015, Yole Développement)



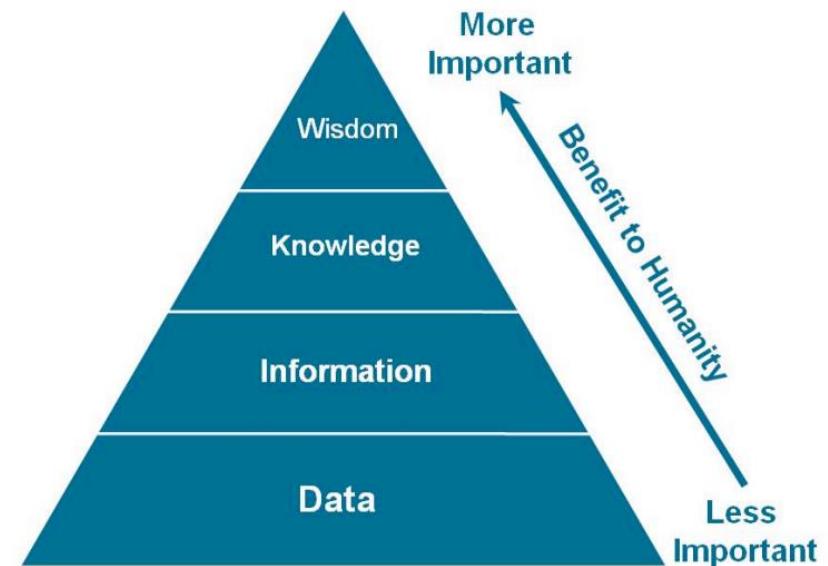
With no slowdown in new facility construction, data centers worldwide will have an increasing need for power.



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# We Evolve Because We Communicate

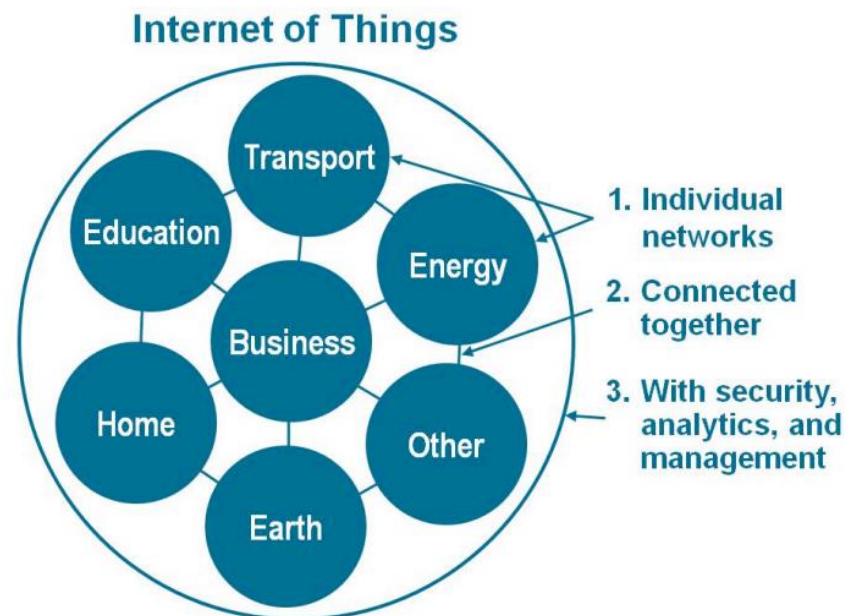
- Humans evolve because they communicate.
  - Once fire was discovered and shared, for example, it didn't need to be rediscovered, only communicated.
  - A more modern-day example is the discovery of the helix structure of DNA, molecules that carry genetic information from one generation to another.
- Humans turn Data into Wisdom.
  - This principle of sharing information and building on discoveries can best be understood by examining how humans process data.



Source: Cisco IBSG, April 2011

# IoT as a Network of Networks

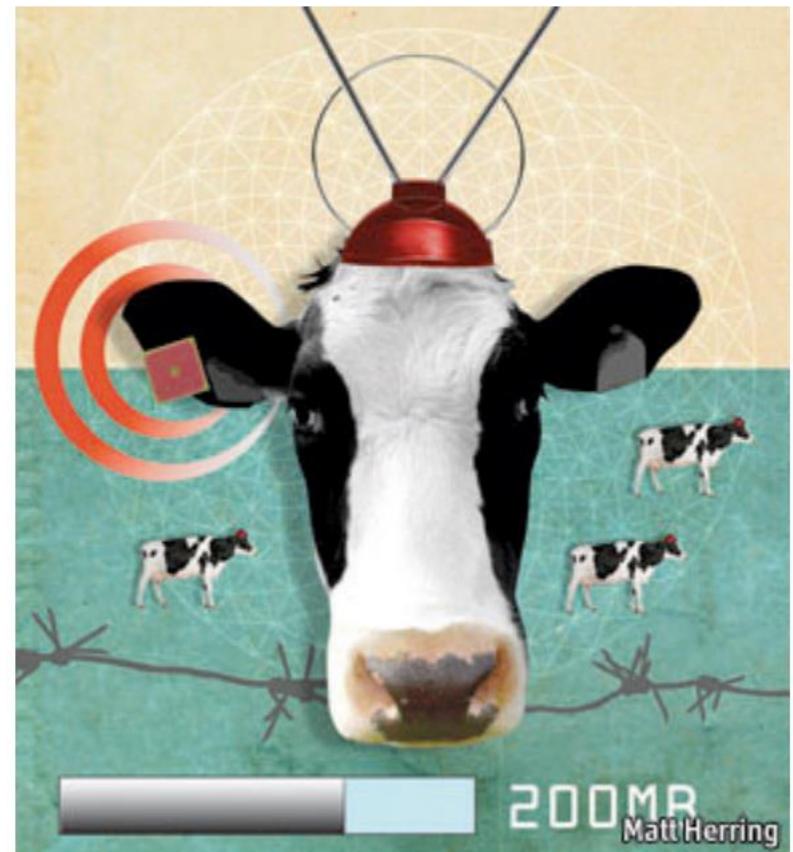
- Currently: IoT is made up of a loose collection of disparate, purpose-built networks.
  - Today's cars, for example, have multiple networks to control engine function, safety features, communications systems, and so on.
  - Commercial and residential buildings also have various control systems for heating, venting, and air conditioning (HVAC); telephone service; security; and lighting.
- In the Future: As IoT evolves,
  - These networks, and many others, will be connected with added security, analytics, and management capabilities.
  - This will allow IoT to become even more powerful in what it can help people achieve.



Source: Cisco IBSG, April 2011

# IoT: Holy Cow!

- A special report in The Economist titled “Augmented Business”
  - Described how cows will be monitored.
  - Sparked, a Dutch start-up company, implants sensors in the ears of cattle.
  - This allows farmers to monitor cows’ health and track their movements, ensuring a healthier, more plentiful supply of meat for people to consume.
  - On average, each cow generates about 200 megabytes of information a year



Source: *The Economist*, 2010.

# Mumbai: A Tale of Two Cities

- One of the areas where IoT can make a significant difference is in closing the poverty gap.
  - People from Dharavi pay for municipal-grade water is \$1.12 per cubic meter.
  - This compares to \$0.03 for residents of Warden Road.
  - The injustice is clear: the poor people of Mumbai pay 37 times more for water (a basic human necessity).
- The main source of the disparity is the higher cost of delivering utility services to poorer neighborhoods because of infrastructure inefficiencies, problems such as leaks, and theft.
- IoT will provide authorities with more information and control in order to identify and fix these problems.



Source: *The Wall Street Journal*, 2009.

Dr. C.K. Prahalad's book, ***The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits***  
<https://www.amazon.com/Fortune-Bottom-Pyramid-Eradicating-Poverty/dp/8177587765>

# Typical Views of the Internet of Things



Industrial Automation



Smart Health



Smart Home



Smart City

# The Internet of Things

“Internet of Objects”    “Machine-to-Machine Era”    “Internet of Everything”

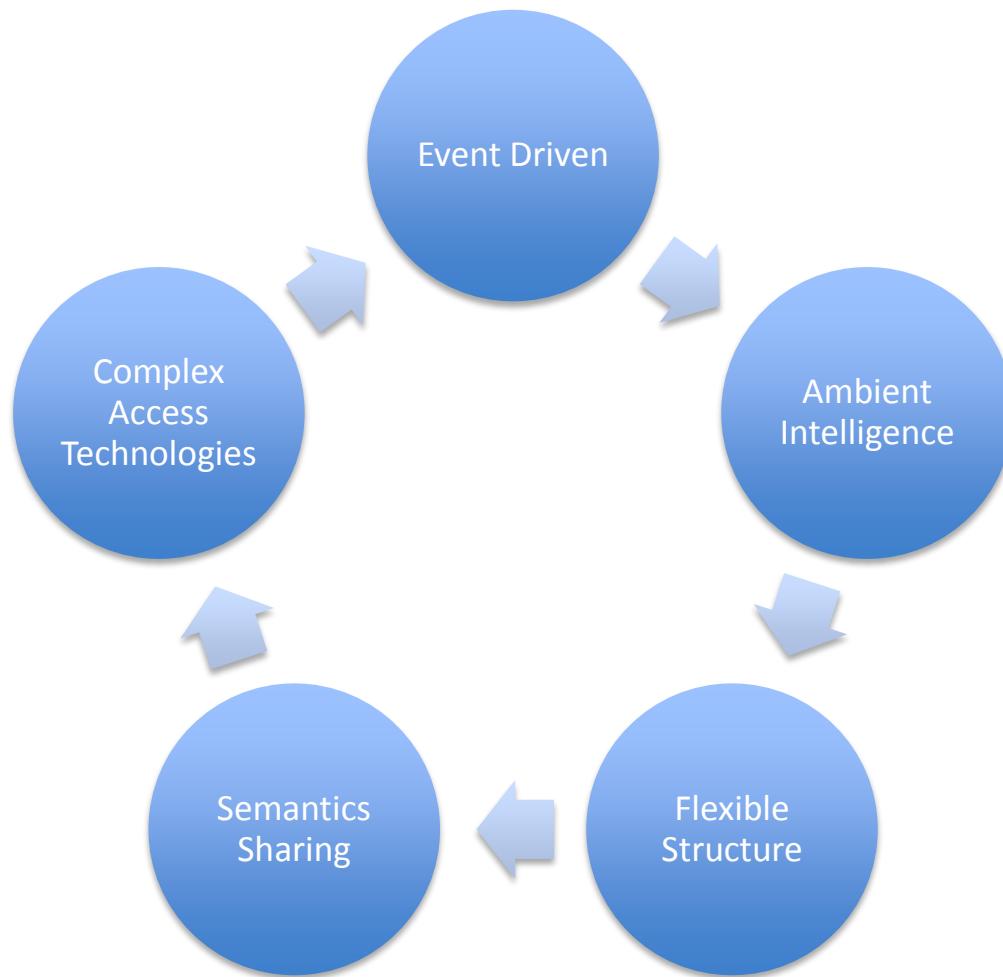
(3) The term "Internet of Things" has come to describe a number of technologies and research disciplines that enable the Internet to reach out into the real world of physical objects.

-----IoT 2008

(4) “Things having identities and virtual personalities operating in smart spaces using intelligent interfaces to connect and communicate within social, environmental, and user contexts”.

-----IoT in 2020

# Internet of Things – Characteristics



# Internet of Things – Enabling Technologies



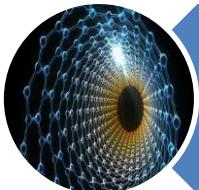
RFID: To identify and track the data of things



Sensors: To collect & process the data, to detect the changes in physical status of things



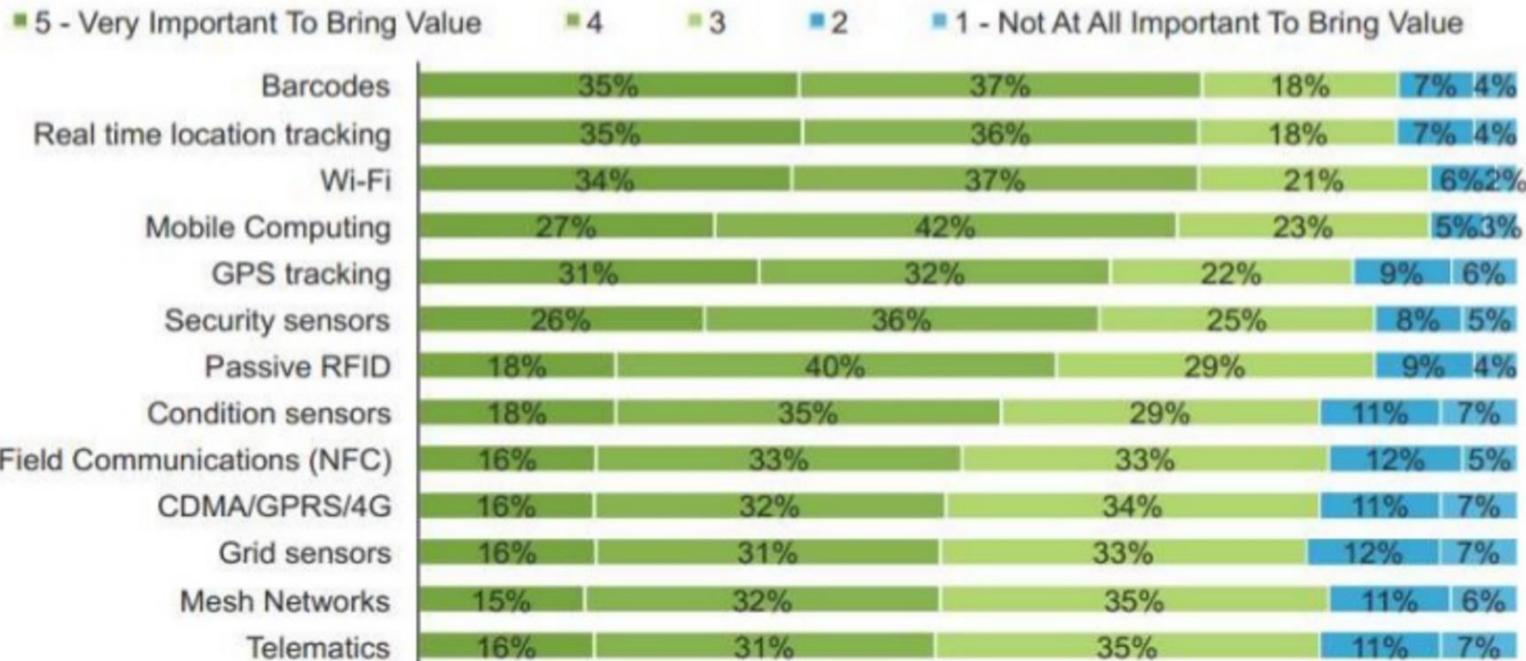
Smart Tech: To enhance the power of network by devolving processing capabilities to different parts of the network



Nano Tech: To make the smaller and smaller things have the ability to connect and interact.

# Device Types valuable to enabling of IoT

Thinking about your company, on a scale of 1 to 5, with 1 being not at all important to bring value and 5 being very important to bring value, please rate the following technologies on how necessary each is to enable Internet of Things solutions.



Base: 646 Global enterprise IT decision makers

Source: A commissioned study conducted by Forrester Consulting on behalf of Zebra, June, 2012



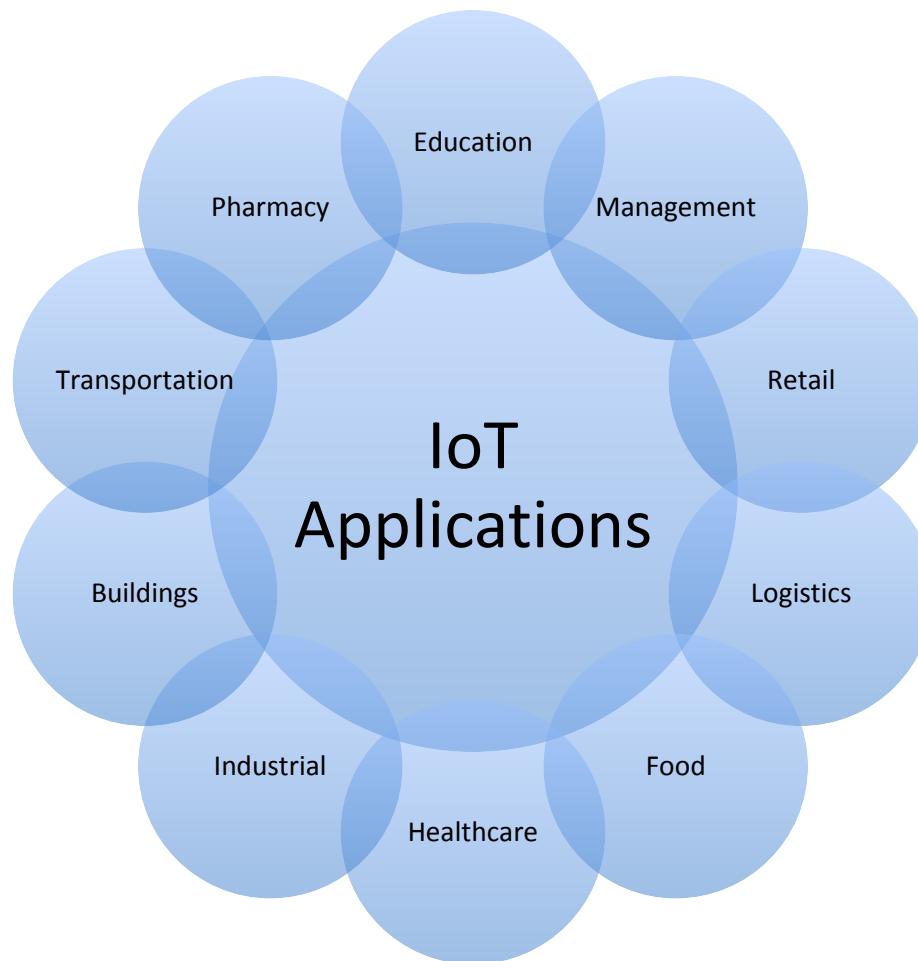
# Internet of Things – A Technical Perspective

Sensing Layer

Communications Layer

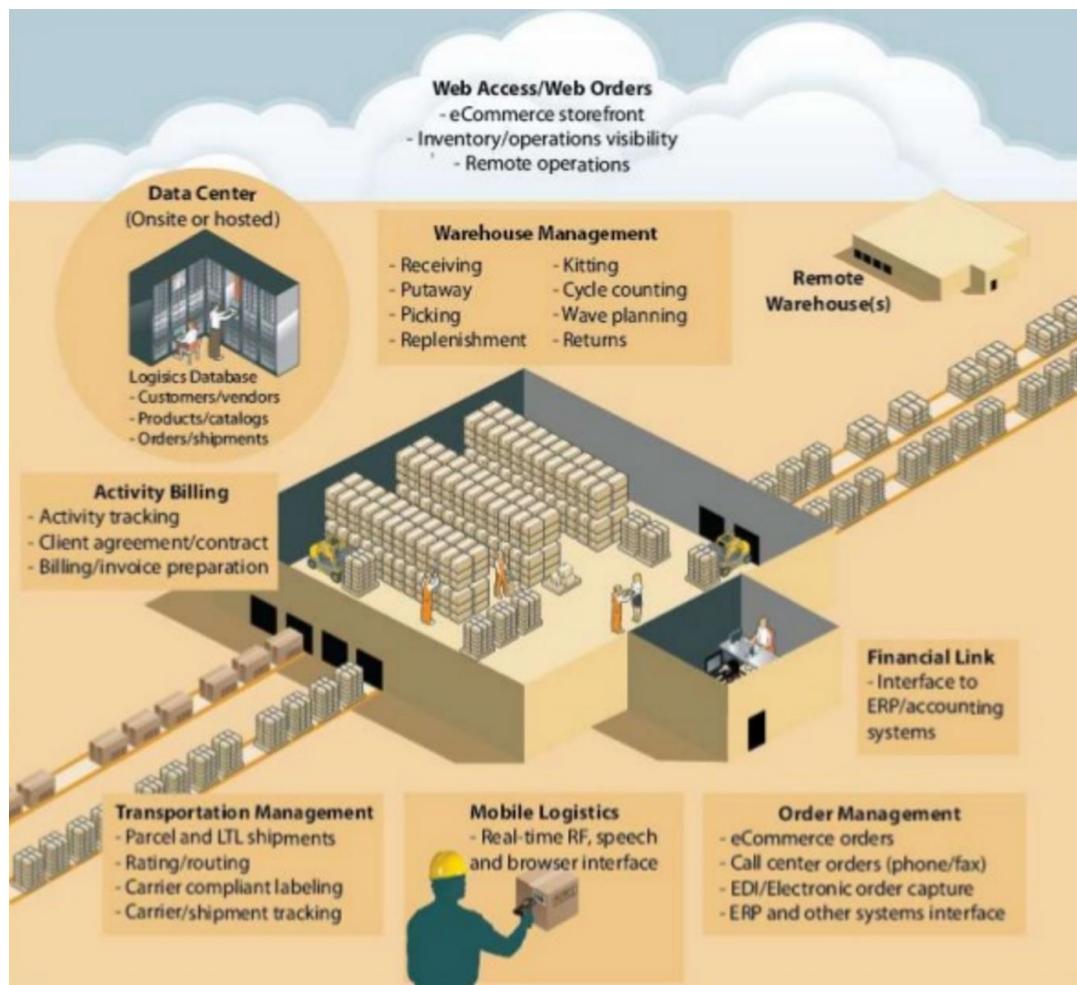
Management Layer

# IoT Applications



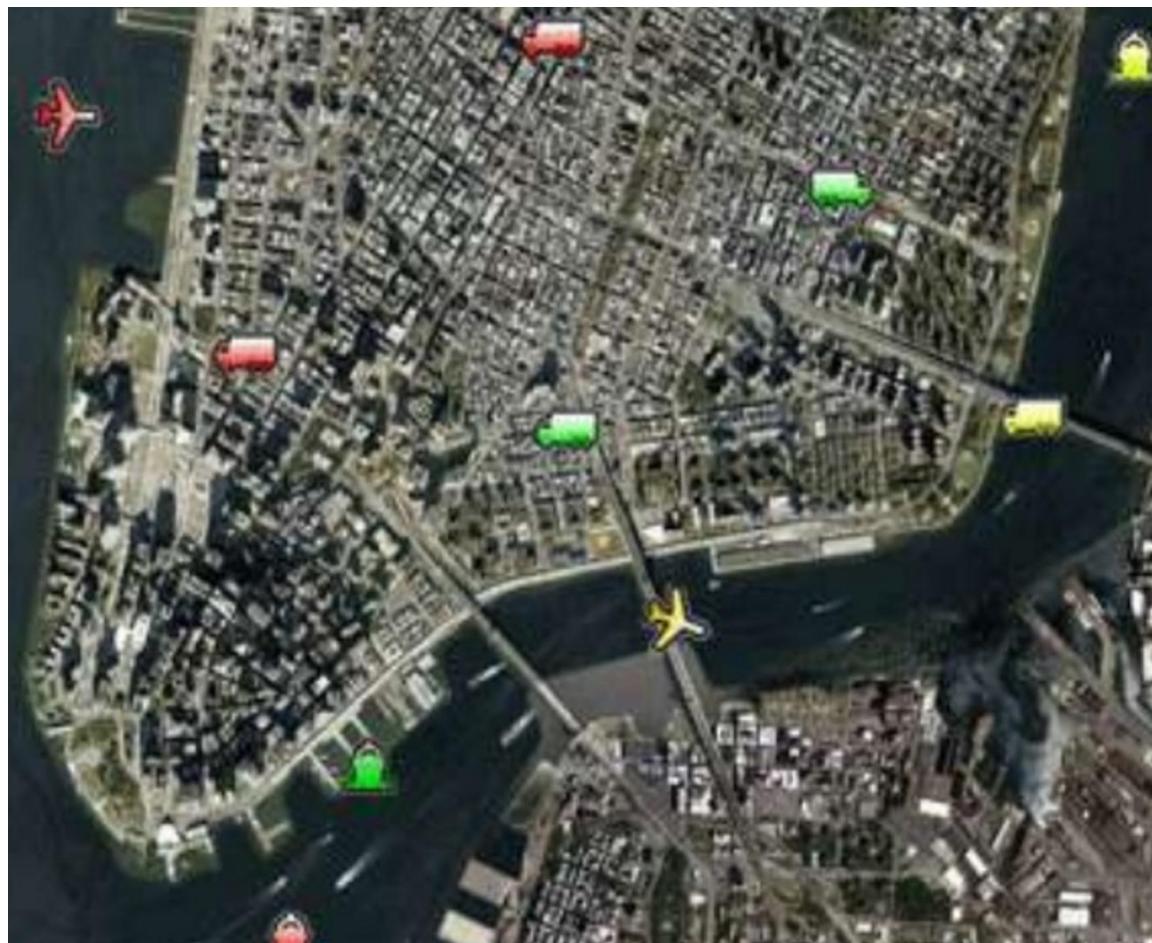
# IoT Applications: Management

- Data management
- Waste management
- Urban Planning
- Production management
- Distribution management
- ...



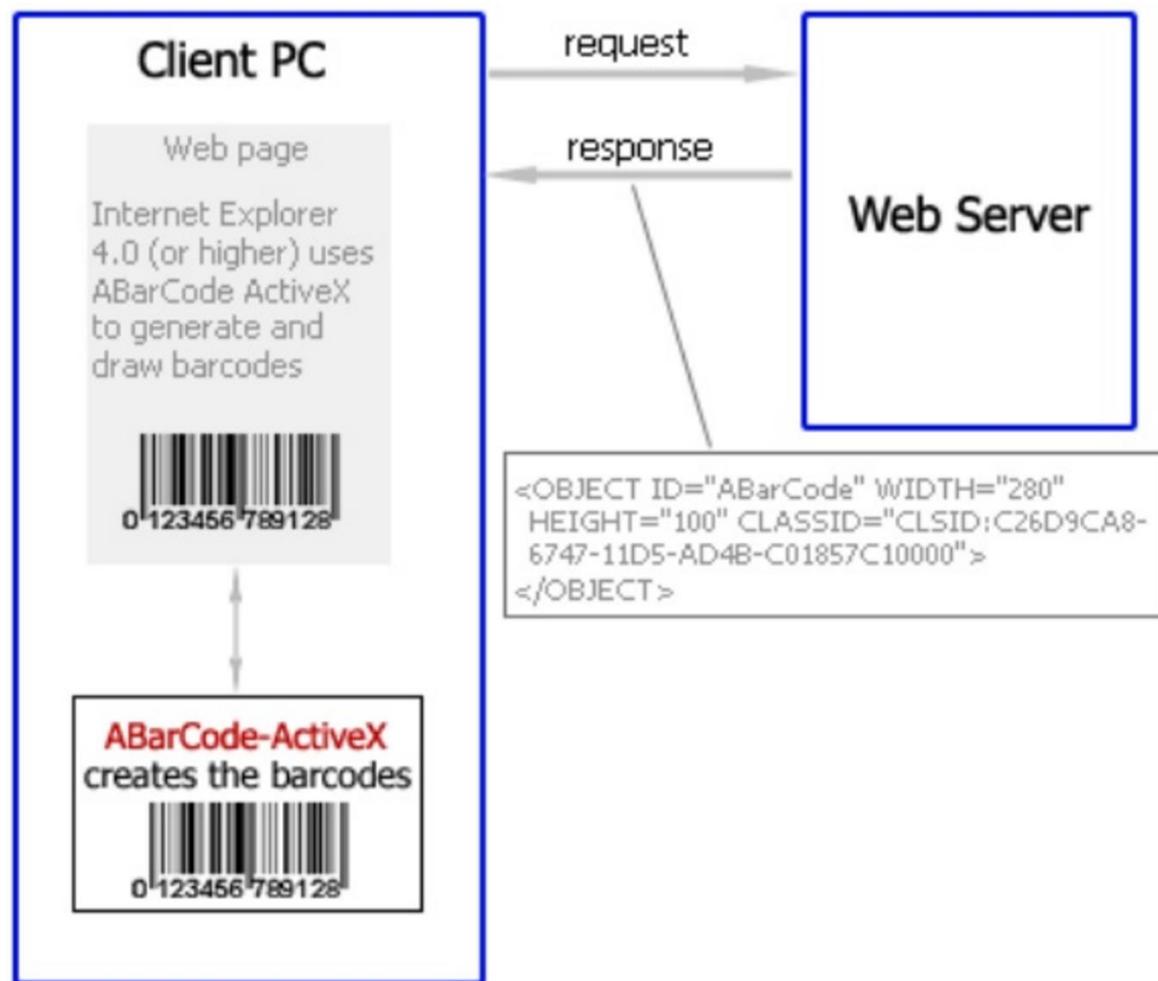
## IoT Applications: Logistics

- Port management
  - Ships, Airlines, Boats
  - containers
  - ETAs, ETDs
- Warehouse management
  - Inventory Control
  - Supply Chain management
- ...



## IoT Applications: Retail

- Intelligent shopping
- Bar code in retail
- Urban Planning
- Electronic tags
- ...



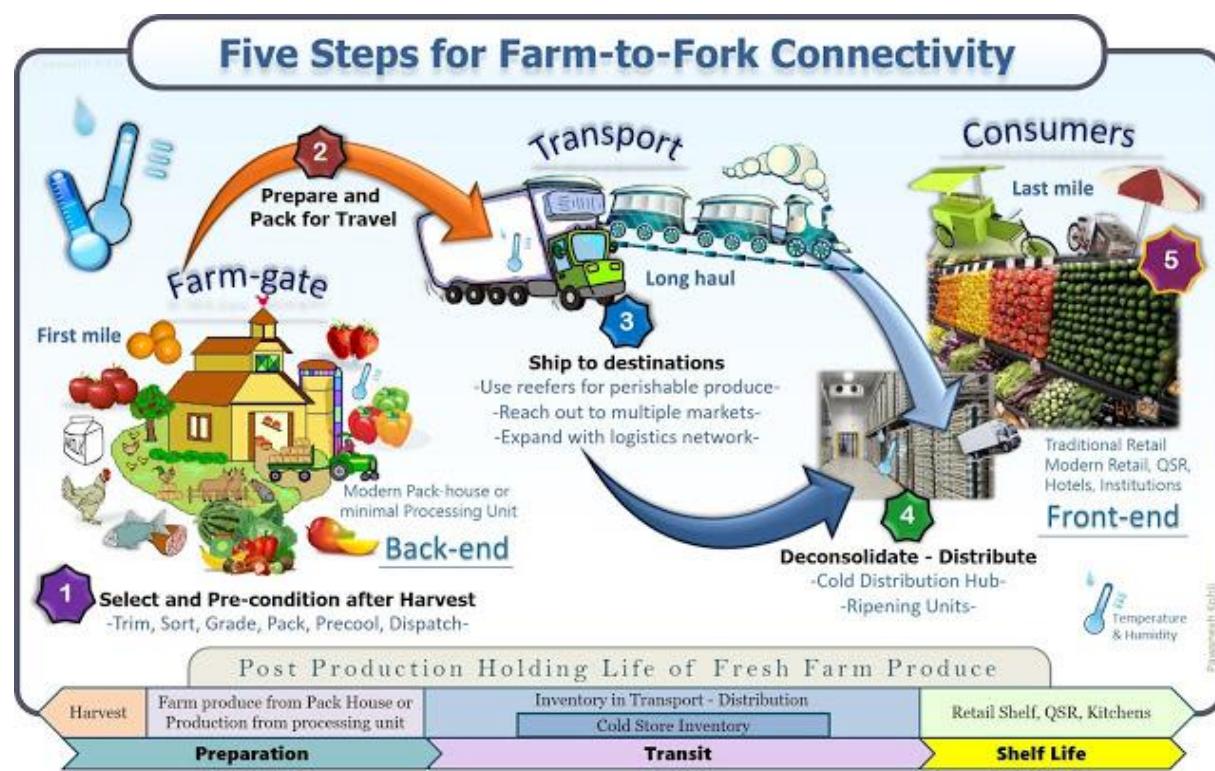
## IoT Applications: Pharmaceuticals

- Intelligent tags for drugs
- Drug usage tracking
- Enable emergency treatment to be given faster and more accurate.
- ...



# IoT Applications: Food

- Control geographical origin.
- Food production management
- Nutrition calculation
- Prevent shortages and overproduction
- Control quality, health and safety
- ...



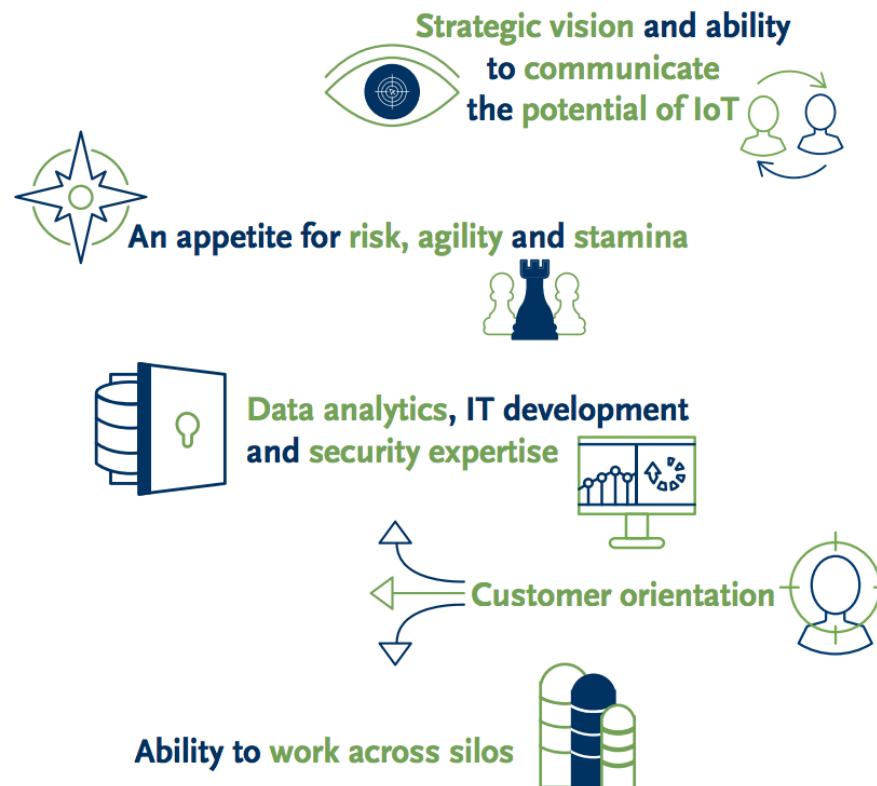
# IoT Applications: Industry

- Production traceability.
- Machine Vision, Motion I/O and Controllers
- Abnormality Diagnosis,
- Sensor Management
- Industrial Robots
- Factory Waste and Energy Management
- ...



# Leadership Demands

Internet of Things demands leaders with:



[https://www.spencerstuart.com/~media/pdf%20files/research%20and%20insight%20pdfs/internetofthingsp2\\_010516.pdf](https://www.spencerstuart.com/~media/pdf%20files/research%20and%20insight%20pdfs/internetofthingsp2_010516.pdf)

# Can you find these skills in a single leader?

“Many companies are waiting for IoT to be defined before they take action and invest. You have to define it yourself so you can tie a solution to it.” - Ulf Henriksson president and CEO of Dematic

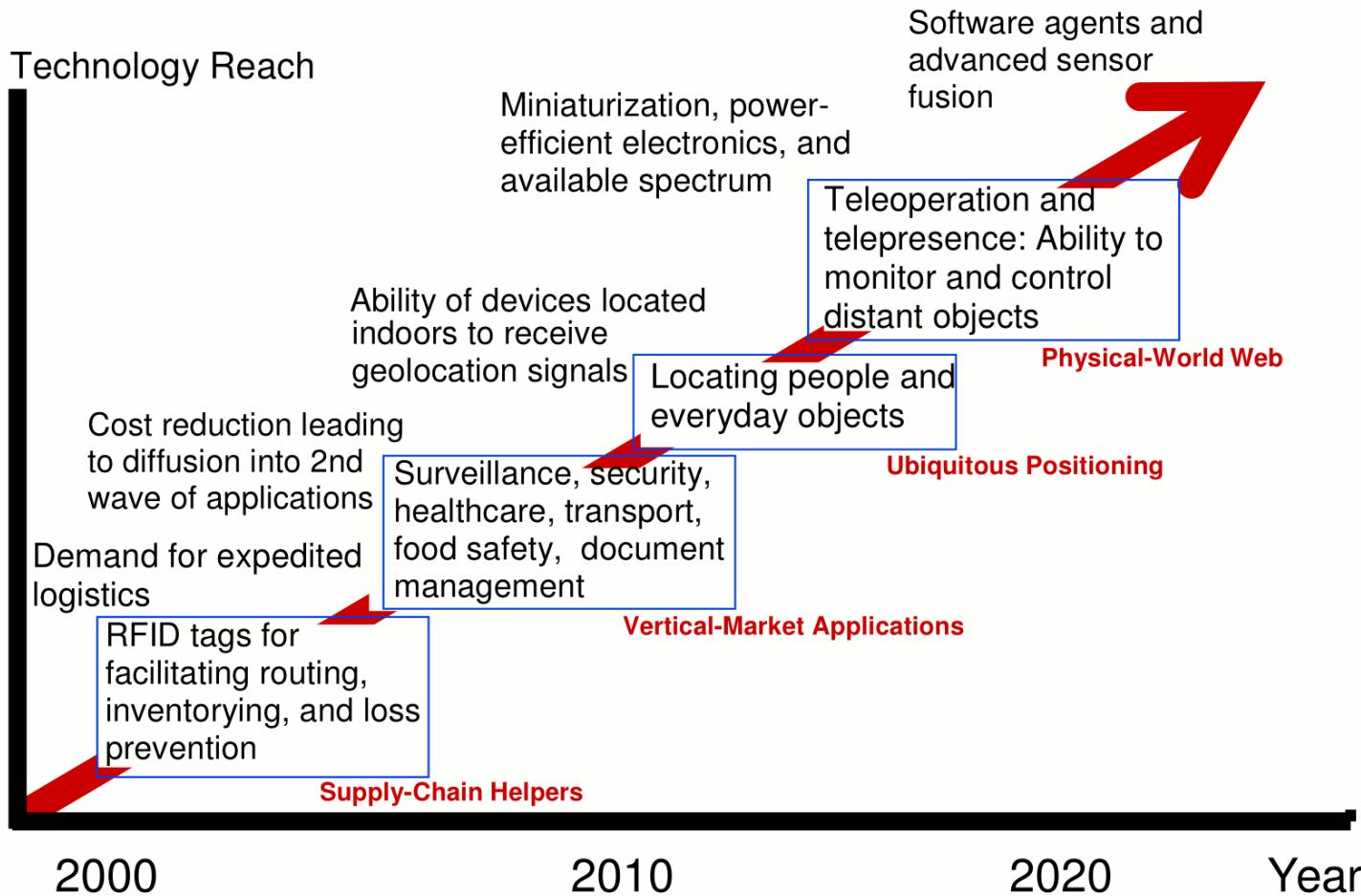
[https://www.spencerstuart.com/~/media/pdf%20files/research%20and%20insight%20pdfs/internetofthingsp2\\_010516.pdf](https://www.spencerstuart.com/~/media/pdf%20files/research%20and%20insight%20pdfs/internetofthingsp2_010516.pdf)

# Hyper-Cycle for Emerging Technologies



Source: Gartner 2015 (<http://www.gartner.com/newsroom/id/3114217>)

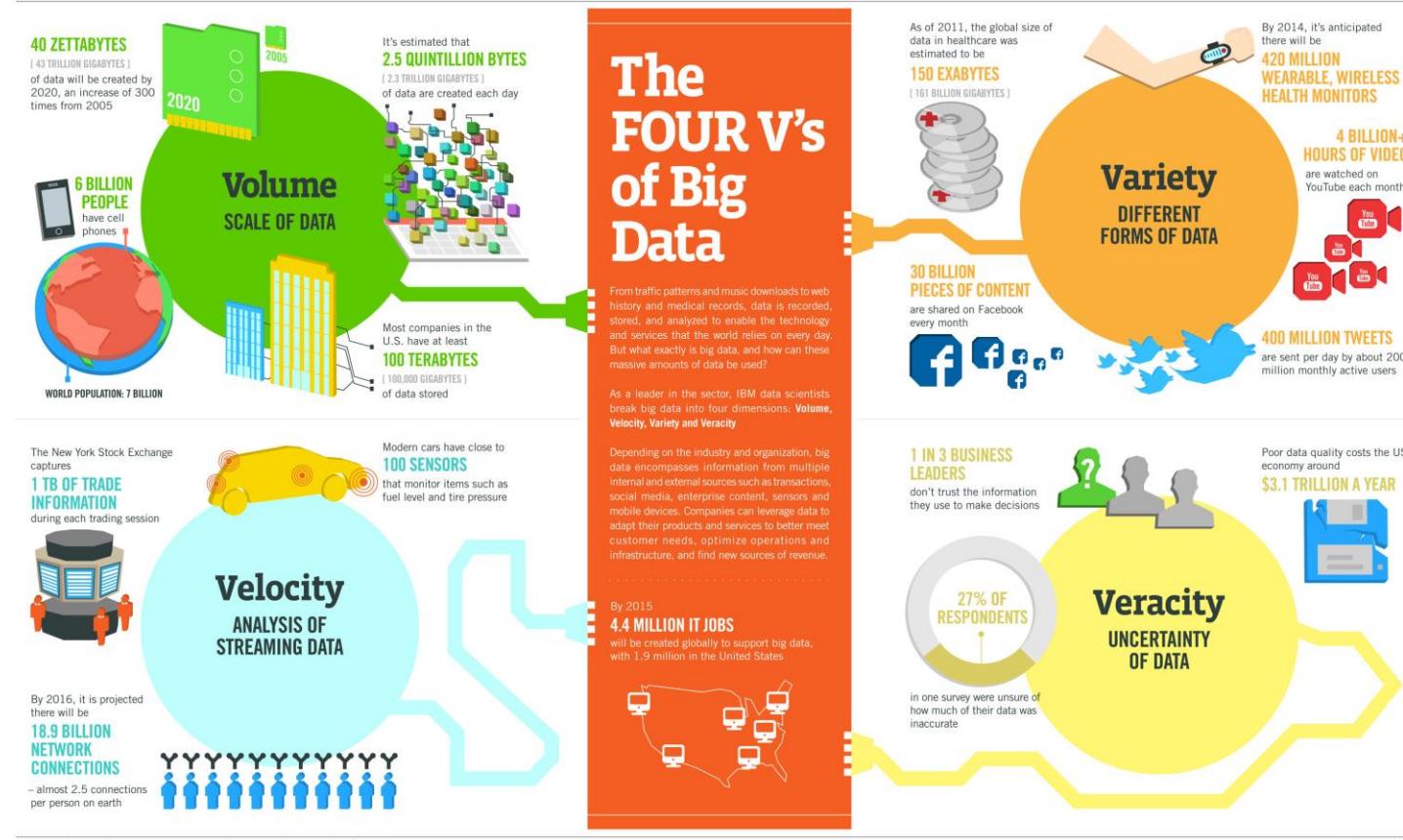
# IoT: Technology Roadmap



Source: SRI Consulting Business Intelligence



# Big Data Analytics – The 4 + 1 V's



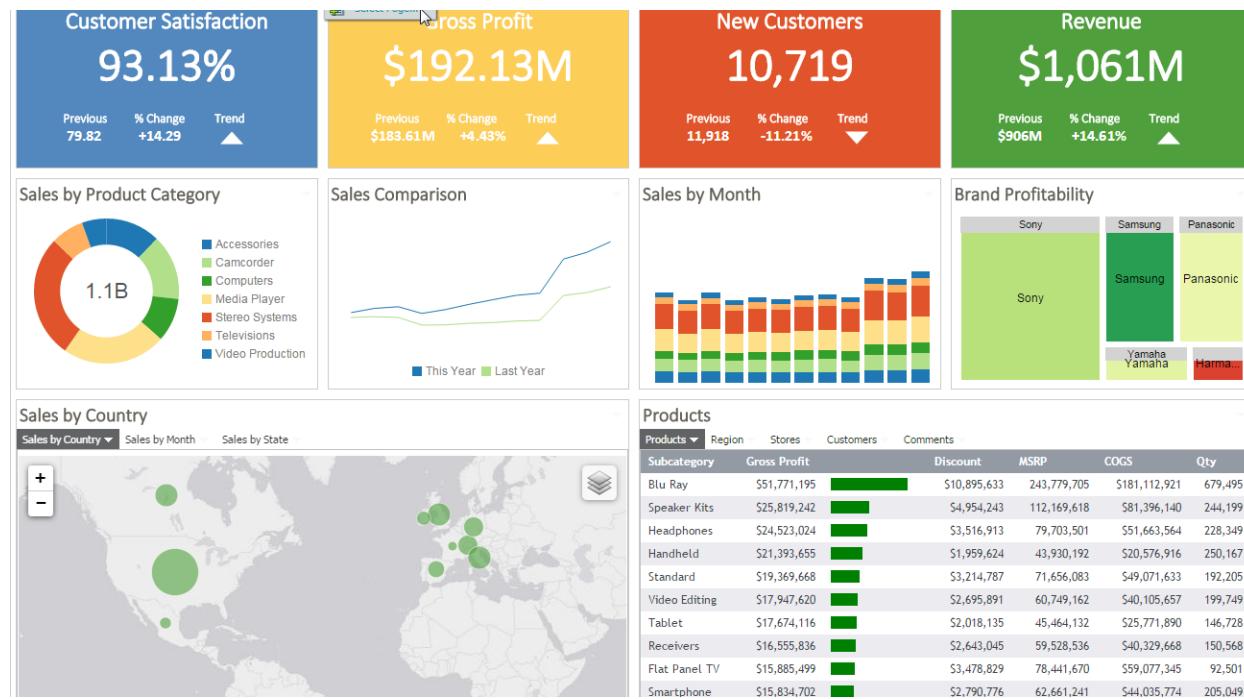
**Value:** It is great having access to big data but unless we can turn it into value it is useless. So you can safely argue that '**Value**' is the most important V of Big Data.

# Big Data Choice – Which database to use?

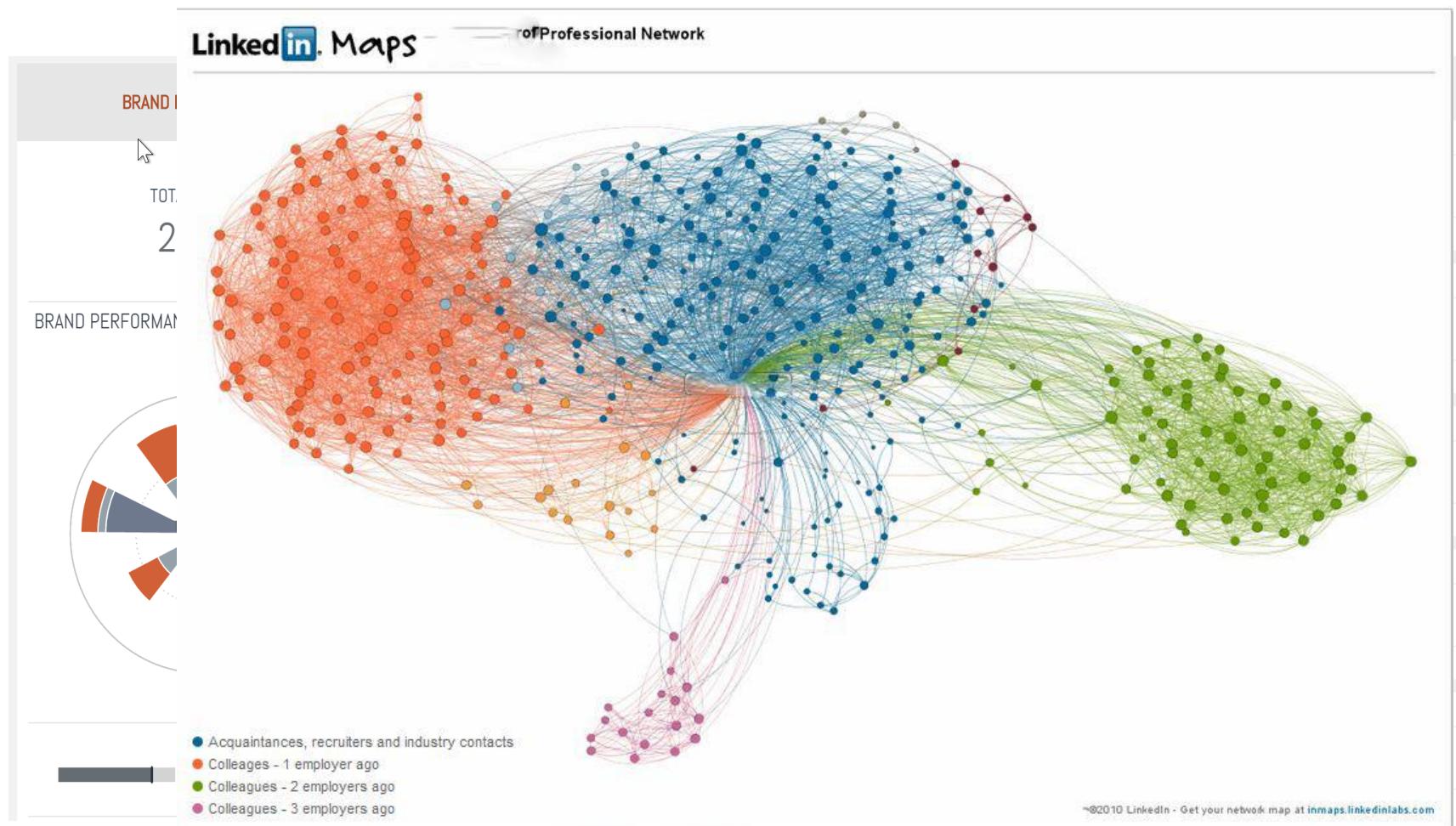
- In the era of big data, RDBMS is no longer the only choice.
- What type of DB to choose? including
  - Key-value pair: Redis, Voldemort, Oracle BDB, Amazon SimpleDB,
  - Column Family: Hbase, Apache Cassandra.
  - Tag Metadata based: SkySpark
  - Document: MongoDB, CouchDB, and
  - Graph databases: Neo4J, InfoGrid, Infinite Graph

# Business Intelligence

- BI technologies provide current, historical and predictive views of business operations.
- Common functions of business intelligence technologies are
  - business performance management,
  - online analytical processing,
  - predictive analytics,
  - prescriptive analytics,
  - reporting,
  - analytics,
  - data mining,
  - process mining,
  - event processing,
  - benchmarking, and
  - text mining,

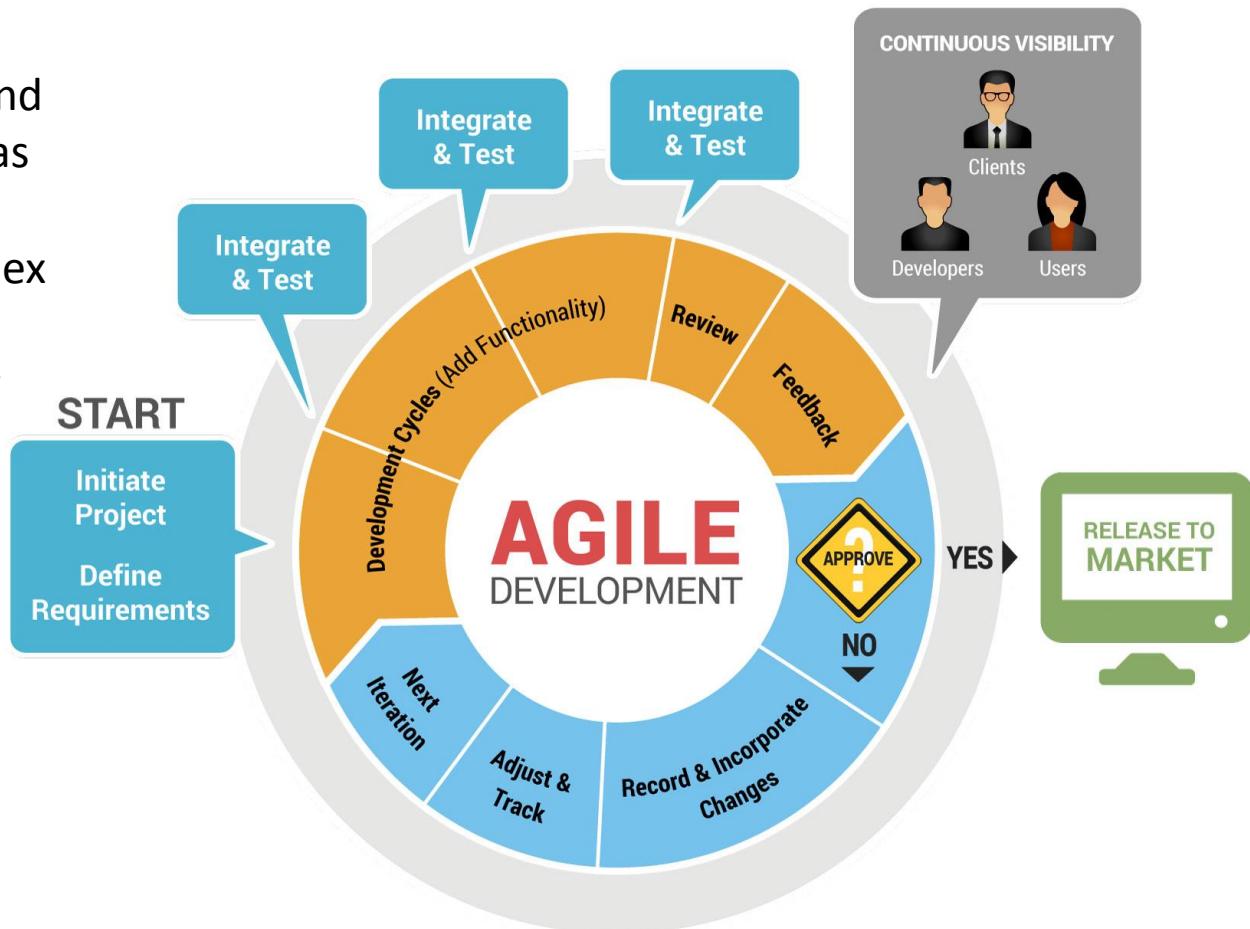


# Big Data Analytics – Visualization



# AGILE Methodology

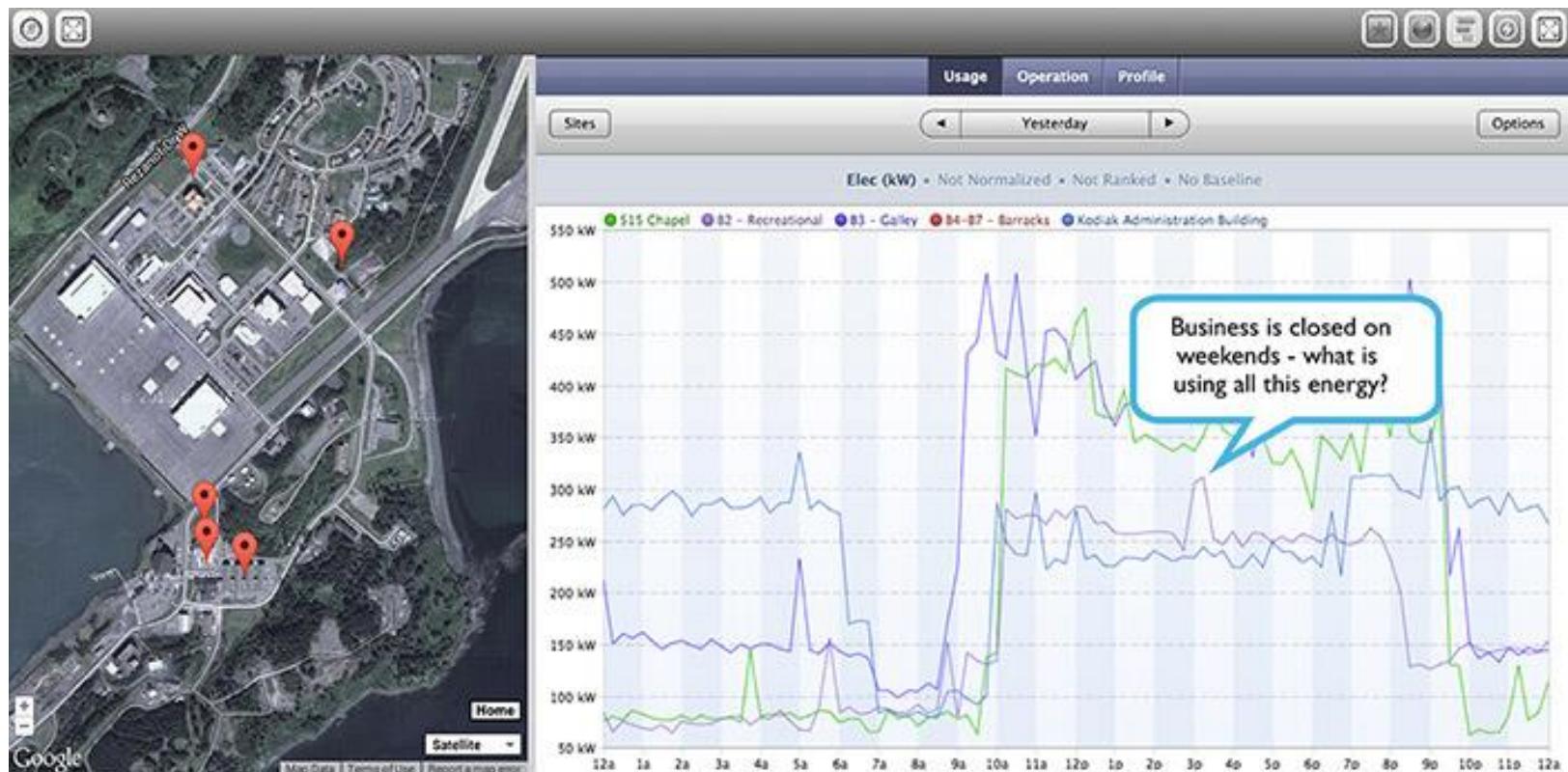
- Allows teams to deliver projects piece-by-piece and
- Make rapid adjustments as needed.
- Especially useful in complex projects,
- Results in more customer needs met
- At less cost.



# Case Study: Building Intelligence



Zeus is a new cloud-based software that analyzes a building's Energy Performance, Costs, and Correlations. Leverage valuable building data to identify faults and patterns of inefficiency that result in ways to improve energy utilization and return on investment.

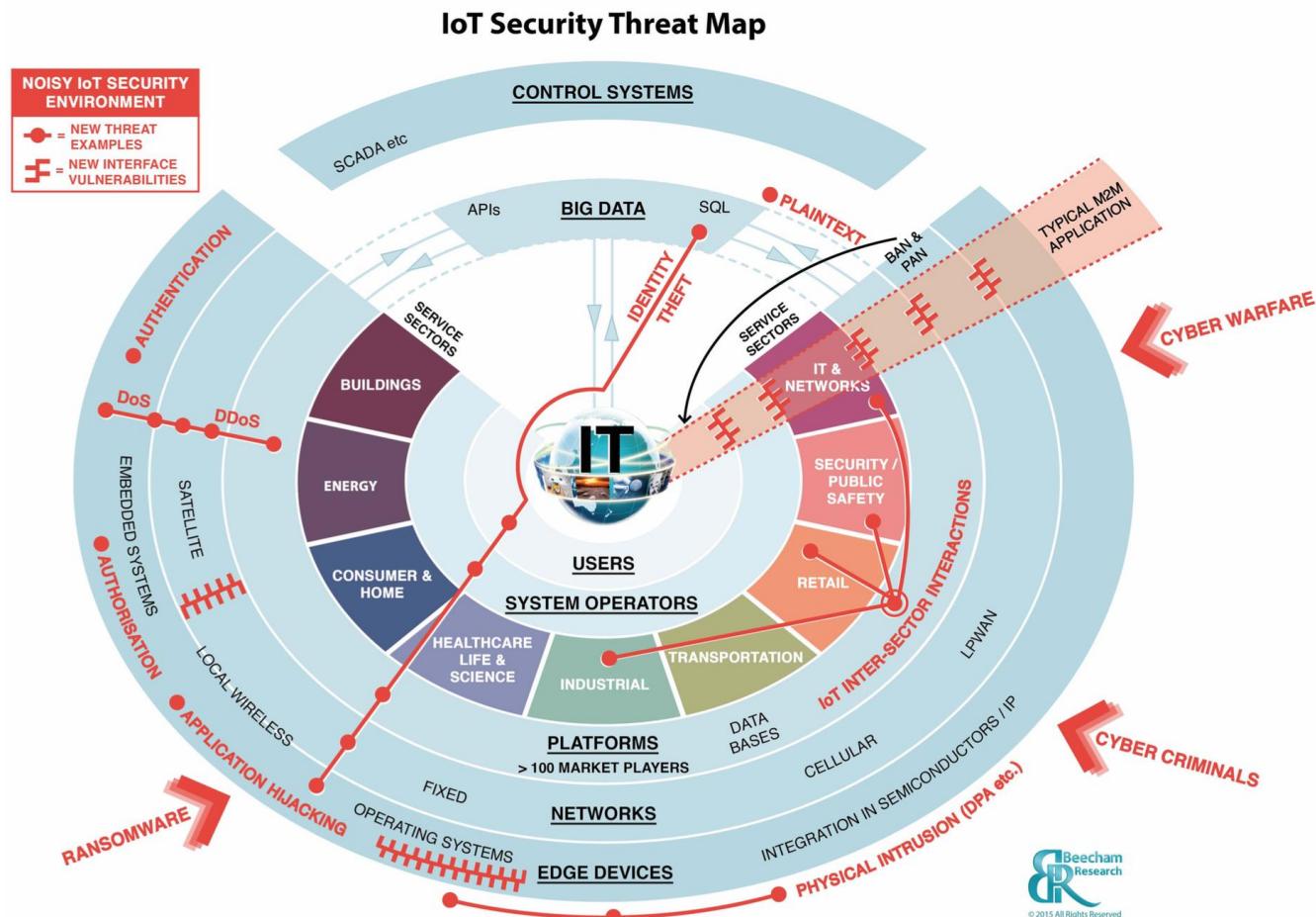


## IoT: Five key challenge areas

- **Security**
  - As the IoT connects more devices together, it provides more decentralized entry points for malware.
  - Less expensive devices that are in physically compromised locales are more subject to tampering.
  - More layers of software, integration middleware, APIs, machine-to-machine communication, etc. create more complexity and new security risks.
  - Expect to see many different techniques and vendors addressing these issues with policy-driven approaches to security and provisioning.

<http://sandhill.com/article/the-internet-of-things-challenges-and-opportunities/>

# IoT Security Threat Map



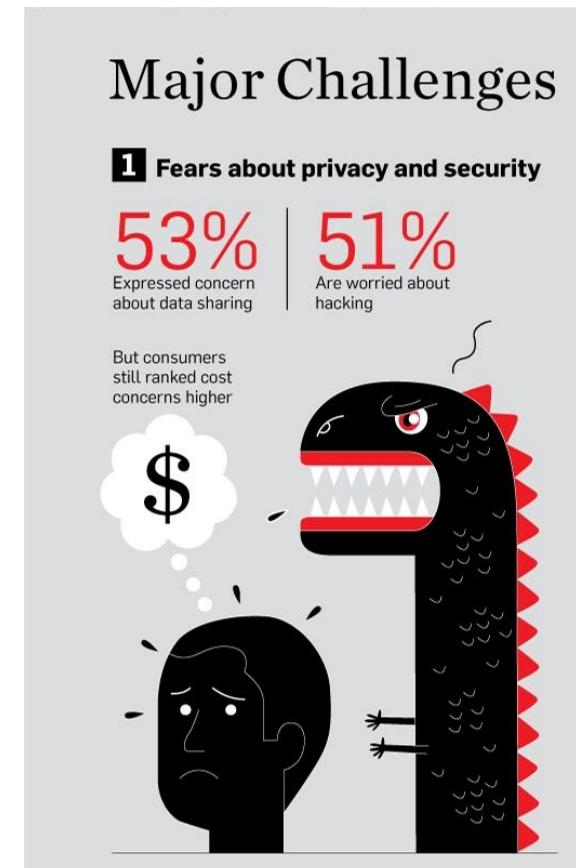
<http://www.beechamresearch.com/>

# IoT: Five key challenge areas

- **Trust and Privacy**

- With remote sensors and monitoring a core use case for the IoT, there will be heightened sensitivity to controlling access and ownership of data.
- Note that two recent high-profile security breaches at **Target** and **Home Depot** were both achieved by going through third-party vendors' stolen credentials to gain access to payment systems. Partner vetting will become ever more critical.
- Compliance will continue to be a major issue in medical and assisted-living applications, which could have life and death ramifications.
- New compliance frameworks to address the IoT's unique issues will evolve.
- Social and political concerns in this area may also hinder IoT adoption

<http://sandhill.com/article/the-internet-of-things-challenges-and-opportunities/>



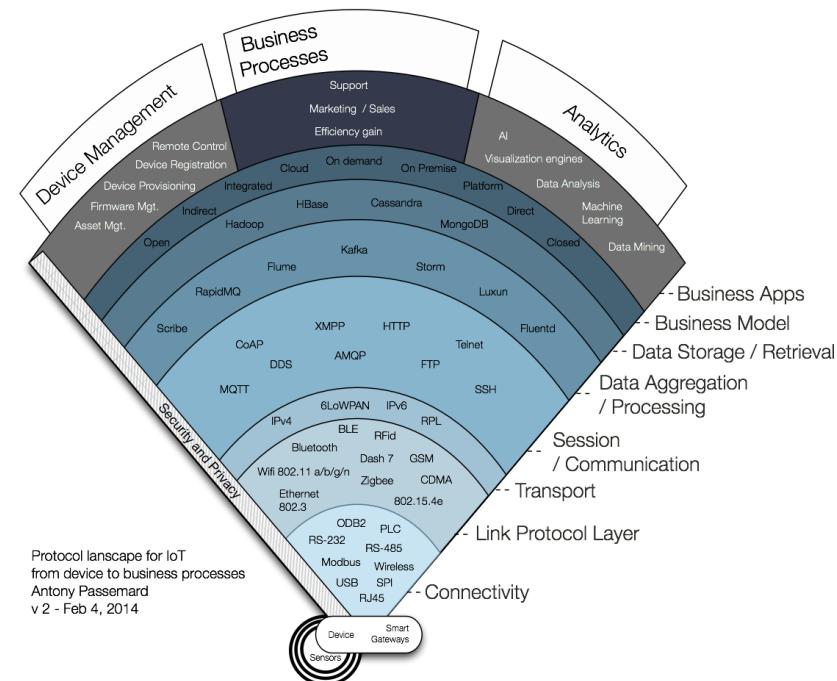
## IoT: Five key challenge areas

- **Complexity, confusion and integration issues**
  - With multiple platforms, numerous protocols and large numbers of APIs, IoT systems integration and testing will be a challenge.
  - The confusion around evolving standards is almost sure to slow adoption.
  - The rapid evolution of APIs will likely consume unanticipated development resources that will diminish project teams' abilities to add core new functionality.
  - Slower adoption and unanticipated development resource requirements will likely slip schedules and slow time to revenues, which will require additional funding for IoT projects and longer “runways” for startups.

<http://sandhill.com/article/the-internet-of-things-challenges-and-opportunities/>

# IoT: Five key challenge areas

- **Evolving architectures, protocol wars and competing standards.**
  - With so many players involved with the IoT, there are bound to be ongoing turf wars as legacy companies seek to protect their proprietary systems advantages and open systems proponents try to set new standard
  - There may be multiple standards that evolve based on different requirements determined by device class, power requirements, capabilities and uses.
  - This presents opportunities for platform vendors and open source advocates to contribute and influence future standards.



<http://sandhill.com/article/the-internet-of-things-challenges-and-opportunities/>

## IoT: Five key challenge areas

- **Concrete use cases and compelling value propositions**
  - Lack of clear use cases or strong ROI examples will slow down adoption of the IoT.
  - Although technical specifications, theoretical uses and future concepts may suffice for some early adopters, mainstream adoption of IoT will require well-grounded, customer-oriented communications and messaging around “what’s in it for me.”
  - Detailed explanations of a specific device or technical details of a component won’t cut it when buyers are looking for a “whole solution” or complete value-added service.
  - IoT providers will have to explain the key benefits of their services or face the proverbial “so what.”

<http://sandhill.com/article/the-internet-of-things-challenges-and-opportunities/>

# IoT: Challenges and Issues

- Society: People, Privacy and Security
  - A policy for people in the Internet of Things
  - Legislation
- Environmental aspects
  - Resource efficiency
  - Pollution and Disaster Avoidance
- Technological
  - Architecture: edge devices, discovery services, security, etc.
  - Governance, naming, identity, interfaces
  - Service openness, interoperability
  - Connections to real and virtual worlds
  - Standards

# IoT: Challenges and Issues

- IoT will inherit the drawbacks of the current internet on an infinitely larger, but more invisible scale.
  - Privacy: will be a huge issue when implementing IoT
  - Identity: Online fragmentation of Identity
  - Efficiency: Person loses identity and becomes an IP address.
  - Decisions: Delegation of too much of our decision making and freedom of choice to things and machines
  - Balancing of different concerns.
- Transitioning to IPv6
- Developing energy sources for billions of devices.
  - Wind, Solar, Hydro-electric, Nuclear
- Establishing common set of standards between
  - Companies, Educational Institutions and Nations

# Case Study: Railroad



## Question:

- Can you think of some Use- cases for application of IoT in the Railroad?
- Safety
- Mobility, and
- Efficiency (Operational)

## Reading

- <http://www.rcrwireless.com/20160908/big-data-analytics/smart-trains-tag31-tag99>
- [http://www.progressiverailroading.com/rail\\_industry\\_trends/article/The-Internet-of-Things-A-world-of-opportunity-for-railroads--47507](http://www.progressiverailroading.com/rail_industry_trends/article/The-Internet-of-Things-A-world-of-opportunity-for-railroads--47507)
- <http://www.computerweekly.com/feature/How-the-Internet-of-Things-could-transform-Britains-railways>
- <http://www.eurotech.com/dla/Library/WP/Eurotech-White-Paper-Rail-Solutions-FINAL.pdf>
- <http://events.windriver.com/wrcd01/wrcm/2016/08/WP-IoT-the-internet-of-trains.pdf>
- [http://www.cisco.com/c/dam/en\\_us/solutions/industries/docs/trans/rail-aag.pdf](http://www.cisco.com/c/dam/en_us/solutions/industries/docs/trans/rail-aag.pdf)
- [http://www.cisco.com/c/dam/en\\_us/solutions/industries/docs/trans/rail-solution-overview.pdf](http://www.cisco.com/c/dam/en_us/solutions/industries/docs/trans/rail-solution-overview.pdf)

# Acknowledgements

- [http://www.cisco.com/c/dam/en\\_us/about/ac79/docs/innov/IoT\\_IBSG\\_0411FINAL.pdf](http://www.cisco.com/c/dam/en_us/about/ac79/docs/innov/IoT_IBSG_0411FINAL.pdf)
- <http://www.fool.com/investing/general/2016/01/18/internet-of-things-in-2016-6-stats-everyone-should.aspx>
- Hyper-Cycle for Emerging Technologies <http://www.gartner.com/newsroom/id/3114217>
- <https://www.accenture.com/us-en/labs-insight-industrial-internet-of-things>
- <http://www.slideshare.net/TheMotleyFool/the-internet-of-things-in-4-charts/4-So-whether-weve-known-it>
- <http://www.rcrwireless.com/20160908/big-data-analytics/smart-trains-tag31-tag99>
- [http://www.progressiverailroading.com/rail\\_industry\\_trends/article/The-Internet-of-Things-A-world-of-opportunity-for-railroads--47507](http://www.progressiverailroading.com/rail_industry_trends/article/The-Internet-of-Things-A-world-of-opportunity-for-railroads--47507)
- <http://www.computerweekly.com/feature/How-the-Internet-of-Things-could-transform-Britains-railways>
- <http://www.eurotech.com/dla/Library/WP/Eurotech-White-Paper-Rail-Solutions-FINAL.pdf>
- <http://events.windriver.com/wrcd01/wrcm/2016/08/WP-IoT-the-internet-of-trains.pdf>
- [http://www.cisco.com/c/dam/en\\_us/solutions/industries/docs/trans/rail-aag.pdf](http://www.cisco.com/c/dam/en_us/solutions/industries/docs/trans/rail-aag.pdf)
- [http://www.cisco.com/c/dam/en\\_us/solutions/industries/docs/trans/rail-solution-overview.pdf](http://www.cisco.com/c/dam/en_us/solutions/industries/docs/trans/rail-solution-overview.pdf)



