AN INCOMPLETE EXPLORATORY TUTORIAL

this presentation is still a work in progress …

THE NEXT TSUNAMI

Dr Shoumen Datta

Are all advantages temporary ● Experts v Dreamers

In the early 1980s, McKinsey created a forecast for AT&T of how many cellular phones would be in use in the world in 2000. McKinsey forecast was 900,000. The actual number was greater than 100 million.

In June 2007, former CEO Steve Ballmer of Microsoft Corporation said in an interview with *USA Today* that there is "no chance that the iPhone is going to get any significant market share. No chance, at all. It's a $500 subsidized item". The iPhone is approaching 50% market share in the US.

Mary Meeker of Kleiner Perkins Caufield & Byers produces a yearly report, Internet Trends, which is the tech bible. Its May 2013 report analyzed the leading players in social media and made predictions on the future of mobile technologies. It did not even mention WhatsApp. Facebook acquired WhatsApp for $19 billion in 2014. This was the largest acquisition in the history of a venture-backed company. It was not even on Mary's radar.

Are experts really "experts" at all? Are "experts" increasingly incorrect and irrelevant?


Grand Challenges

In 1854, Ferdinand de Lesseps obtained a concession from Sa'id Pasha, the Khedive of Egypt and Sudan, to create a company to construct a canal open to ships of all nations. De Lesseps convened the *Commission Internationale pour le percement de l'isthme des Suez* consisting of 13 experts from seven countries. The commission produced a unanimous report in December 1856 containing a detailed description of the canal complete with plans and profiles. The Suez Canal Company (*Compagnie universelle du canal maritime de Suez*) came into being on 15 December 1858 and work started on the shore of the future Port Said on 25 April 1859. International opinion was sceptical and Suez Canal Company shares did not sell well overseas. Britain, United States, Austria and Russia did not buy a significant number of shares. All French shares were quickly sold in France. A contemporary British sceptic claimed:

One thing is sure our local merchant community doesn't pay practical attention at all to this grand work and it is legitimate to doubt that the canal's receipts could ever be sufficient to recover its maintenance fee. It will never become a large ship's accessible way in any case.

The British government had opposed the project from the outset to its completion. The canal opened on 17 November 1869.

The first ship through the canal was the British P&O liner *Delta*. Although *L'Aigle* was officially the first vessel through the canal, HMS *Newport*, captained by George Nares, passed through it first. On the night before the canal was due to open, Captain Nares navigated his vessel, in darkness and without lights, through the mass of waiting ships until it was in front of *L'Aigle*. When dawn broke the French were horrified to find that the Royal Navy was first in line and that it would be impossible to pass them. Nares received both an official reprimand and an unofficial vote of thanks from the British Admiralty for his actions in promoting British interests and demonstrating such superb seamanship.

After the opening the Suez Canal Company was in financial difficulties. Less than 500 ships passed during the first few years. External debts forced Said Pasha's successor, Isma'il Pasha, to sell his country's share in the canal for £4 million (about £86 million in 2013) to the United Kingdom in 1875 but French shareholders still held the majority. Prime Minister Benjamin Disraeli was accused by William Ewart Gladstone of undermining Britain's constitutional system, because he had not obtained consent from Parliament when purchasing the shares with funding from the Rothschilds.

In 2012, nearly 20,000 ships used The Suez Canal. On an average, 50 ships navigate the canal daily, carrying more than 300 million tons of goods per year. On August 5, 2014, President Sisi of Egypt announced the building of a new Suez Canal project to add 45-mile parallel lane to allow more ships to use this freight transportation option (www.theguardian.com/world/2014/aug/05/egypt-build-new-suez-canal).

Grand Challenges

Data by Datta

CONNECTED CONTENT

CONTENTS

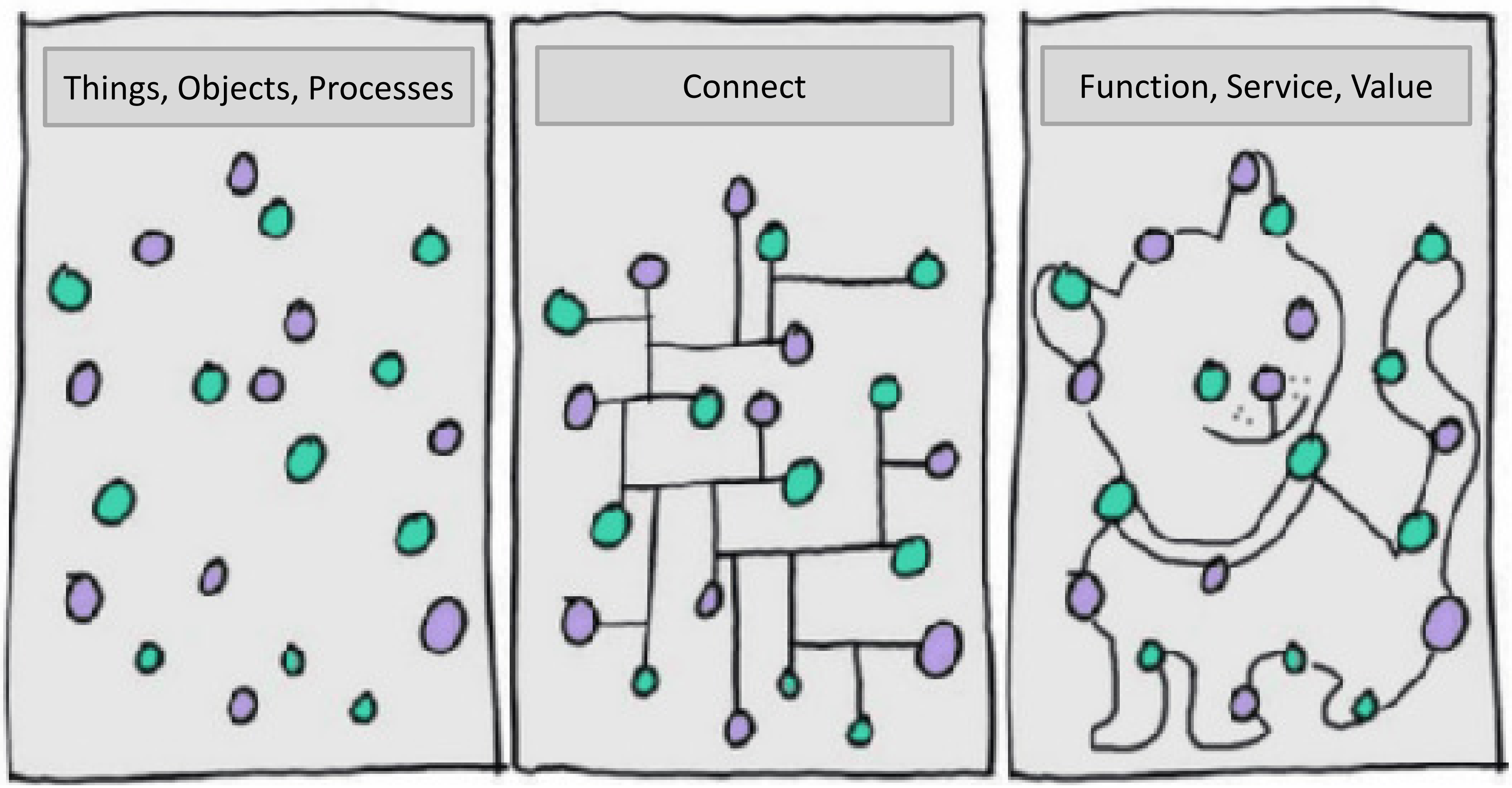
This tutorial (work in progress) attempts to outline the scope of the industrial internet - which is inextricably linked with the internet of things (IoT) and cyberphysical systems (CPS).

Please send comments to Dr Shoumen Palit Austin Datta shoumendatta@gmail.com or email to shoumen@mit.edu

For more information please see http://tinyurl.com/SD-86935

EVOLUTION

THE INDUSTRIAL INTERNET



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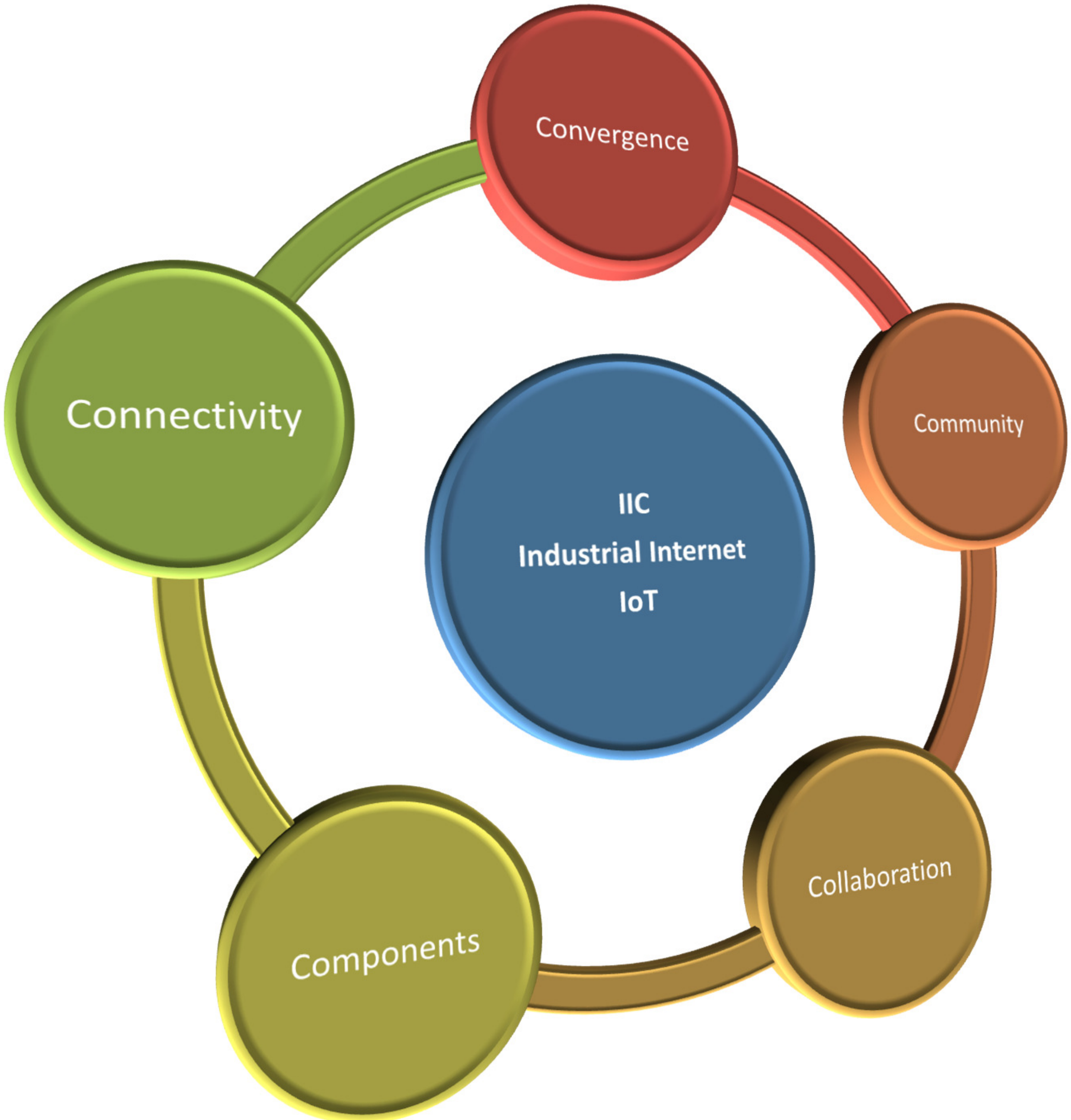
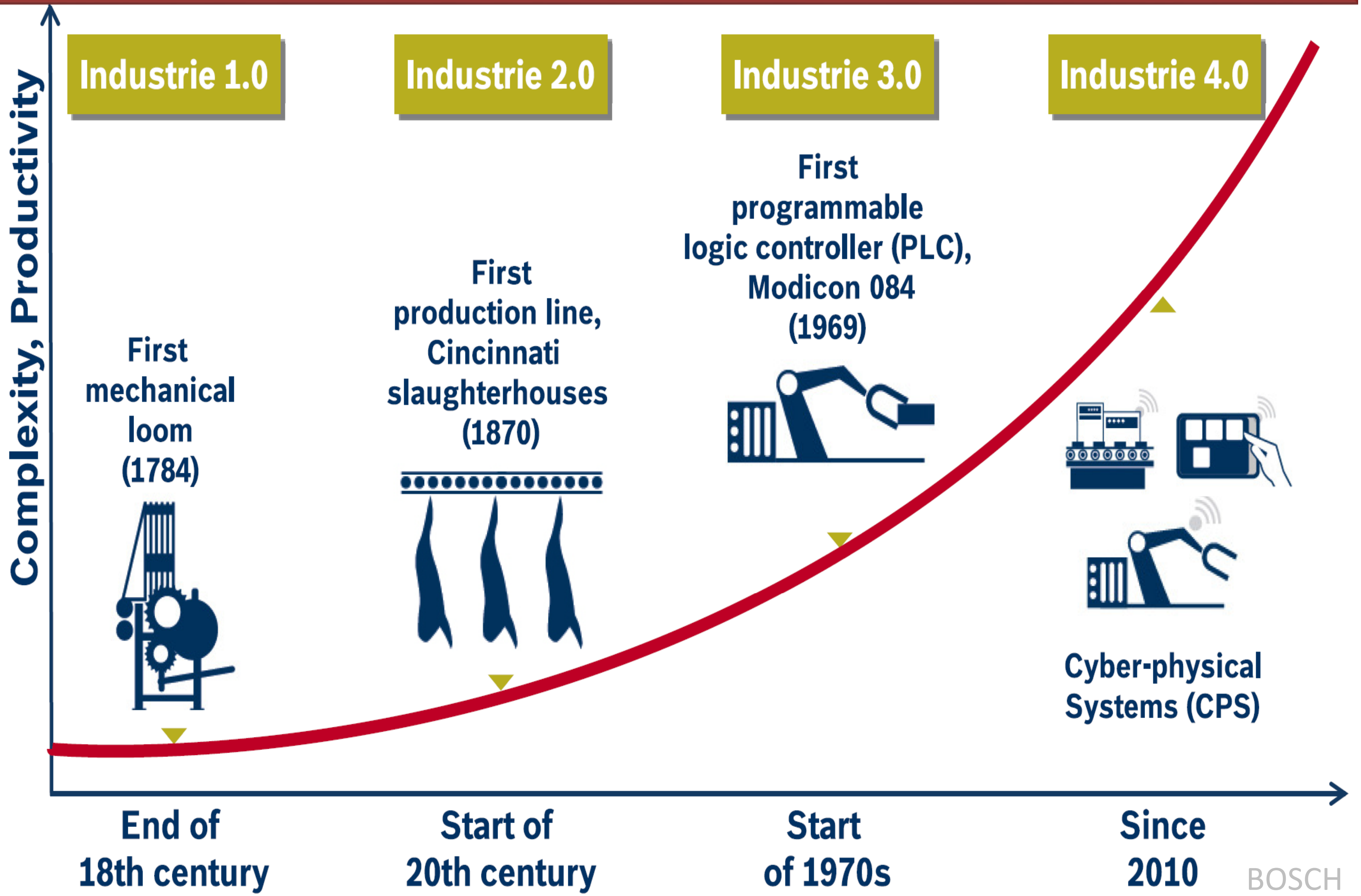

Convergence
Community
Connectivity
IIC
Industrial Internet
IoT
Collaboration
Components

THE NEXT REVOLUTION ??



INDUSTRIAL INTERNET OF SMART THINGS

IIOST

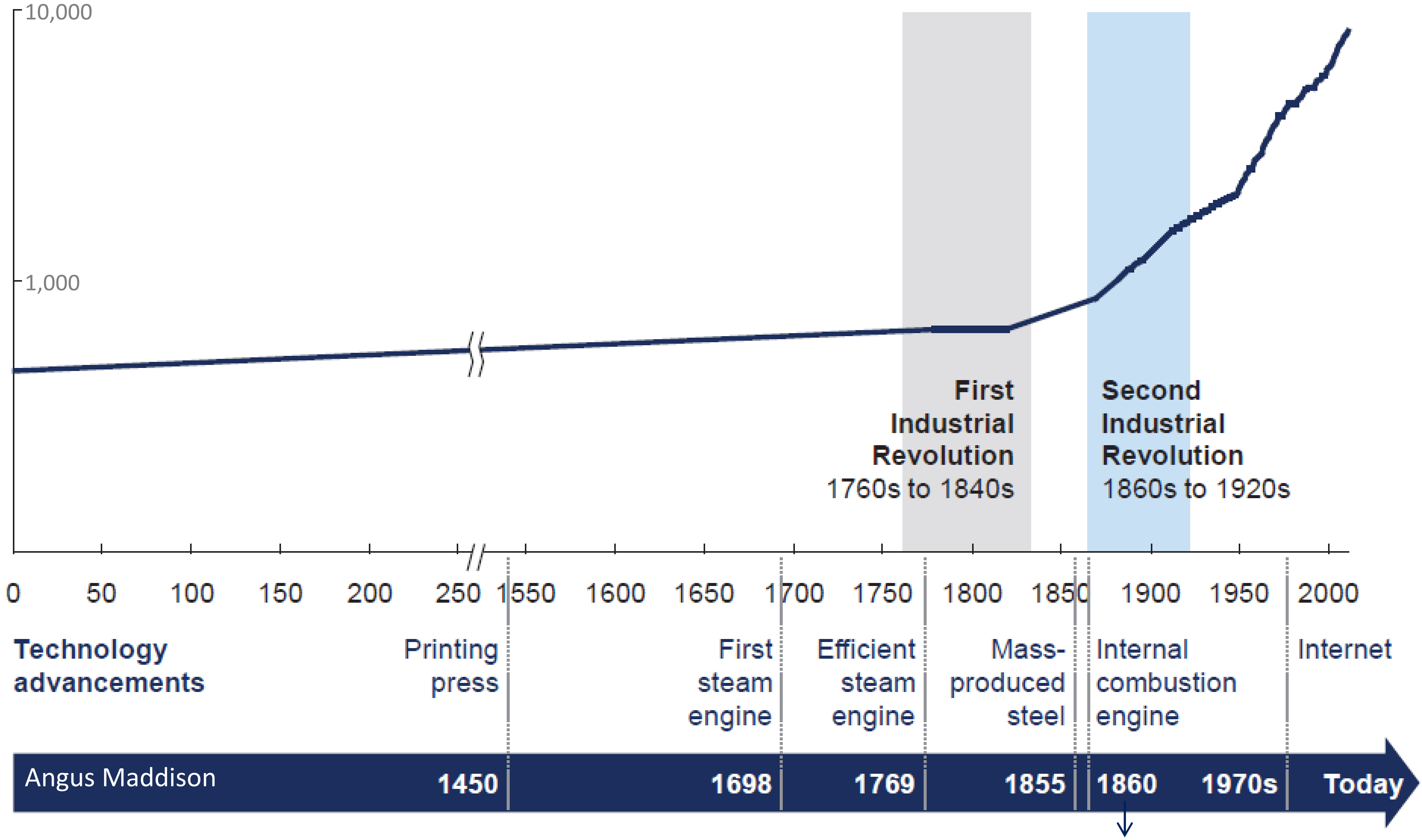
open source
OS
open standards
inside

HOW INCOMPLETE IS THIS TUTORIAL ? MANAGING EXPECTATIONS

The content presented here was collected from various sources to serve as an overview. This tutorial is not an original contribution by the author and it is grossly incomplete. But, it may provide some basic clues about the amorphous concepts underlying the next wave of progress which includes the industrial internet (which, in turn, partially includes the Internet of Things as well as the Internet of Everything). This discussion excludes several important concepts – for example – what is **not** included in the internet of everything and cyber-physical systems (CPS). Networked cyber-physical systems (nCPS) are a part of the evolving future of the industrial internet which will converge to impact energy, healthcare, security, manufacturing, transportation and other verticals. CPS will be discussed in a separate presentation. Time centricity in CPS is an important attribute which may not be as critical in IoT or even in some of the industrial internet applications which are in "real time" but does not require robust time guarantees. In true CPS, the semantics of time and time criticality is key, for example, autonomous regulation of cardiac pacemakers or jet engine performance monitoring to control turbine efficiency, temperature & fuel consumption in-flight.

The historical context

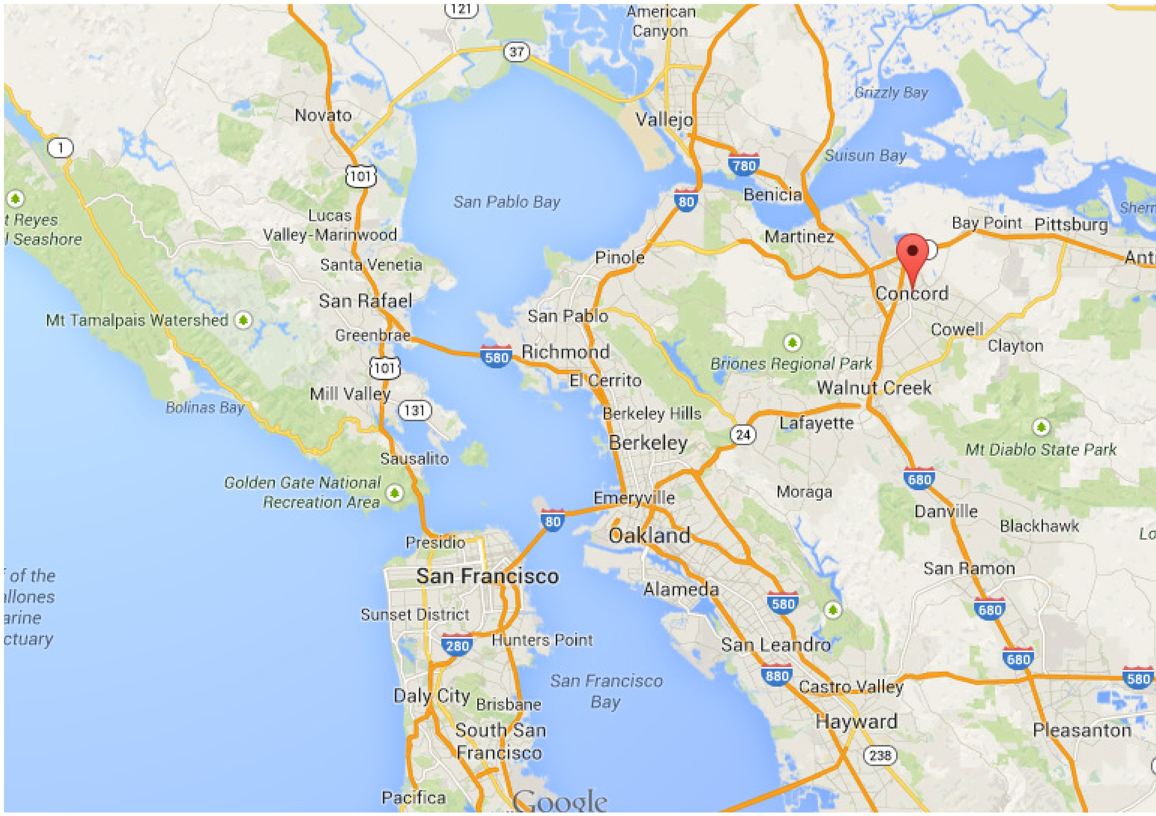
Industrial Growth over 2000 years: measured as global GDP per capita (in US$)



GE traces its beginnings to Thomas A. Edison, who created the light bulb and established Edison Electric Light Co in 1878. In 1892, a merger of Edison General Electric Co and Thomson-Houston Electric Co created General Electric Company (GE). GE is the only company listed in the Dow Jones Industrial Index today that was also included in the original index in 1896. First electricity generating station opened at Niagara Falls in 1895 and transmitted electricity 20 miles away to Buffalo, NY. Distribution used two-phase AC techniques invented by Nikola Tesla and it was more efficient than previous AC systems.

The gradual emergence …

A milestone - Diffusion of the Internet - NetDay 1996



President [Bill Clinton](#) installing computer cables with Vice President [Al Gore](#) on NetDay at [Ygnacio Valley High School](#) (Concord, CA - Mar 9, 1996)

Another milestone – Internet as an Infrastructure

Another First in San Francisco Public Schools in 1996-1997

Felicia Voss, Student at Thurgood Marshall

CISCO SYSTEMS
NETWORKING ACADEMY

The Cisco Networking Academies program is in its first full year at schools. The pilot semester at one site, Thurgood Marshall Academic High School in San Francisco, provides an indication of the potential impact: more than 15 percent of the students involved in the school's semester program in spring 1997 secured summer jobs as a direct result of their one-semester experience.

And for teachers who have seen the early impact on students and their futures, the Academy stands as a model for school-to-work programs.

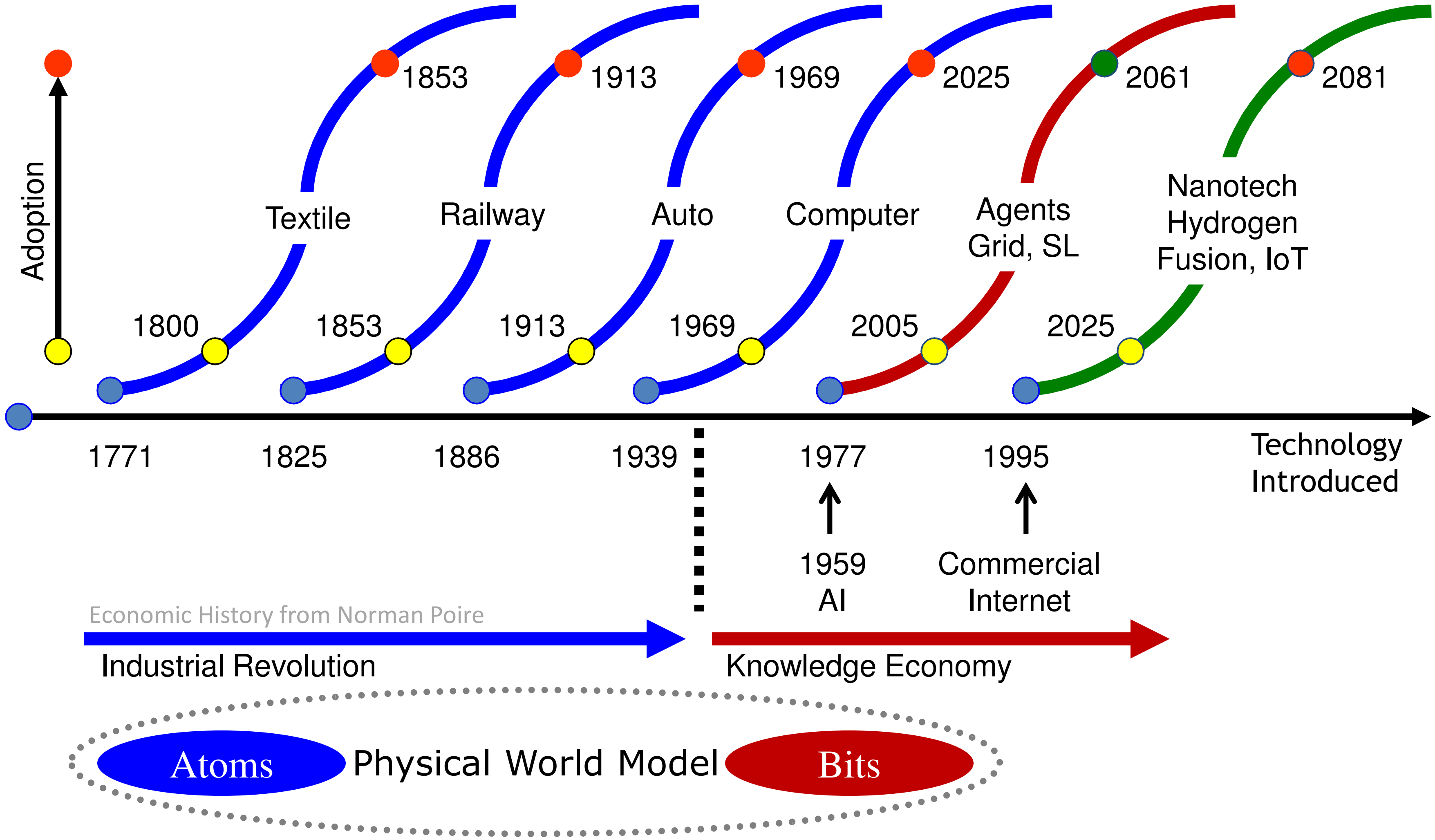
Dennis Frezzo technology instructor at Thurgood Marshall, says, "In one leap, Cisco has helped us have the most effective school-to-work program I've seen locally, and we're proud of that."

20 years later – Connectivity Costs – The Long March Ahead

	Total pop. living on less than $2 per day	Fixed Broadband as % of Income at $2 per day	Mobile Broadband as % of income at $2 per day
China	359,575,234 (~27%)	38.0	25.4
Colombia	7,016,538	30.7	48.9
Nigeria	124,159,302	63.9	21.3
Peru	3,577,091	29.5	23.5
Philippines	38,817,437	37.5	18.9
Zambia	10,444,784 (~87%)	134.9	35.4

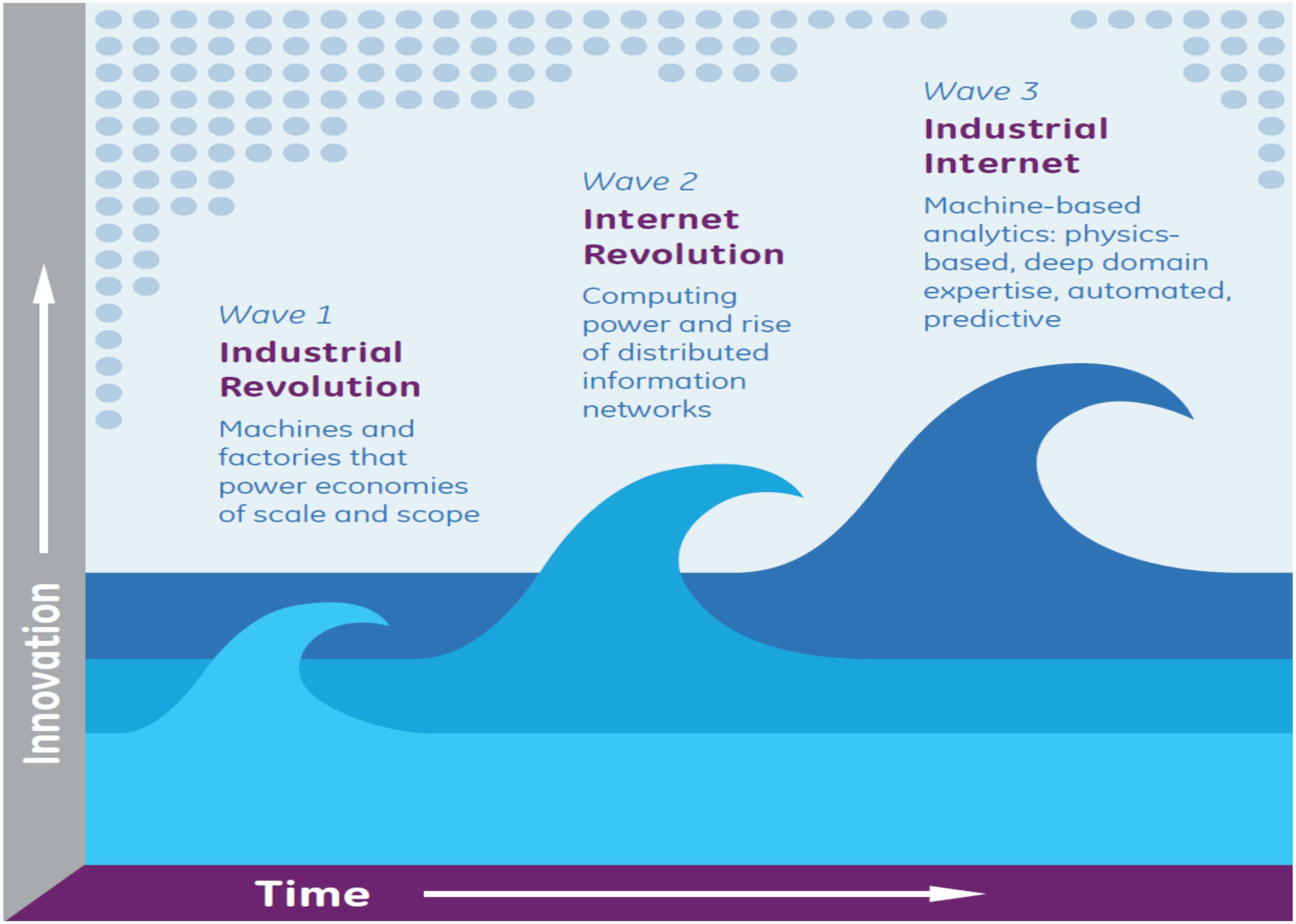
ITU

Conceptual advances adds to the *Wealth of Nations* for about 100 years



It takes 30 years for ideas to gain traction before they grow exponentially. If 1995 is considered the DOB for the commercial internet, then the Industrial Internet may reach that stage by 2025.

Sum of Parts – The Combination of the Industrial Revolution with the Evolution of the Internet



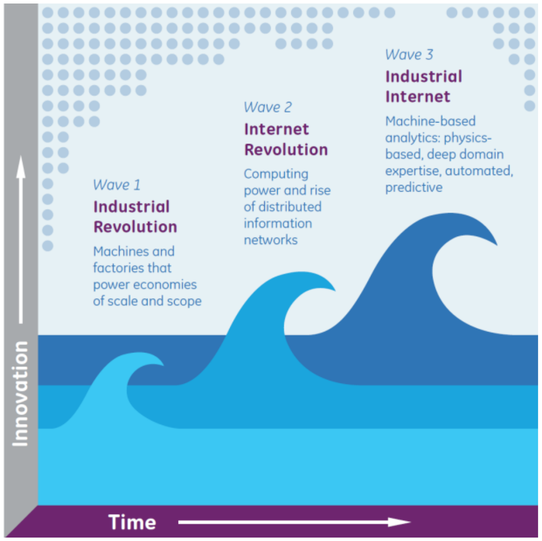
Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

RFID

∑(IoT, CoT, IoE, IoP, D2B, D2D, M2M, O2O, P2P, V2V)

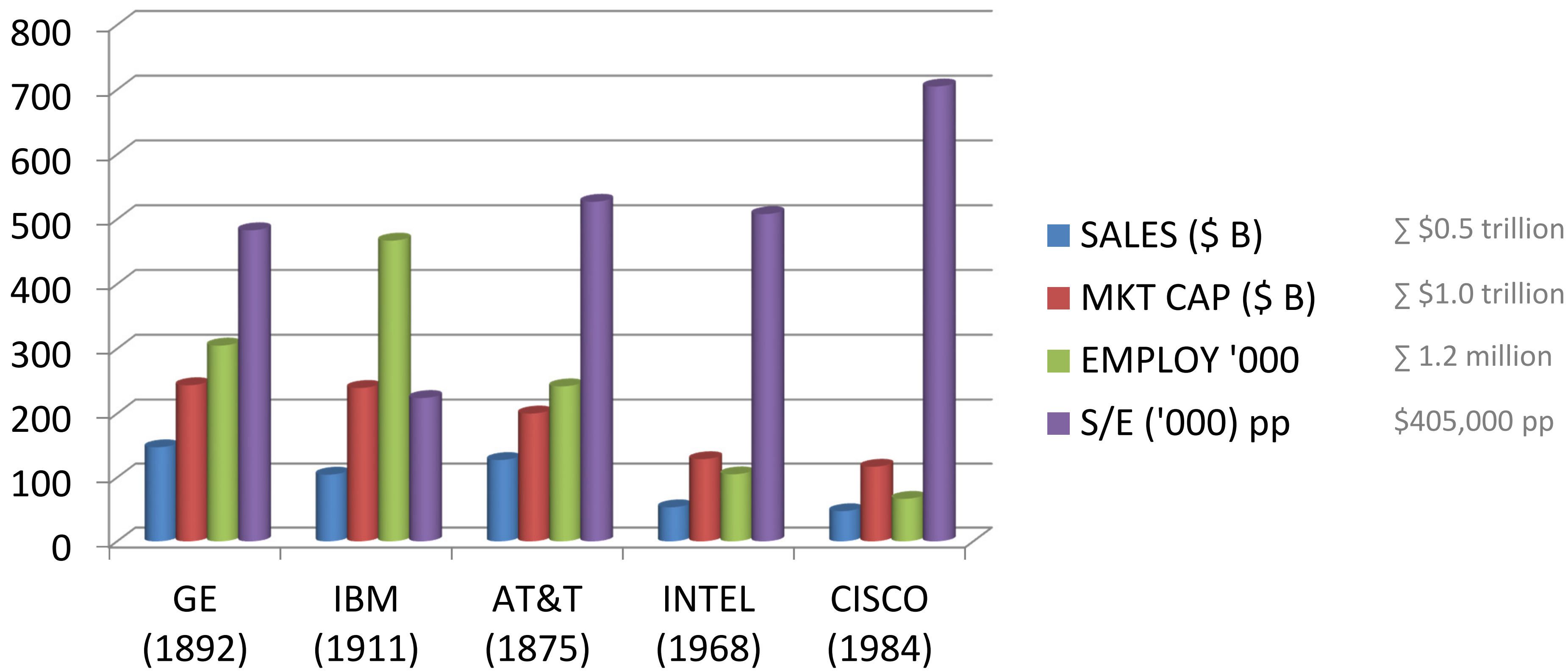
The Industrial Internet

Economic Value from the Management of Information Entropy and Application of the Cybernetics Approach



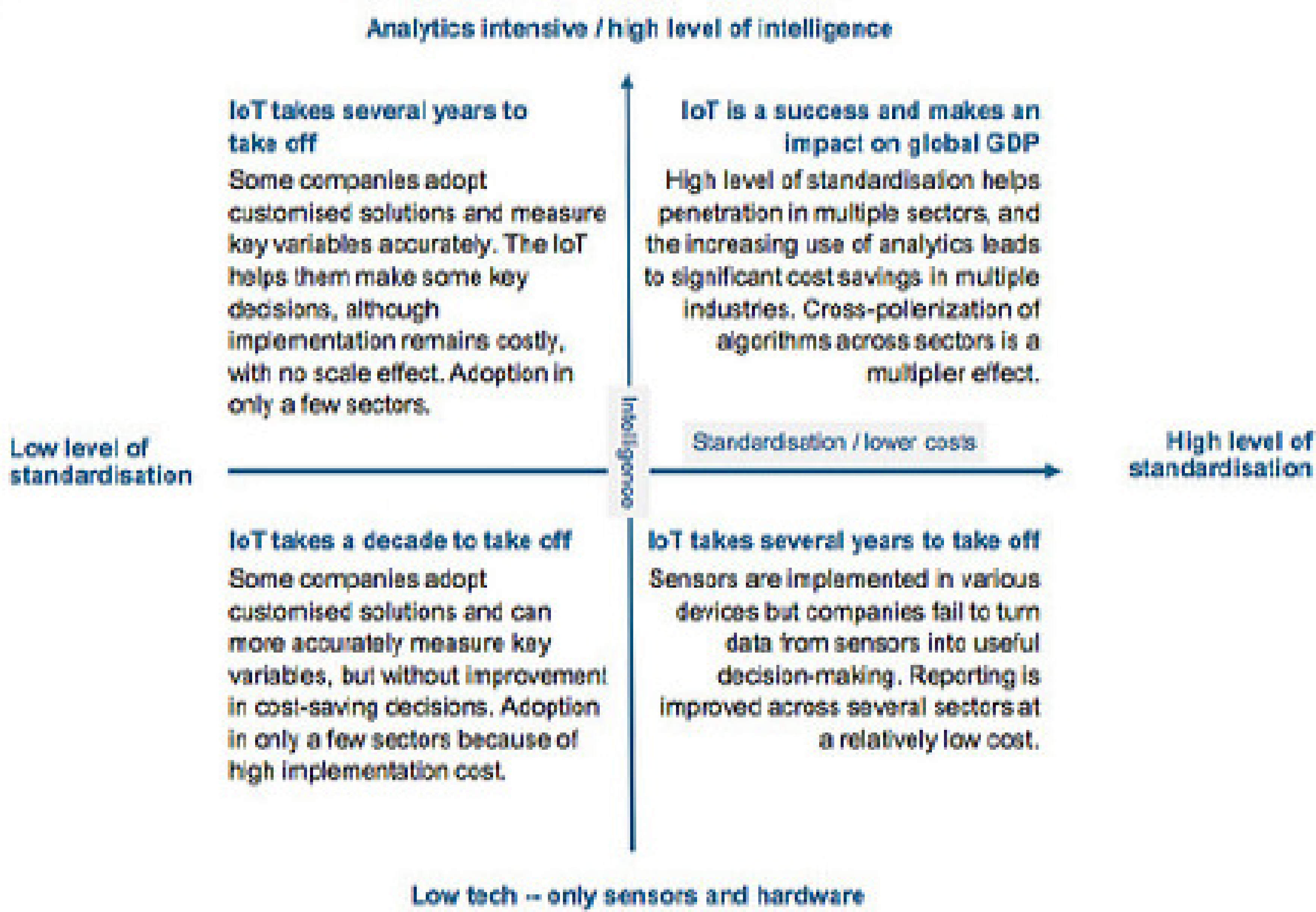
Dr Shoumen Datta

Leaders of the Industrial Internet Movement in the US



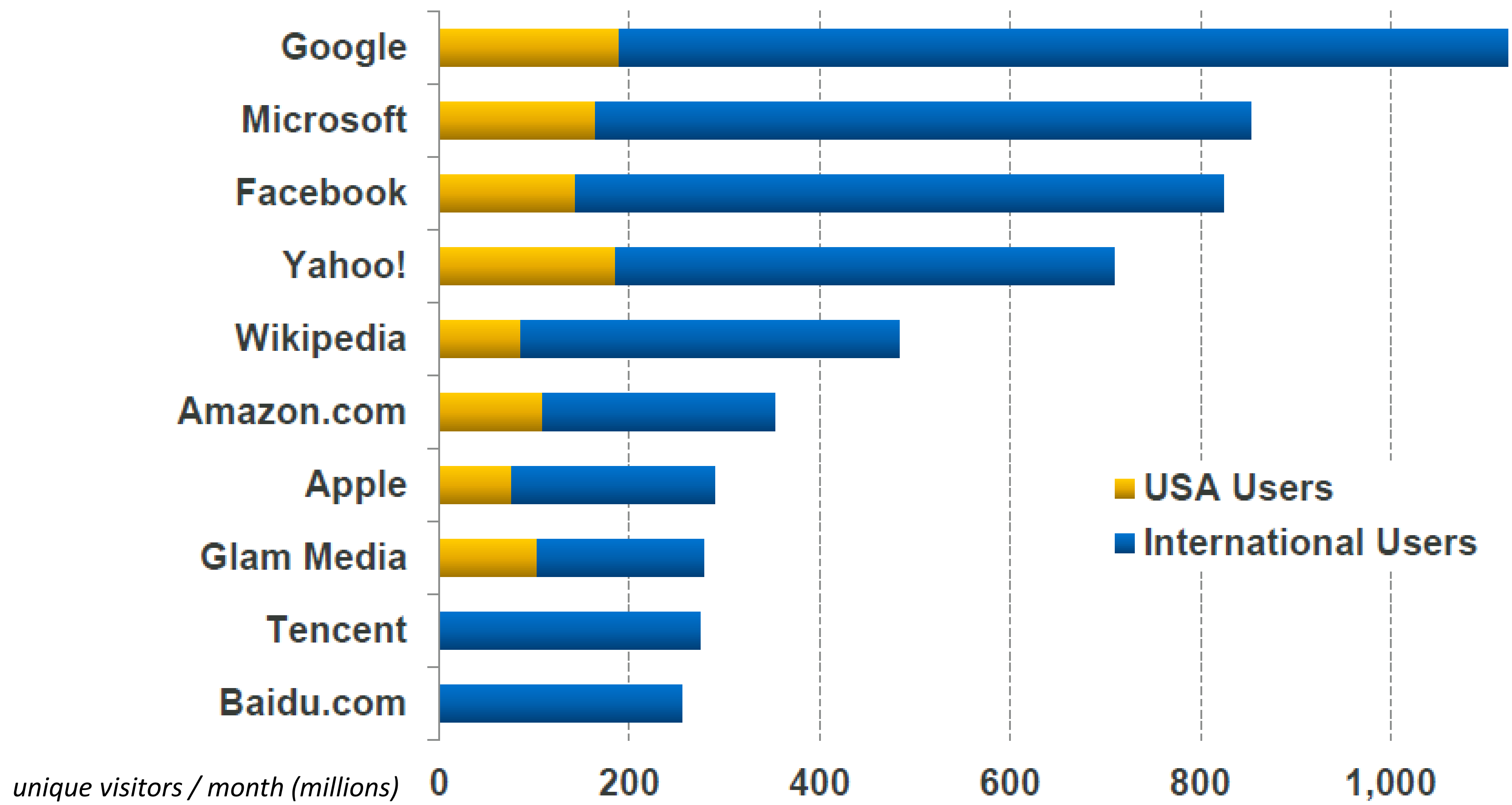
COMPANY (founded)	2013 SALES ($ B)	MKT CAP ($ B)	EMPLOYEES ('000)	Sales per Employee
GE (1892)	147.36	243.74	305	$483,000
IBM (1911)	104.51	239.53	467	$224,000
AT&T (1875)	127.43	200.06	242	$527,000
INTEL (1968)	53.34	128.76	105	$508,000
CISCO (1984)	47.25	116.9	67	$705,000

Standardization is a key driver for the industrial internet - IoT



Morgan Stanley

Top 10 Reasons why the US must proactively collaborate with global agencies and nations to seek interoperability standards



comScore, 2013

80% of Top 10 global "internet properties" are "Made in USA"
20% of the users are "Made in USA" (80% of users are global)

At the beginning …

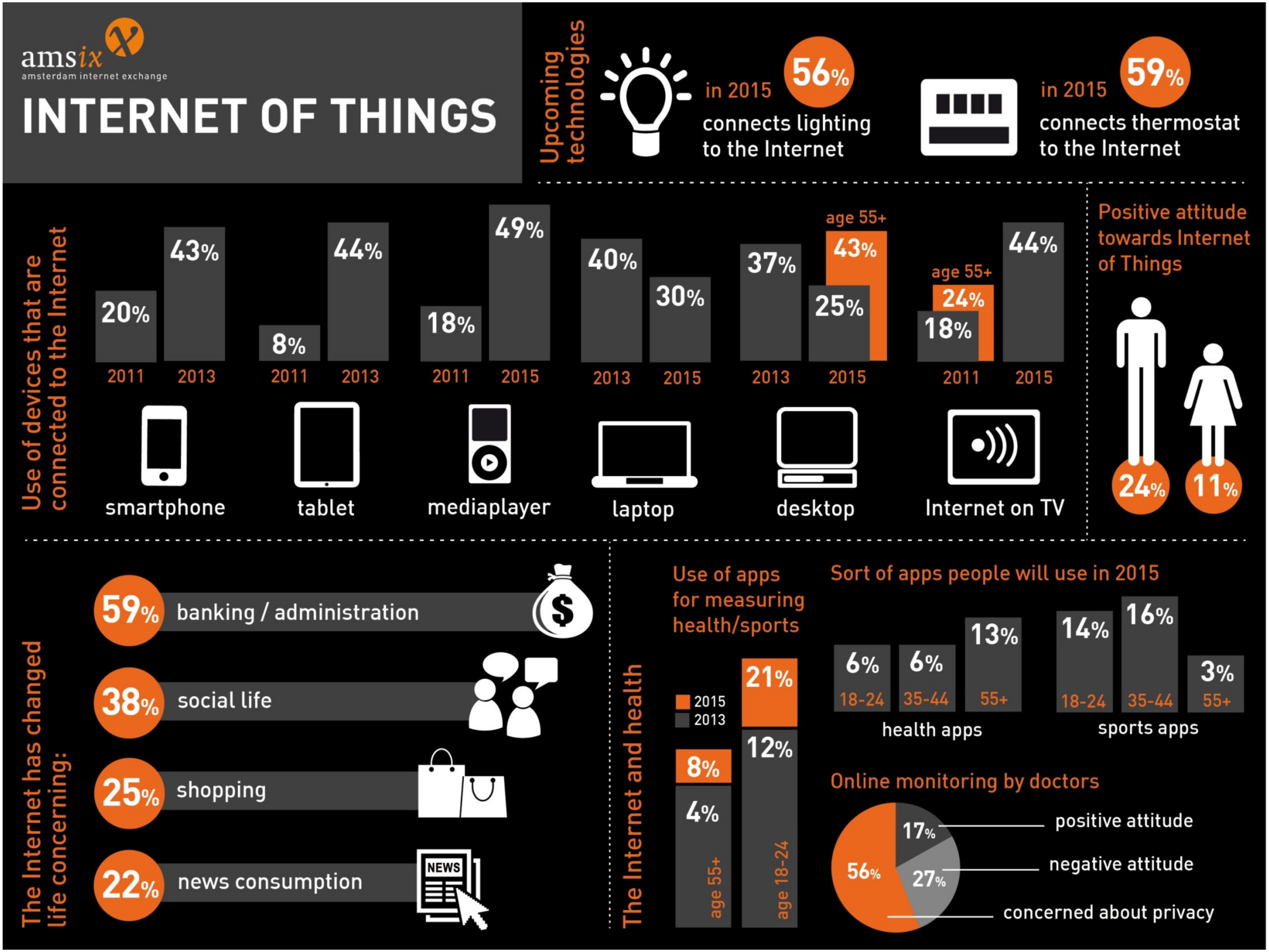
At the beginning - How did the IoT concept / industrial internet start ?

The grand vision of the Industrial Internet may have started circa 1988 with the work of Mark Weiser of Xerox Palo Alto Research Center (XPARC) who predicted that computers may *"weave themselves into the fabric of everyday life"* and influence the future of business as well as lifestyle technologies, in his 1991 article in the *Scientific American*. The release of the commercial internet in 1995 paved the way for the Industrial Internet of the future. In 1998, Sanjay Sarma (MIT) extended the idea of using RFID tags on objects for track and trace purposes. To make it feasible for businesses to use RFID tags in the management of their supply chains, the price of the RFID tag had to be reduced, significantly. Sarma suggested RFID tags contain only a reference number (electronic product code) rather than any actual data about the object. It was against the conventional wisdom. At the time, RFID tags were used and designed to contain data about the object or product. By eliminating need for data storage on the tag, the cost of the RFID tags were reduced. Sarma designed the EPC to act as an unique URL to access the object data stored on the Internet. In 1999, Sarma along with colleagues David Brock and Sunny Siu co-founded the Auto ID Center to transform this vision made possible by the "emerging" medium and the platform of the internet. The internet was still in its infancy and immature to act as a catalyst to augment business processes and industrial productivity. Sarma, Brock and Siu were later joined by Kevin Ashton who was loaned to the Auto ID Center at MIT from Proctor & Gamble. Auto ID Center at MIT developed the EPC and other technical concepts and standards prevalent today in the global RFID industry. Sarma, Brock and Ashton coined the term Internet of Things which envisioned objects /things connected to object-specific data on the internet which could be accessed using the unique EPC on the tag attached to the object. IoT is a vision, not a technology. In 2000, a paper by Sarma *et al* gave birth to that IoT concept. Please download (MIT-AUTOID-WH-001) *THE NETWORKED PHYSICAL WORLD* from this link http://tinyurl.com/Industrial-Internet (this folder contains many papers). Professor Sarma talked about the IoT at the MIT Sloan Symposium. It is on YouTube http://tinyurl.com/MIT-IoT-1998

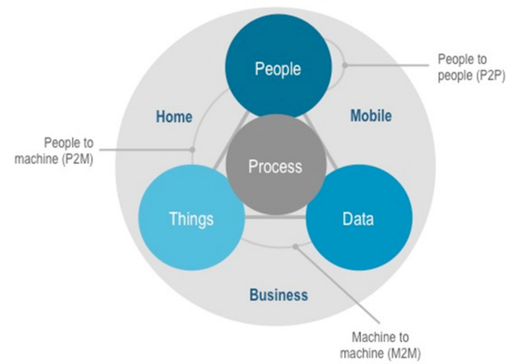
I was a part of the Auto ID initiative since 2001 as a member of the Technology Board at Auto ID Center.

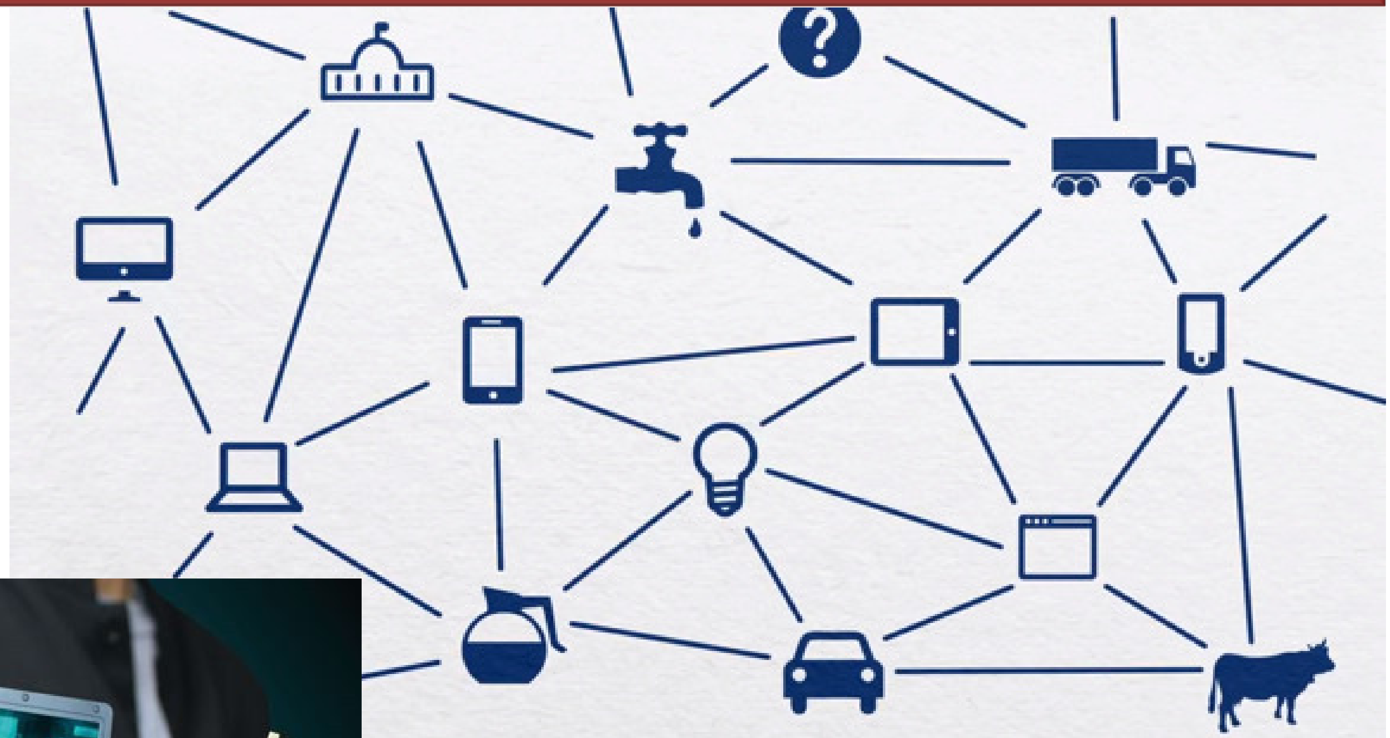
The industrial internet started with the birth of Internet of Things

What does it “look” like …


amsix
amsterdam internet exchange
INTERNET OF THINGS
Upcoming technologies
in 2015 56% connects lighting to the Internet
in 2015 59% connects thermostat to the Internet
Use of devices that are connected to the Internet
smartphone: 2011 20%, 2013 43%
tablet: 2011 8%, 2013 44%
mediaplayer: 2011 18%, 2015 49%
laptop: 2013 40%, 2015 30%
desktop: 2013 37%, 2015 25%, age 55+ 43%
Internet on TV: 2011 18%, age 55+ 24%, 2015 44%
Positive attitude towards Internet of Things
24%
11%
The Internet has changed life concerning:
59% banking / administration
38% social life
25% shopping
22% news consumption
NEWS
The Internet and health
Use of apps for measuring health/sports
2015
2013
age 55+: 4%, 8%
age 18-24: 12%, 21%
Sort of apps people will use in 2015
health apps: 18-24 6%, 35-44 6%, 55+ 13%
sports apps: 18-24 14%, 35-44 16%, 55+ 3%
Online monitoring by doctors
17% positive attitude
27% negative attitude
56% concerned about privacy

Are any one these illustrations representative of the Industrial Internet or the IoT (Internet of Things) or the Internet of Everything (IoE) ?





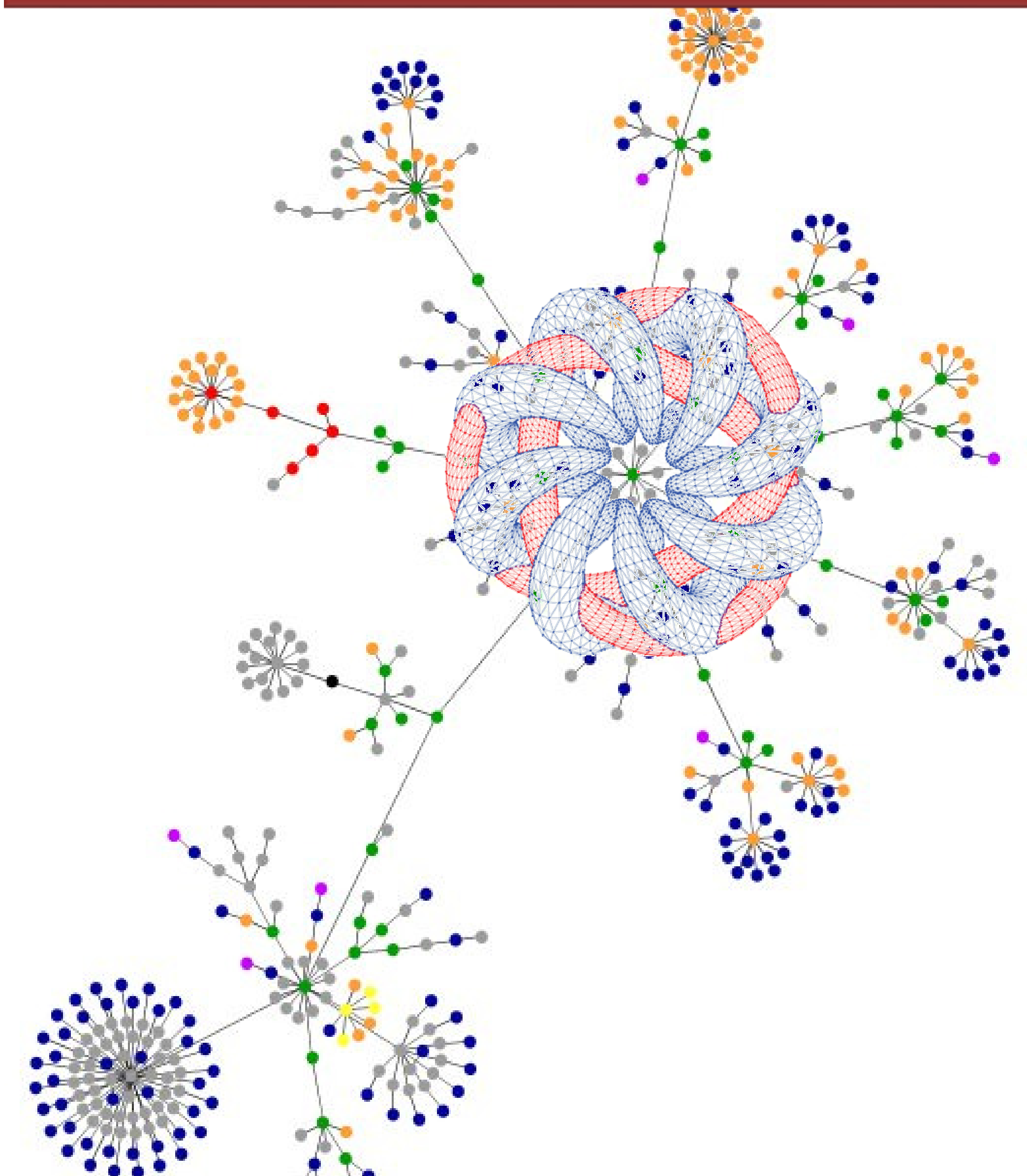
Robot-aided Manufacturing Harley-Davidson

It is difficult to include the innumerable elements and all dependencies in context of the user and the connectivity (required at the point of use).

Is there a key characteristic …

CONNECTIVITY

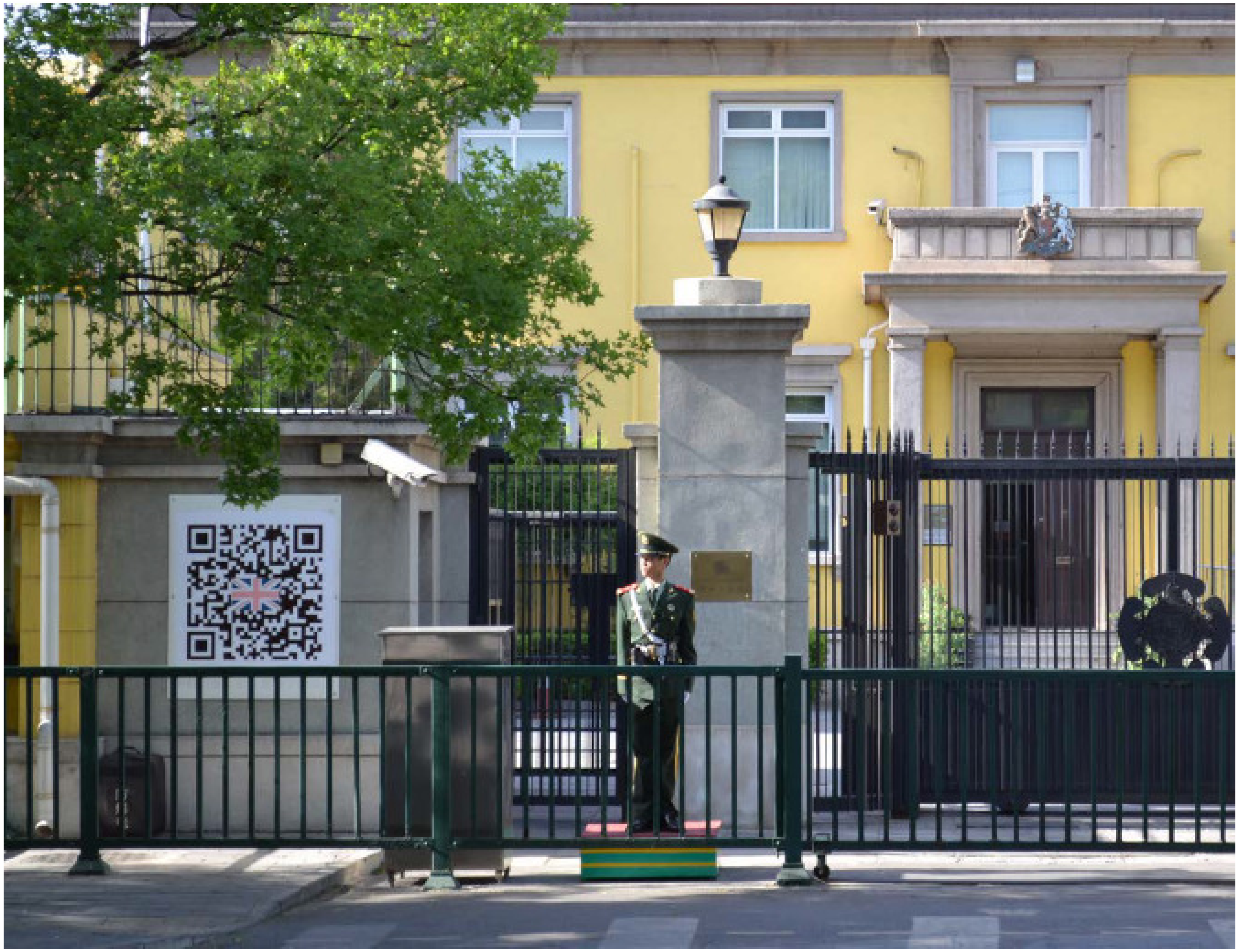
key for the Industrial Internet



Social Network Graph

"Attempting to define precisely what is included or excluded is a fruitless exercise. It is a matter of emphasis and focus. "

CONNECTED – *Big Brother using QR code ?*



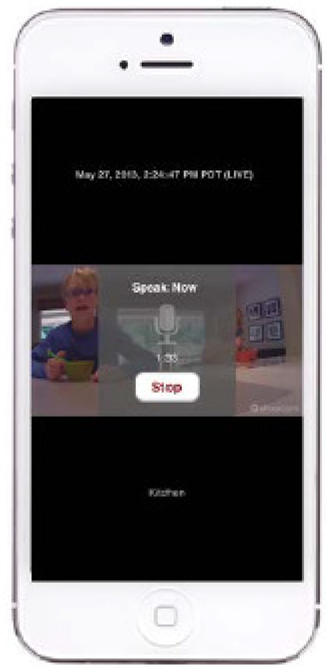
British Embassy, Beiijing

CONNECTED – *Big Brother meets Big Mother*

When I am on the road, I still join my husband in singing bedtime lullabies using Dropcam, a Wi-Fi video monitoring camera that streams to my phone and computer.

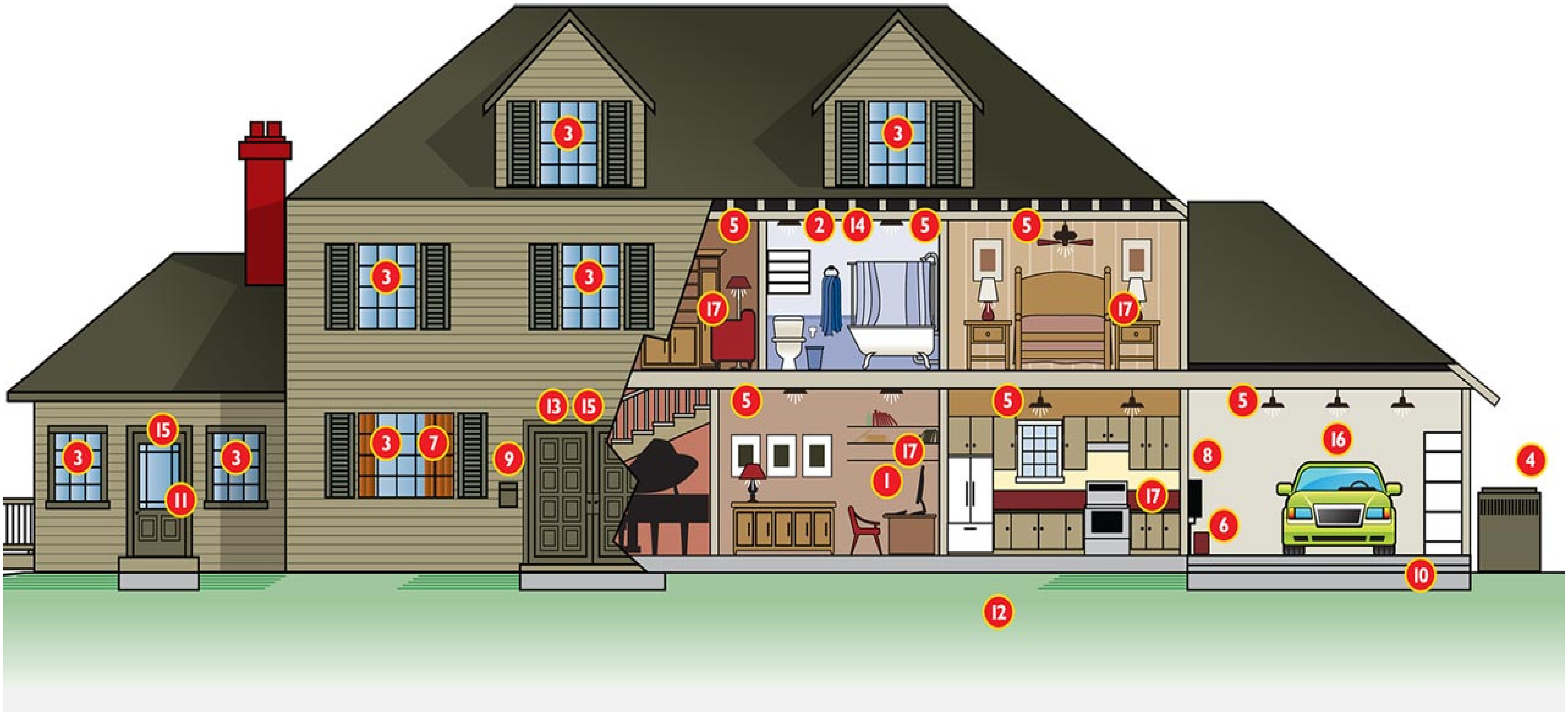
– Randi Zuckerberg

Parents Can See & Talk With Children While Away From Home



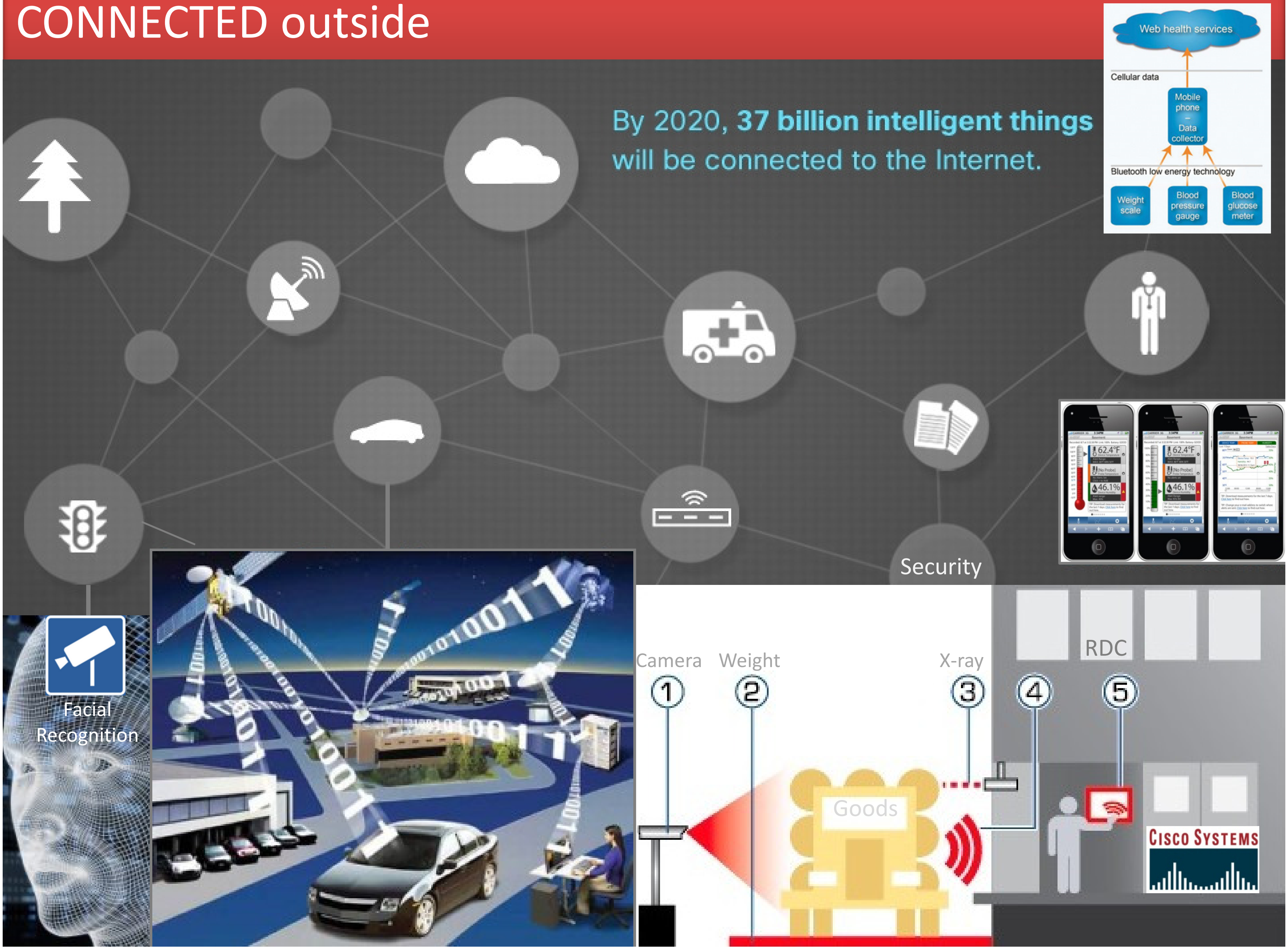
Source: Dropcam,5/13. Mashable, 4/13

CONNECTED inside

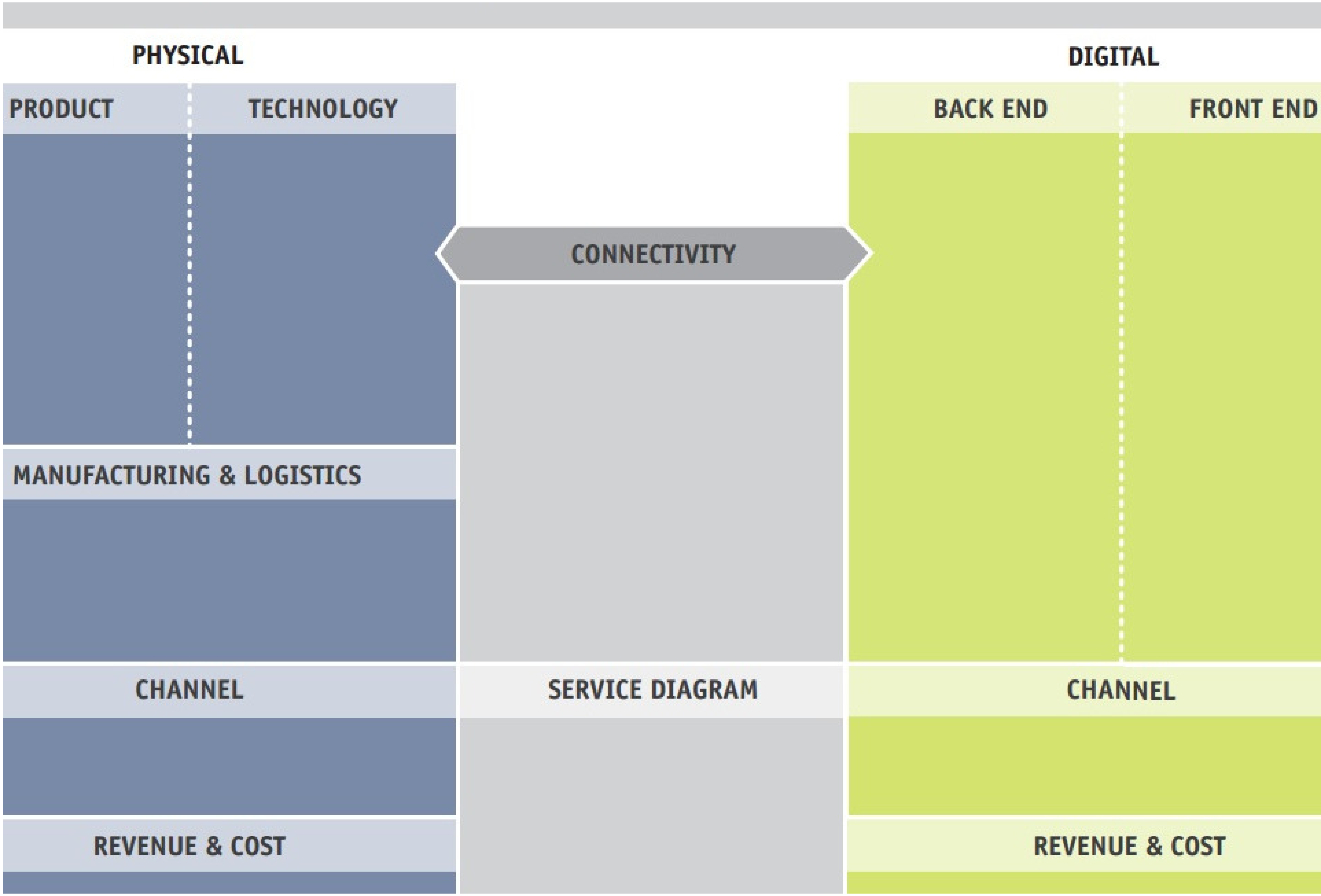


1	Ambient Intelligence Agent (AmI) Control	6	Automatic Pet Feeder	12	Lawn Moisture Sensor
2	Light Sensor	7	Motorized Drapes	13	Face Recognition Sensor
3	Windows and Door Control	8	Automatic Watering	14	Motion Sensors
4	HVAC Control	9	Mailbox Sensor	15	Door Sensors
5	Lighting Control	10	Driveway Sensor	16	AmI Interface with Car
		11	Security System	17	AmI Interface with Smart Phone

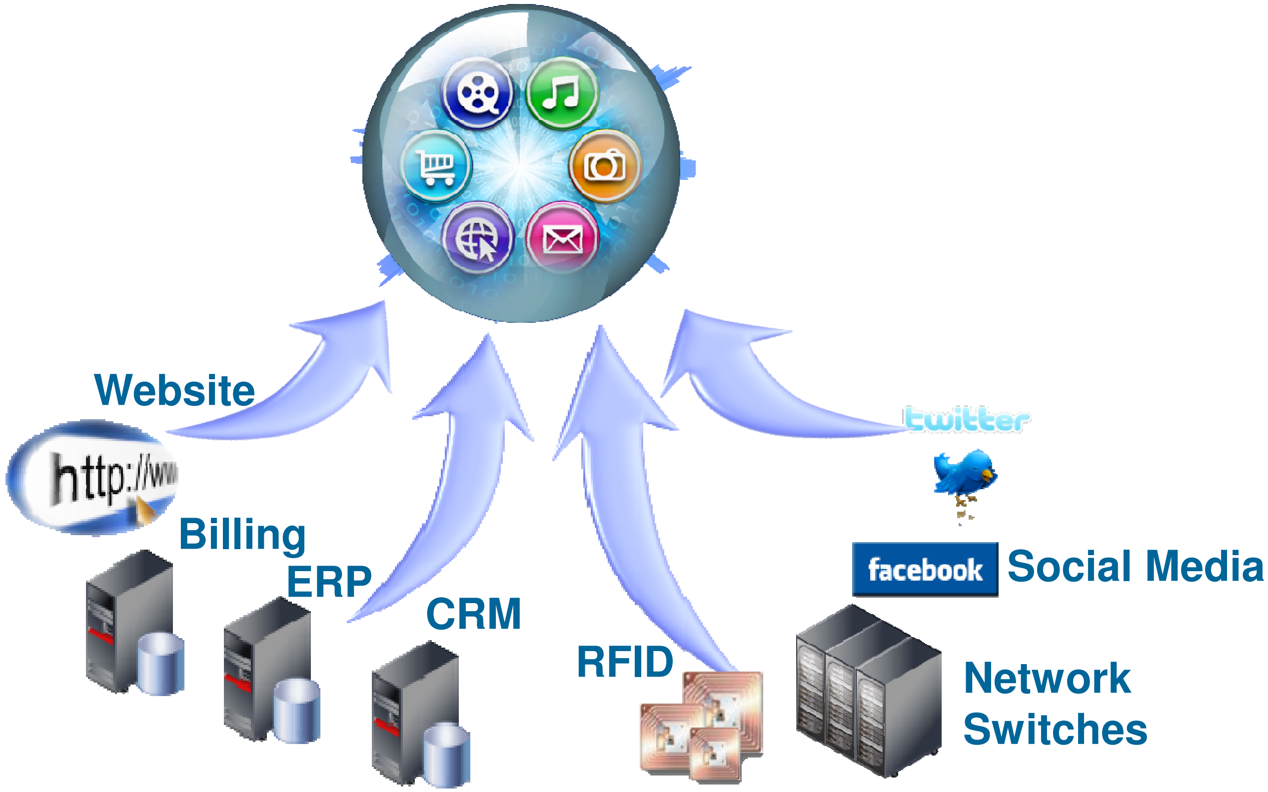
CONNECTED outside



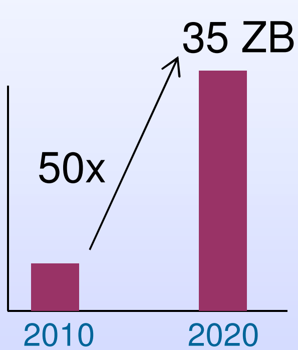
CONNECTED → BITS (DIGITAL DATA) to ATOMS (THE PHYSICAL WORLD)



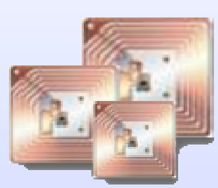
CONNECTED → ALL DATA



Volume

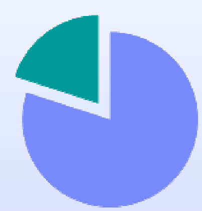


Velocity



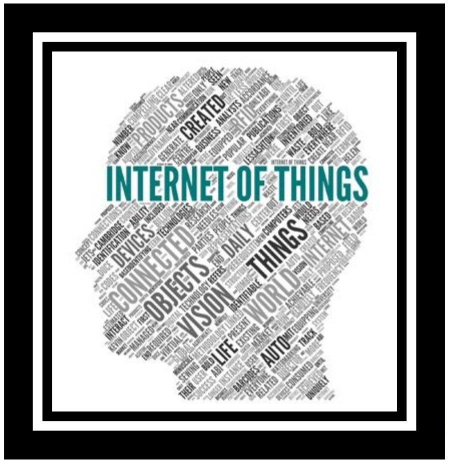
30 billion +
RFID sensors

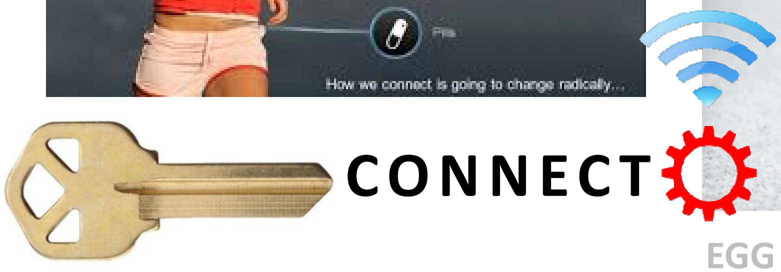
Variety



80% of data
unstructured

Vast number of people continue to extend the concept of connectivity





EGG MINDER by Rafael Hwang • QUIRKY + GE

★ 2003 - the industrial internet ideas in my book chapter.
MIT Library → http://dspace.mit.edu/handle/1721.1/41908

★ 2003 – framework of analytics (published paper in 2007).
MIT Library → http://dspace.mit.edu/handle/1721.1/41906

★ 2007 – context, semantics, connectivity (published paper in 2012).
MIT Library → http://dspace.mit.edu/handle/1721.1/41902

★ 2007 – illustration of industrial internet in my working paper.
MIT Library → http://dspace.mit.edu/handle/1721.1/41900

★ 2008 – illustration published by European Supply Chain Group.
MIT Library http://dspace.mit.edu/handle/1721.1/57508

References to some of my earlier thoughts on topics related to the internet of things. A few of the concepts may find some use within the context of the industrial internet products, services and analyses of big data.

What can you do with connected data? Automate insurance underwriting!

United States Patent **8,214,314**
***Bonissone*, et al.** **July 3, 2012**

System and process for a fusion classification for insurance underwriting suitable for use by an automated system

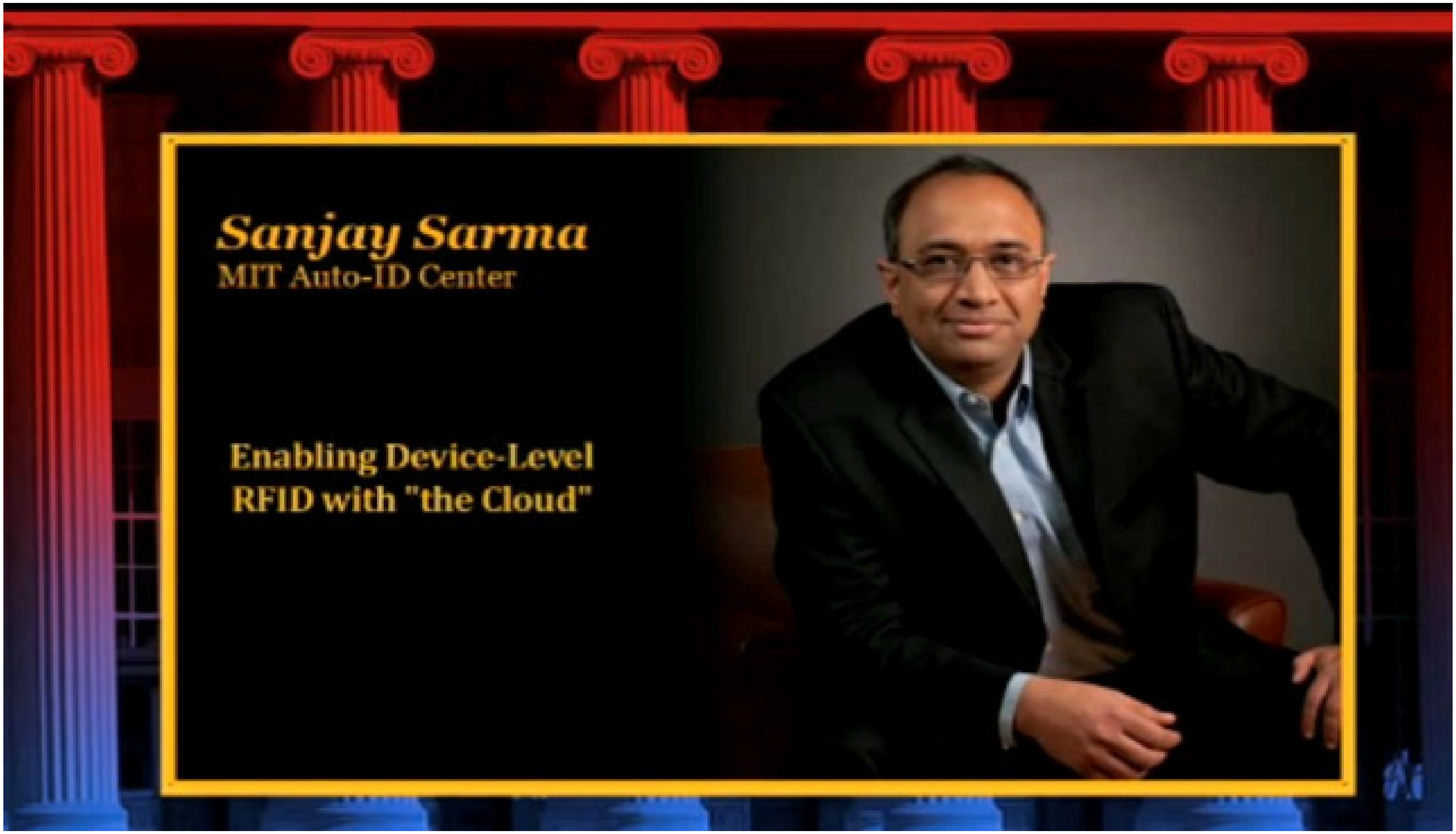
Abstract

A method and system for fusing a collection of classifiers used for an automated insurance underwriting system and/or its quality assurance is described. Specifically, the outputs of a collection of classifiers are fused. The fusion of the data will typically result in some amount of consensus and some amount of conflict among the classifiers. The consensus will be measured and used to estimate a degree of confidence in the fused decisions. Based on the decision and degree of confidence of the fusion and the decision and degree of confidence of the production decision engine, a comparison module may then be used to identify cases for audit, cases for augmenting the training/test sets for re-tuning production decision engine, cases for review, or may simply trigger a record of its occurrence for tracking purposes. The fusion can compensate for the potential correlation among the classifiers. The reliability of each classifier can be represented by a static or dynamic discounting factor, which will reflect the expected accuracy of the classifier. A static discounting factor is used to represent a prior expectation about the classifier's reliability, e.g., it might be based on the average past accuracy of the model, while a dynamic discounting is used to represent a conditional assessment of the classifier's reliability, e.g., whenever a classifier bases its output on an insufficient number of points it is not reliable.

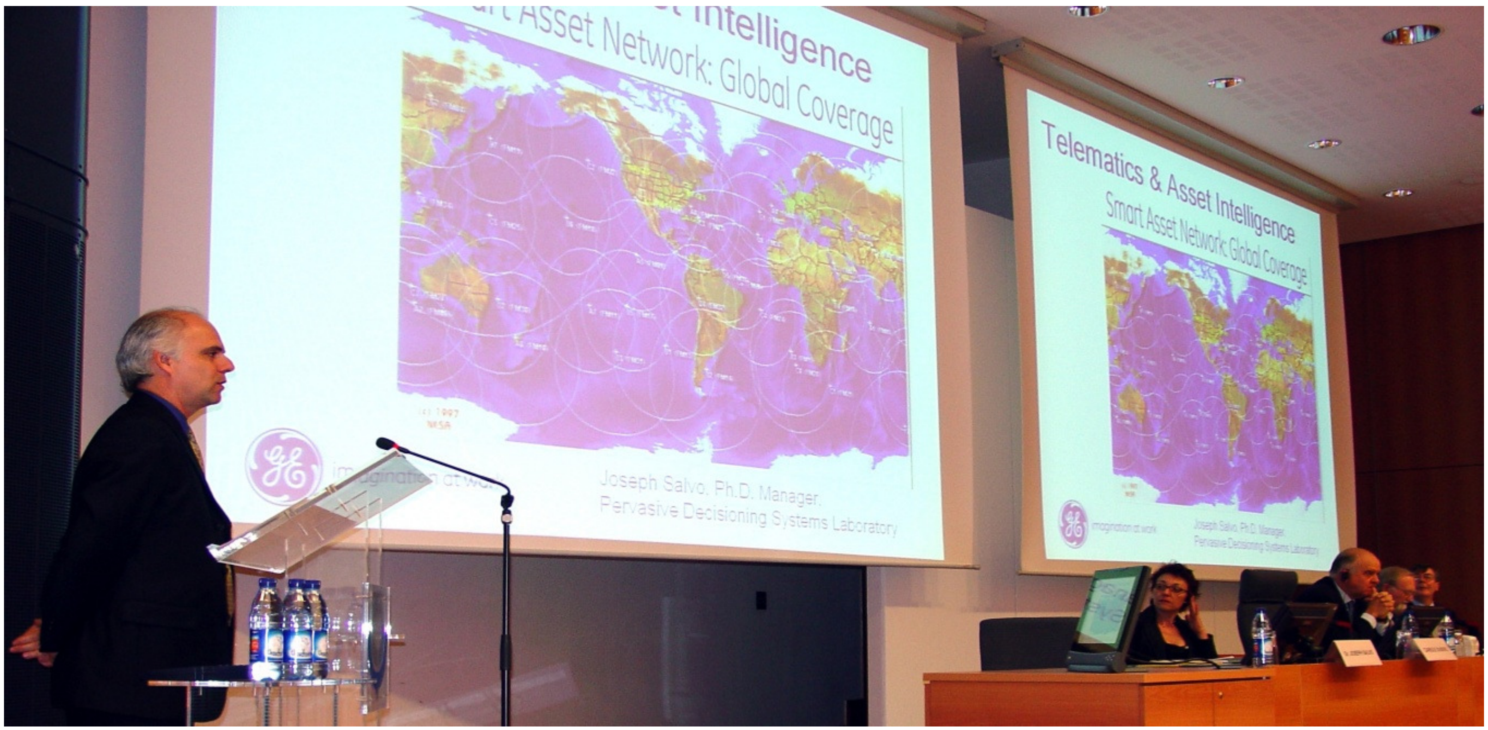
Inventors: ***Bonissone; Piero Patrone*** (Schenectady, NY), **Aggour; Kareem Sherif** (Niskayuna, NY), **Subbu; Rajesh Venkat** (Troy, NY), **Yan; Weizhong** (Clifton Park, NY), **Iyer; Naresh Sundaram** (Clifton Park, NY), **Chakraborty; Anindya** (Schenectady, NY)
Assignee: **Genworth Financial, Inc.** (Richmond, VA)
Family ID: **33309734**
Appl. No.: **12/131,545**
Filed: **June 2, 2008**

Early influencers …

My concepts, suggestions and applications were influenced by a few key collaborators



My concepts, suggestions and applications were influenced by a few key collaborators



Dr Joe Salvo
GE Global Research
World Customs Organization (Brussels, 2006)

My concepts, suggestions and applications were influenced by a few key collaborators

★★★★ General Paul Kern
Commanding General
US Army Materiel Command
US Department of Defense
http://www.cohengroup.net

My concepts, suggestions and applications were influenced by a few key collaborators

Dr Sokwoo Rhee (1-179 MIT, 2009)

My concepts, suggestions and applications were influenced by a few key collaborators

JrJung Lyu, Kajunori Miyabayashi, Sokwoo, Rhee, Reuben Slone, Louis Brennan, Finn Kydland, Pekka Vepsalainen, Peter Koudal

Helsinki, 2006

My premature suggestions …

The idea of CONNECTIVITY between the edge and the core

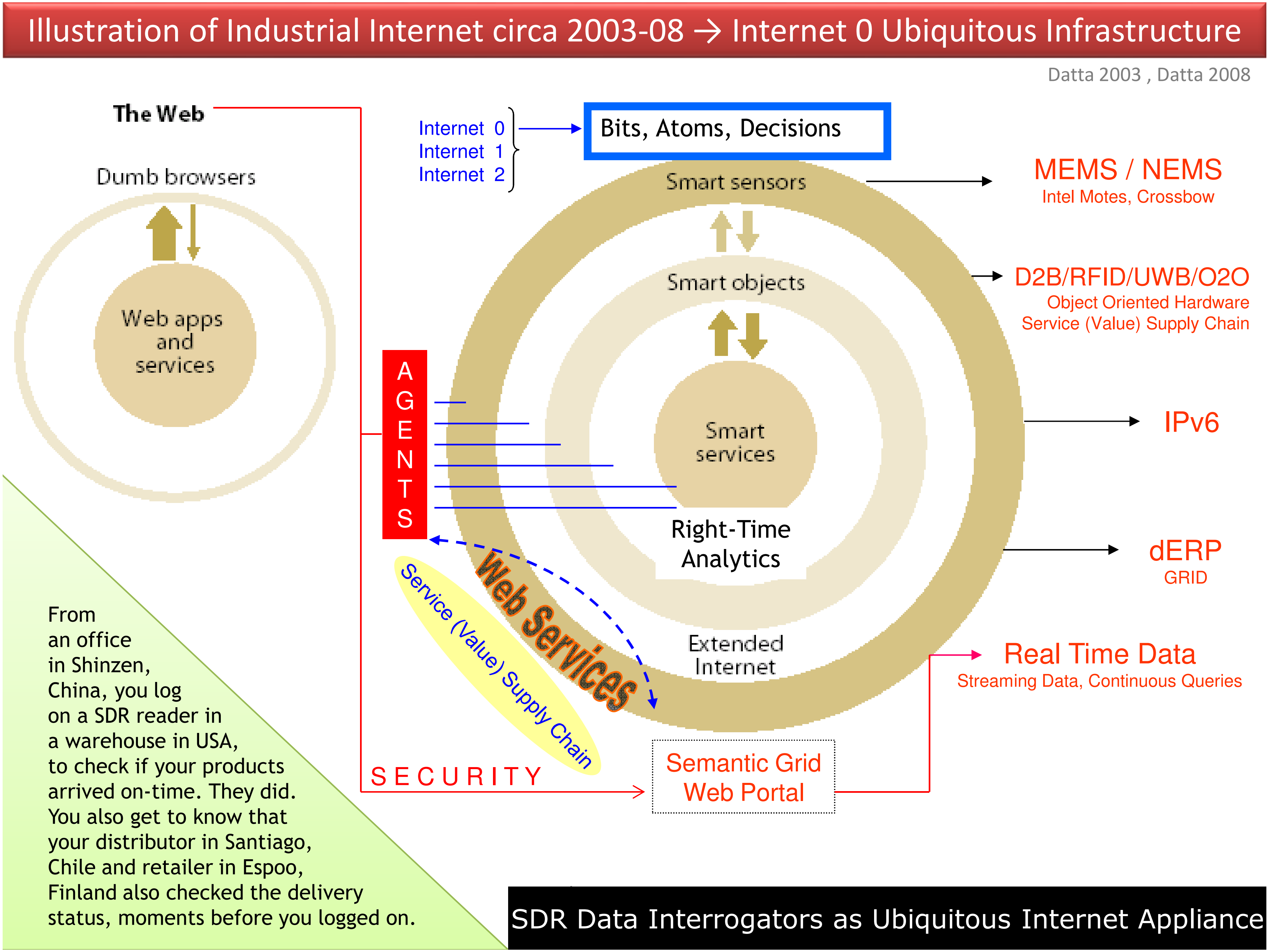
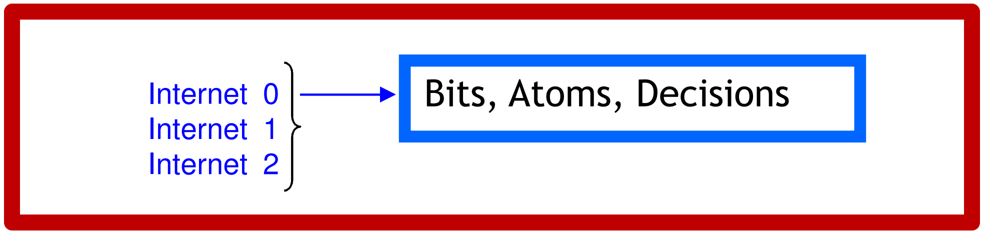


Illustration of Industrial Internet circa 2003-08 → Internet 0 Ubiquitous Infrastructure
Datta 2003 , Datta 2008
The Web
Dumb browsers
Web apps and services
Internet 0
Internet 1
Internet 2
Bits, Atoms, Decisions
Smart sensors
Smart objects
Smart services
Right-Time Analytics
Extended Internet
AGENTS
Web Services
Service (Value) Supply Chain
SECURITY
Semantic Grid Web Portal
MEMS / NEMS
Intel Motes, Crossbow
D2B/RFID/UWB/O2O
Object Oriented Hardware
Service (Value) Supply Chain
IPv6
dERP
GRID
Real Time Data
Streaming Data, Continuous Queries
From an office in Shinzen, China, you log on a SDR reader in a warehouse in USA, to check if your products arrived on-time. They did. You also get to know that your distributor in Santiago, Chile and retailer in Espoo, Finland also checked the delivery status, moments before you logged on.
SDR Data Interrogators as Ubiquitous Internet Appliance

Illustration of Industrial Internet circa 2003-08 → Internet 0 ← About Small Data

Datta 2003 , Datta 2008



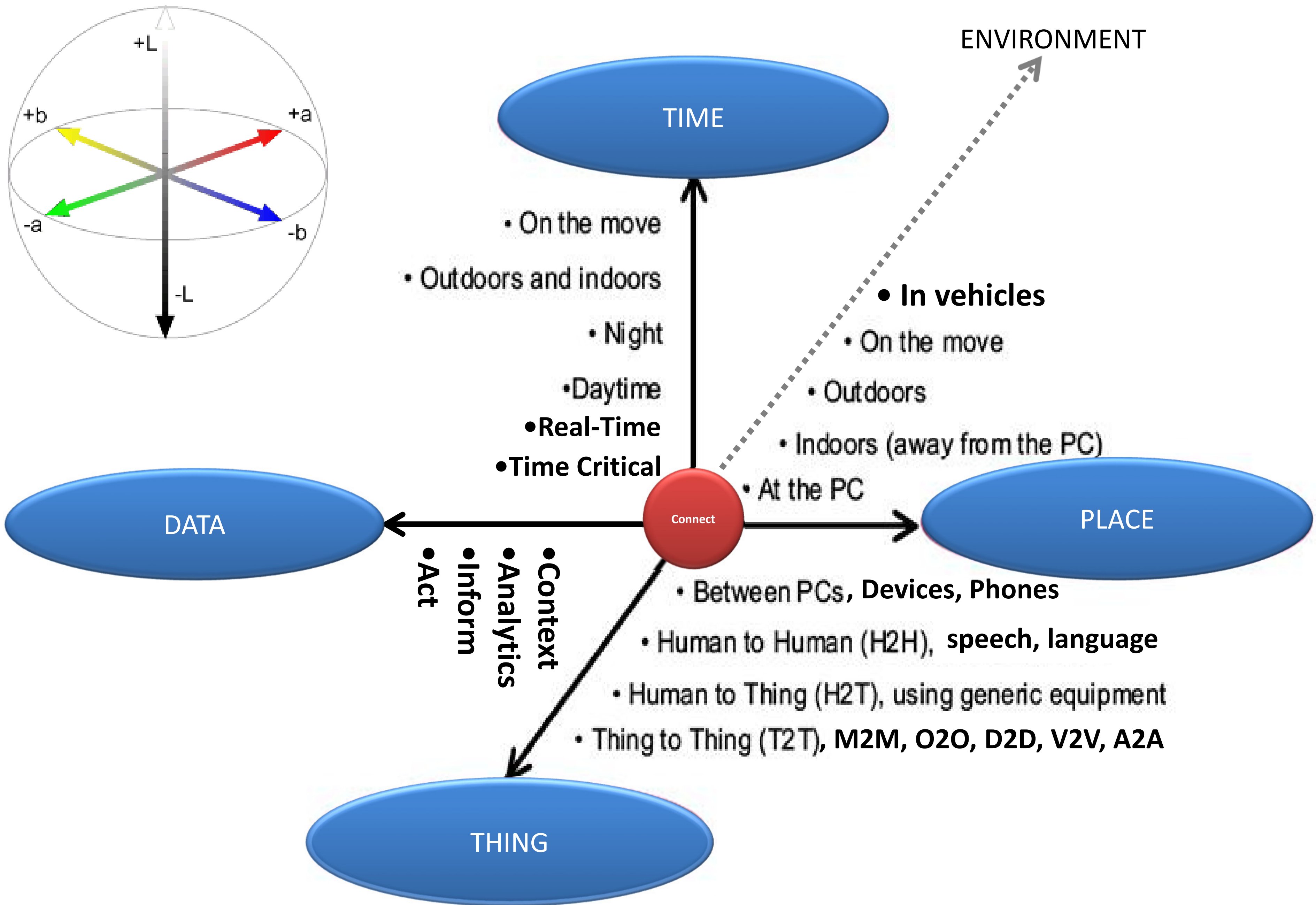
Lost in hype ?

This illustration uses the concept of Internet 0, Internet 1 and Internet 2.

The purpose was to indicate that small amounts of data (0) can be as important as "big" data in transactions, updates, control parameters, autonomous response and anything else that may be instantiated based on data ("bit dribbling" was the term used by N Gershenfeld & R Krikorian). Internet 1 referred to standard data volume (neither small or too big) and Internet 2 was implied to be the future "fat pipe" carrying high volume of data.

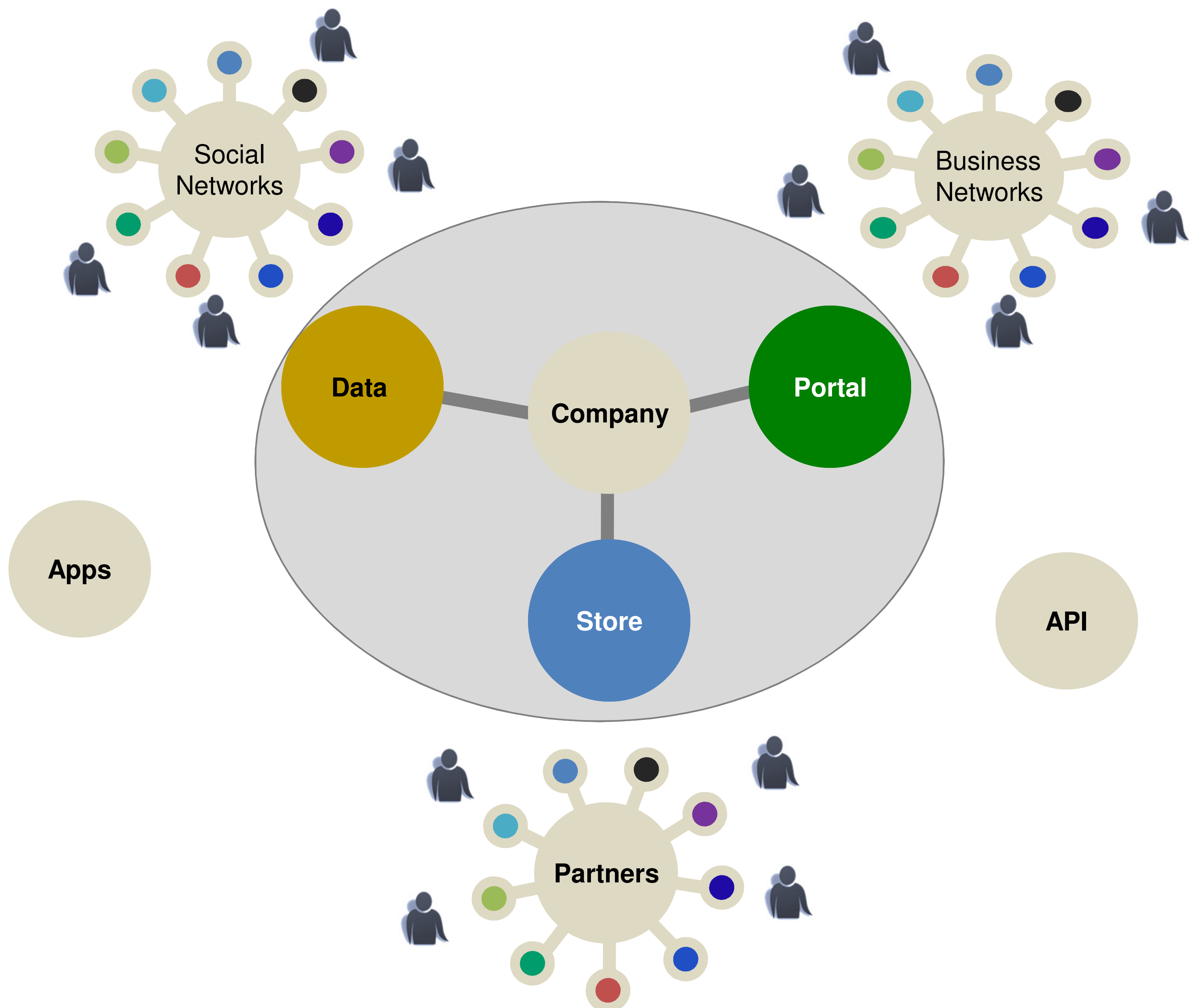
In the opinion of the author, the value and significance of small data (2003) appears to have been overshadowed by the hype/buzz from big data (2013).

Dimensions of the IoT and Industrial Internet circa 2005



(Modified from ITU) Datta, 2005

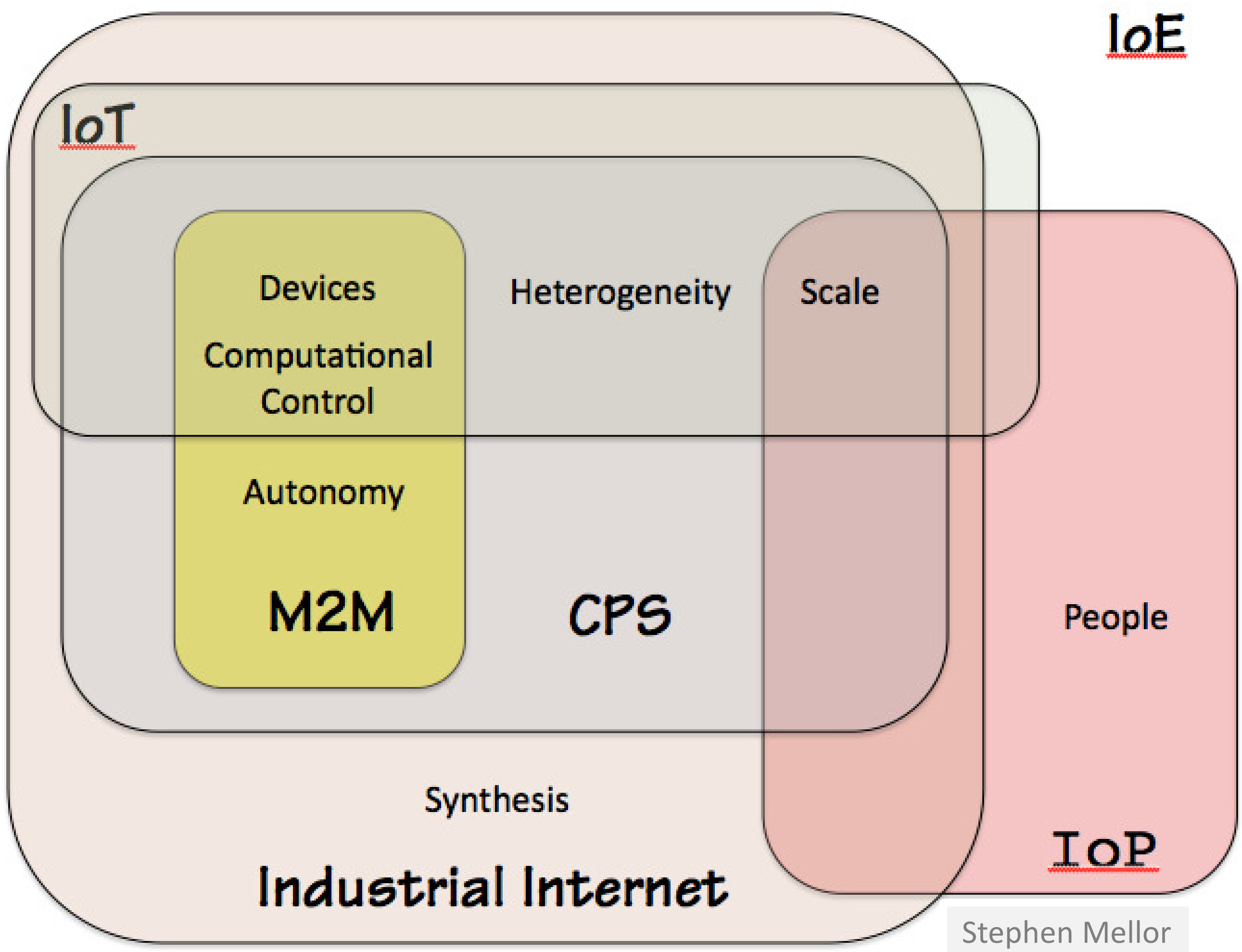
After a decade – This is the 2013 perspective of edge-core data from www.apigee.com



Anything different?

A current version …

Gradual evolution of the internet of things (IoT) which (in this version) embraces the internet of everything (IoE), internet of people (IoP), M2M and the Industrial Internet



"Attempting to define precisely what is included or excluded is a fruitless exercise – it is a matter of emphasis and focus."

The Elusive Quest

for Standards and Interoperability

Which group may catalyze the move from the austerity of standards to the prosperity from interoperability?

1. Thread

Developed by Google's Nest Labs, ARM and Samsung, it expects to build a low-power mesh network as an alternative to Wi-Fi, Bluetooth and more. It use 2.4GHz unlicensed spectrum, it is built on existing standards, such as IEEE 802.15.4, IETF IPv6 and 6LoWPAN. Therefore, existing devices which use ZigBee / 6LoWPAN can easily migrate. It already connects more than 250 products on the market and has partnered with Mercedes-Benz, Whirlpool and light bulb maker LIFX. Big Ass Fans, Silicon Labs, Freescale and Yale Security are other founding members.

2. Open Interconnect Consortium

Defining the wireless connectivity to enable billions of devices to connect with each other. Set up (7/14/2014) by Intel, Dell and Samsung it also include Atmel, Broadcom, Wind River and others. It is currently focusing on smart home and office technologies but plans to target vertical sectors like automotive and health care. It expects to certify devices compliant with its standards.

3. AllSeen Alliance

Led by the Linux Foundation and Qualcomm plus big names like LG, Sharp, Panasonic, Cisco and Microsoft. There are 51 organisations in this alliance (as of July 2014) pushing for IoT standards.

4. HyperCat

A group of 40 UK-based companies, including IBM, ARM and BT, have developed an IoT standard called Hypercat, an interoperability layer that allows devices, such as lamp posts and smart meters, to interact with each other. Like an address book, it lets applications ask data hubs what types of data it holds and what permission it needs to ask them, making sense of it without human aid. It can browse machines, search by metadata and uses standards such as HTTPS. It was developed by 40 UK-based tech firms, including IBM, Intel and ARM, startups and universities that joined 12 months ago with £6.4m grant from the Technology Strategy Board (TSB) of the UK government.

5. HomeKit

Apple announced a software platform it claims will allow devices, such as locks, lights and thermostats, to be controlled from one app. Partners include Philips, which makes the Hue connected light bulb, iHome, Osram Sylvania and Texas Instruments.

6. Industrial Internet Consortium

Intel, IBM, AT&T, GE and Cisco formed the IIC (03/27/2014) which is managed by OMG and focused on "industrial internet" apps in markets including manufacturing, oil and gas exploration, healthcare and transportation.

Modified from Paul Duffy

Ubiquitous computing scenarios …

Fundamental Theme and Salient Feature of the IoT vision is based on CONNECTIVITY

Cartoon copied from a PhD thesis submitted at a Danish university. Wireless sensor networks illustrated as key infrastructure .

CONNECTIVITY powered by MESH NETWORKING

CONNECT

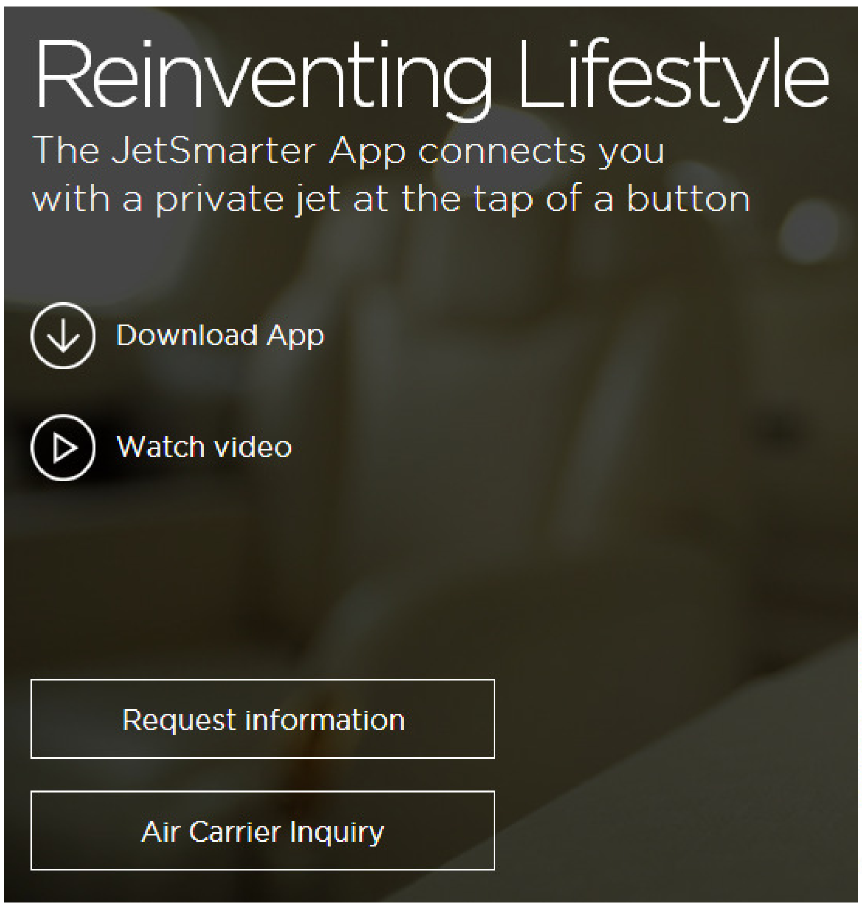
UBER CONNECTIVITY - *transforming the taxi trade*

Push to Talk
Say current location and where you're going. Your voice message will be delivered instantly to all nearby available taxis

Bid to Win
Increase your chance of hailing a cab during peak hours by offering extras tips up front (in addition to regular fare)

Real Time Tracking
View your taxi's location in real-time, push to talk to the driver directly to coordinate pick-up

Think Smarter
Get JetSmarter



THE APP-LIST

THE UBER OF PRIVATE JETS IS HERE

Summon a private jet to pick you up with the touch of a button.

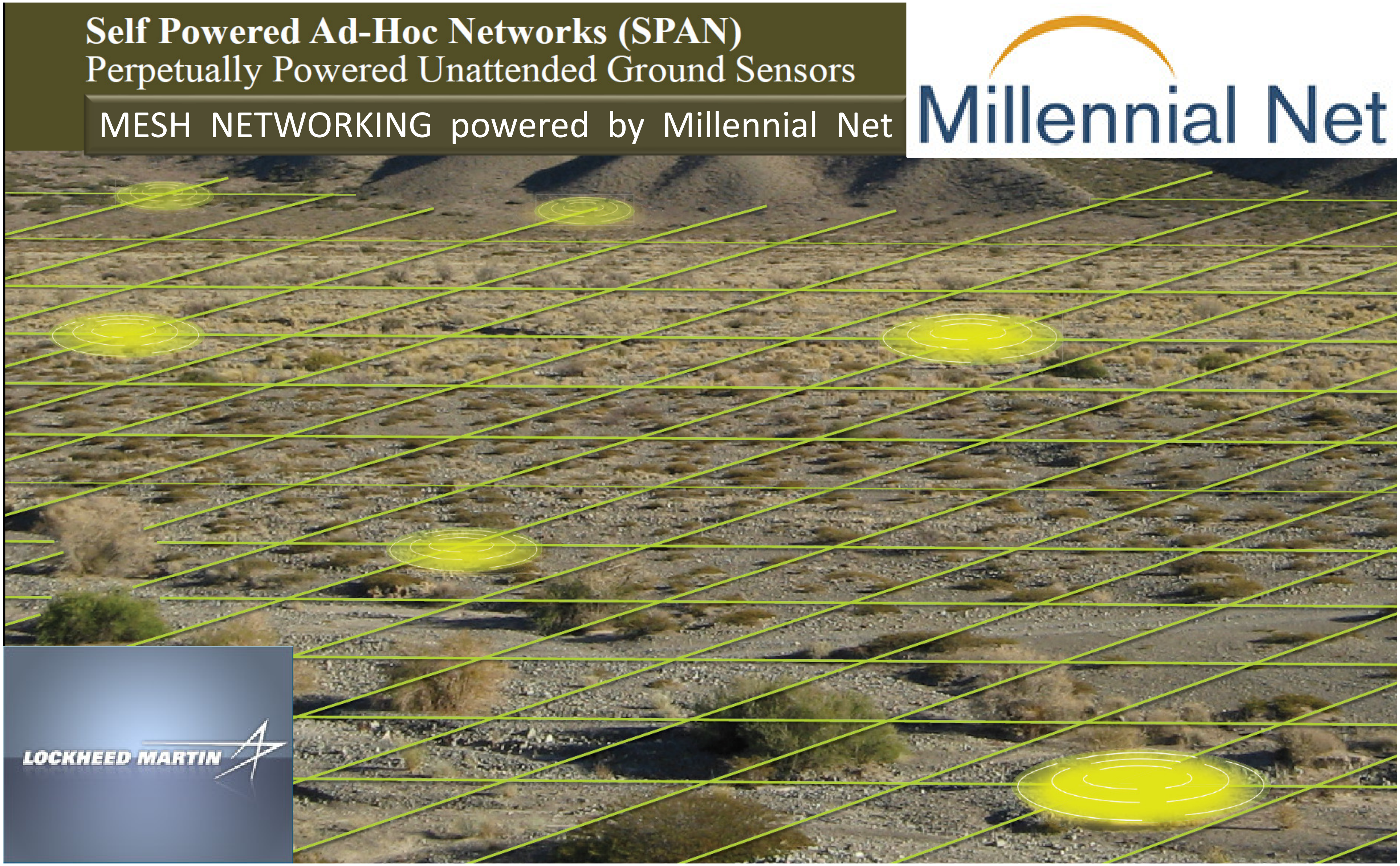
By Lauren Fisher on Aug 1, 2014

Share:

Your ticket to escaping August's insane summer weekend traffic is here. Modeled as the Uber for private jets, Jetsmarter allows app users to charter a plane from anywhere in the world at a moment's notice. The app offers instant pricing, and boasts rates that are 17% cheaper than the Marquis Jet Card, and the option to choose from five different air carrier sizes from 'Very Light Jet' to 'Heavy Jet'. Flights are available to anywhere, from New York to Tokyo, and can be booked by the hour. The ultimate in luxury travel, Jetsmarter takes Uber's genius vision to the next level. For a cool $3K, you can really can be in the Hamptons by cocktail hour.

Jetsmarter app is free and available for download here.

Rhee, Sokwoo, et al., “Coordinating protocol for a multi-processing system,” US Patent 6.804.790 issued on October 2004
Rhee, Sokwoo, et al., "Photoplethysmograph signal-to-noise line enhancement" US Patent 6,699,199 issued on March 2004
Rhee, Sokwoo, et al., “Isolating ring sensor design,” US Patent 6,402,690, issued on June 2002
Rhee, Sokwoo, "Network Protocol" US Patent Pending, Application No. 20030099221, filed on November 2002
Rhee, Sokwoo, et al., "Protocol for Configuring a Wireless Network" US Patent Pending, Application No. 20050037789, filed on May 2004
Rhee, Sokwoo, et al., “Communicating over a Wireless network” US Patent Pending, Application No. 20060285579, filed on May 2006



Inter-domain integration scenarios

CONNECTIVITY

INTEROPERABILITY

INTEGRATION

INTELLIGENCE

SENSE-RESPONSE

ACTUATORS

SMALL DATA / BIG DATA

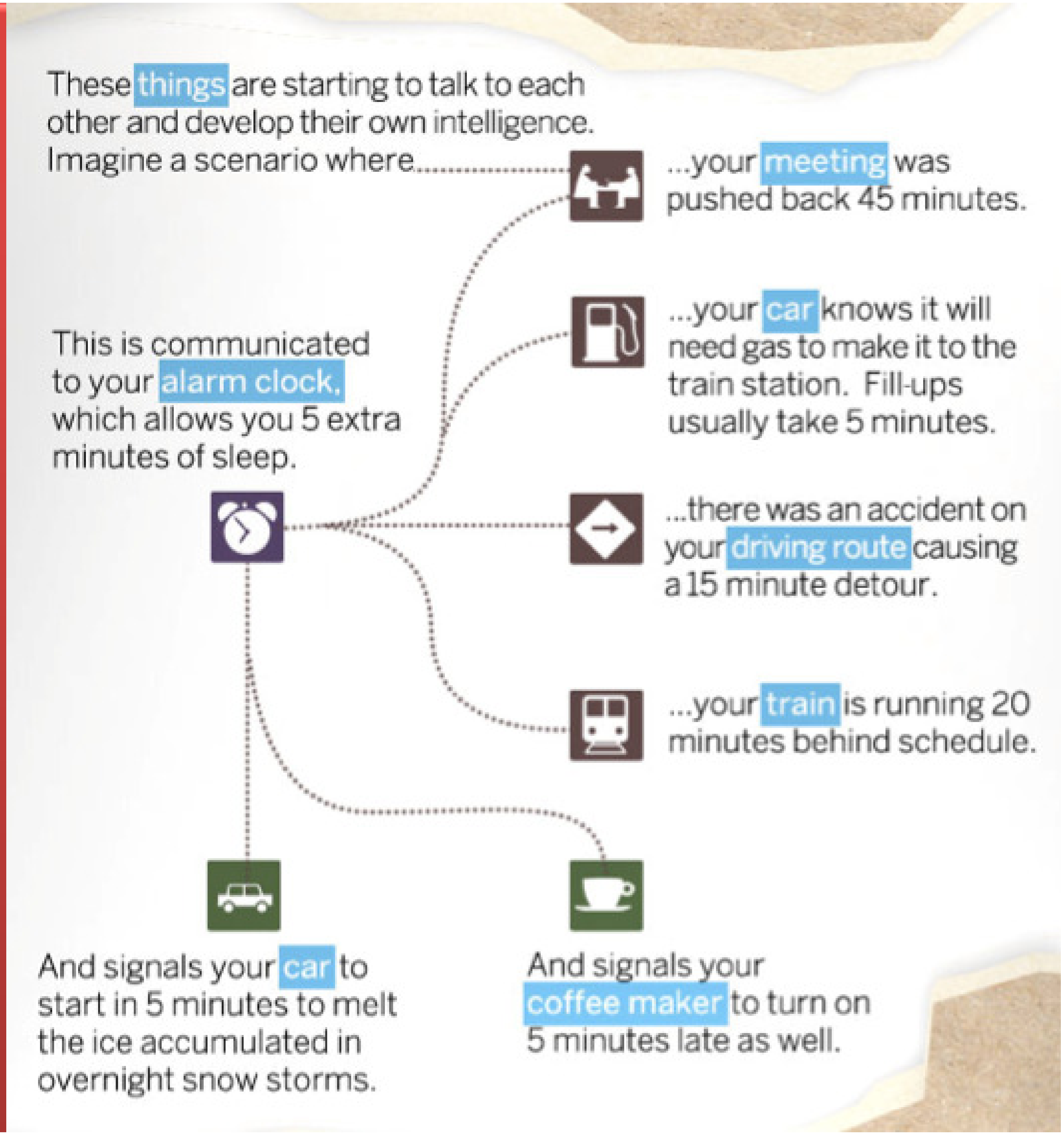
ANALYTICS

AUTONOMOUS

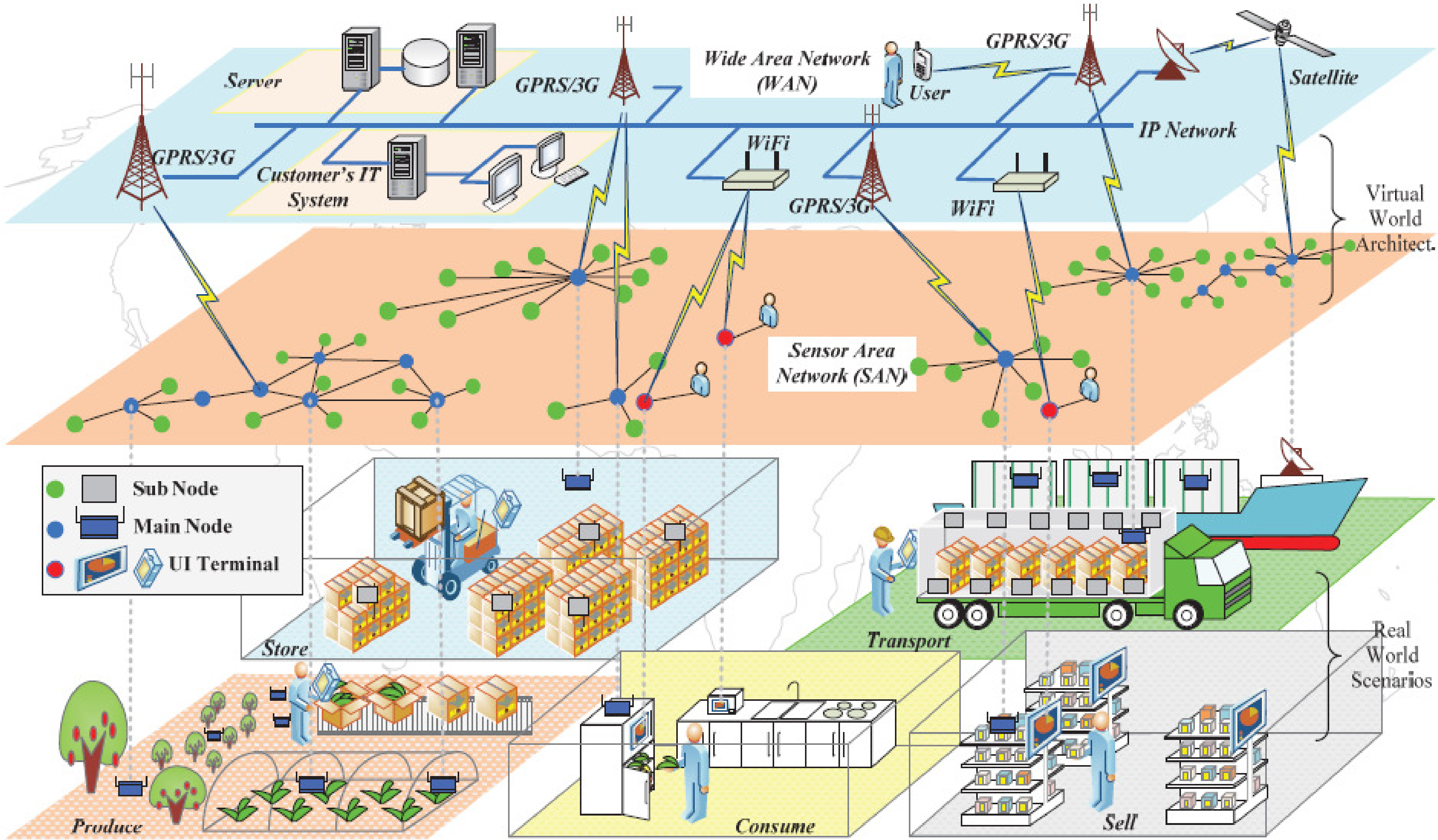
ECOSYSTEMS

STANDARDS

ECONOMIC IMPACT



Connectivity generates data from/about distributed devices, locations, sensors, status

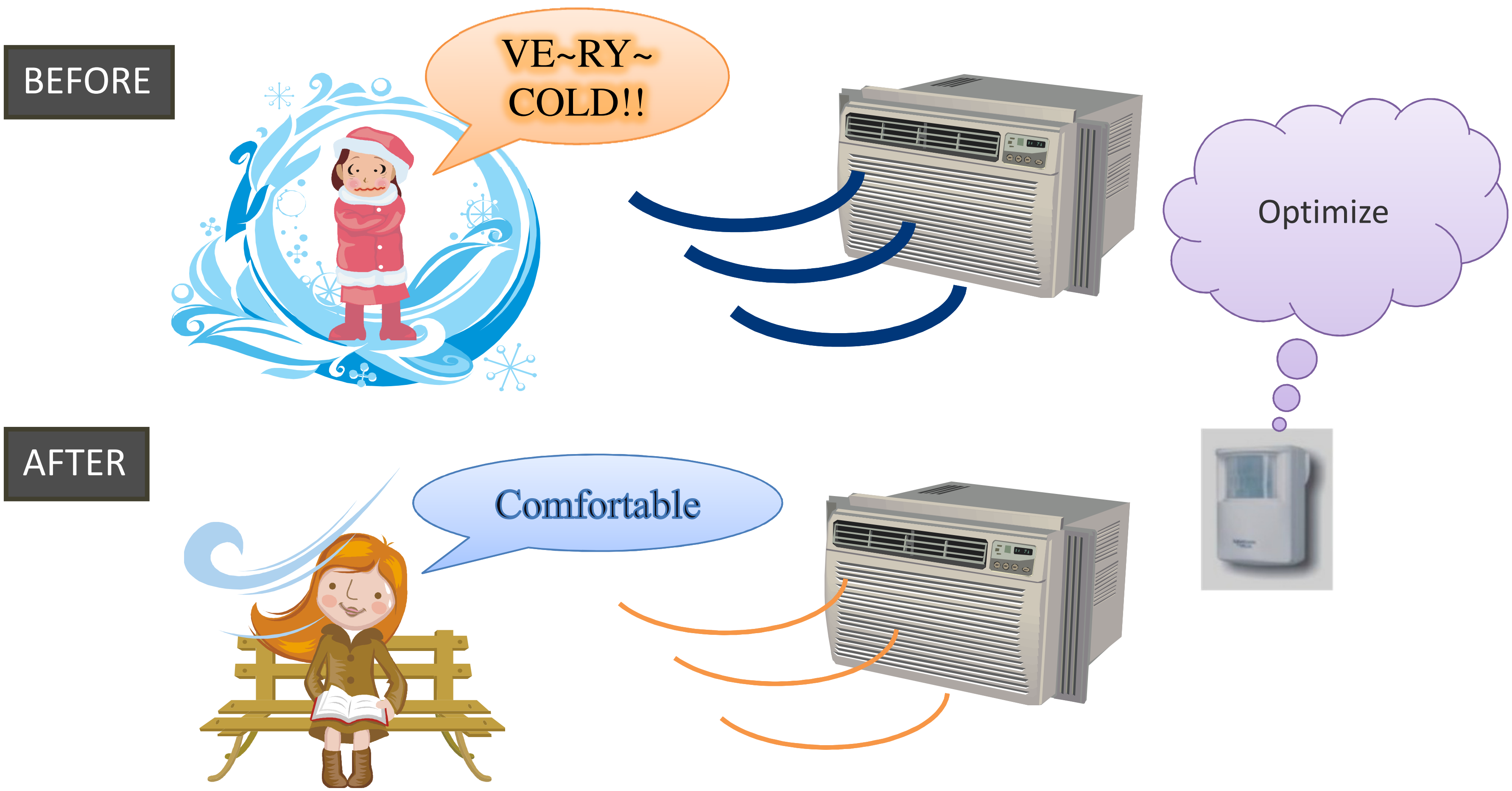


Asking correct questions in the context of the problem is key to unlocking value from data analytics. It may suggest solutions or trigger autonomous responses to adapt, optimize, transact or execute within a system or between multiple system of systems.

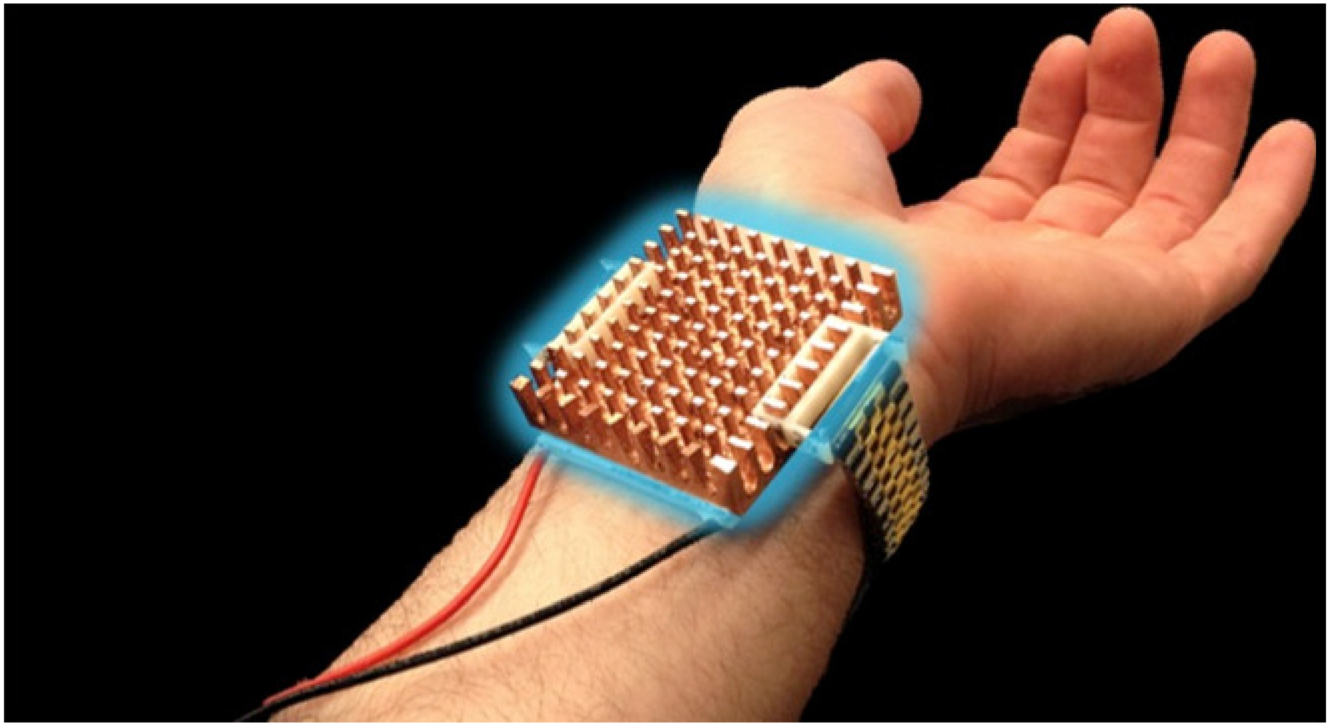
Industrial Internet – Energy Domain

Energy efficiency

Energy Efficiency - *answers, not numbers* - Customer Satisfaction

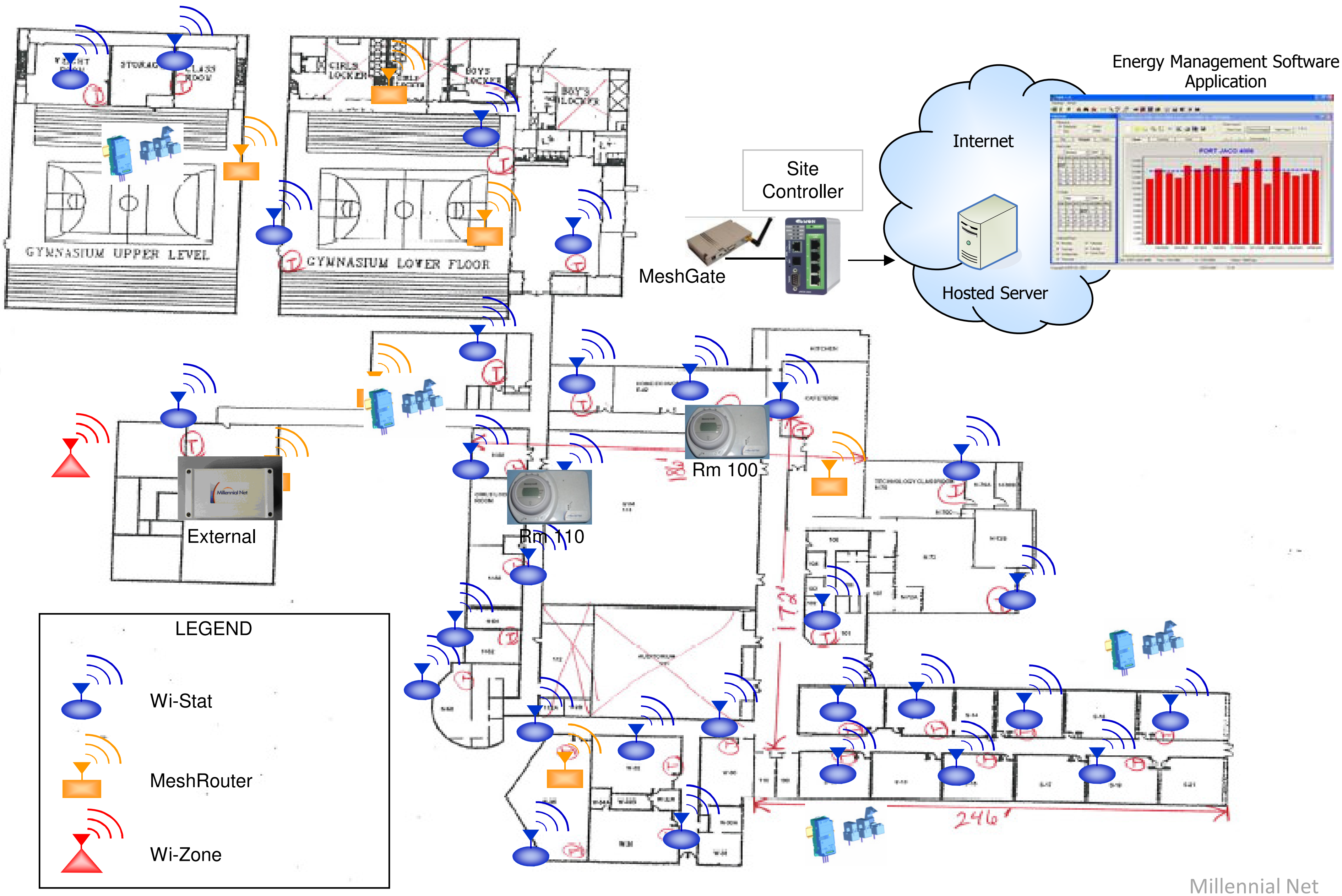


Why cool the house, just cool yourself with WRISTIFY

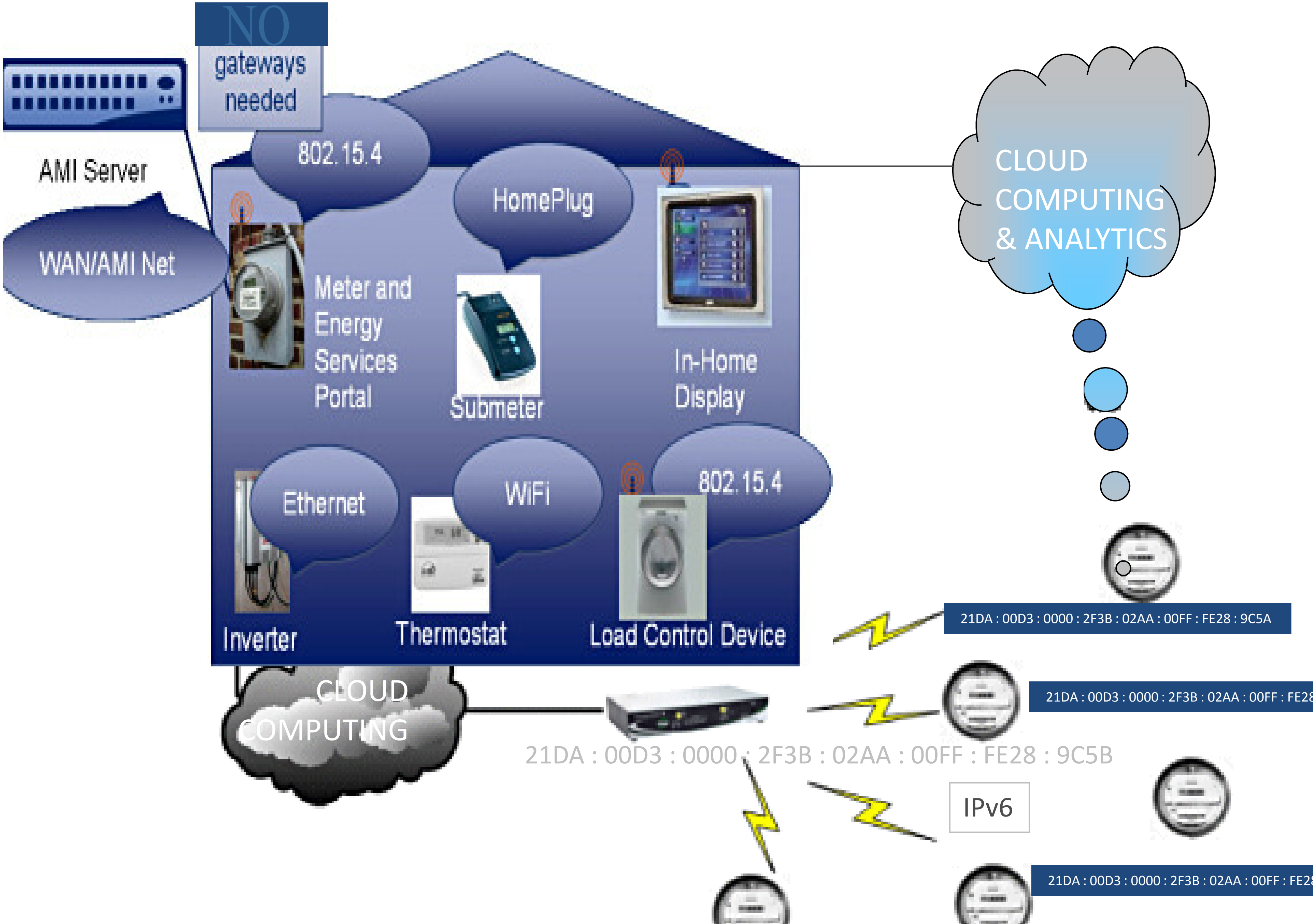


WRISTIFY by Sam Shanes, MIT undergraduate

Energy Management System using Wireless Sensor Network

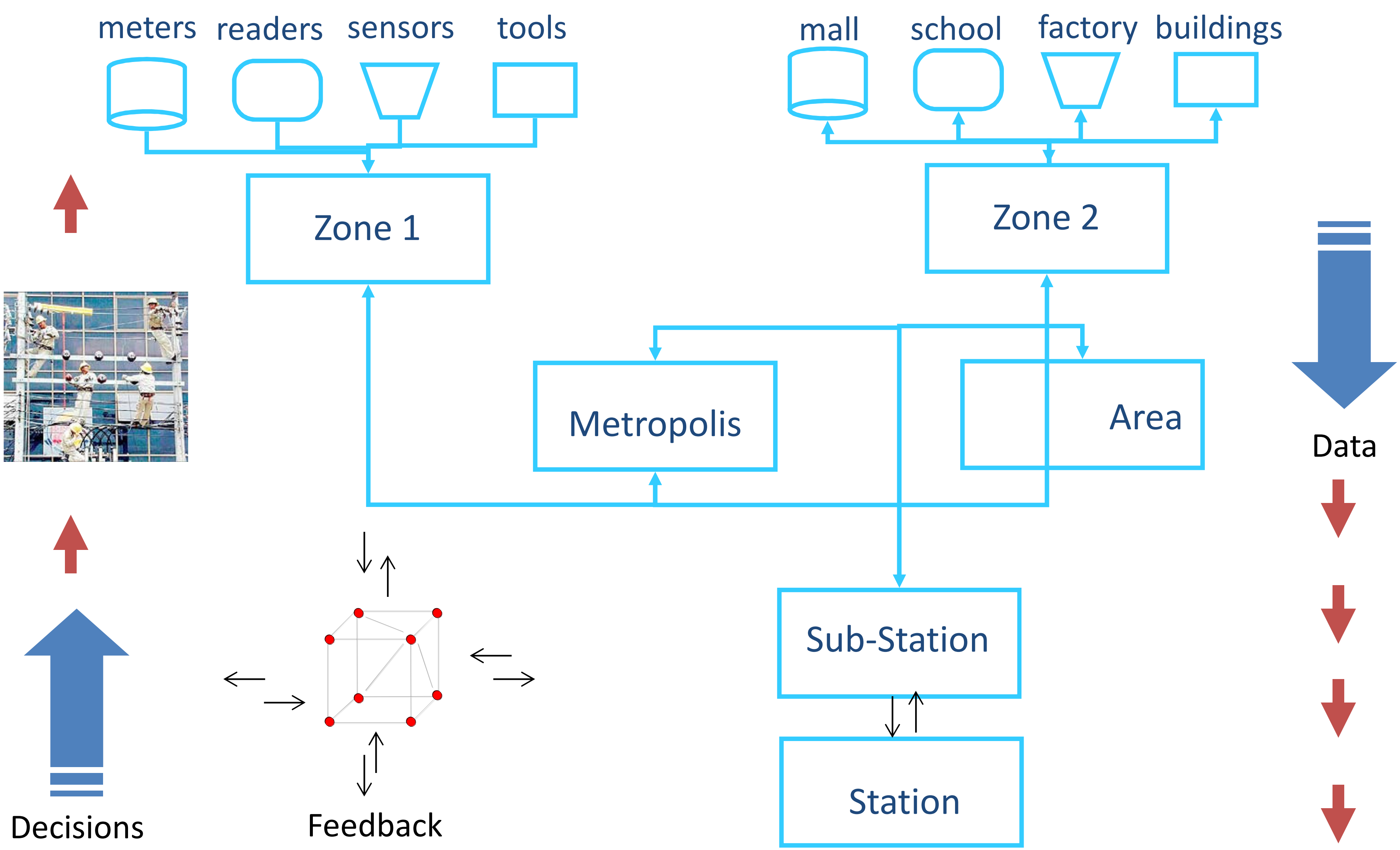


Millennial Net



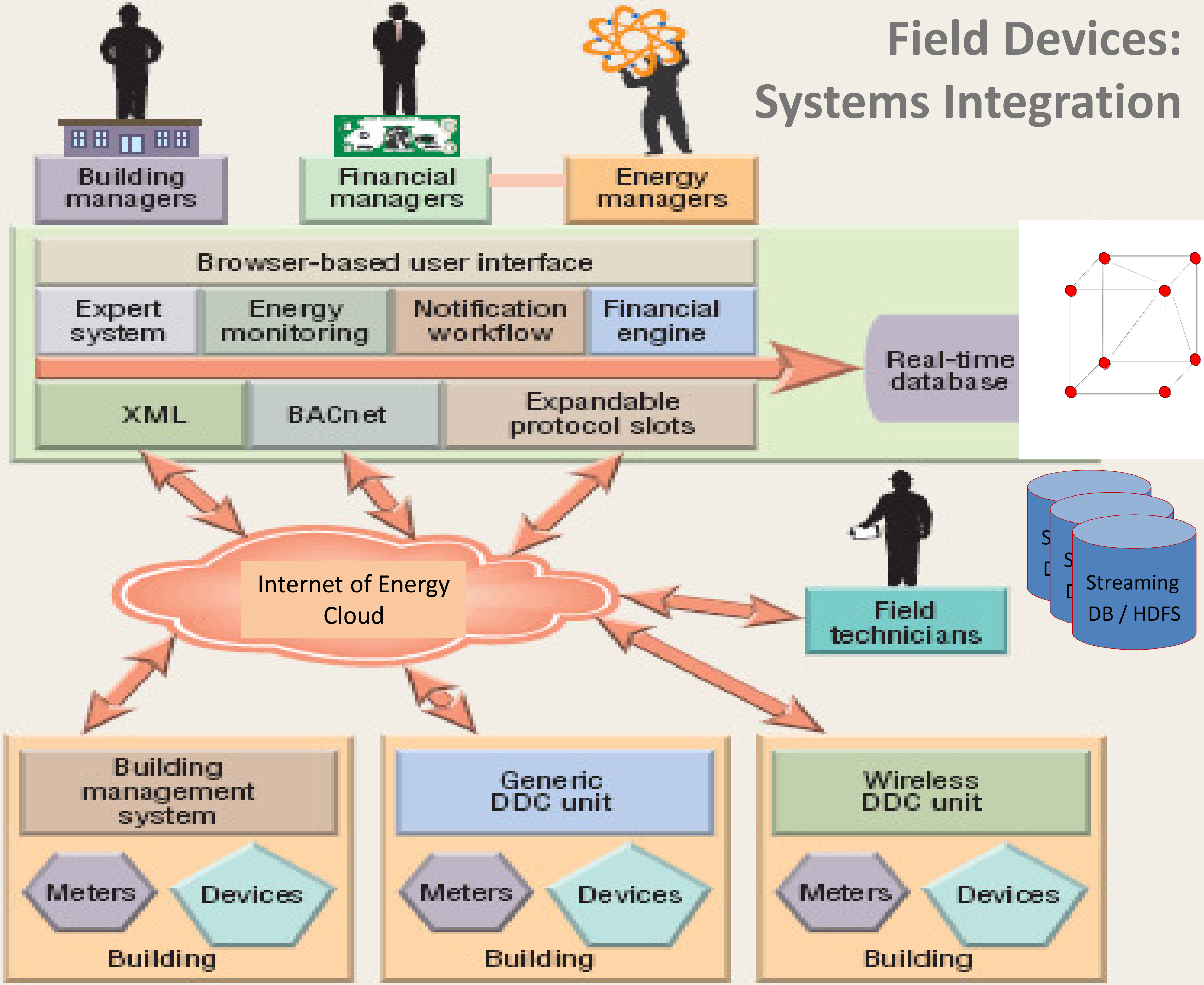
MITOCHONDRIA

Wireless Sensor Mesh Networks Integrated with Monitors, Devices and Places



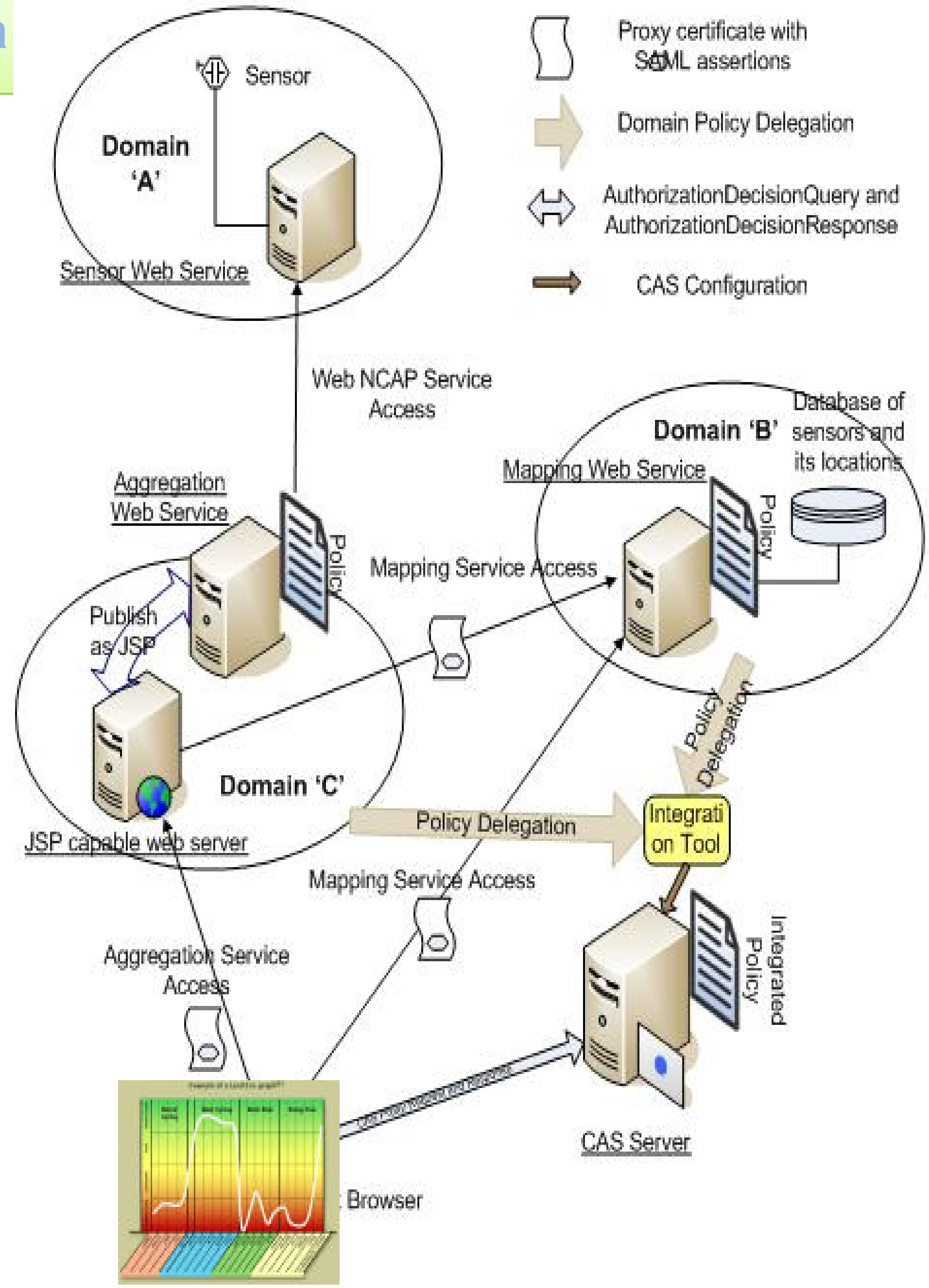
ENERGY EFFICIENCY

Field Devices: Systems Integration



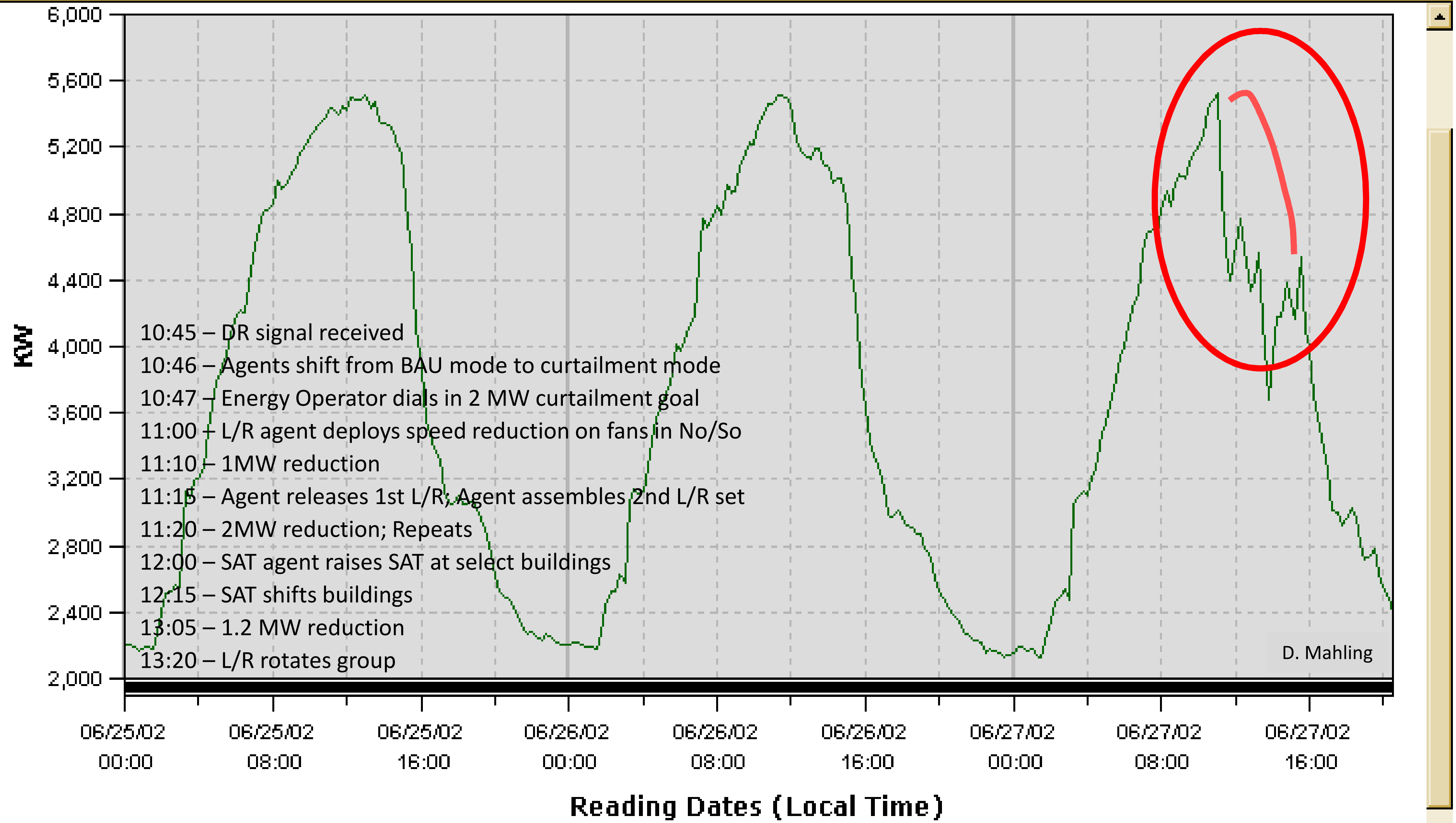
Intelligent reports using data

- Analysis of system efficiency
- Early warning of system exception
- Analysis for power consumption
- Analysis of environmental sensor
- Reports for warning and data



ENERGY EFFICIENCY - granular data enables demand response, load balancing & usage regulation

Energy Load Balancing – Automated Demand Response



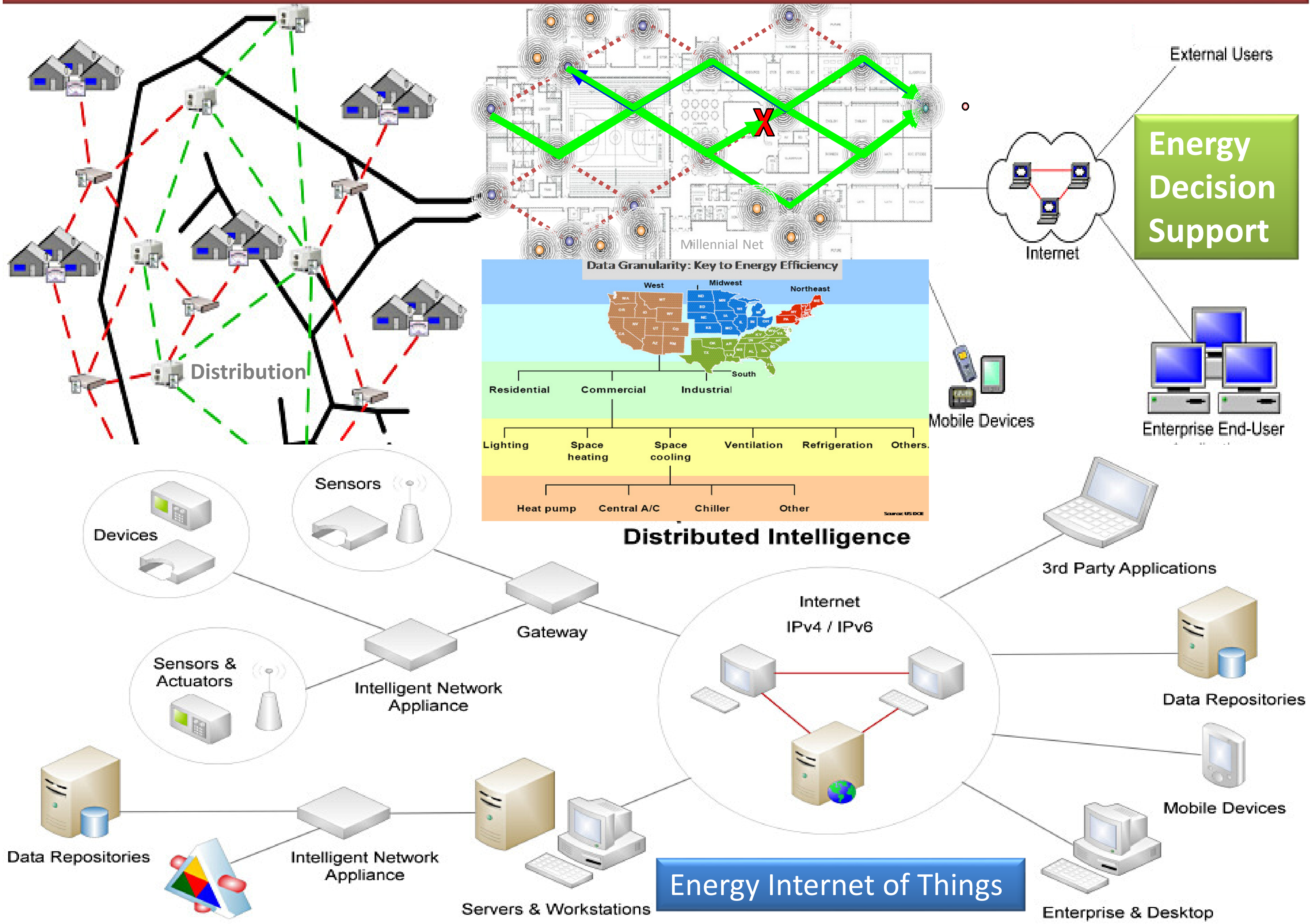
Graph Legend

Bank of America : Northern CA

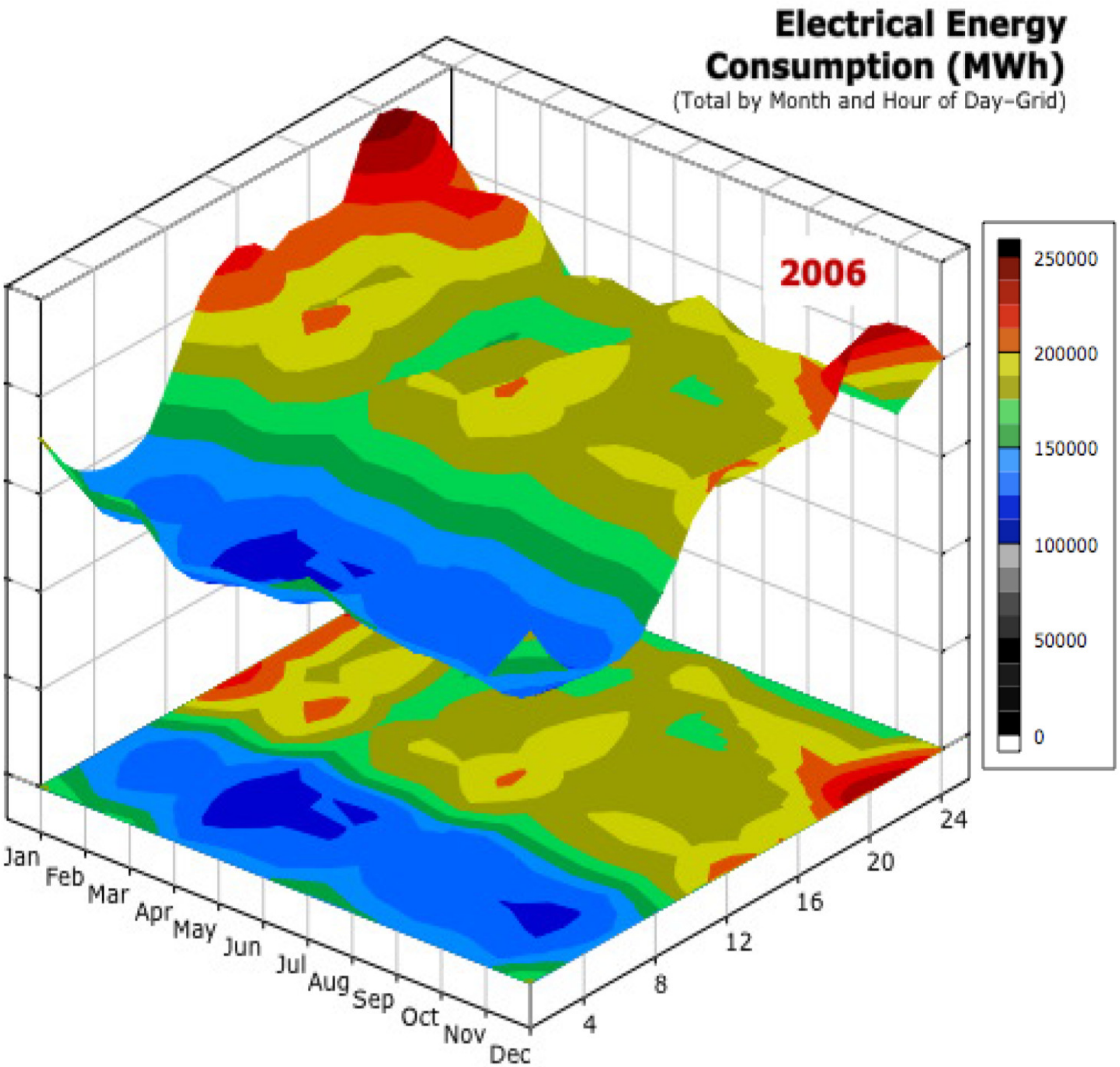
Northern CA -> Demand 15 Minute (KW)

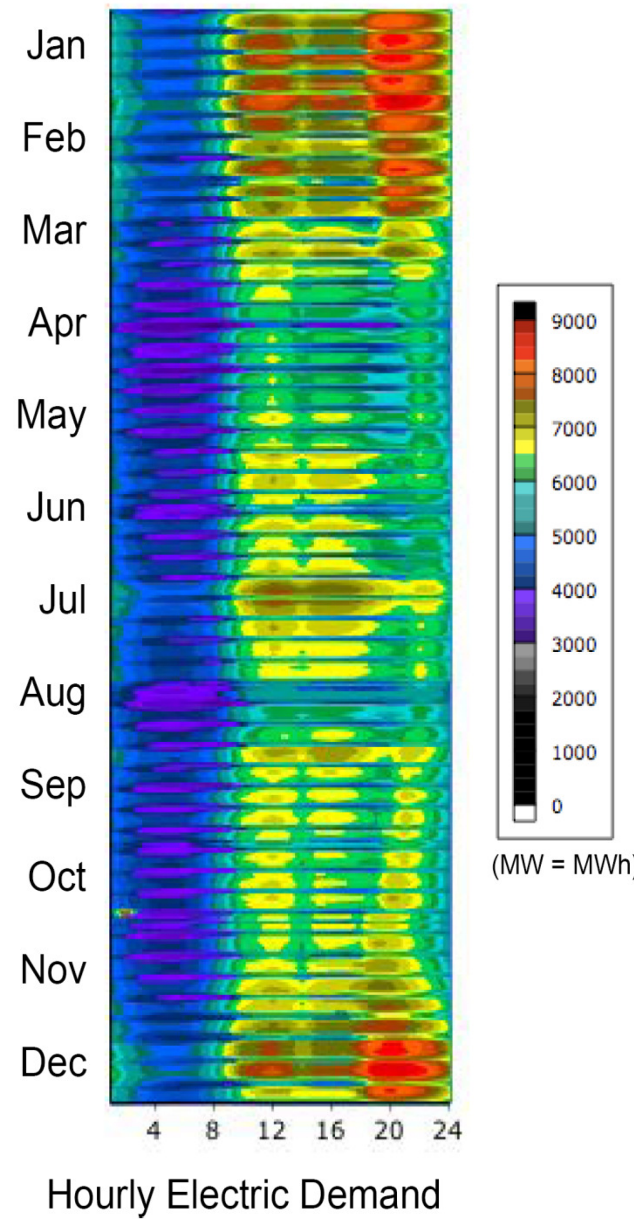
- Signal to building system - curtail 2 MW for ~4 hrs across 78 sites
- Base load for 78 retail branches approximately 10 megawatts (MW)
- Signal received at 10:45am [15 min ahead of start time 11am]
- Curtailment commenced at 11am and completed at 4pm

Energy Efficiency – Consumption, Distribution, Production – Data Visibility



Energy Efficiency – Consumption, Distribution, Production – Country Data

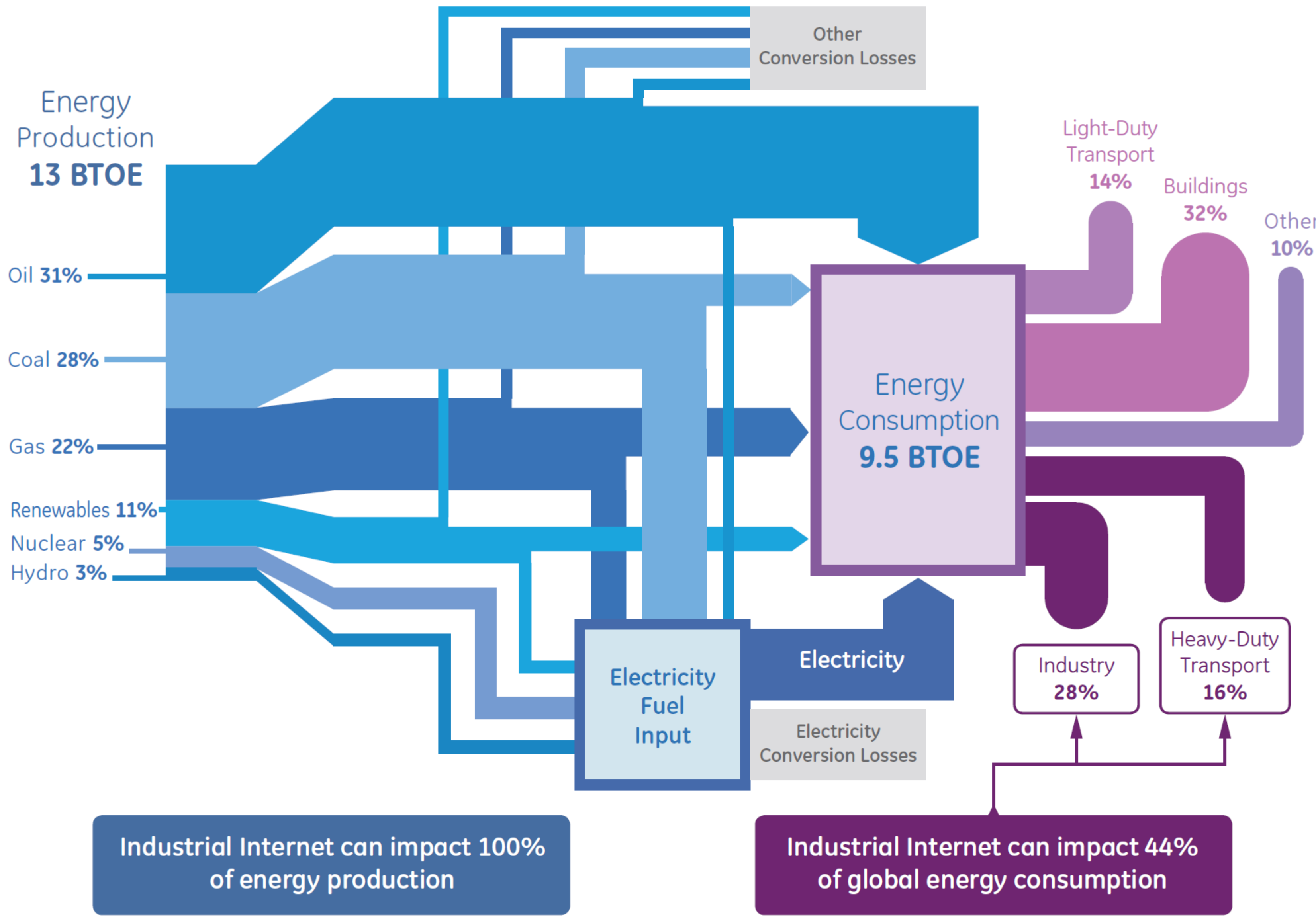




Source: MIT Portugal

ENERGY EFFICIENCY and THE INDUSTRIAL INTERNET

Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

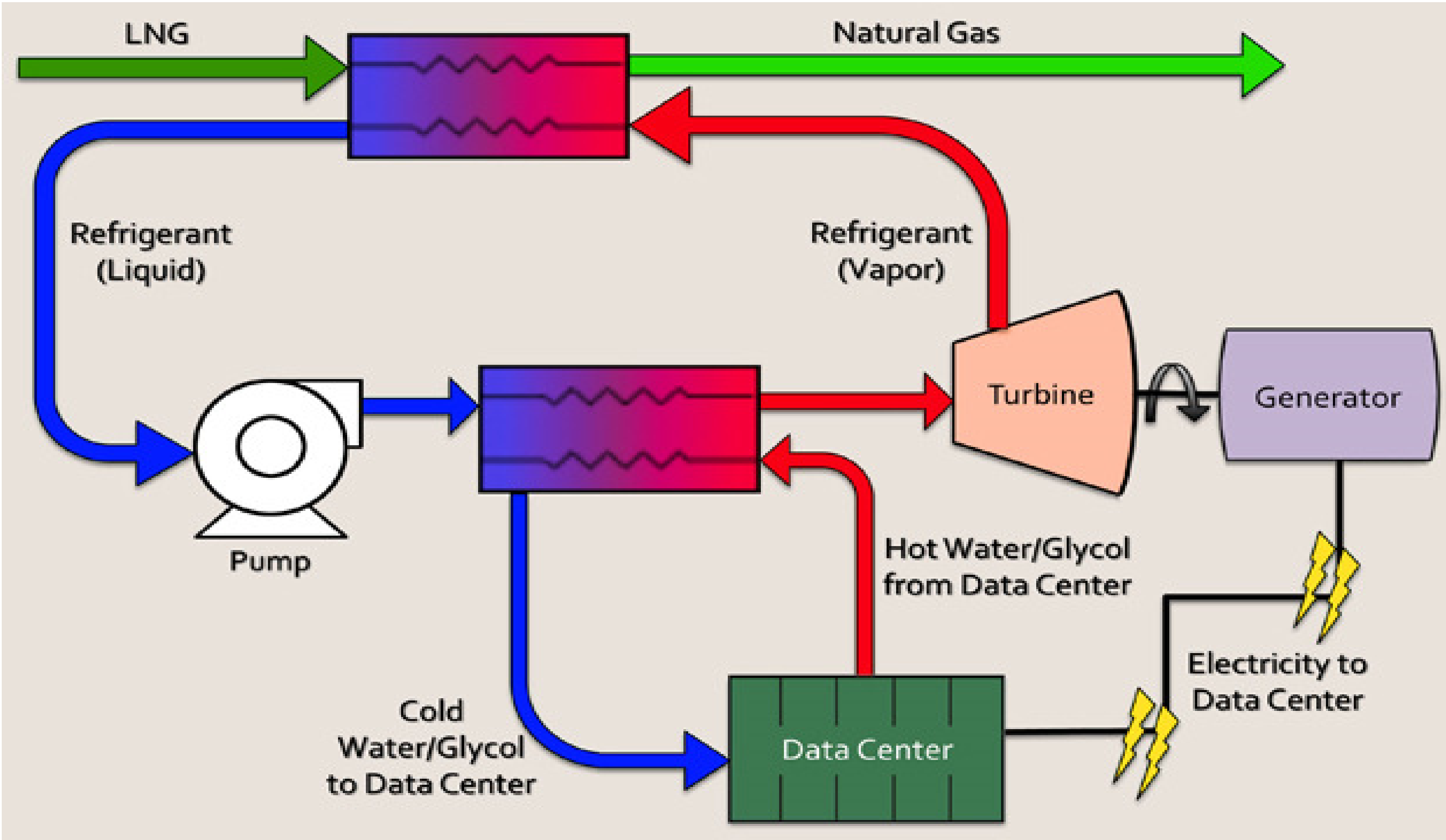


Connectivity between energy production and energy consumption can reduce waste

ENERGY RECLAMATION – Is this really an efficient model ?

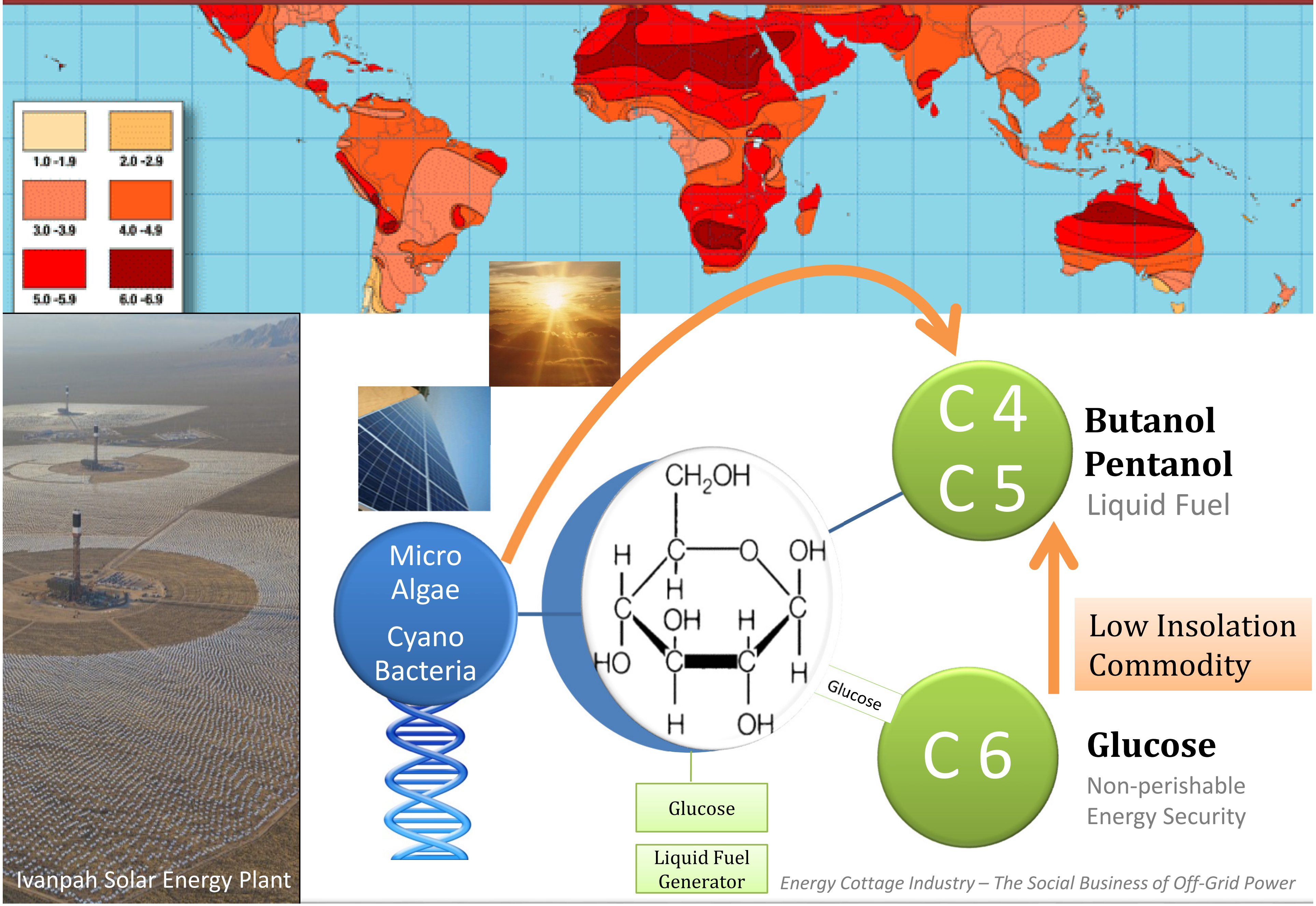
Exhaust air re-used to reclaim part of the energy and reduce energy wastage

ENERGY RECLAMATION – This is really an efficient model

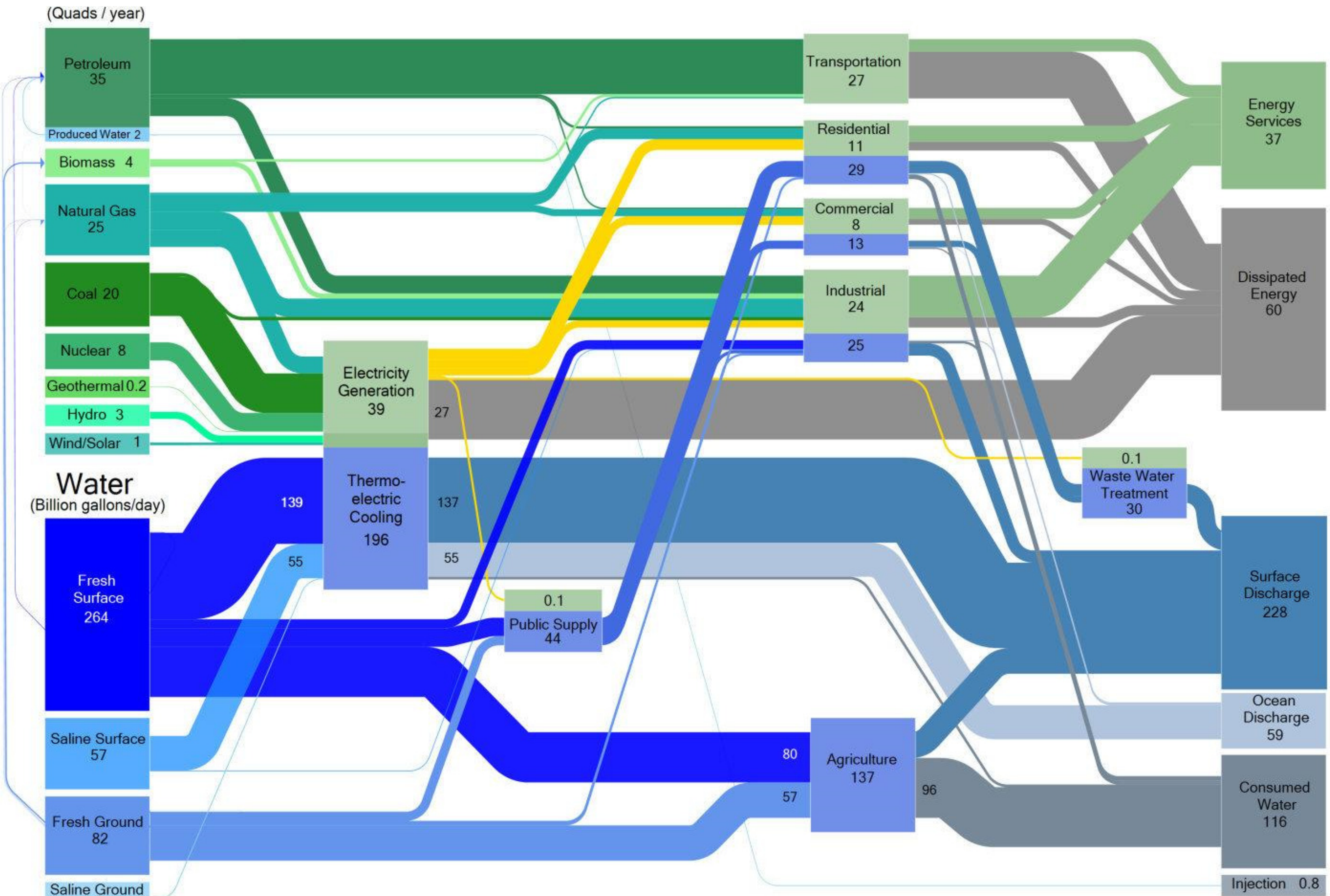


Cool data centers use "cold" produced when converting stored liquid gas into pipeline-ready gas. Build Data Centers adjacent to LNG terminals at ports – not in the Arctic Circle (TeraCool).

ENERGY as a SERVICE – Sunshine as a Service (SaaS)

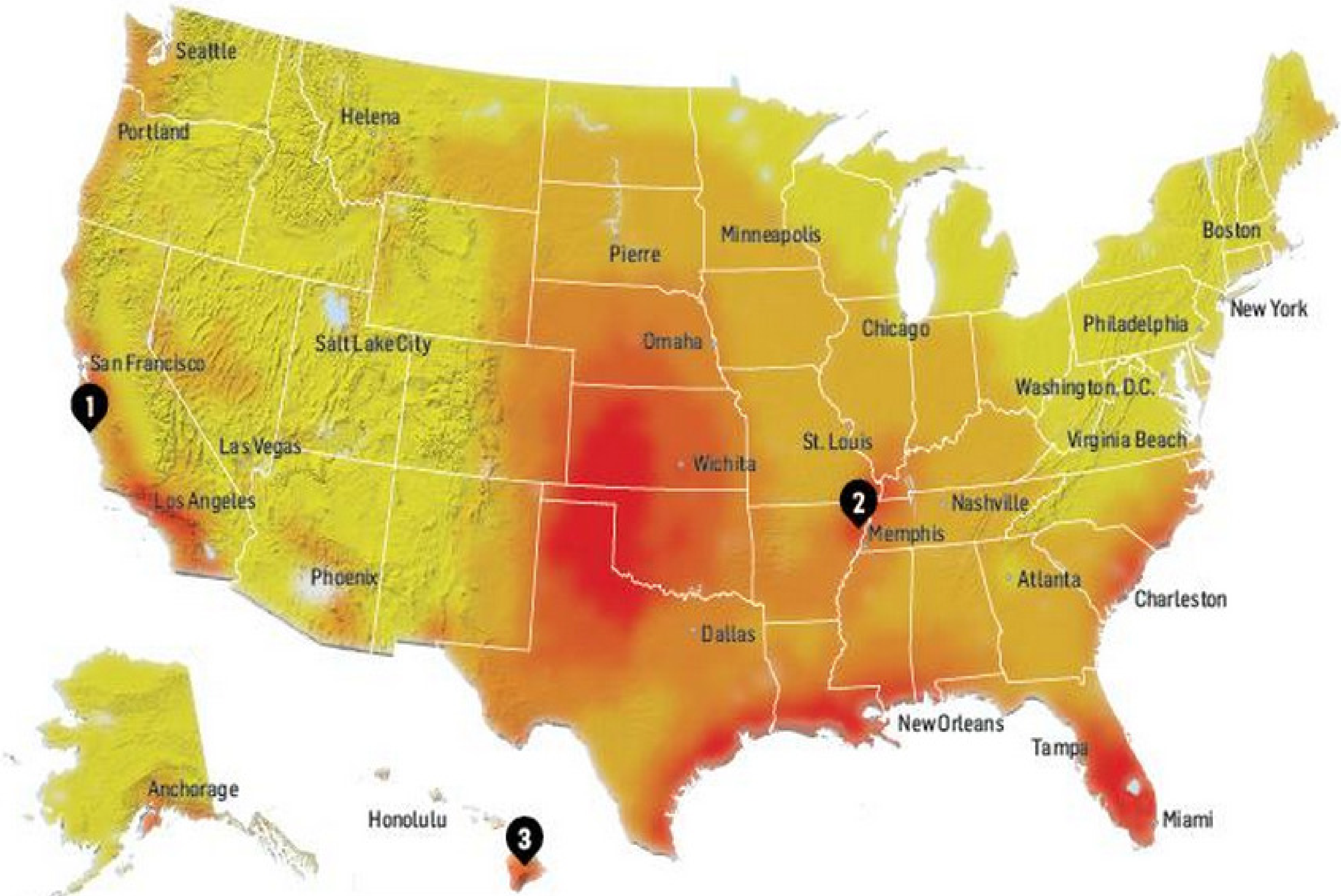


ENERGY and WATER – How smart cities must converge the management



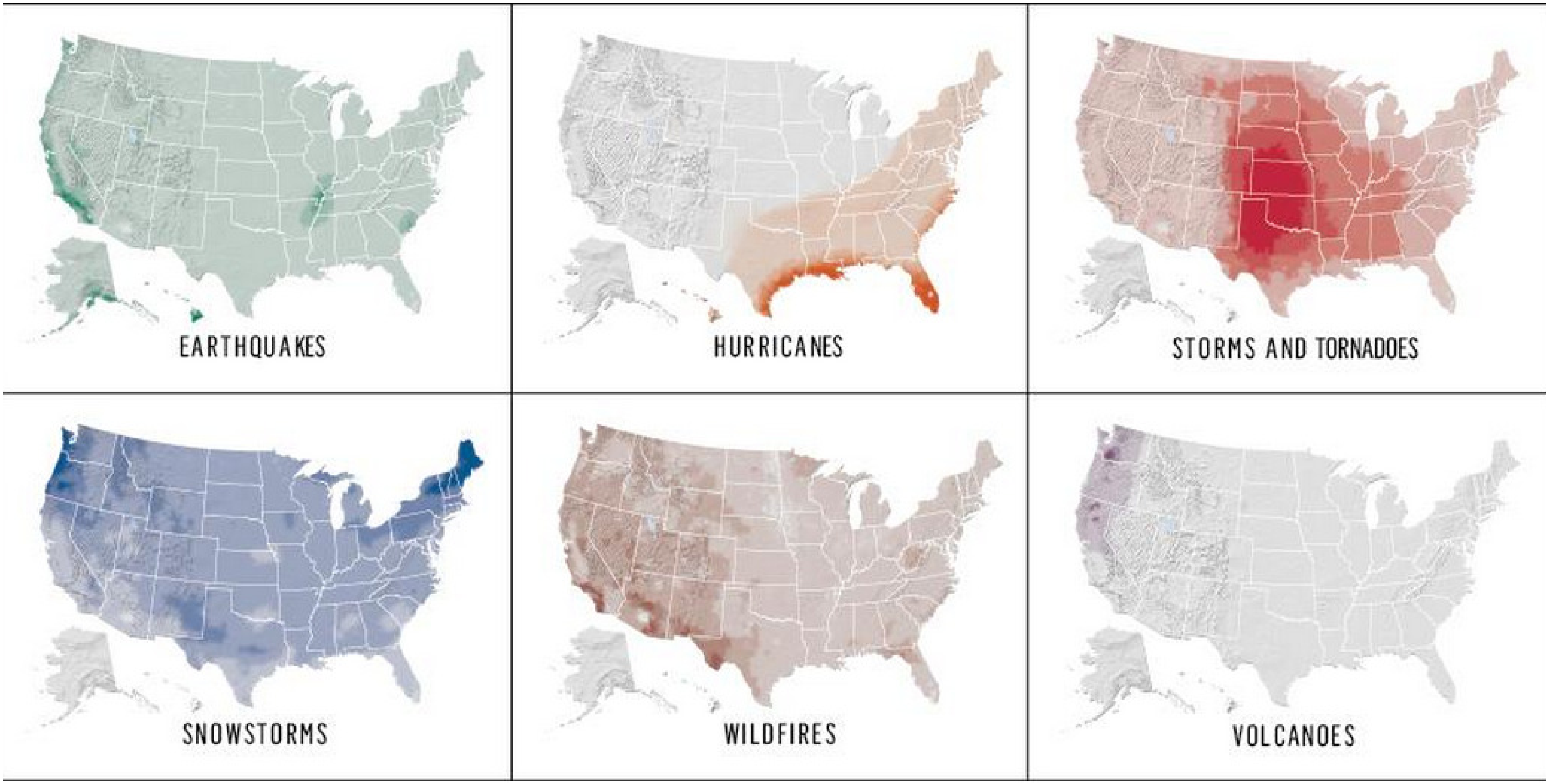
Energy reported in Quads/year. Water reported in Billion Gallons/Day.

How smart cities must become smarter for natural disaster management



Level of risk based on property locations and the likelihood of damage caused by natural disasters (color intensifies with the amount of danger) ▪ Risk Management Solutions

First Response System – Natural Disasters and "Crash to Care" Scenario Planning



Integrate paramedic response with UAV, transportation, remote monitoring, hospital beds, HR and security

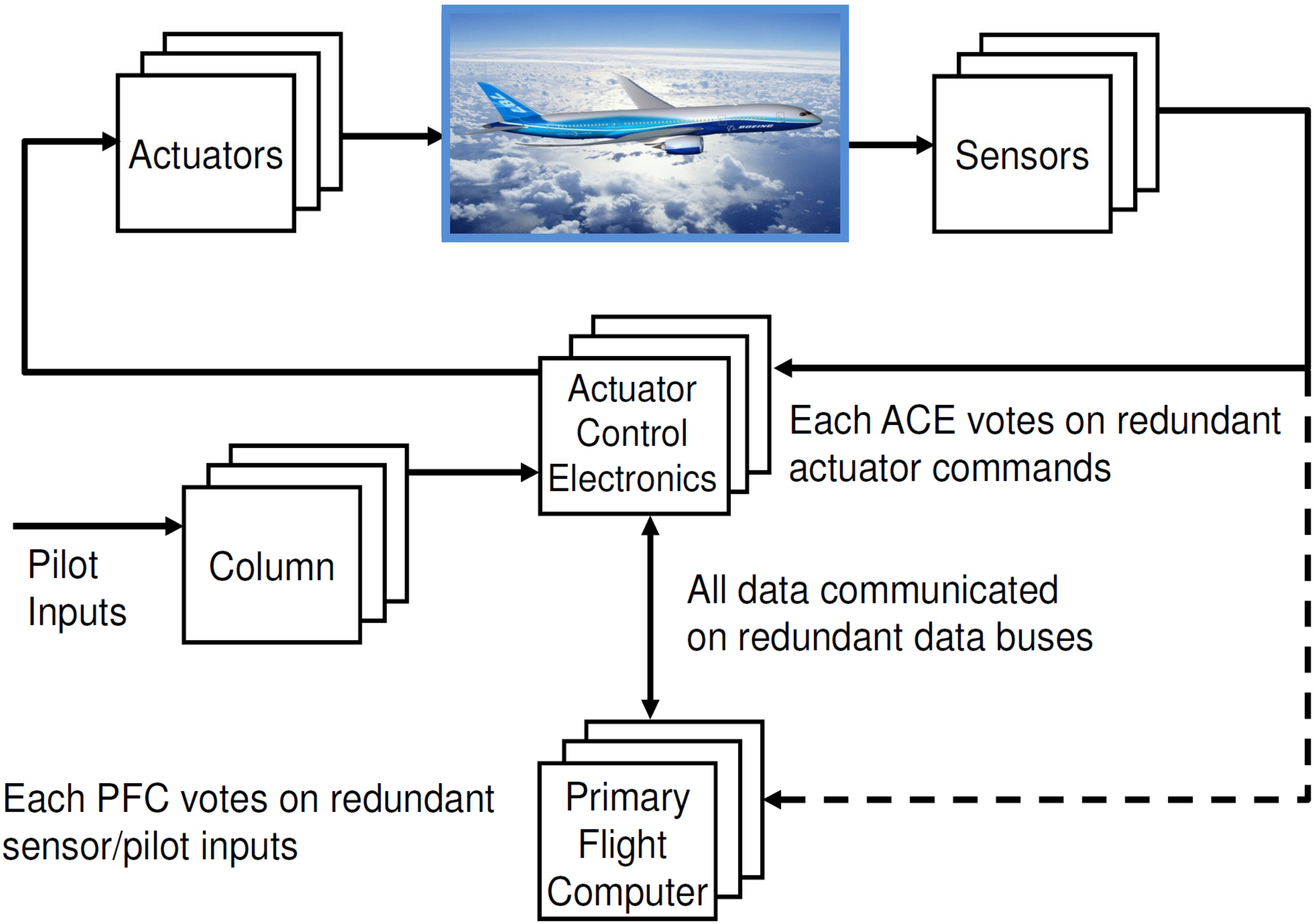
Robotic Manufacturing with Operations Management (Supply Chain, Inventory, Replenishment)

Integrate robotic decision support systems with SCM, transportation, fuel economy, transaction cost analysis

Domain Specific Scenario

Aircraft Maintenance

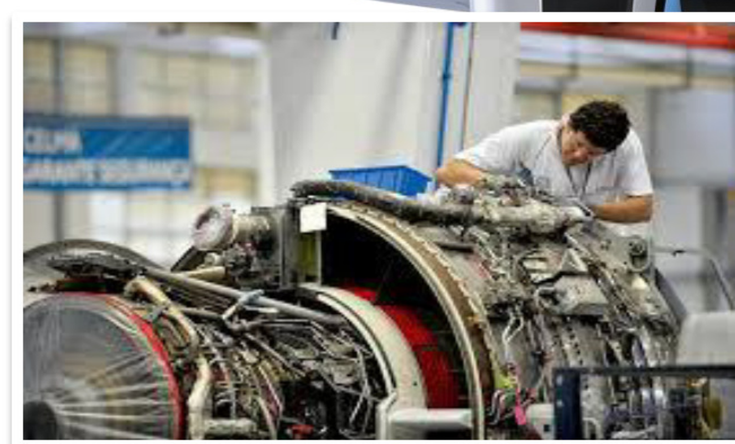
Classical Triple Control System – Redundancy increases complexity, system size and power consumption



Add “on the ground” issues to the issues “in the air” and we are looking down a financial drainage system

19,975 commercial aircraft globally

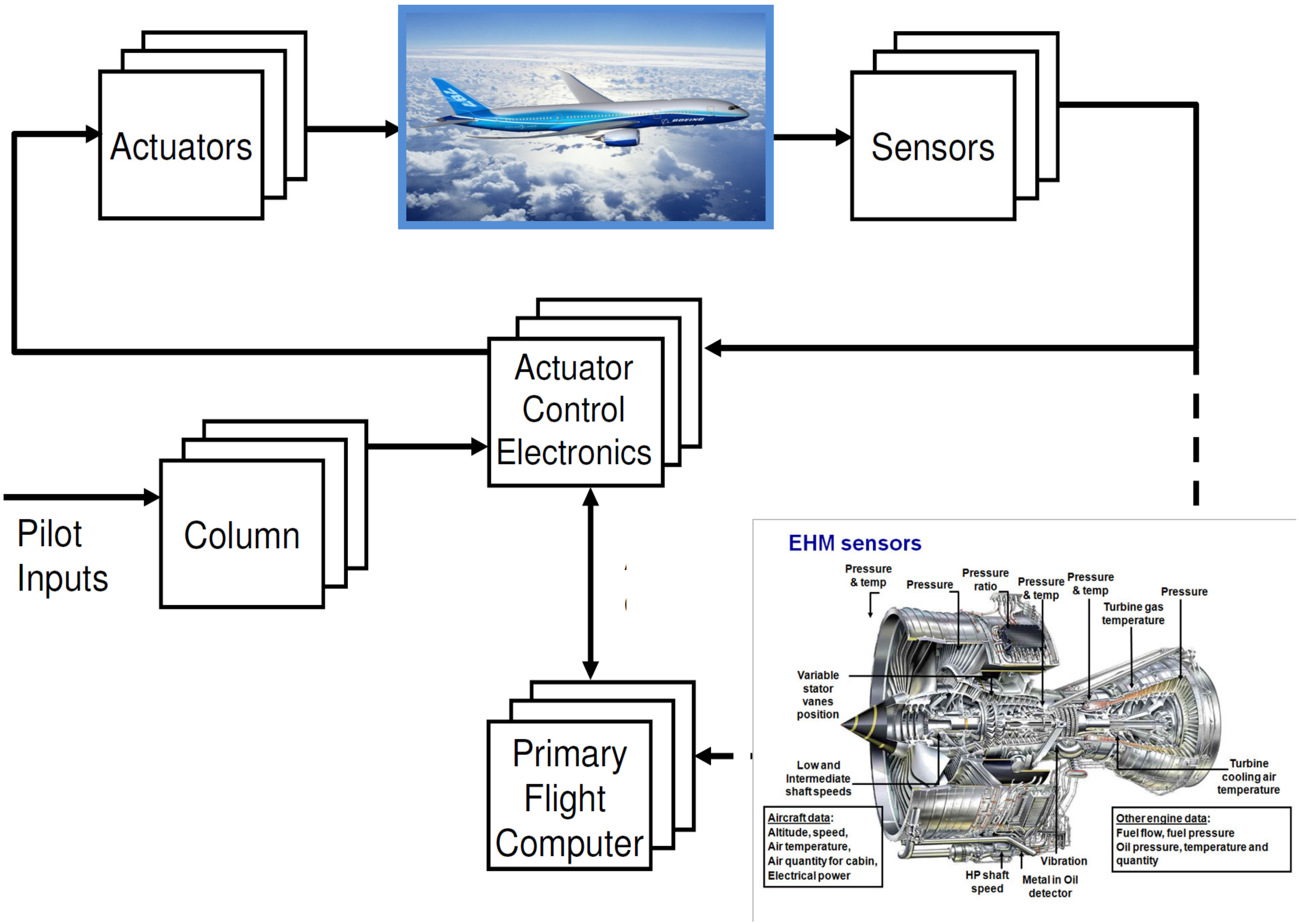
205 million man-hours to service annually*



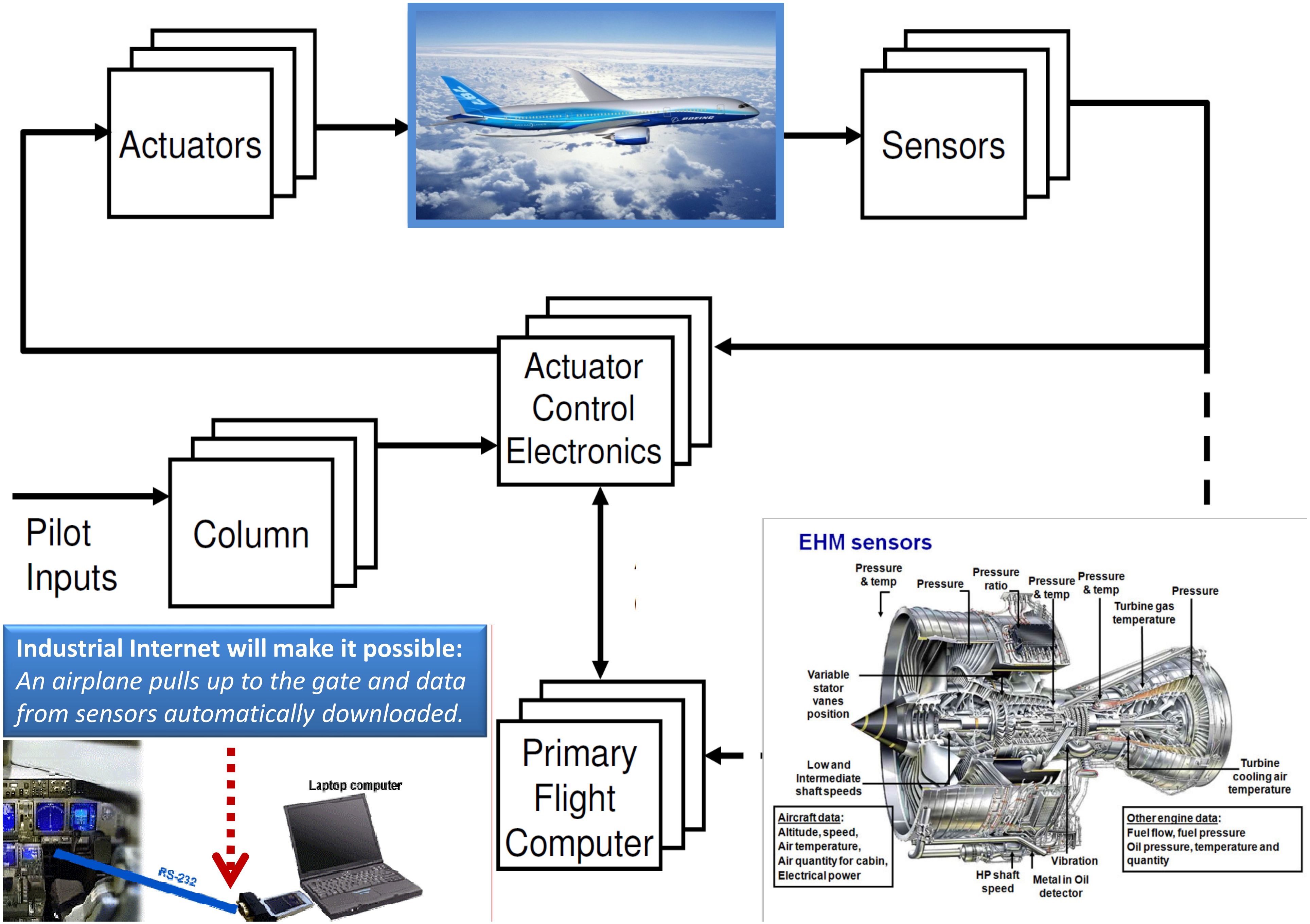
Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

Aviation may harbor vast inefficiencies which presents enormous opportunities for economic growth

Classical Triple Control System – Redundancy increases complexity, system size and power consumption



Classical Triple Control System – Redundancy increases complexity, system size and power consumption

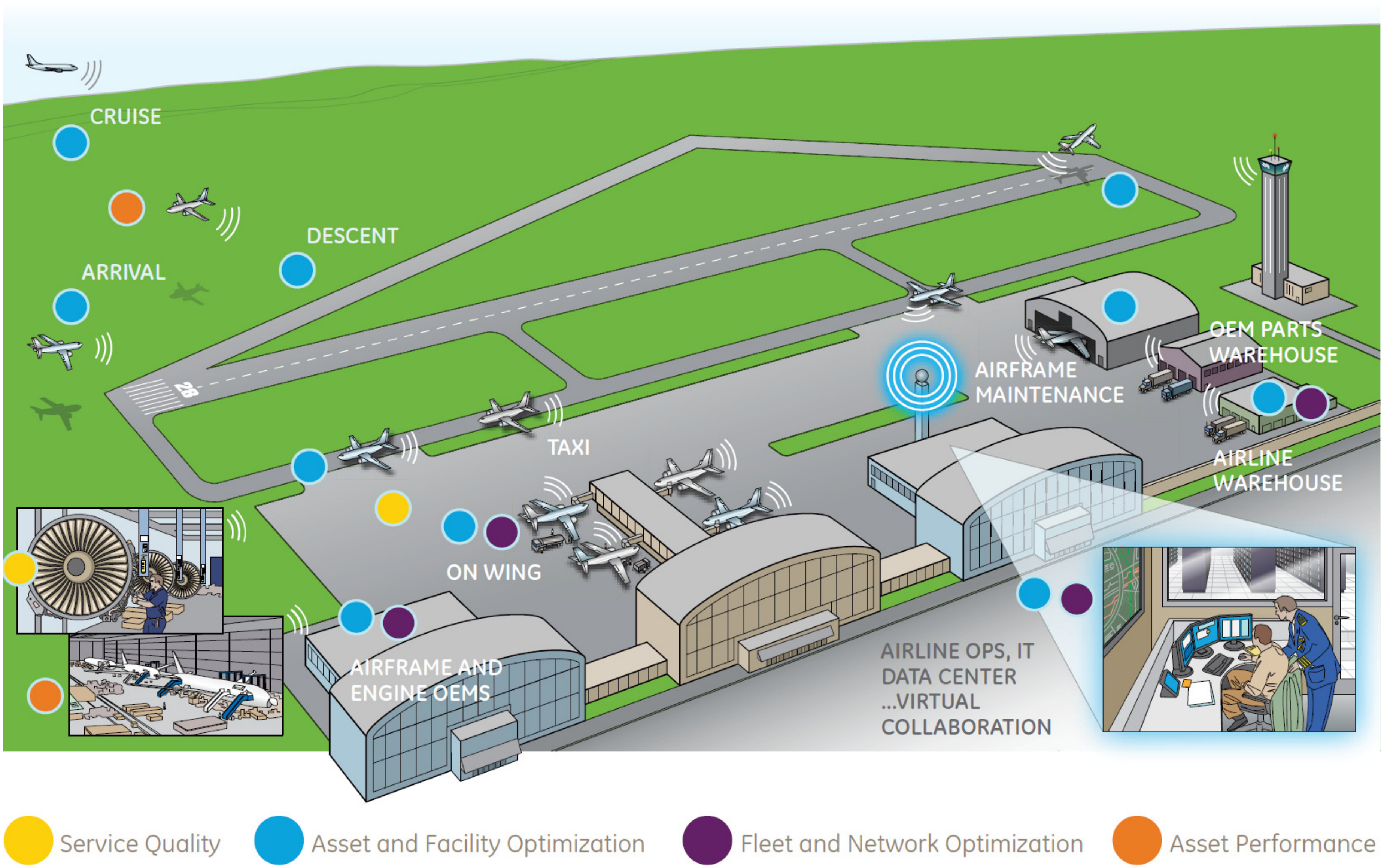


Aviation – Aircraft Maintenance and Diagnostics
The Industrial Internet will re-shape maintenance

An airplane lands and data from sensors automatically downloaded to local and global maintenance centers. Reduces downtime, predicts potential inventory of spare parts from in-flight data and optimizes performance.

Aviation – Aircraft Diagnostics and Maintenance

The Industrial Internet will optimize asset optimization & visibility

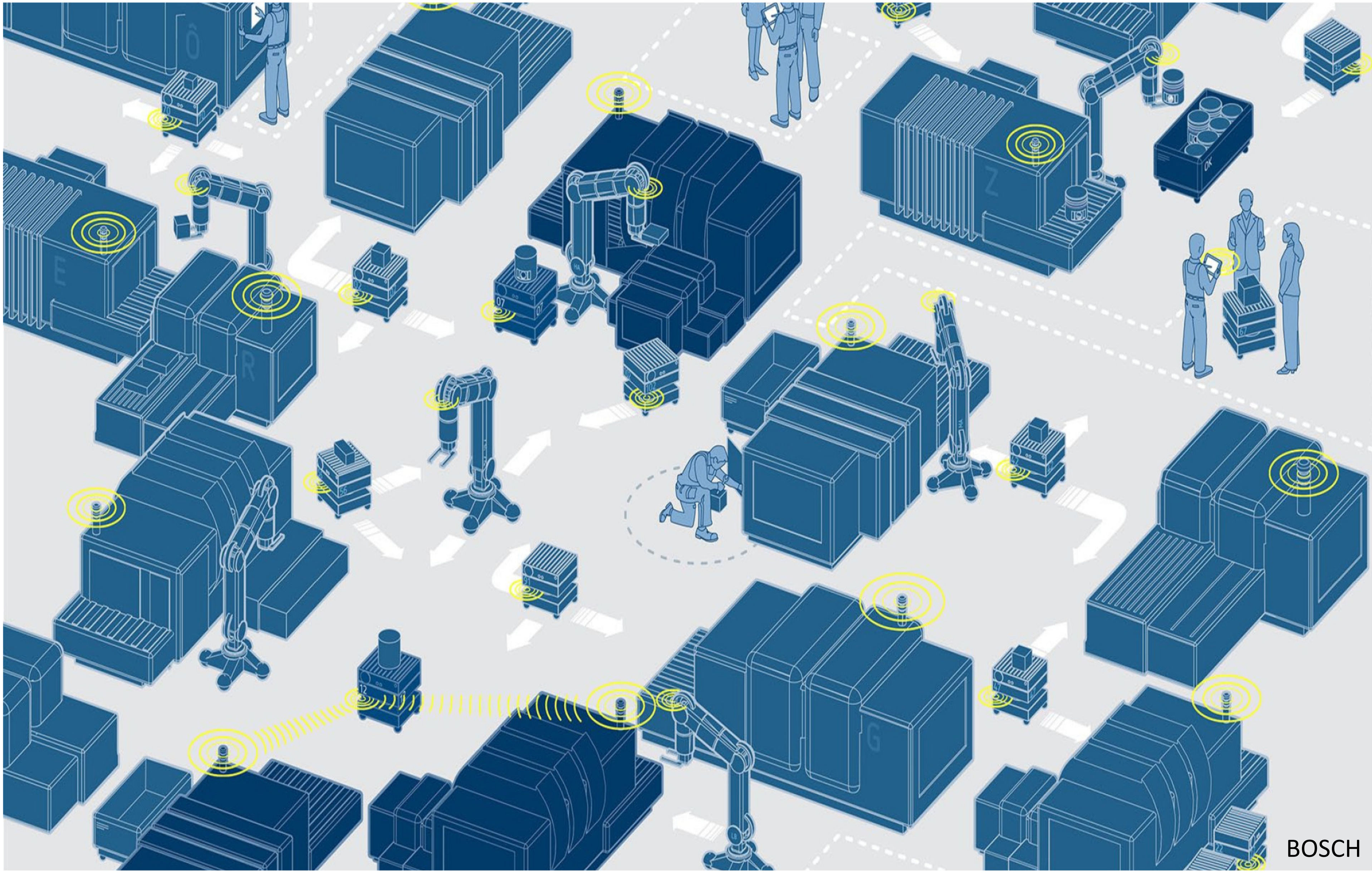


Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

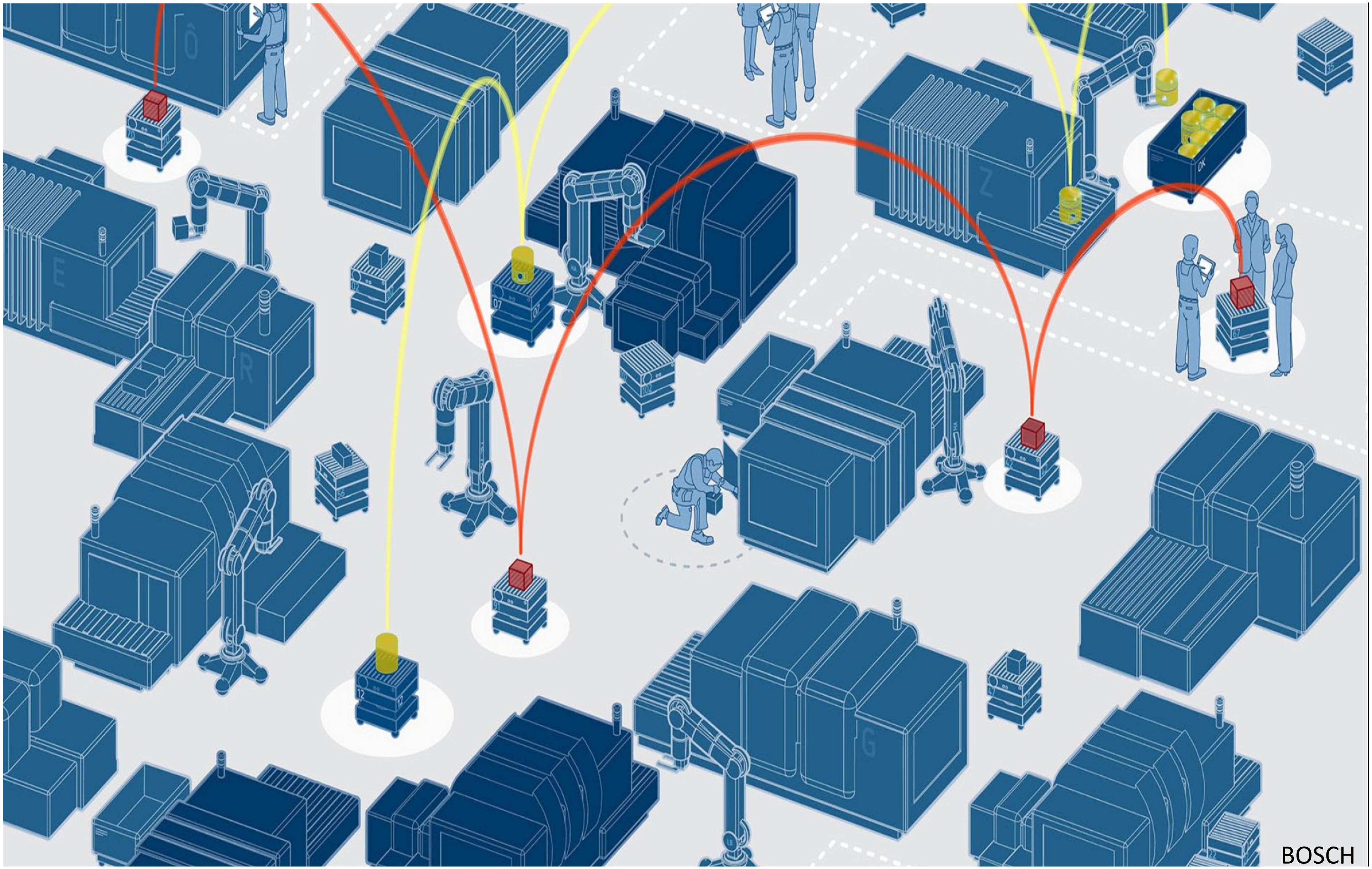
Domain Specific Scenario

Smart Manufacturing

Smart Factory
Improves Agility in Manufacturing



Smart Factory
Improves Flexibility for Variant Configuration

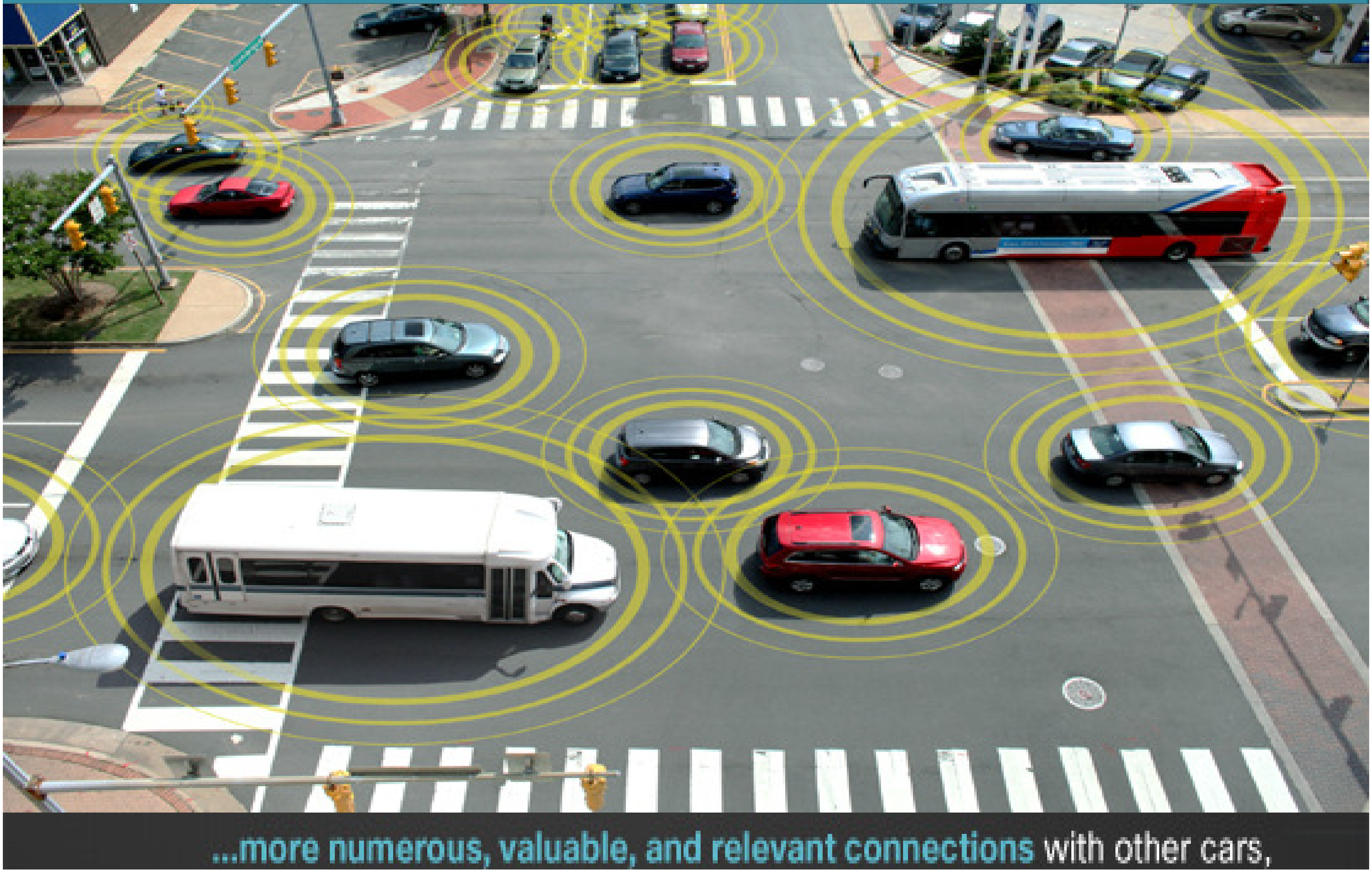


V2V Domain Specific Scenario

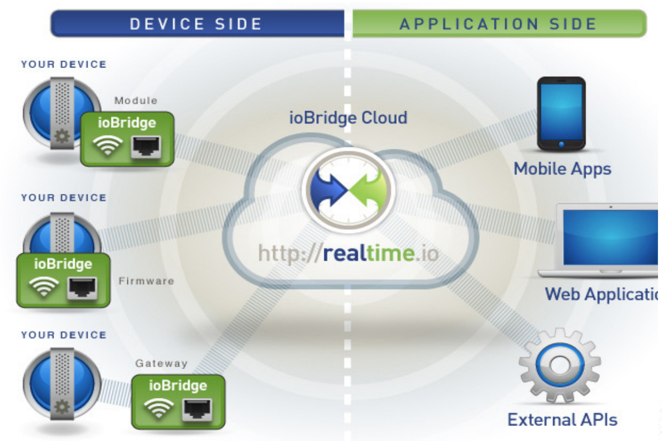
Connectivity, Communication, Integration, Automation

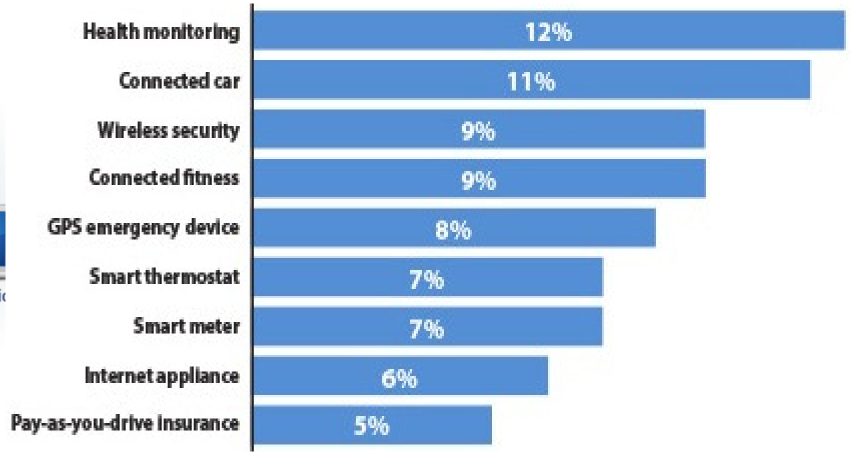
Within Limits ?

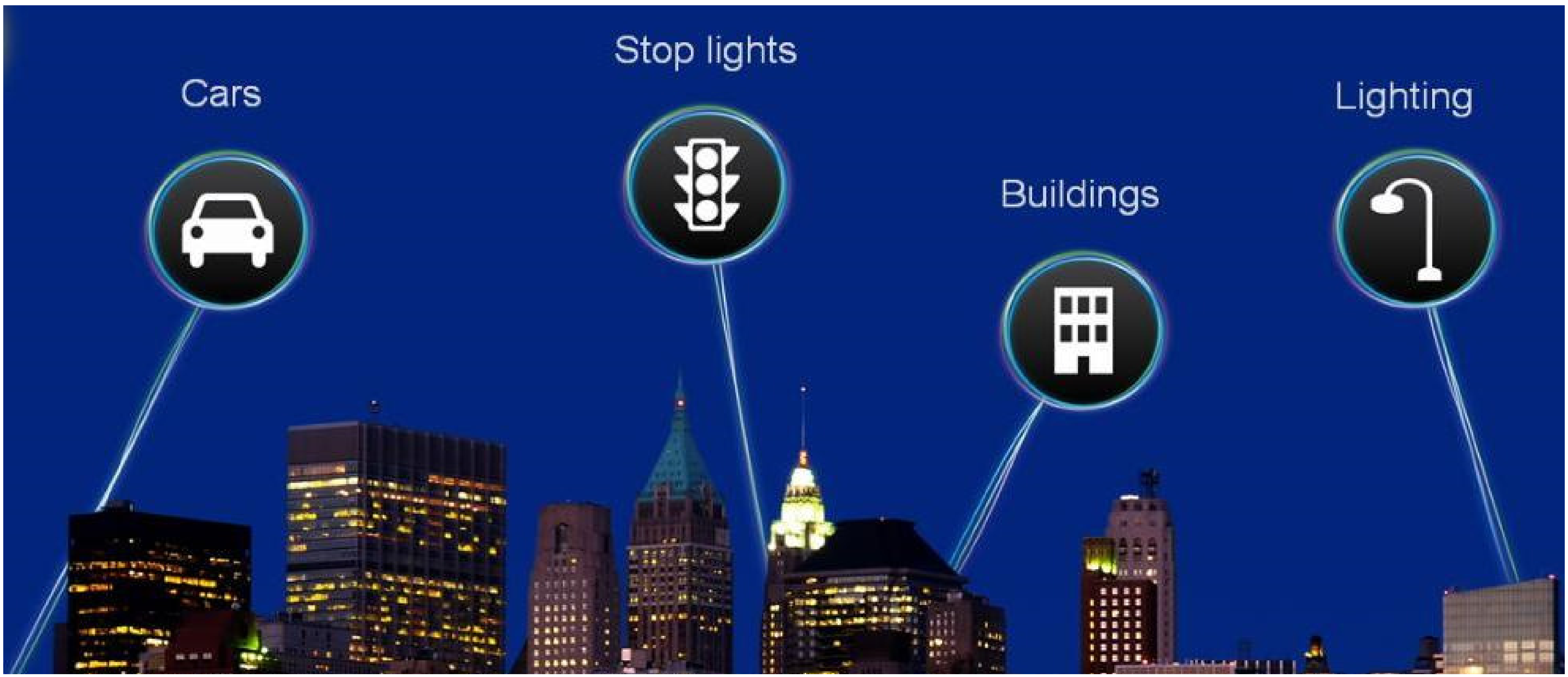
Industrial Internet of service delivery: flow of information proportional to connectivity



Industrial Internet of service delivery – functionality is proportional to integration





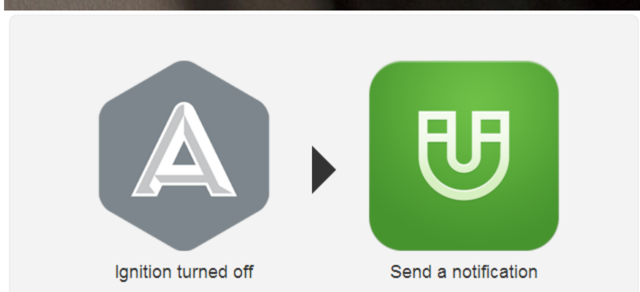


Reduce emissions by 15% and save about 1 billion liters fuel pa (in Germany alone)

How? By synchronizing vehicle speed with traffic lights online to eliminate stop and start at red lights. Demonstrated in Las Vegas using Audi A6 navigating 50 sets of traffic lights. Testing is underway in Verona with 60 traffic lights. In Berlin, select Audi customers are driving cars fitted with online traffic information that can link up to a total of 1000 traffic lights.

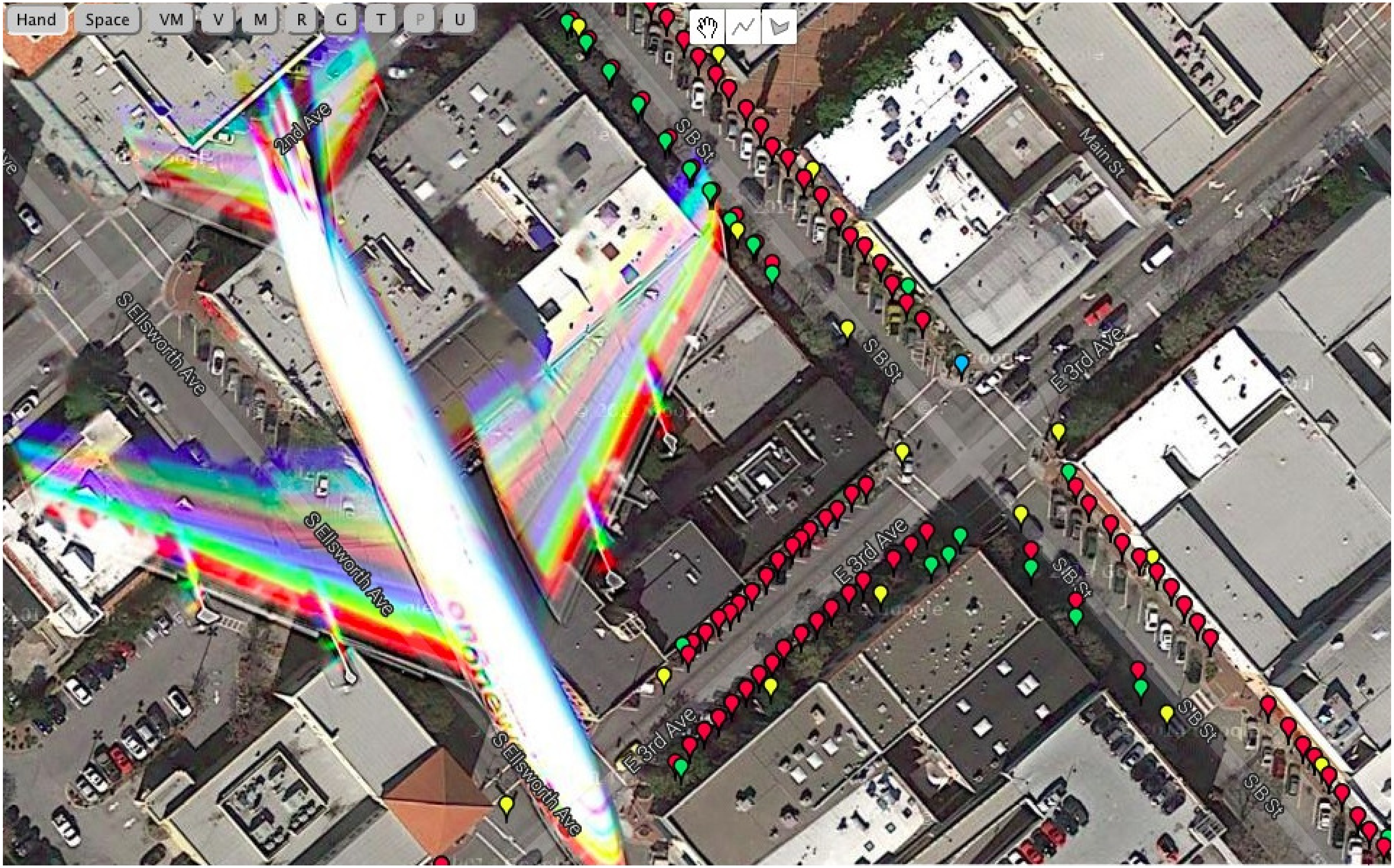
CAR TALKS TO CLOUD

For auto diagnostics, jealous spouses, concerned parents, geo-fence fanatics and auto shut-off for theft prevention



Notes: Add your parents push.co account to your IFTTT account to enable this recipe.

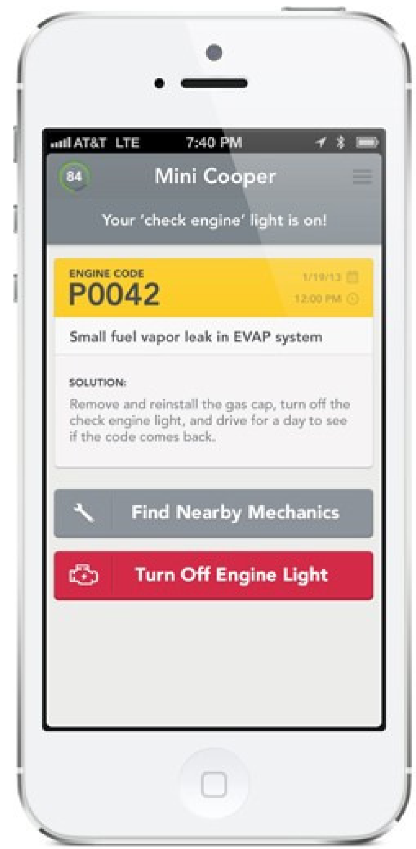
Industrial Internet ← IoT Services → Parking Spaces Talks to Cars



Google Earth photo of a plane flying over downtown San Jose, CA. Parking space sensors showing available car parking spaces using Parker™ by Streetline (Photo courtesy of Zia Yusuf, President & CEO, Streetline Inc)

Industrial Internet – IoT – Services Ecosystem → Convergence

↓↑



Automobile Big Data - Services v Privacy

Industrial Internet IoT Services Ecosystem Convergence

The Korea Herald ENGLISH EDITION

Latest News [Graphic News] IMF cuts world growth outlook

Samsung Electronics to provide telematics service to Tata Motors

Like 2 Tweet 1 Email Print

Published : 2014-02-14 20:31
Updated : 2014-02-14 20:31

A model poses with a Tata Motors Zest vehicle during the 12th Auto Expo 2014 in Noida, India, on Feb. 7. (Bloomberg)

Samsung Electronics will provide Tata Motors with infotainment programs as its first step into the smart car business.

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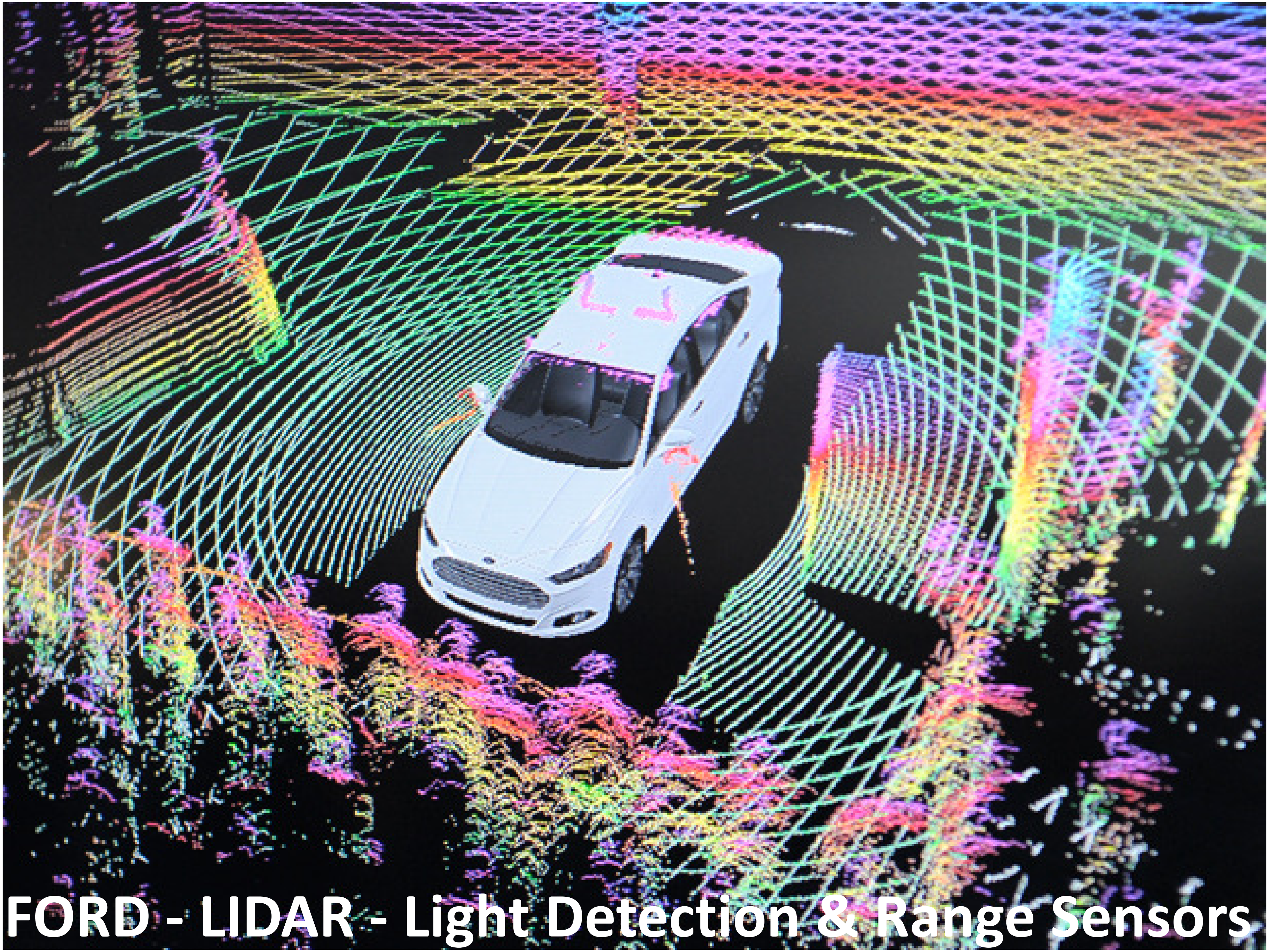
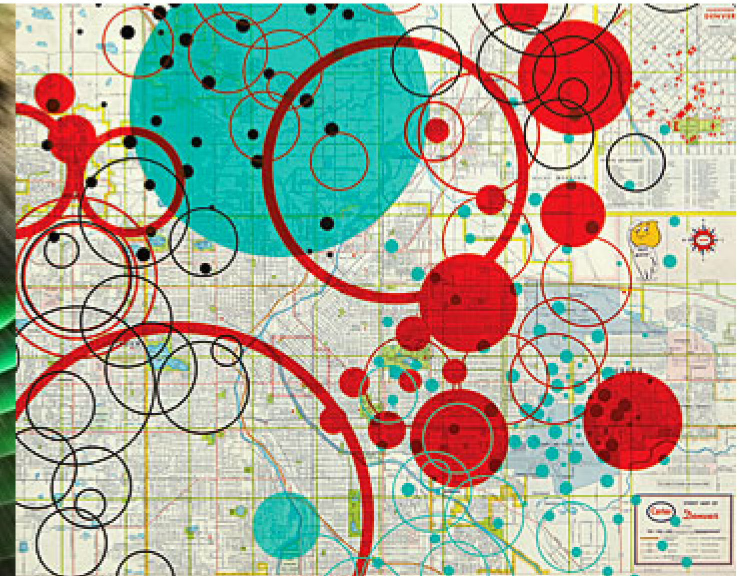
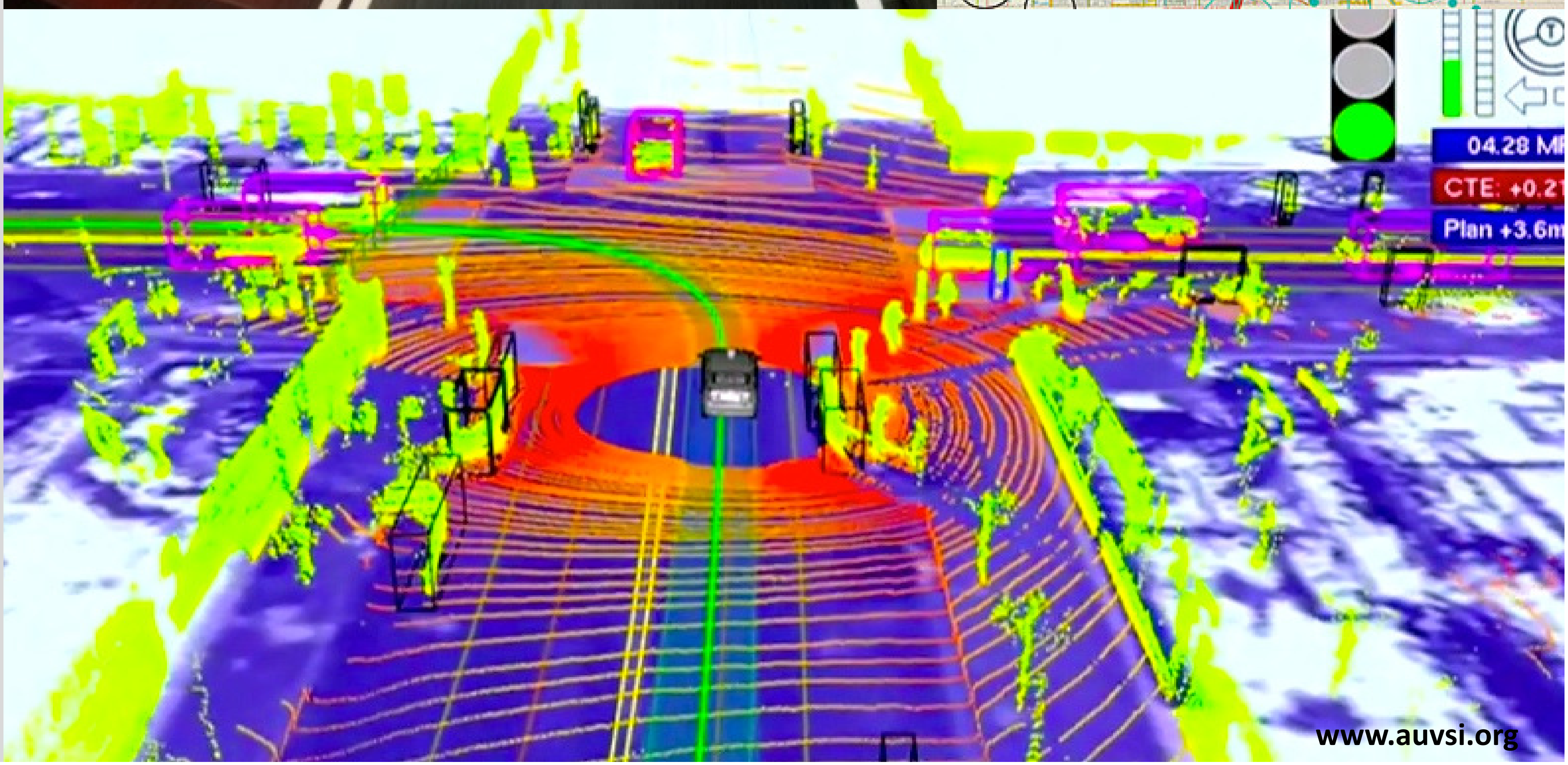


FORD - LIDAR - Light Detection & Range Sensors

AUTONOMOUS VEHICLES





Convergence → When these boxes start dissolving then the SMART WORLD will start evolving

Mobile e-commerce

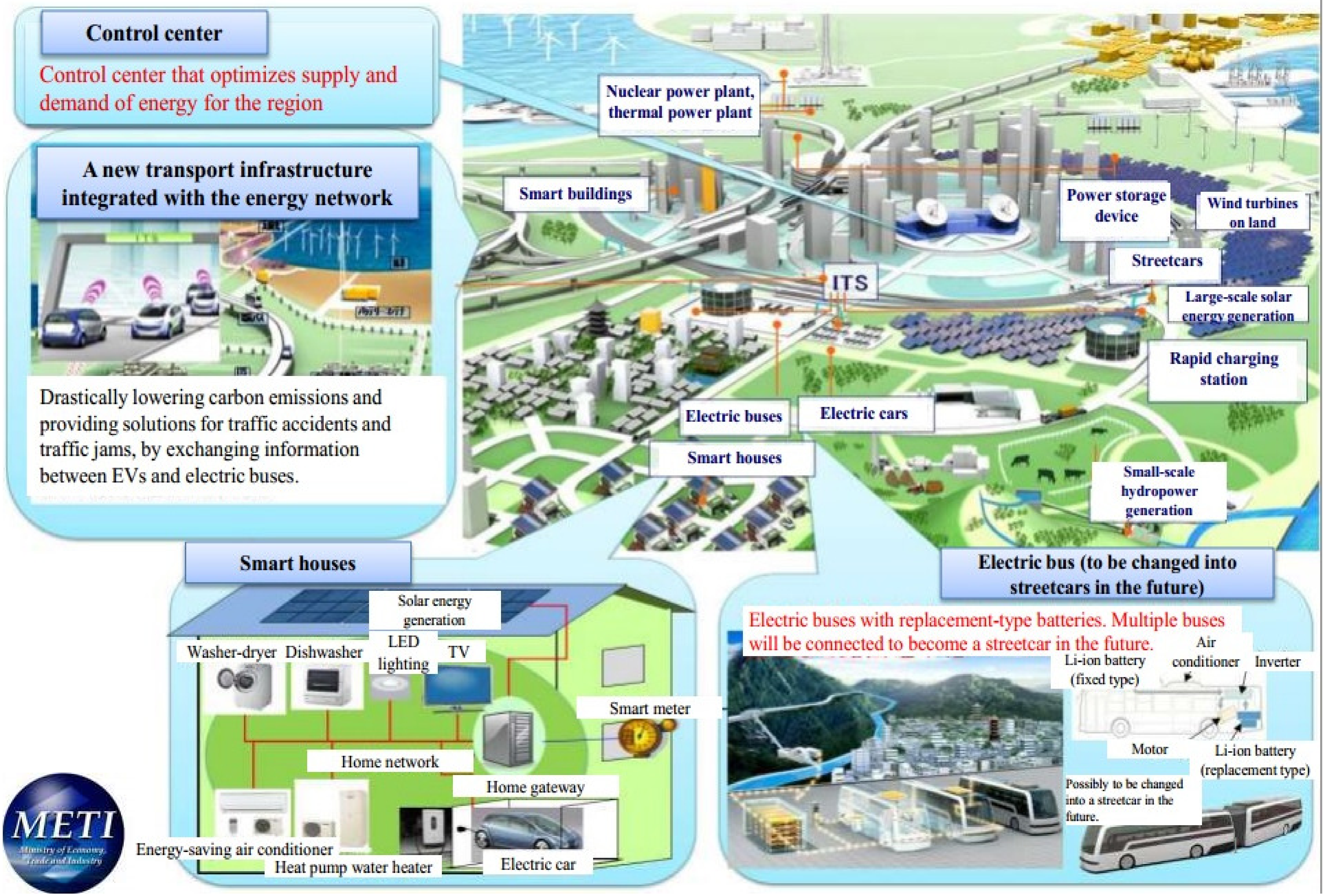
Supply chain management

Emergency assistance

Mobile communications

Inter-modal transportation

A SMARTER PLANET begins with SMART CITIES



Domain Specific Scenario

NADA.ORG

NERDS AGAINST DRINKING ACCIDENTS

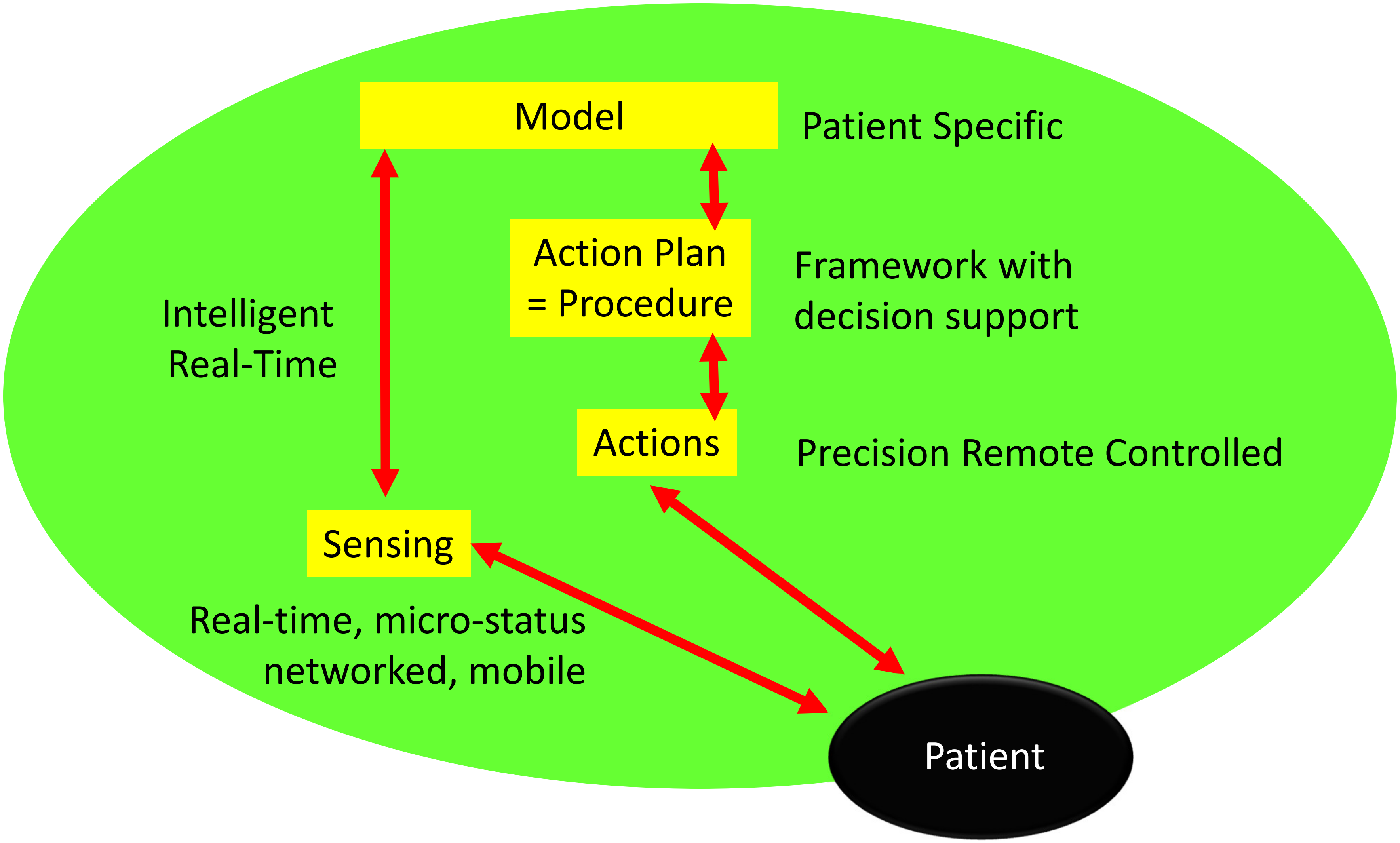
Drinking and Driving are not synonymous


Integrated breathalyzer with retina scan, facial identification, biometric ignition and smartphone

Domain Specific Scenario

Medical Device Integration

One Remit of CIMIT – Sense, ***then***, Respond – Future Integrated Healthcare Monitoring



The distinction between healthcare and other industry is in differentiation of scalability. Patient centricity as a service is not scalable but patient centric infrastructure (architecture) is scalable.

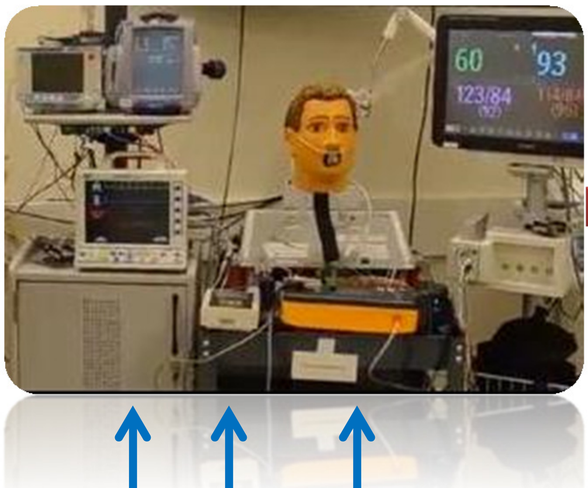
Autonomous Control of Morphine Infusion Pump – Medical Device Integration Model

Infusion Pump

Capnometer

Patient Simulator
Ventilator

Intelligent Monitor



Vital Signs Monitor

Simulator connected to vital signs monitor

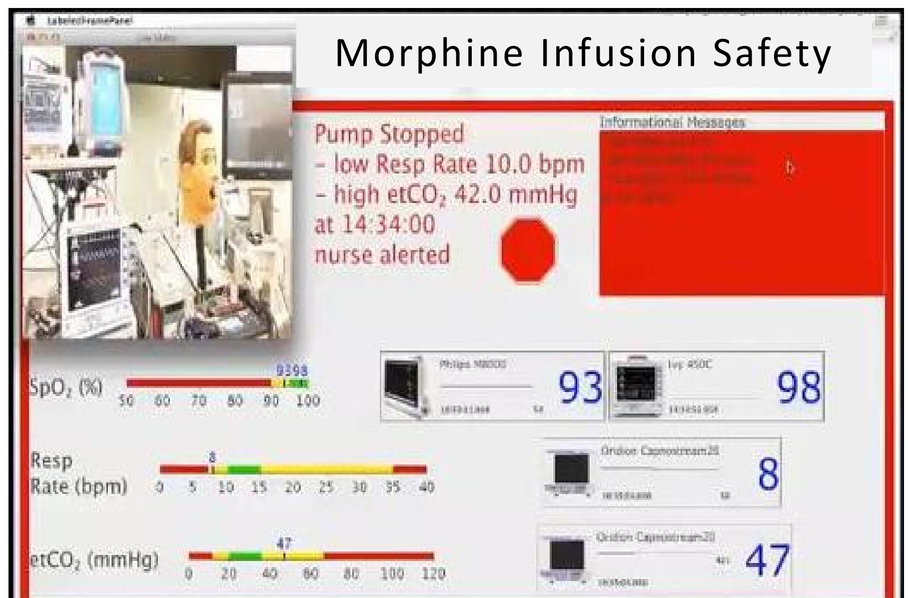
Fluke ProSim 8 connected to intelligent monitor

⬇ O_2 Saturation

⬇ Respiratory Rate

⬆ end-tidal CO_2

Connected Data
Collective Analysis
Automated Response



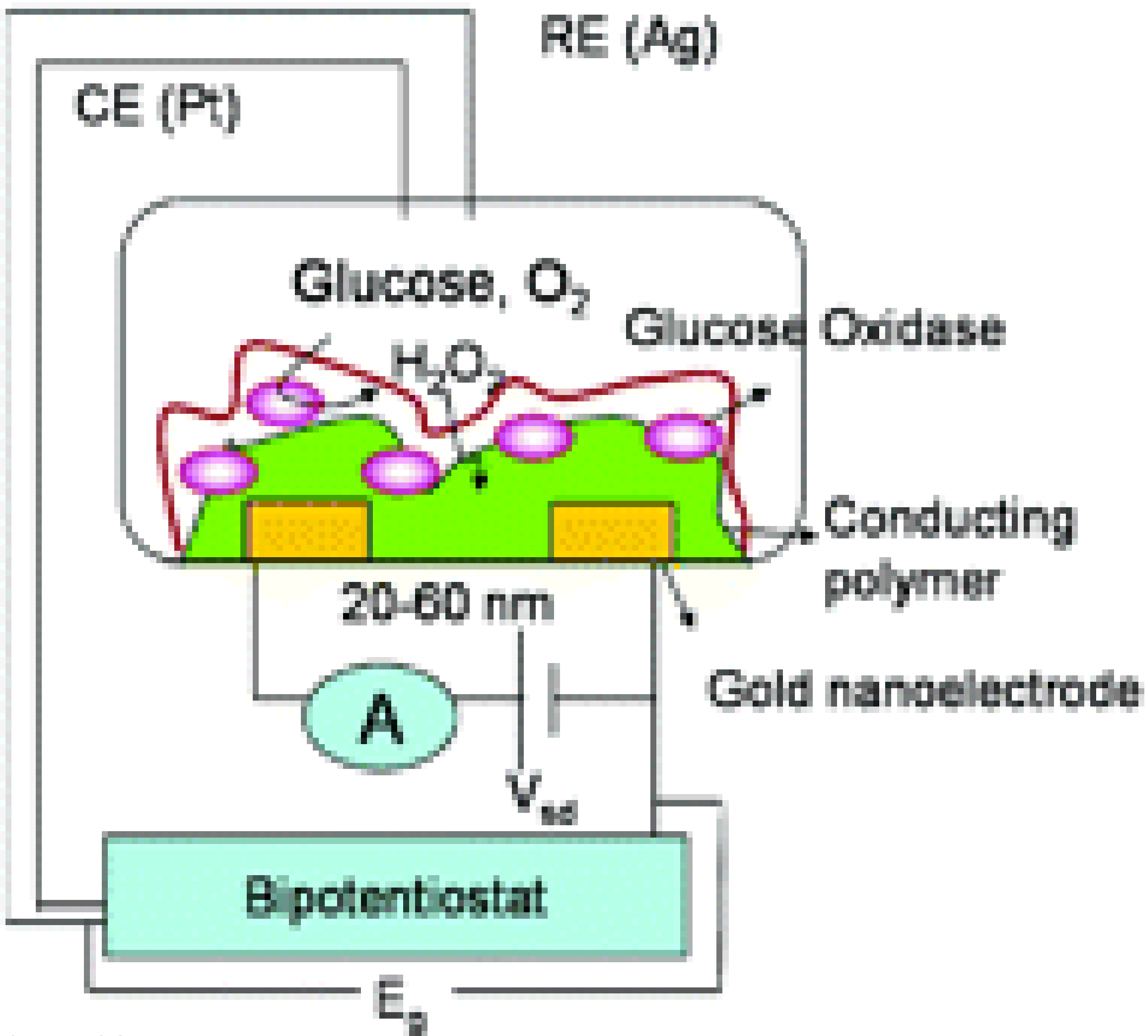
Patient Controlled Analgesia Safety Application

Julian Goldman MD (MDPnP.org and Partners.org)
Massachusetts General Hospital, Harvard Medical School
Harvard – MIT Center for Integrative Medicine and Information Technology

Domain Specific Scenario

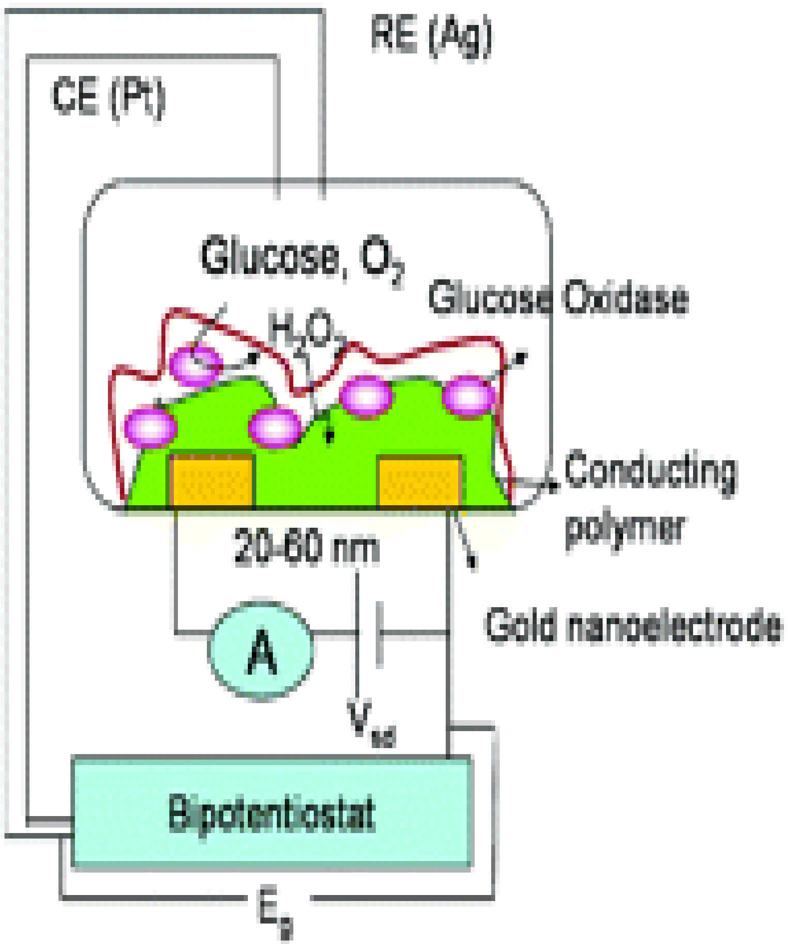
Health Monitoring

Domain Specific Anchor for Internet of Health and Wellness – Glucose NanoSensor



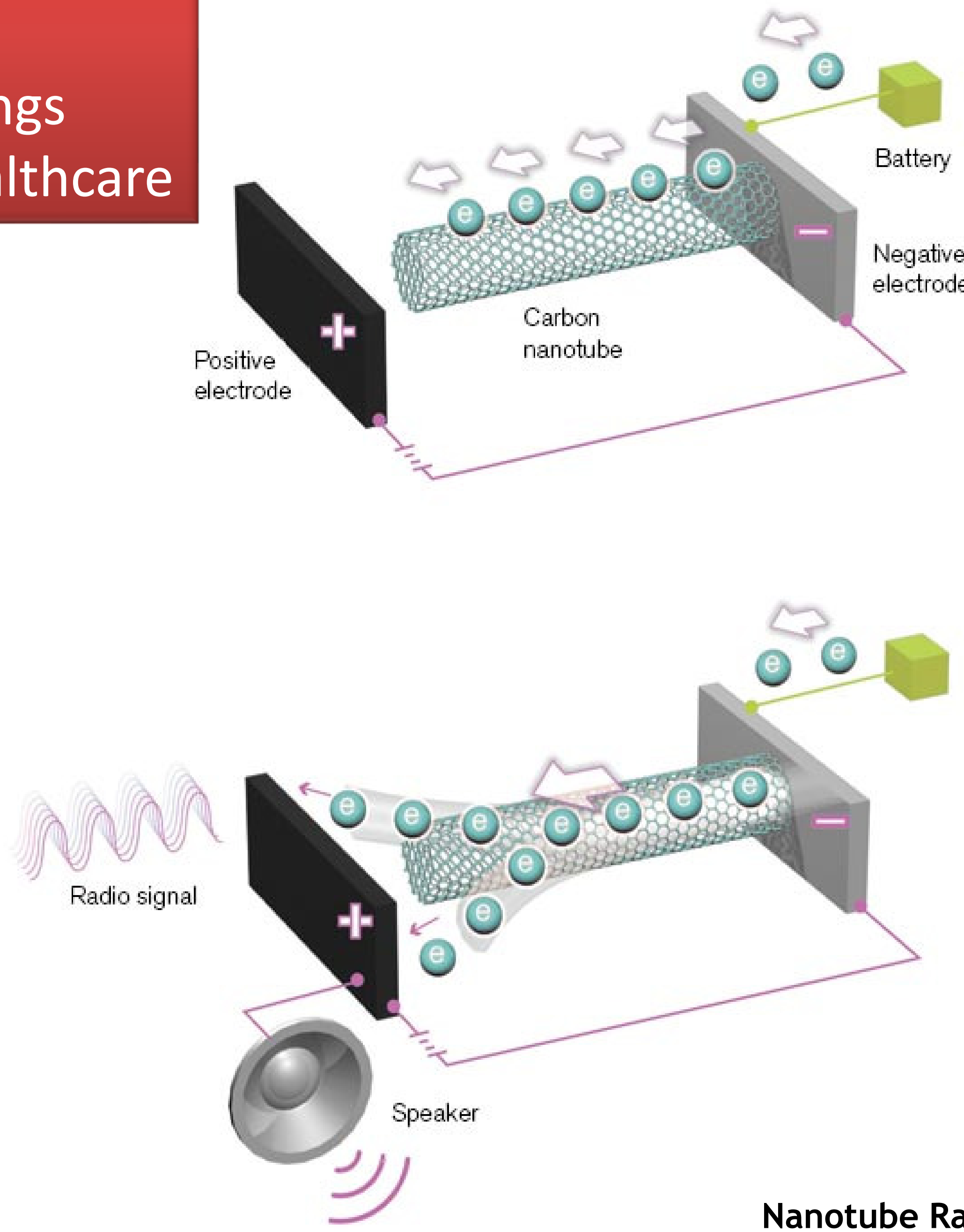
NanoLetters (2004) 4 1785-1788

The Industrial Internet
The Industrial Internet of Things
The Industrial Internet of Healthcare



Blood Glucose Nano-sensor

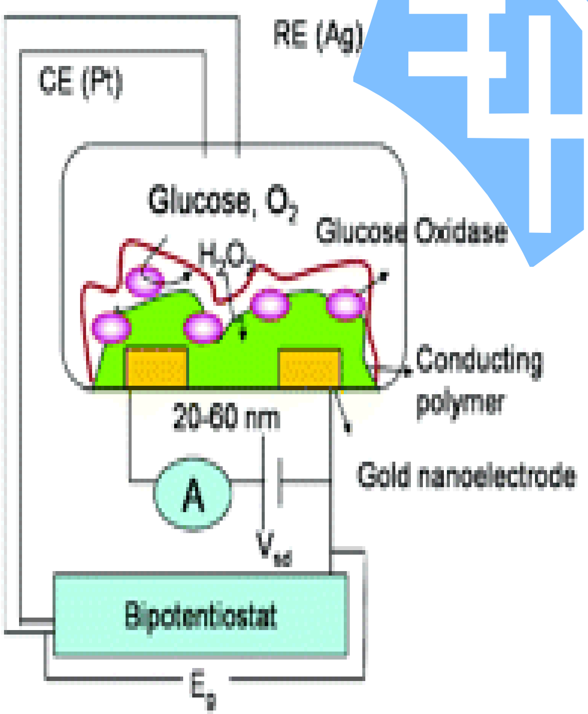
NanoLetters (2004) 4 1785-1788



Nanotube Radio

NanoLetters (2007) 7 3508-3511

Integrated Glucose NanoSensor NanoRadio



Hypothetical (S. Datta)

Diabetes affects 25.8 million people
8.3% of the U.S. population

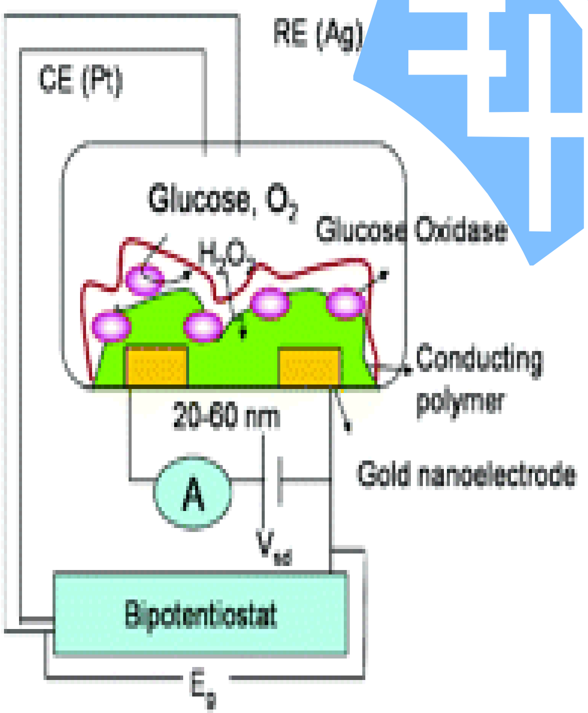
DIAGNOSED
18.8 million people

UNDIAGNOSED
7.0 million people

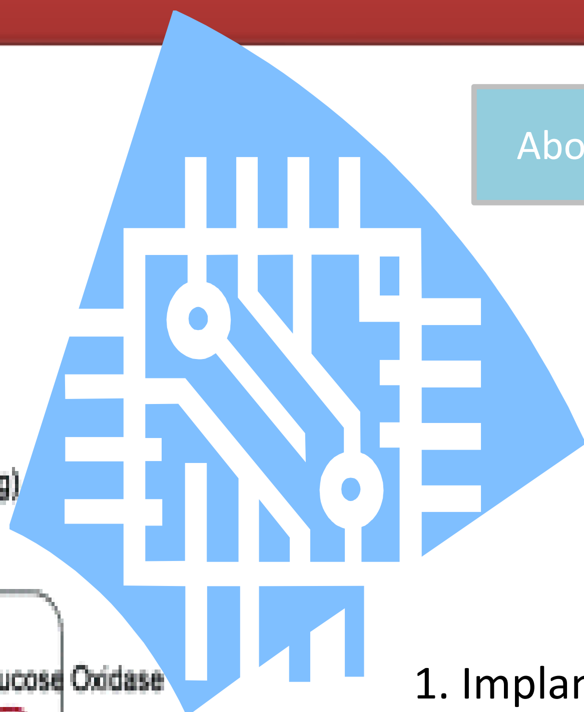
http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2011.pdf

Industrial Internet - Remote Heath Monitoring

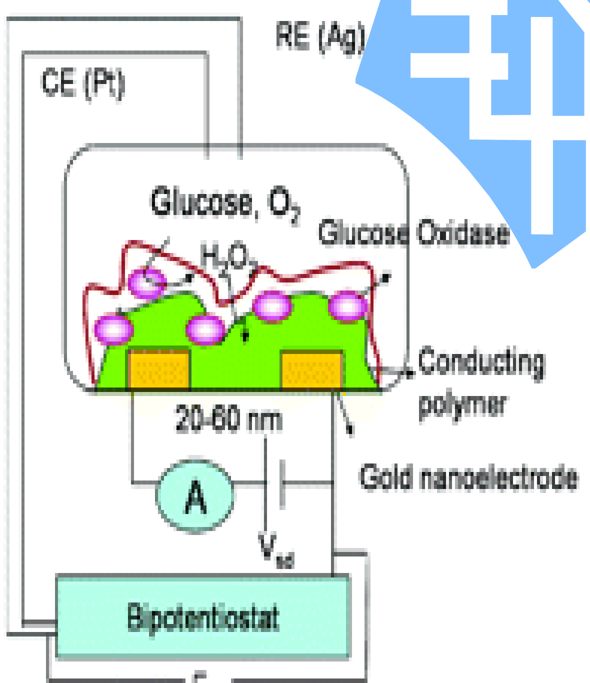
May I implant a glucose nano-sensor nano-radio chip on your shoulder? You are fat. You could become diabetic.



Glucose NanoSensor NanoRadio ecosystem of health-care monitoring may create major economic impact



About 30 million individuals in US affected by diabetes



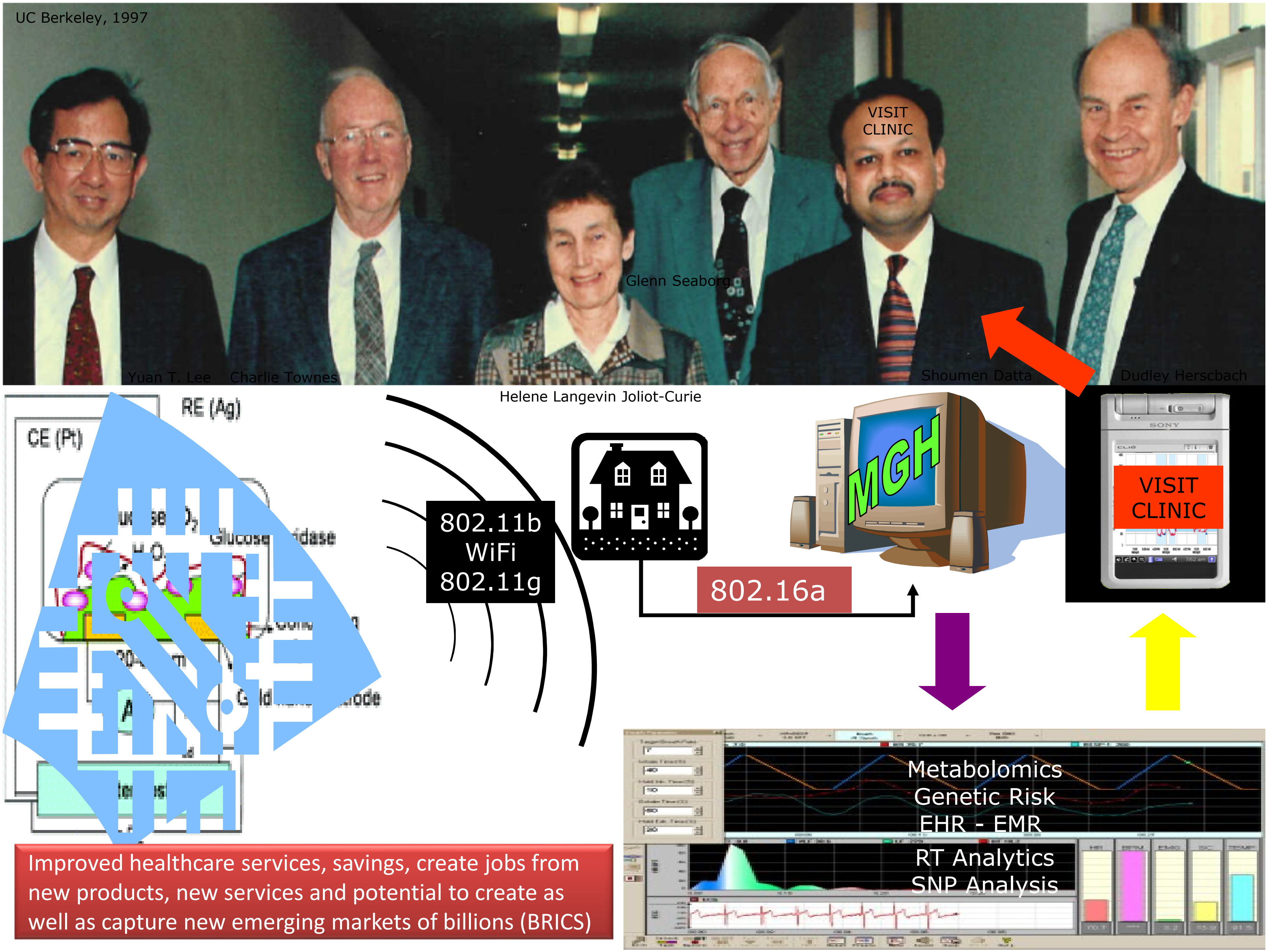
http://www.cdc.gov/nchs/fastats/diabetes.htm

1. Implanted wireless sensor transmits blood glucose data from home or office or airport (WiFi/WAN/gateway)

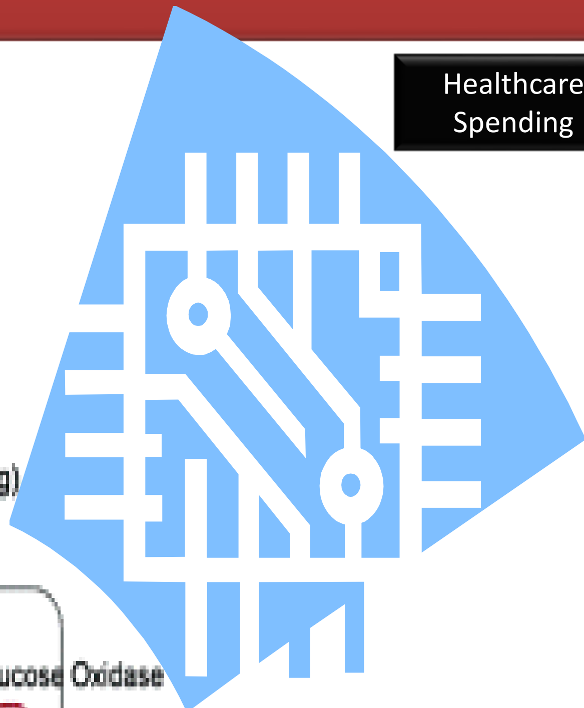
2. Data travels from you to your hospital or clinic (MAN)

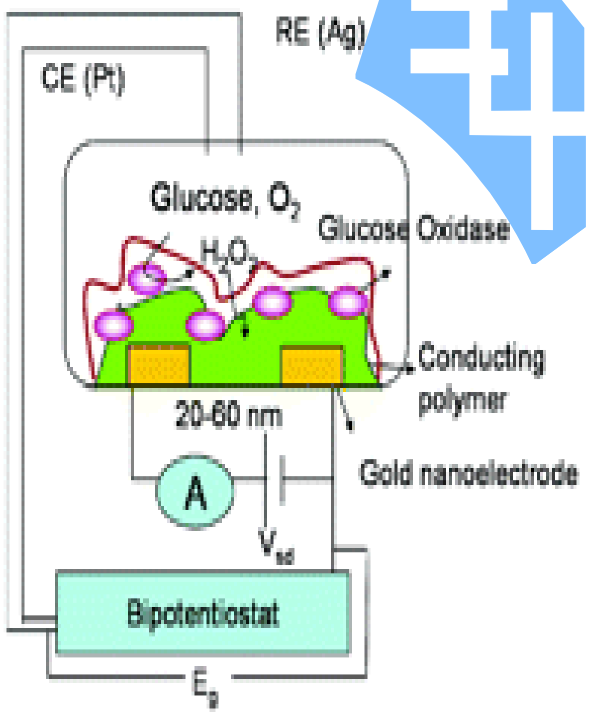
3. Blood glucose data updates risk and patient profile

4. If you need medical attention or insulin or other treatment then auto-responder sends message or calls

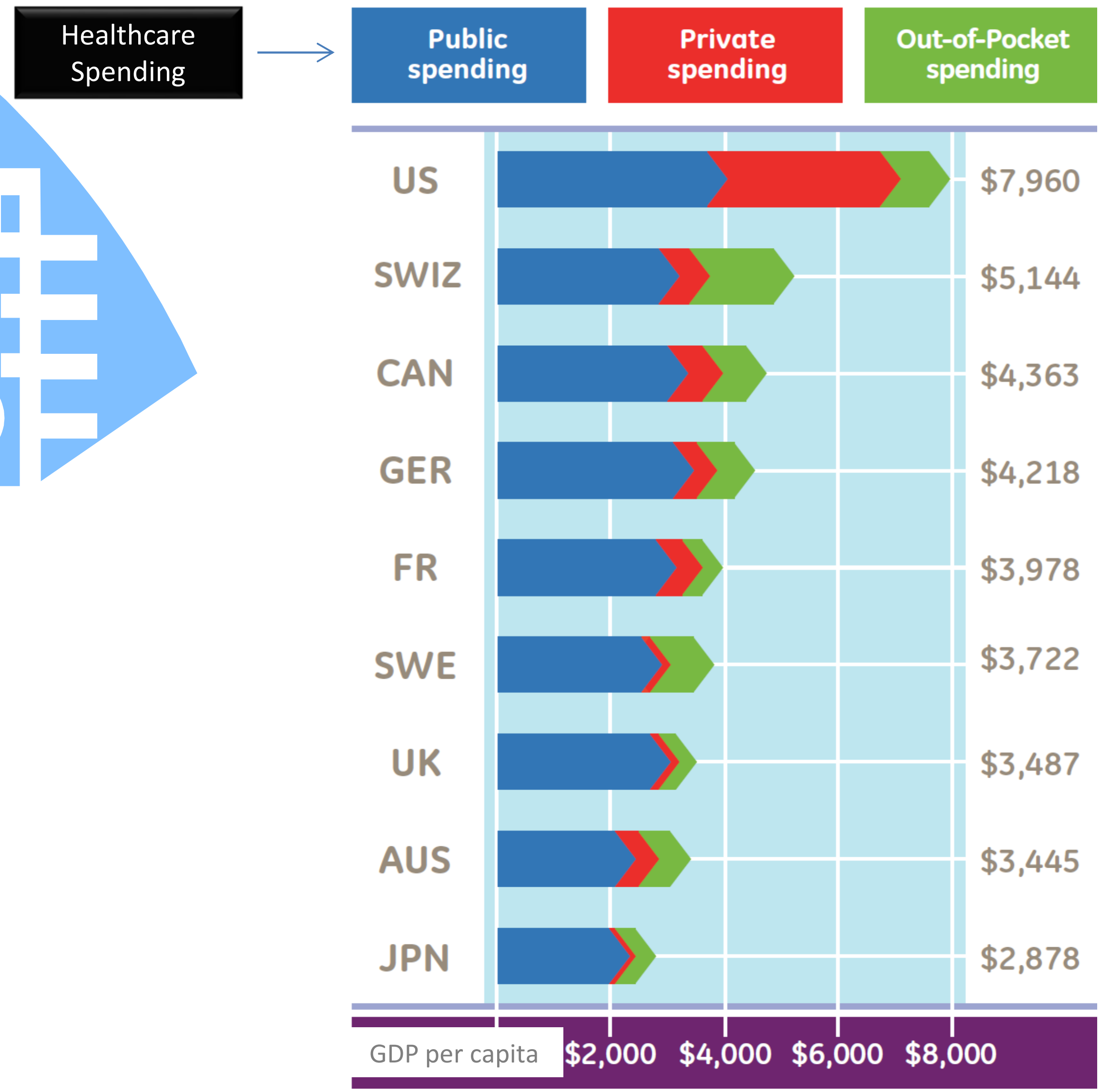

UC Berkeley, 1997
VISIT
CLINIC
Glenn Seaborg
Yuan T. Lee
Charlie Townes
Shoumen Datta
Dudley Herscbach
Helene Langevin Joliot-Curie
RE (Ag)
CE (Pt)
802.11b
WiFi
802.11g
MGH
SONY
VISIT
CLINIC
802.16a
Metabolomics
Genetic Risk
EHR - EMR
RT Analytics
SNP Analysis
Improved healthcare services, savings, create jobs from new products, new services and potential to create as well as capture new emerging markets of billions (BRICS)

Glucose NanoSensor NanoRadio ecosystem of health-care monitoring may have a major economic impact

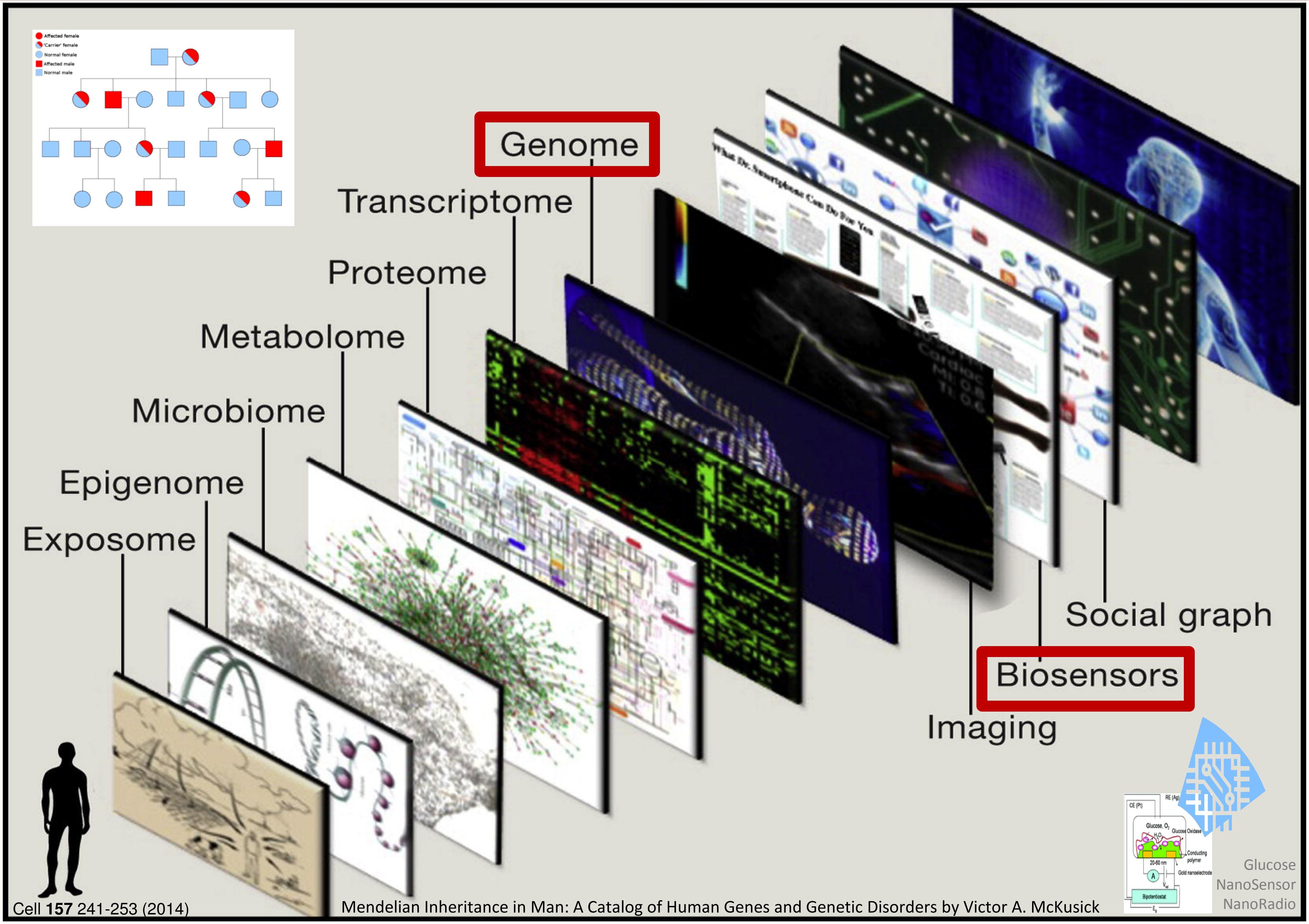




http://www.cdc.gov/nchs/fastats/diabetes.htm

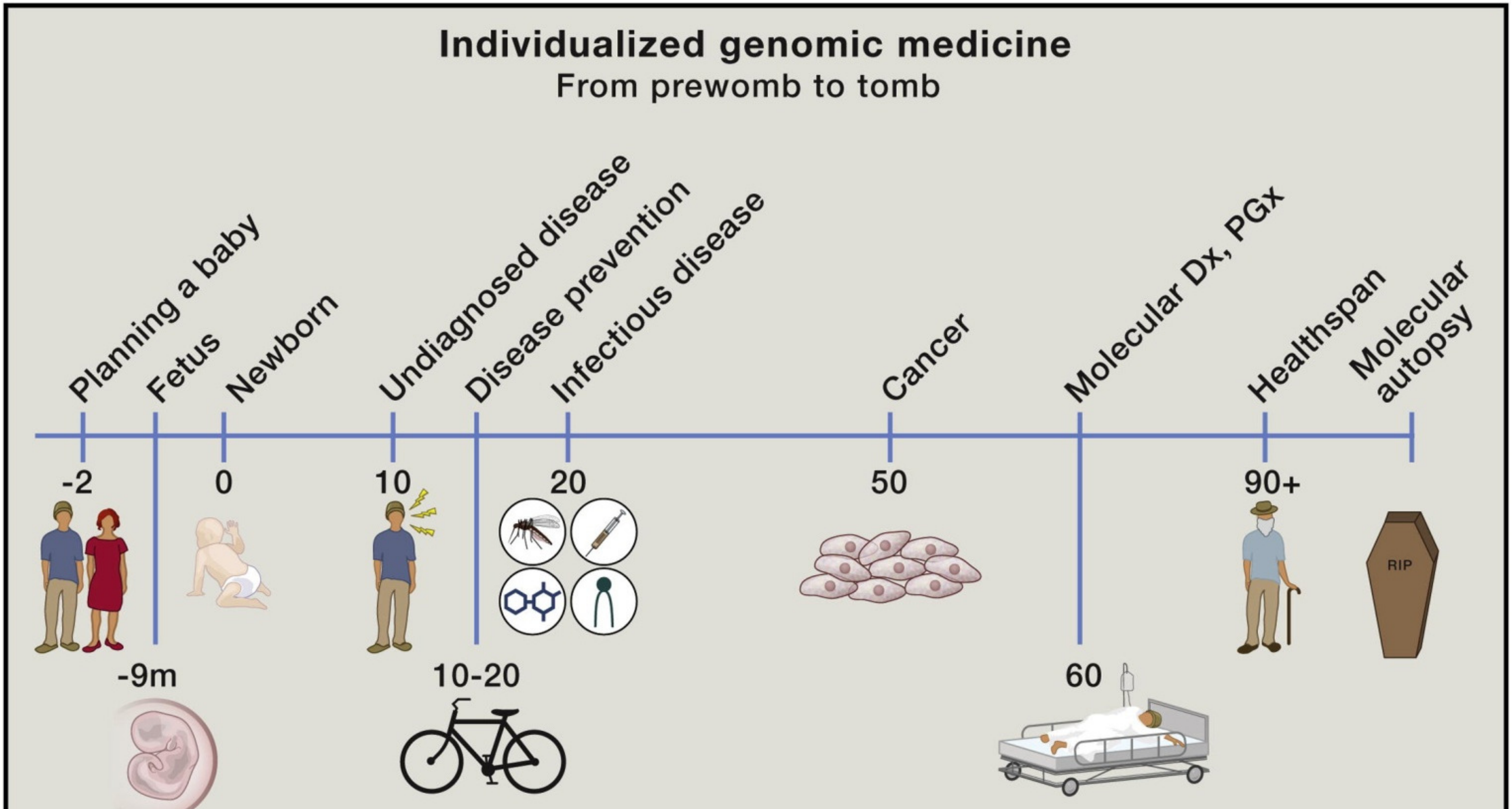


Human Genomics in the industrial internet era - Is your genome connected to mine?



Human Genomics in the Age of the Industrial Internet

Designer Drugs Transmitted in the Wireless Hospital



Cell **157** 241-253 (2014)

Domain Specific Scenario

Early Detection and Prevention

Sensor enabled wearables - appropriate attributes may improve preventive medicine

Hands-Free
- Voice / gesture control

Always-On
- Low power consumption
- Instant wake
- Background working / sensing

Environment -Aware
- GPS
- Accelerometer
- Compass
- Camera
- Microphone
- Other Sensors

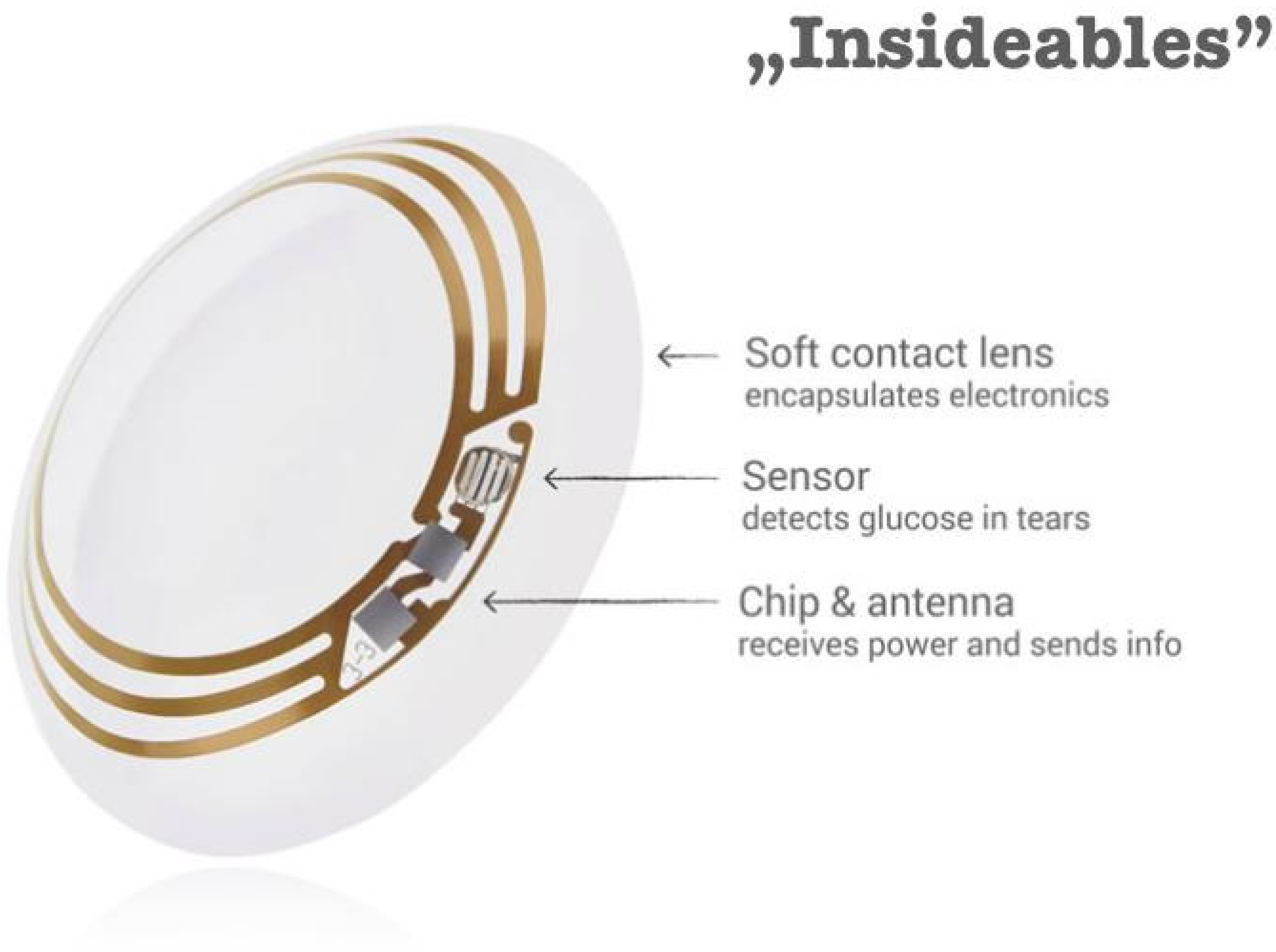
Connected
- Wi-Fi
- 3G / 4G
- Bluetooth
- NFC

Attention-Getting
- Less distracting when receiving alerts / reminders / messages

Development Platform
- 3rd party apps
- API partners
- Accessories

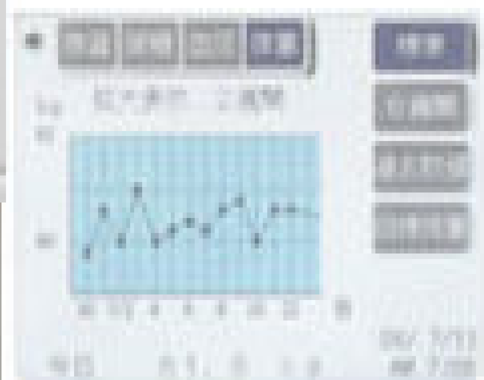
MIT

Glucose Sensors can reduce the morbidity due to Glaucoma



umcn.nl

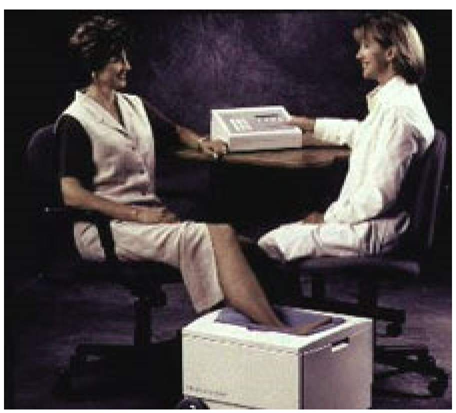
Pay-Per-Pee Home Health – IoT Wireless Toilet Bowl Connected to Health Informatics



Weigh-scale, BMI, FOBT, urine analysis, sugar, ketone body analysis, blood pressure monitor, pulse oximeter, networked to phone via WiFi and/or Bluetooth with biometrics and face recognition for secure communication with physician and hospital or clinic, globally.

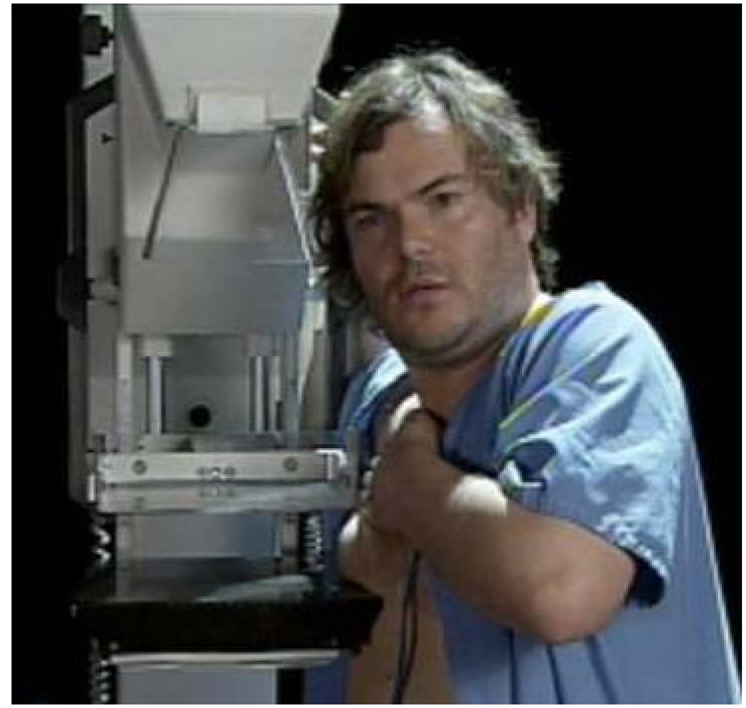
Walgreens Specials - $1.99 for 24-pack Diet Coke • $1.99 for Bone Density • $1.99 Mammogram

PDEXA SCAN
BONE MINERAL
DENSITY PROFILE



Value Network Ecosystem Testbed

Walgreens – Retail Healthcare
GE – Equipment
Cisco – IPv6 Routers
AT&T – Data Transmission
Intel – MIPS
IBM – Data Analytics
Samsung – Diagnostic Apps
Walmart – Grocery Supply Chain



US Healthcare spending nears $4 trillion (2013)

Spending category	Costs estimated in NHEA categories (in billions)		Costs estimated with sources other than NHEA (in billions)			
	Direct Costs		Direct Costs		Indirect/ Imputed costs	
Hospital care	Hospital care	$814				
Professional services	Physician and clinical services	$516				
	Dental services	$105				
	Other professional services	$68				
	Other personal health care	$129				
			All other ambulatory	$19		
			CAM practitioner costs	$31		
			Weight-reducing centers	$2		
Long-term care (LTC)	Home health care	$70				
	Nursing home care	$143				
			Homes for the elderly	$17		
Prescription drugs	Prescription drugs	$259				
Retail products and services	Durable medical equipment	$38				
	Other non-durable medical products	$45				
			CAM products	$2		
			Health publications	$2		
			Nutrition/supplements	$56		
Direct administrative costs	Total non-personal health care	$408				
Supervisory care					Supervisory care	$492
Total		**$2,594**		**$129**		**$492**

Deloitte

Low Cost of Healthcare in India leaves billions in the dust without access to healthcare

Cancer Treatment

$2,900 HCG Oncology, India
$22,000 U.S. average

Kidney Dialysis

$12,000 Deccan Hospital, India
$66,750 U.S. average

Fast Forward → Penny Per Person Per Use Per Day

$1 - Bone density

$1 - Mammogram

at the corner of Happy and Healthy in every zip code in India, China, Indonesia

data transmitted to specialists and reports sent to individuals, doctor and clinic

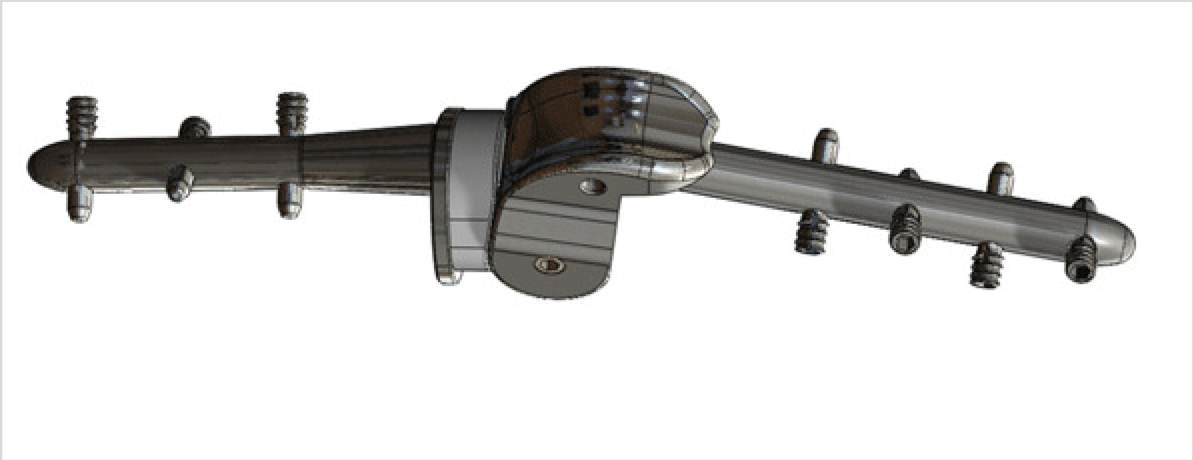
The micro-revenue earnings potential with 10% penetration for population of 3+ billion & aging!

Domain Specific Scenario

3-D Printing in Healthcare

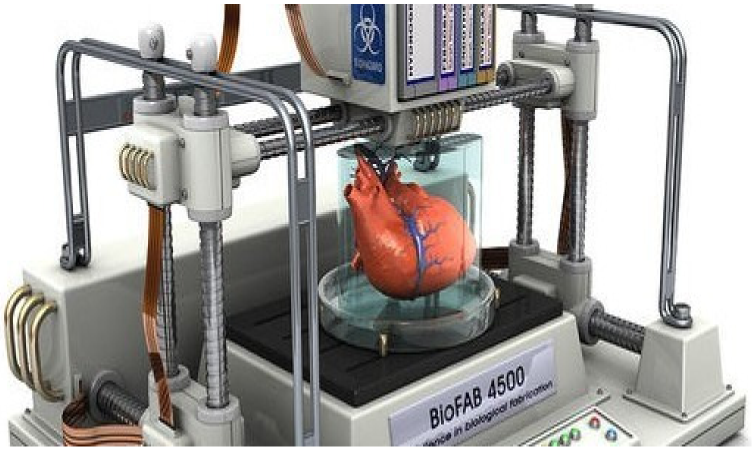
Innovation in manufacturing and digital design

3-D Printing
Design of Prosthetics and Orthopedic Imaging



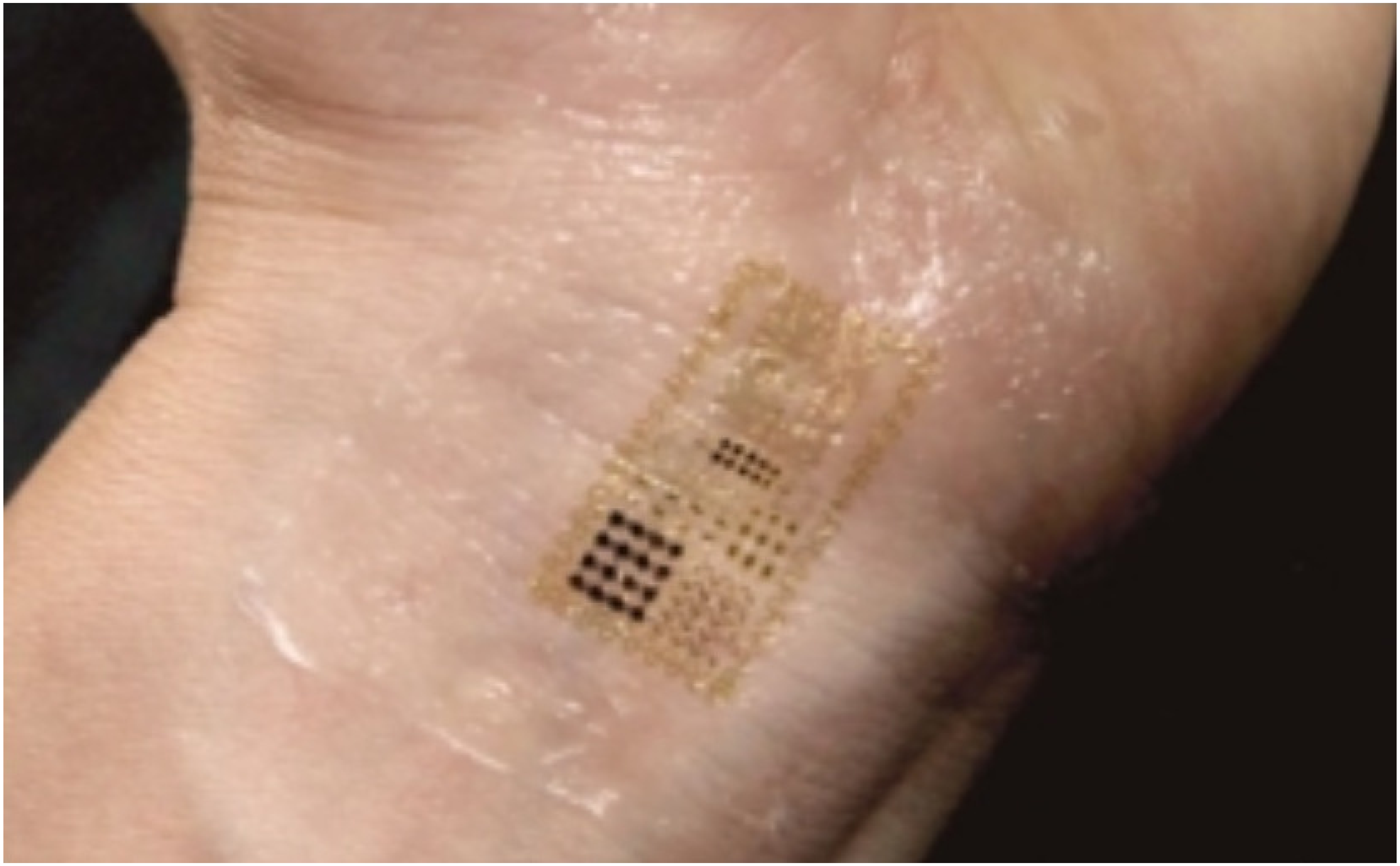
Cyrano L. Catte II (above) is the first feline to receive a total knee arthroplasty (TKA). Femoral and tibial components were created with a direct metal laser sintering (EOS).

3-D Printing of Medical Devices



http://bit.ly/3D-Print-A-Tooth
http://bit.ly/3D-Print-Medical-Devices

Artificial Skin with embedded sensory surface talks to smart phone via capacitive sensing using Touchcode adapted for printed i-Skin



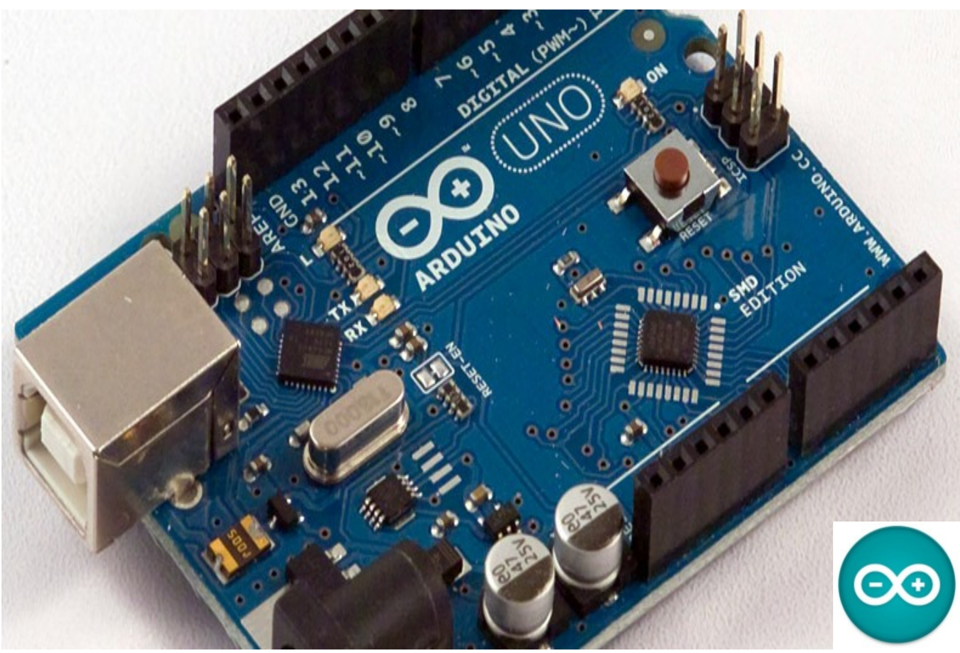
Your medicine can inform your doctor about its kinetics, bio-availability and side effects. It can alert your pharmacist about potential over-dose if multiple medications contain same or similar active ingredients. Your medicine can query and adjust dosage.

Paradigm Shift in Global Healthcare Economics

3D Printed Medical Devices + OS Hardware / Software

arduino inside

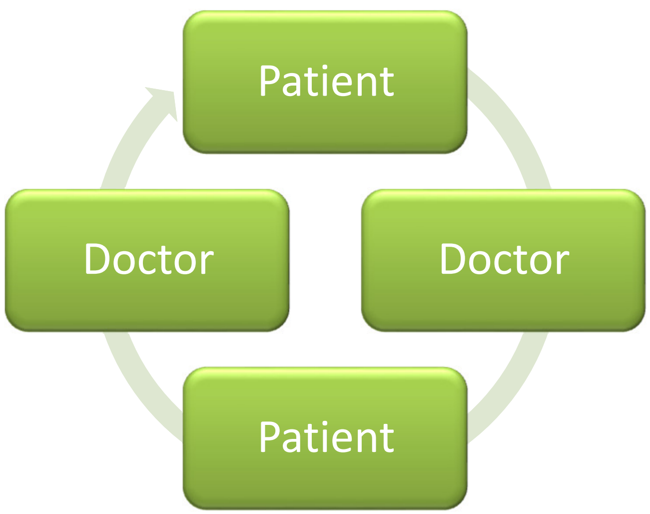
ARDUINO AT HEART

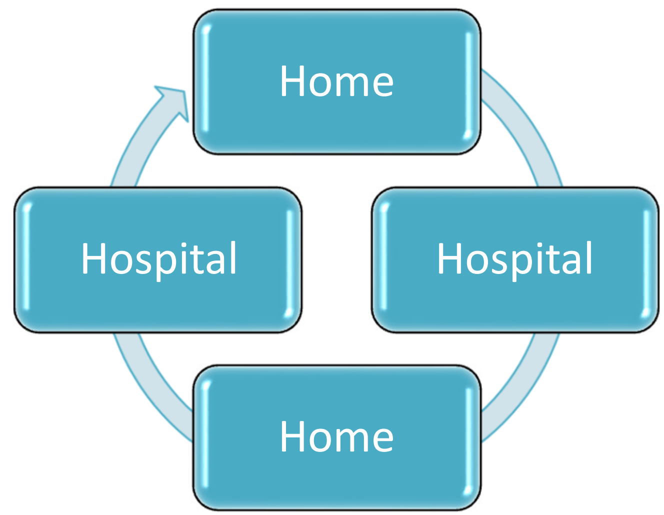


Domain Specific Scenario

Healthcare Management

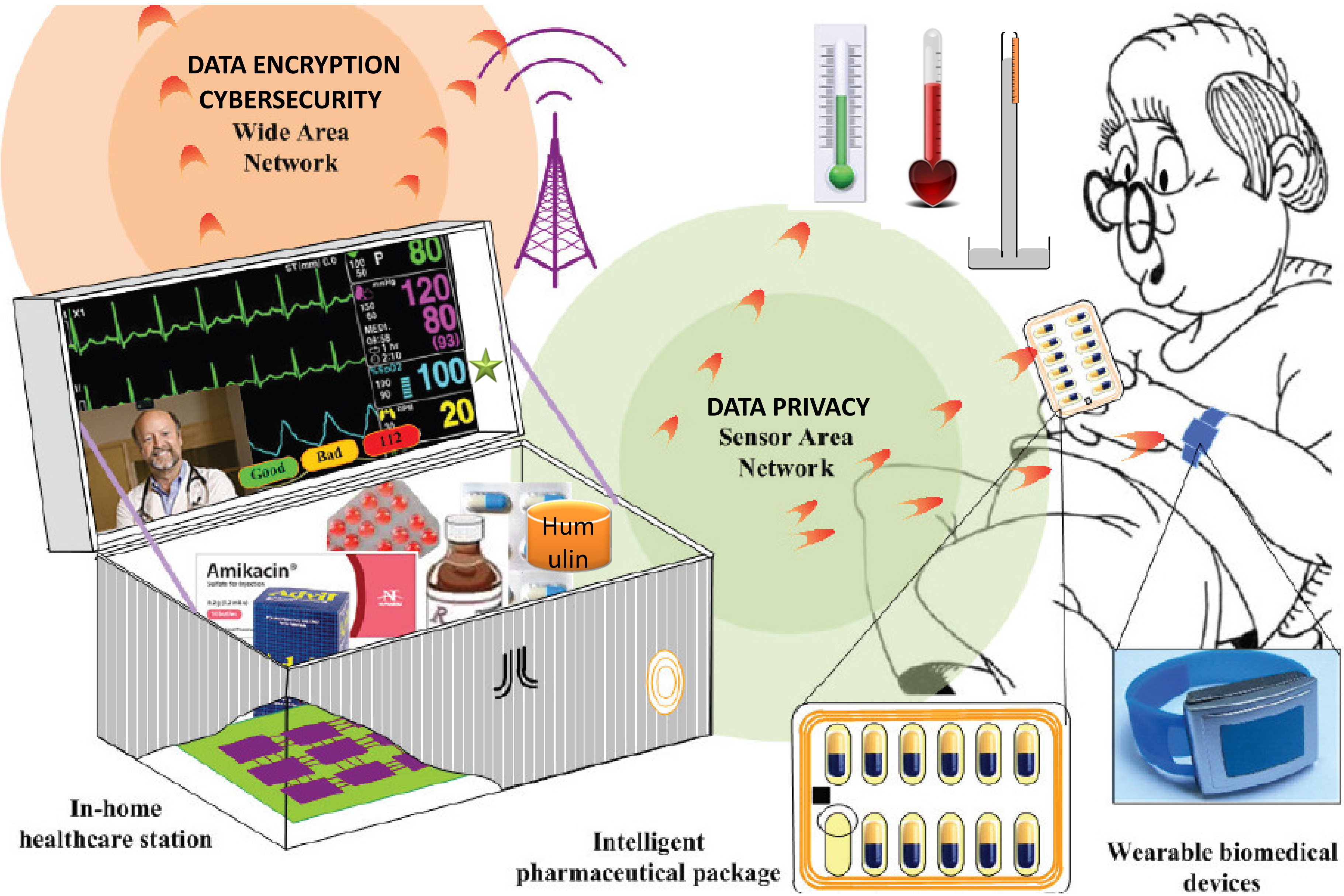
Healthcare Management - Fundamentally Closed Loop & Quintessentially Patient Specific





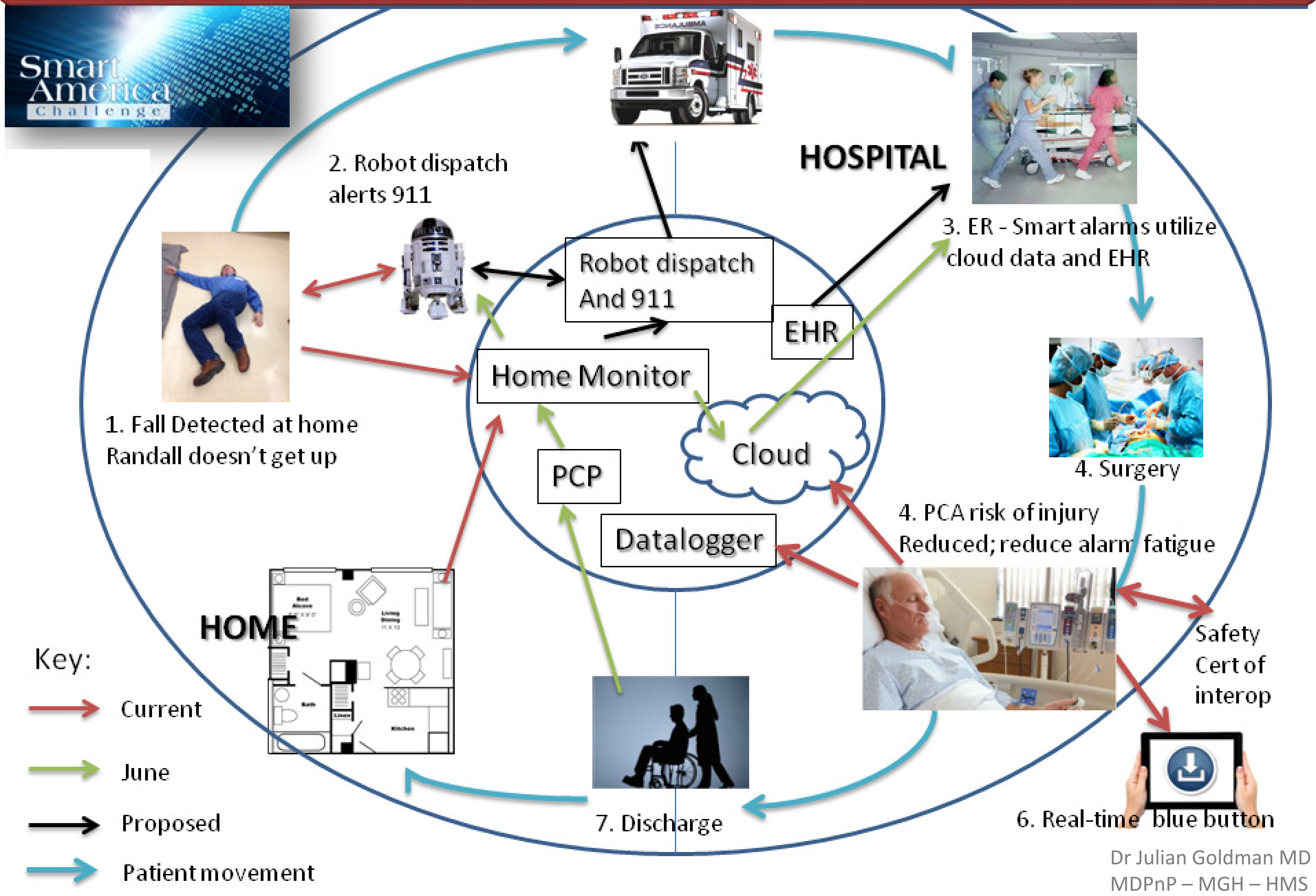
The buzz of "innovation" in healthcare often fails to differentiate between tools and services. Tools and technologies used to deliver healthcare are easy targets for innovation, modularity and scalability. This is innovation in health related tools, ***not healthcare***. Innovation in healthcare is about ***delivery*** of healthcare which is a closed loop management system uniquely focused on one patient (not scalable) and relevant tools must converge at the point of care. The infrastructure (data, transmission, security, privacy) to deliver healthcare may be scalable but innovation to enhance the quality, functionality and reliability of the infrastructure may or may not have an impact on the QoS of healthcare delivery at POC.

Harry at home with hypercholesterolemia : Larry - Do I need Lipitor today?

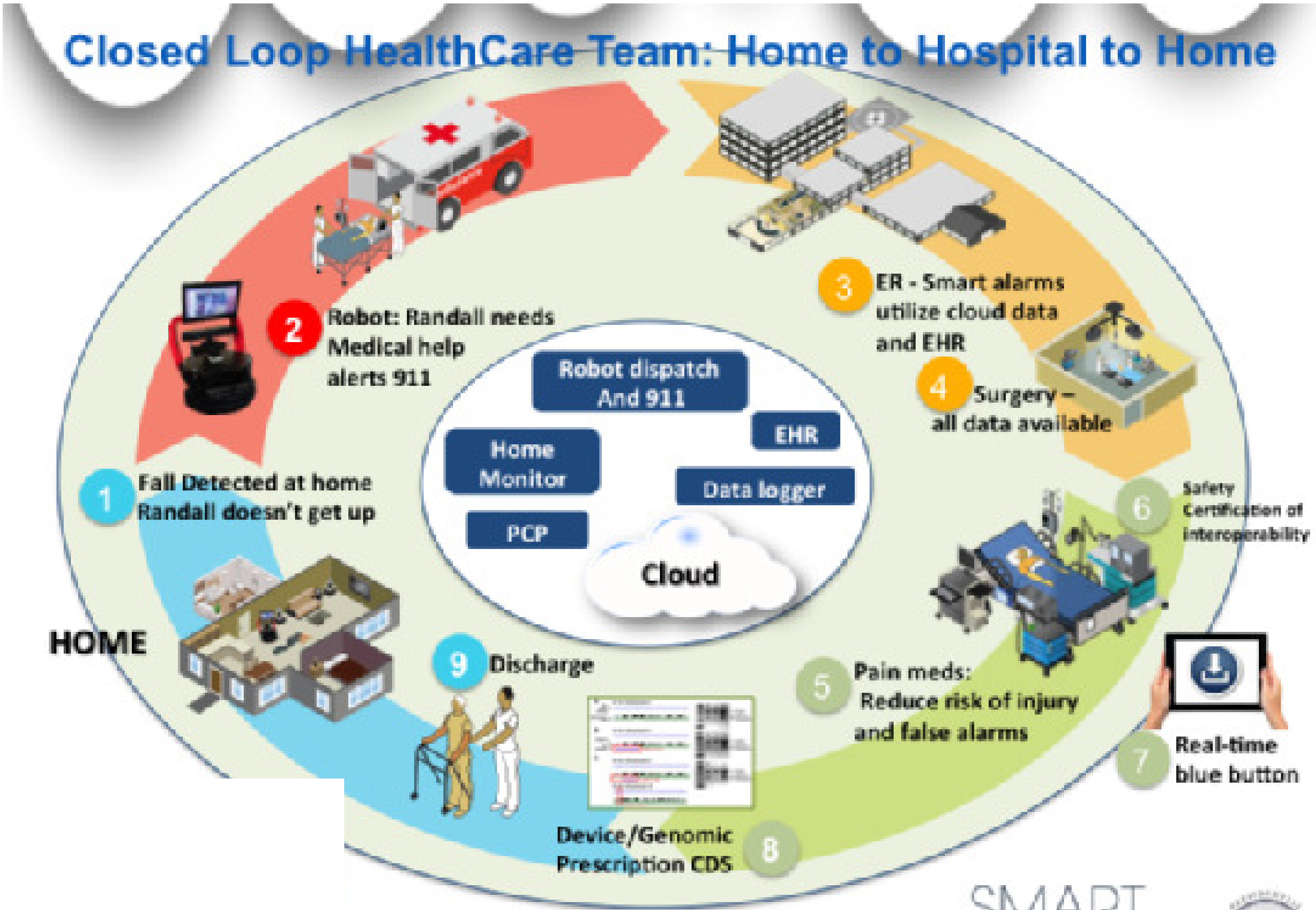


Dr Jameson: Thanks for avoiding KFC. Your LDL-VLDL ratio looks good. No Lipitor today.

Healthcare Management - Fundamentally Closed Loop & Quintessentially Patient Specific



Dr Julian Goldman MD
MDPnP – MGH – HMS



Dr Julian Goldman MD
MDPnP – MGH – HMS


GLOBAL THREAT
WAITING AREA
OBESITY
BIRD FLU
GLOBAL WARMING

Healthcare Management at the Point of Care – Convergent? Transparent? Secure?

Patient Record – can you see the history from a prior visit in a different hospital?
Patient Data – monitoring device data – does it converge on a real time dashboard?
Patient Profile – created specifically using history + device data + genetic background
Patient Symptoms –
Recommended Tests –
Patient Profile – update with symptoms and test data from labs
Patient Diagnosis –
Patient Prescription – link to pharmacy, check for cross reactivity, side effects, allergy
Patient Discharge – follow up plan, outpatient schedule, in-home care plan
or
Patient Hospital Admissions – ward assignment, nurse-physician team, family circle
Patient Progress – tests? surgery? therapy?
Patient Discharge – follow up plan? in-home care? rehab?
Patient Billing – insurance plans, co-payments

To improve the lives of people, the buzz of "innovation" in healthcare must shift from easy targets (tools, wearables, printables) to embrace the (often chaotic) systems perspective to organize, optimize and better orchestrate a seamless delivery of end-to-end healthcare which results in a measurable increase in the quality of life of the patient or person (if applicable to preventative medicine through remote monitoring).

Domain Specific Scenario

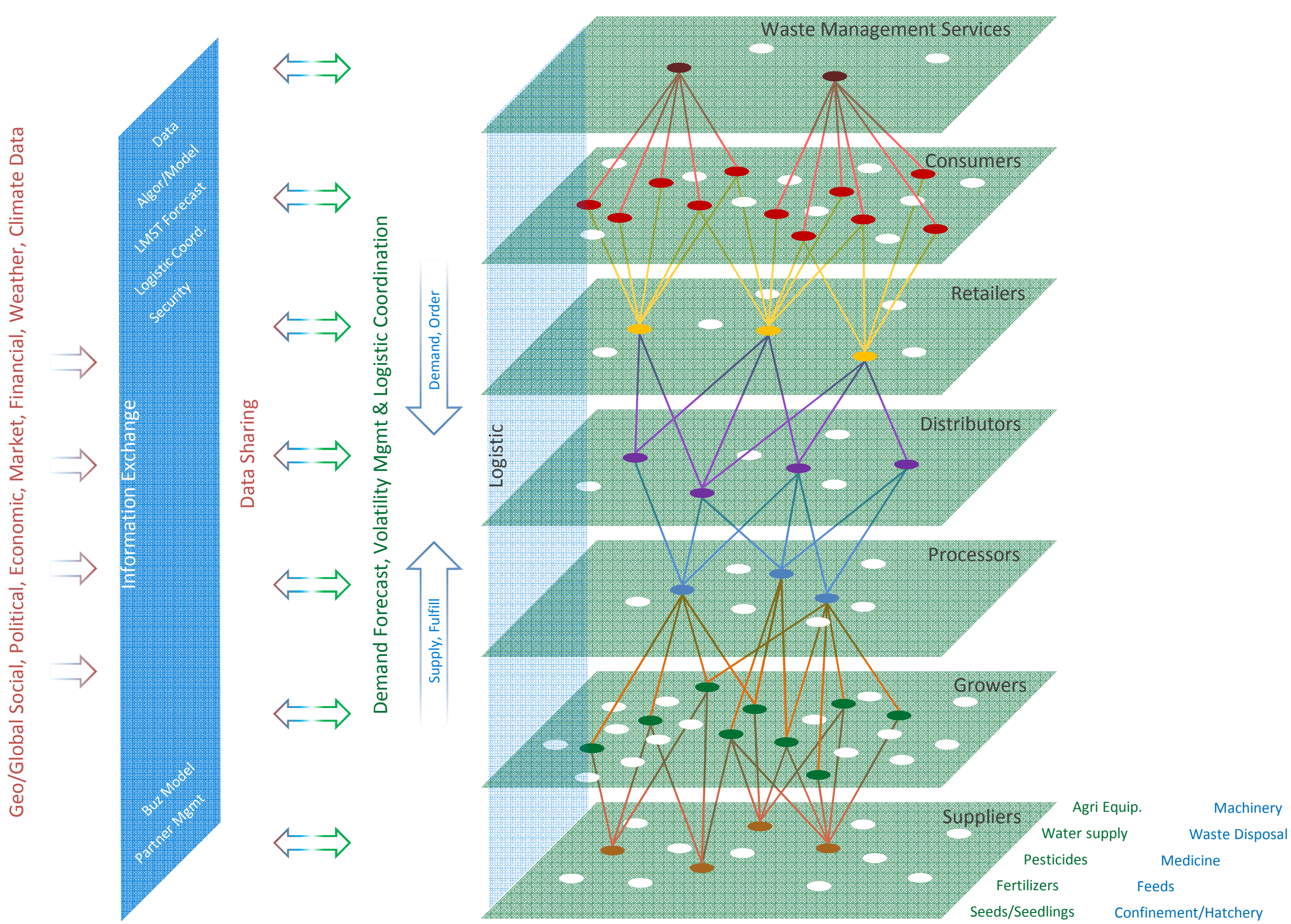
Real Time Precision Farming Platform

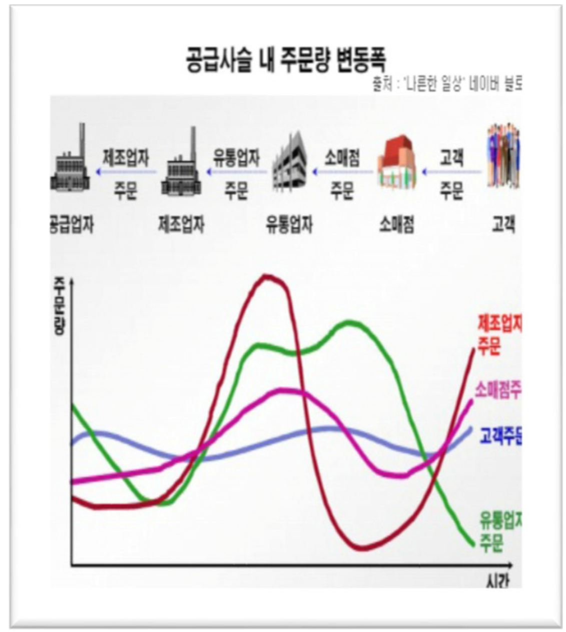
Precision Farming - Supply Network Planning - Decision Systems Support

Value Network	Service Supply Chain	Food Supply Chain	Big Data Economy

Performance: Reduce response time & Avoid out of stock

Cost: Optimize logistic, reduce inventory & avoid over-production





Dr Shi-Wan Lin, Intel

End 2 End Platform - convergence of ecosystem of inter-dependent systems

The potential convergence of Precision Farming ecosystem

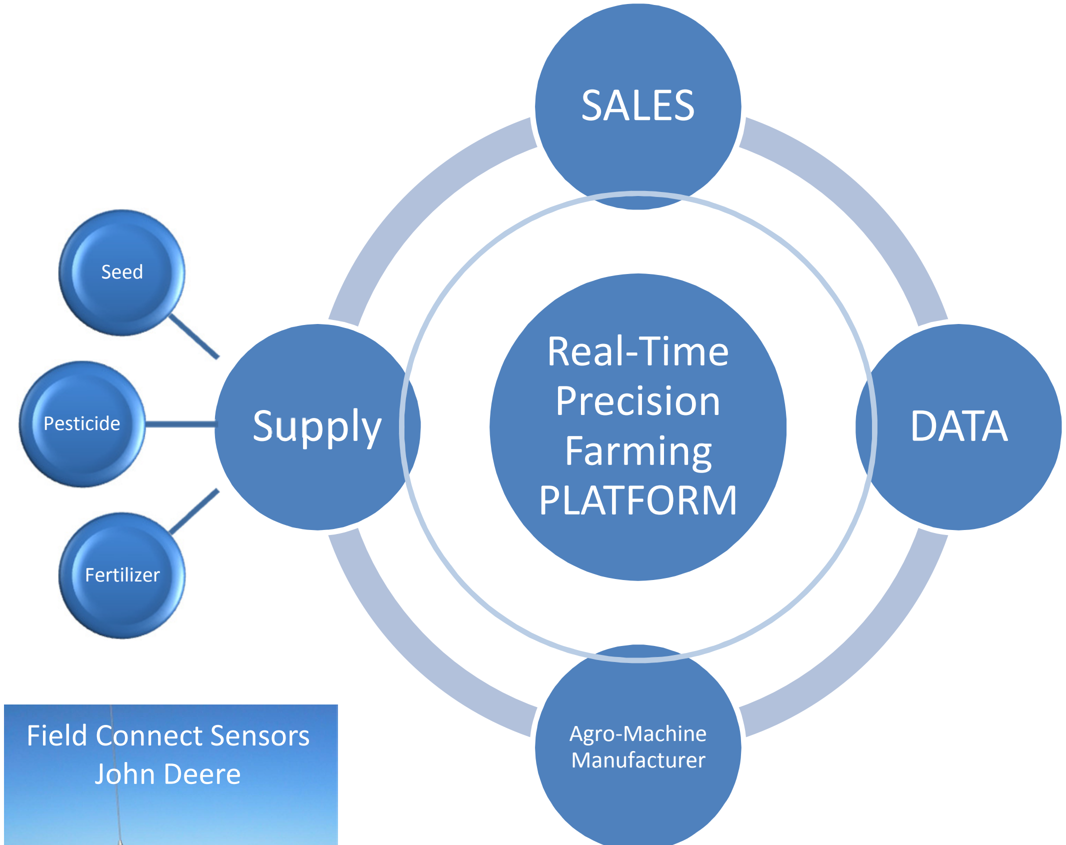
- Seed to Mouth (S2M)
- Farm to Fork (F2F)

with other ecosystems, such as:

- Smart Cities
- Autonomous Transportation and operations management for trusted and secure supply chain network of partners.

Compliance with SOX-409 type regulations and DHS e-manifest are a part of this scenario. Additional links to energy and environmental systems are also obvious. Food safety, security, nutrition, availability and consumption are inextricably linked with global health, malnutrition, infant mortality and healthcare, in general.

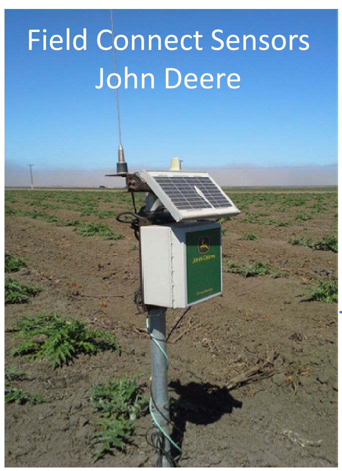
Retail Supply Chain – Sourcing / Distribution / Warehouse / Transportation
Track & Trace – Commodity Traders – Risk Management – Regulators (FDA)



-Measure, understand and apply
-Impact of data on quality & yield

-Weather data
-GPS micro-localization data
-Soil chemistry (GCMS) specifics
-Seed (sterile unless cultivated)
-Fertilizers (catalytic vs toxicity)
-Protection (pesticide, herbicide)
-Storage, shelf-life and waste
-Country of origin - goods supply

Leverage data to run long and short term simulations to plan for "what if" to optimize profit
- Weather patterns
- Demand uncertainty
- Export and import
- Tariff, cost, excise
- Regulatory policy



- Optimize MRO to improve asset uptime
- Mobile data collection and dissemination
  - soil sample / nutrient analysis (GCMS)
  - moisture monitors / field connect data
  - temperature / dielectric constant
  - color and chemistry of crops
  - growth rate / fertilizer distribution
  - weather micro-impact / acidity-alkalinity

Farming in California alone is a $50 billion industry

TEST BED DEVELOPMENT

[1] Create Scenario

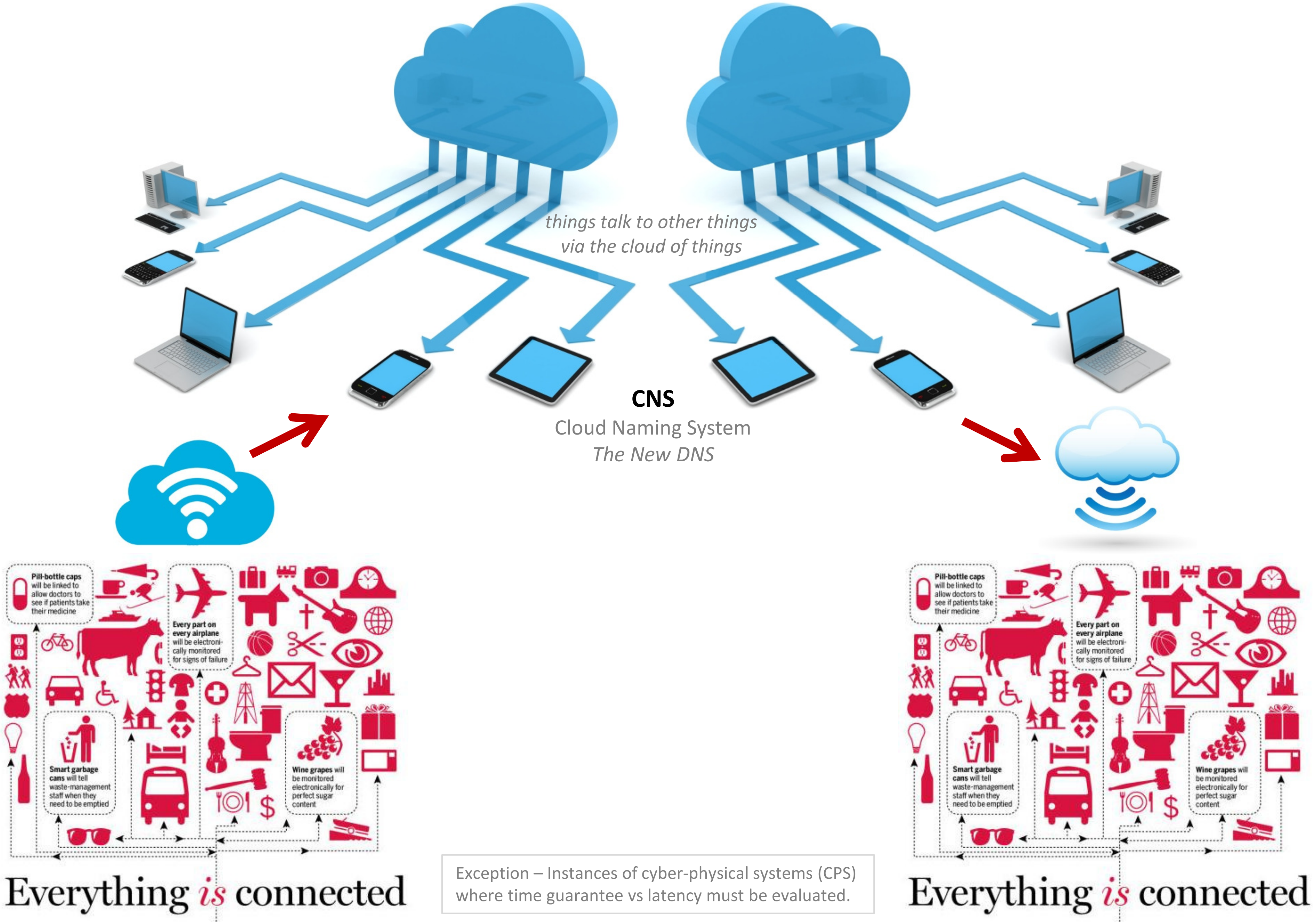
[2] Architecture

[3] Stack (Data)

Architectures to Connect

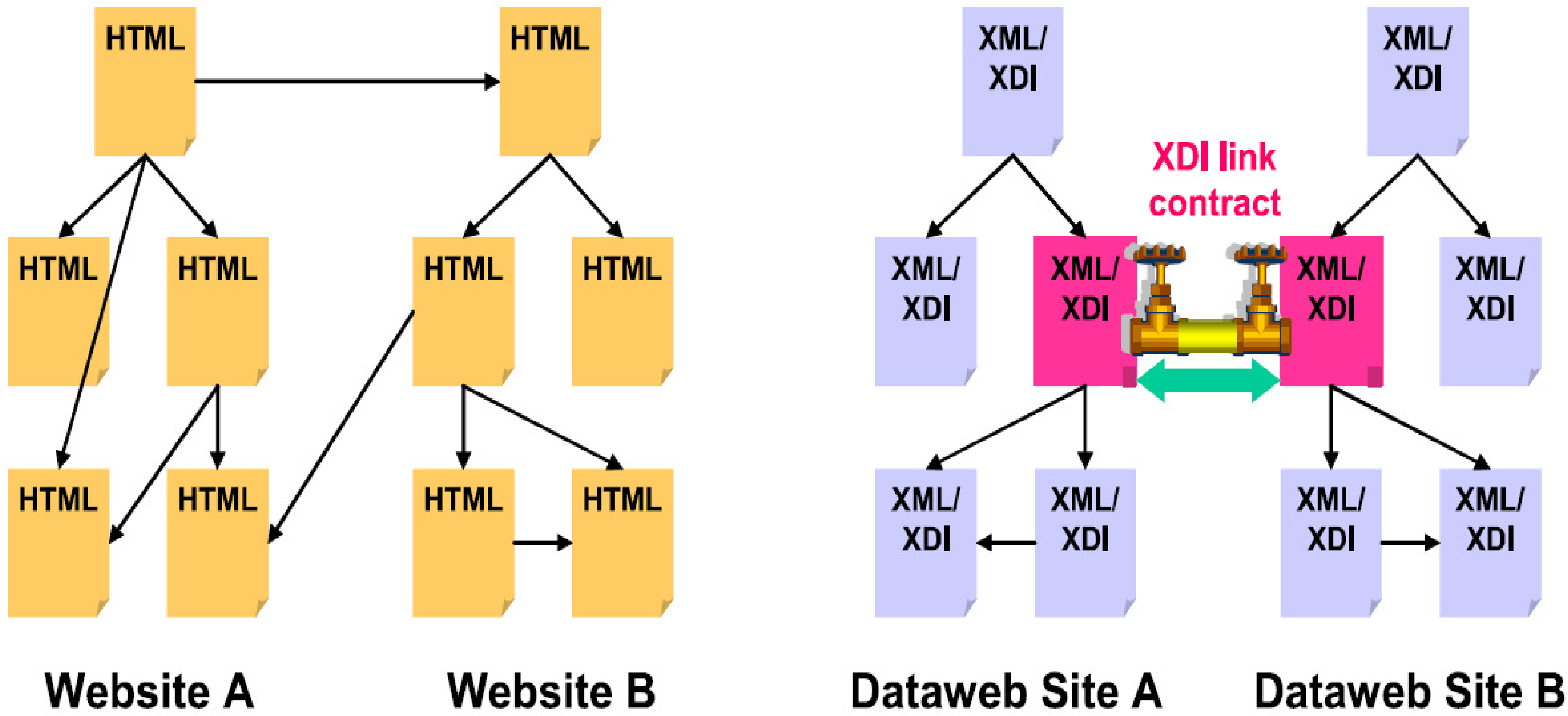
The operational key of the Industrial Internet depends on [1] Architecture and [2] Data (Stack Structure)

The Industrial Internet – Internet of Things (IoT) – Internet of Everything (IoE) – Cloud of Things



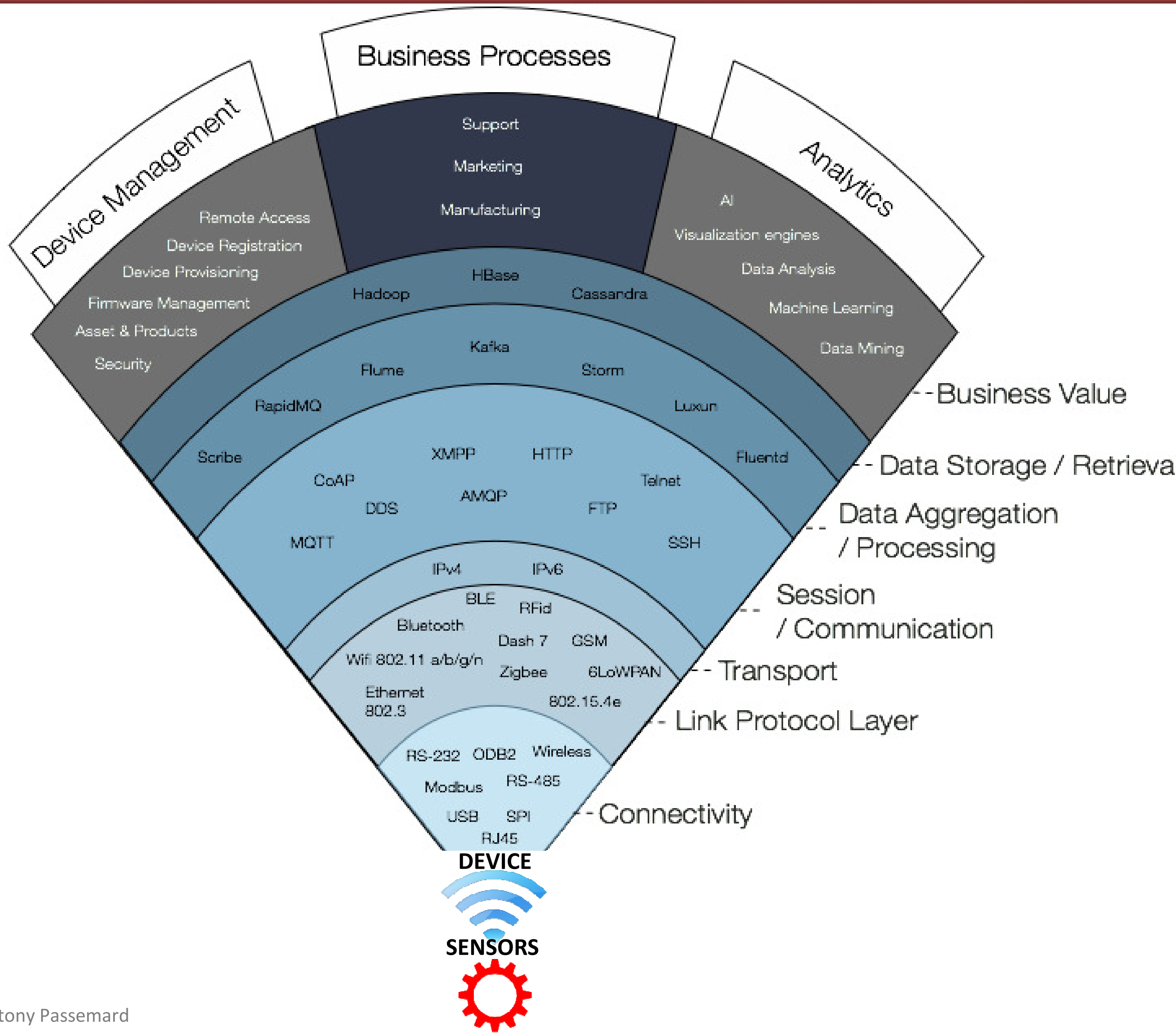
Exception – Instances of cyber-physical systems (CPS) where time guarantee vs latency must be evaluated.

Sharing Data circa 2004



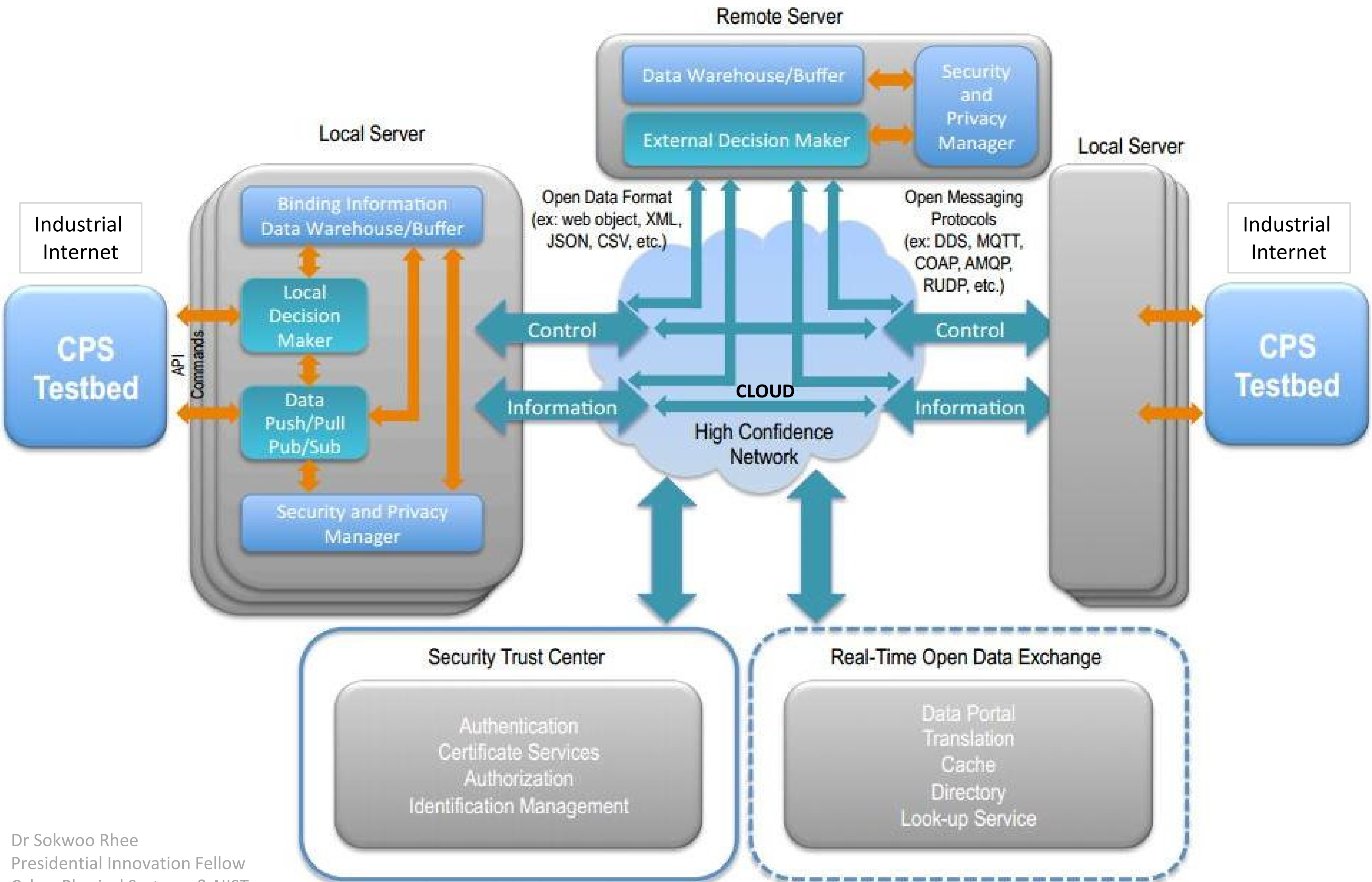
www.oasis-open.org/committees/download.php/6434/wd-xdi-intro-white-paper-2004-04-12.pdf
www.oasis-open.org/committees/tc_home.php?wg_abbrev=xdi

A Version of Potential Protocol Landscape for The Industrial Internet – Internet of Things (IoT)



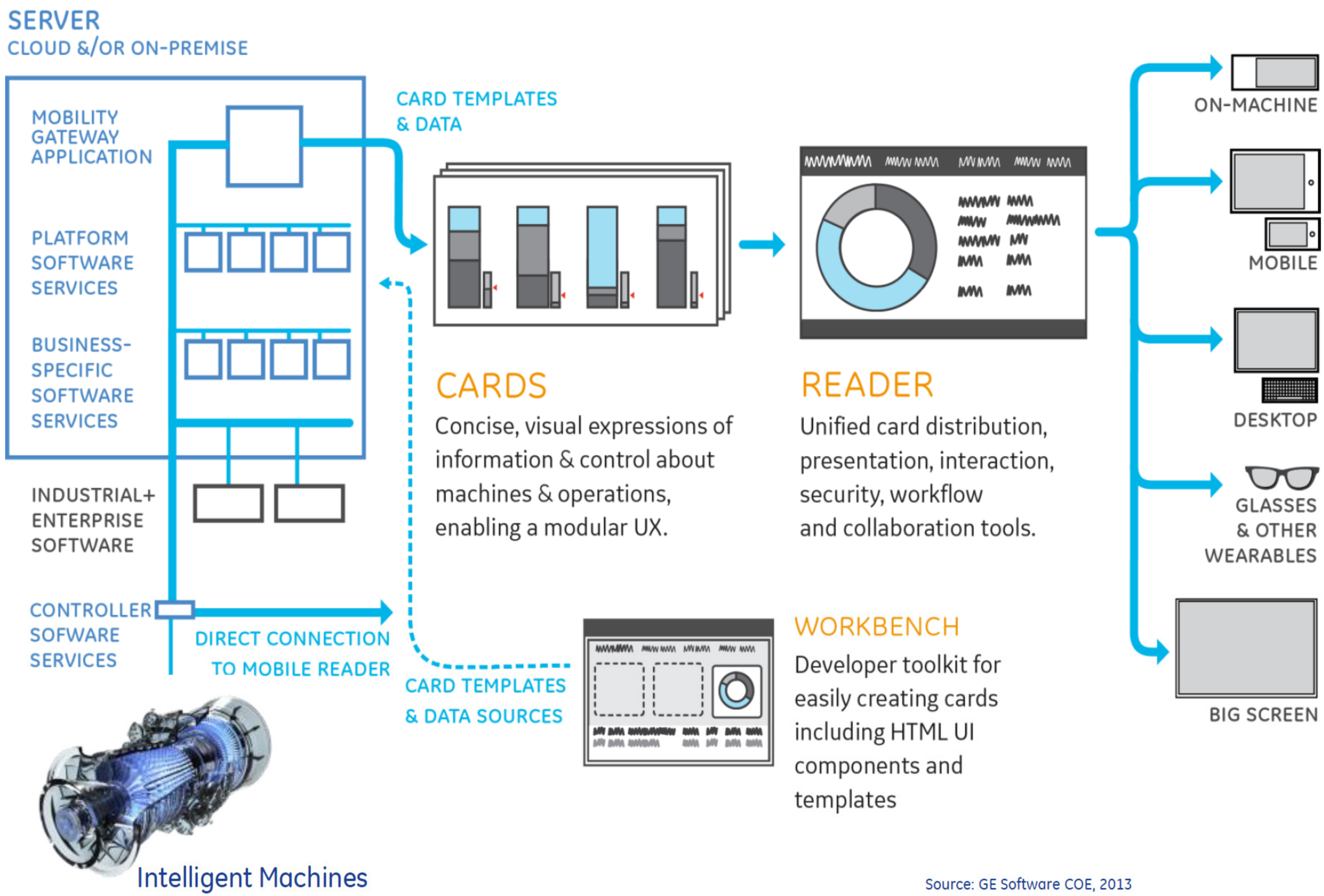
Adapted from Antony Passemard

Industrial Internet Architecture – CyberPhysical Systems Perspective



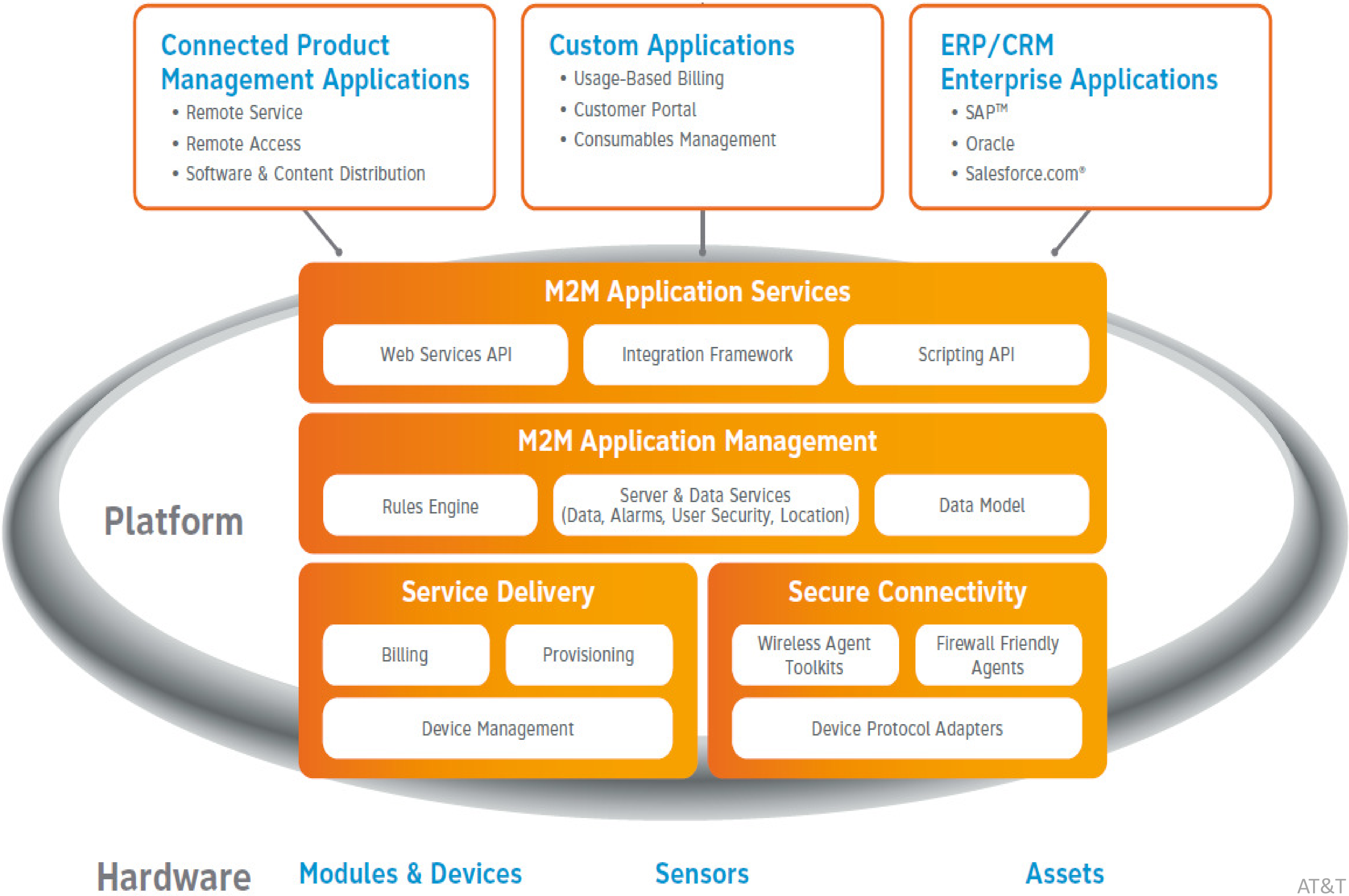
Dr Sokwoo Rhee
Presidential Innovation Fellow
Cyber-Physical Systems & NIST

Industrial Internet – The Man-Machine Integration and Connection



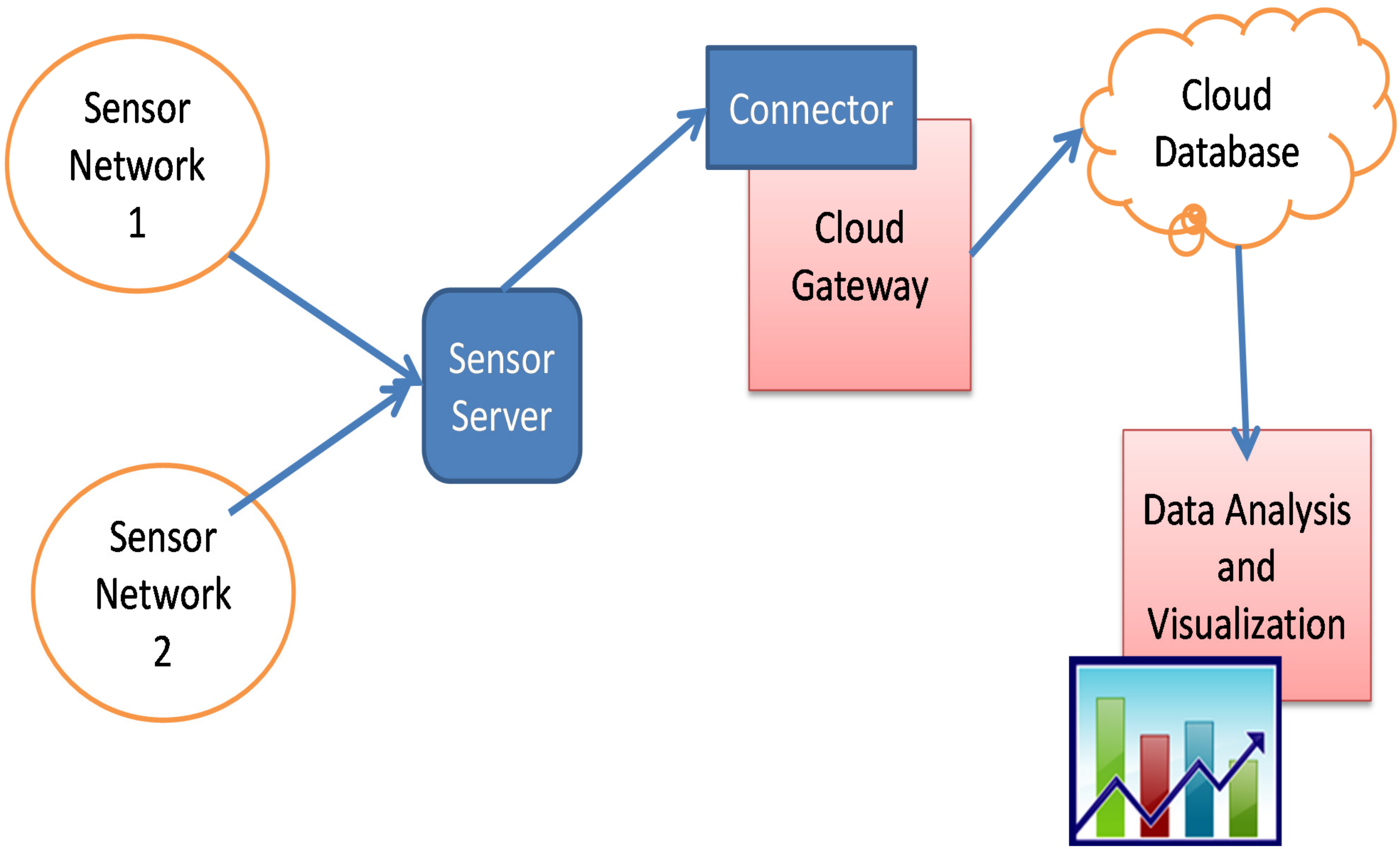
Source: GE Software COE, 2013

Choice of Platforms – Machine 2 Machine (M2M) Perspective

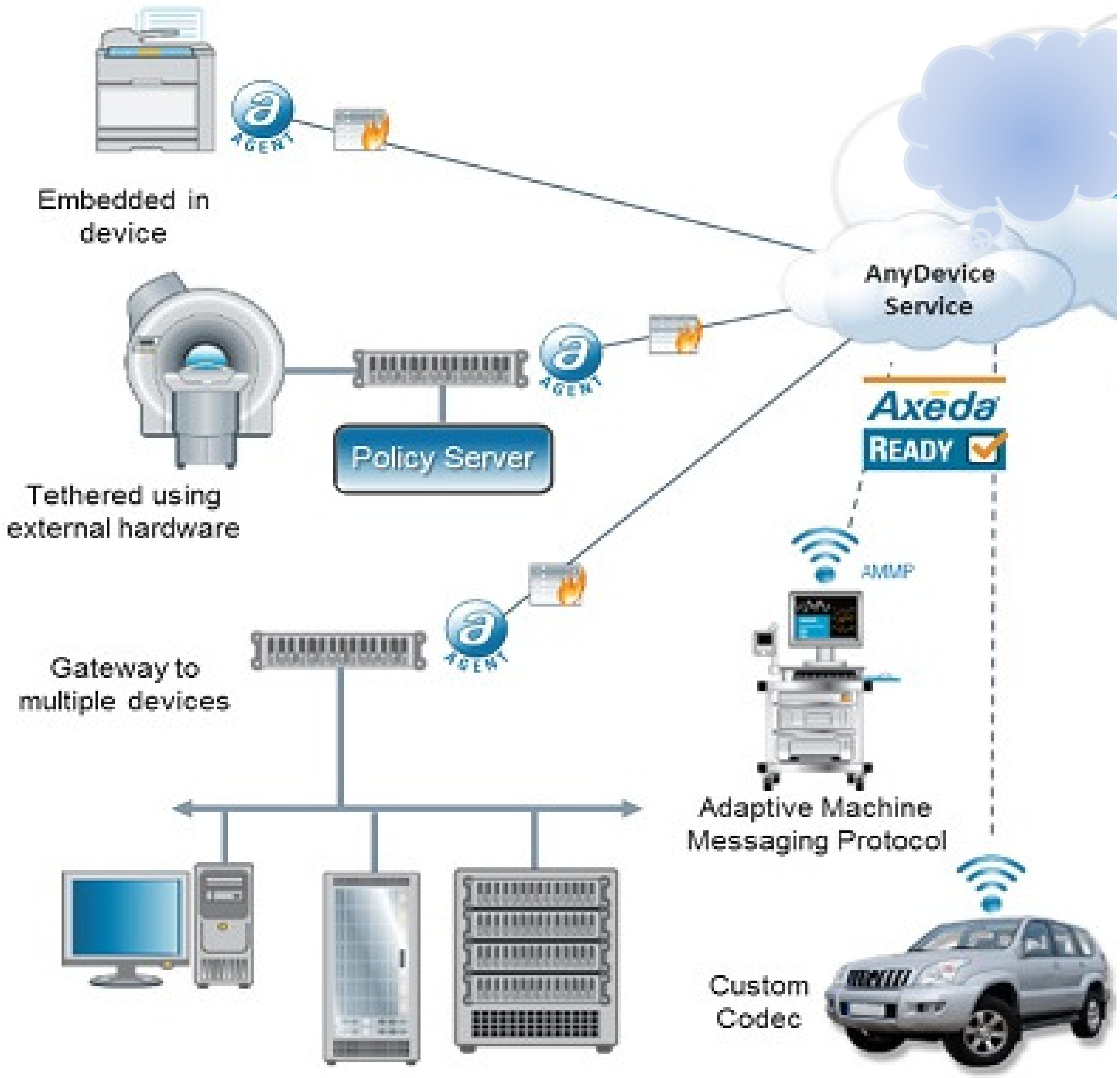


AT&T

Cloud of Sensors



More Clouds


Embedded in device
AGENT
AnyDevice Service
Tethered using external hardware
Policy Server
Axeda READY
AMMP
Gateway to multiple devices
Adaptive Machine Messaging Protocol
Custom Codec

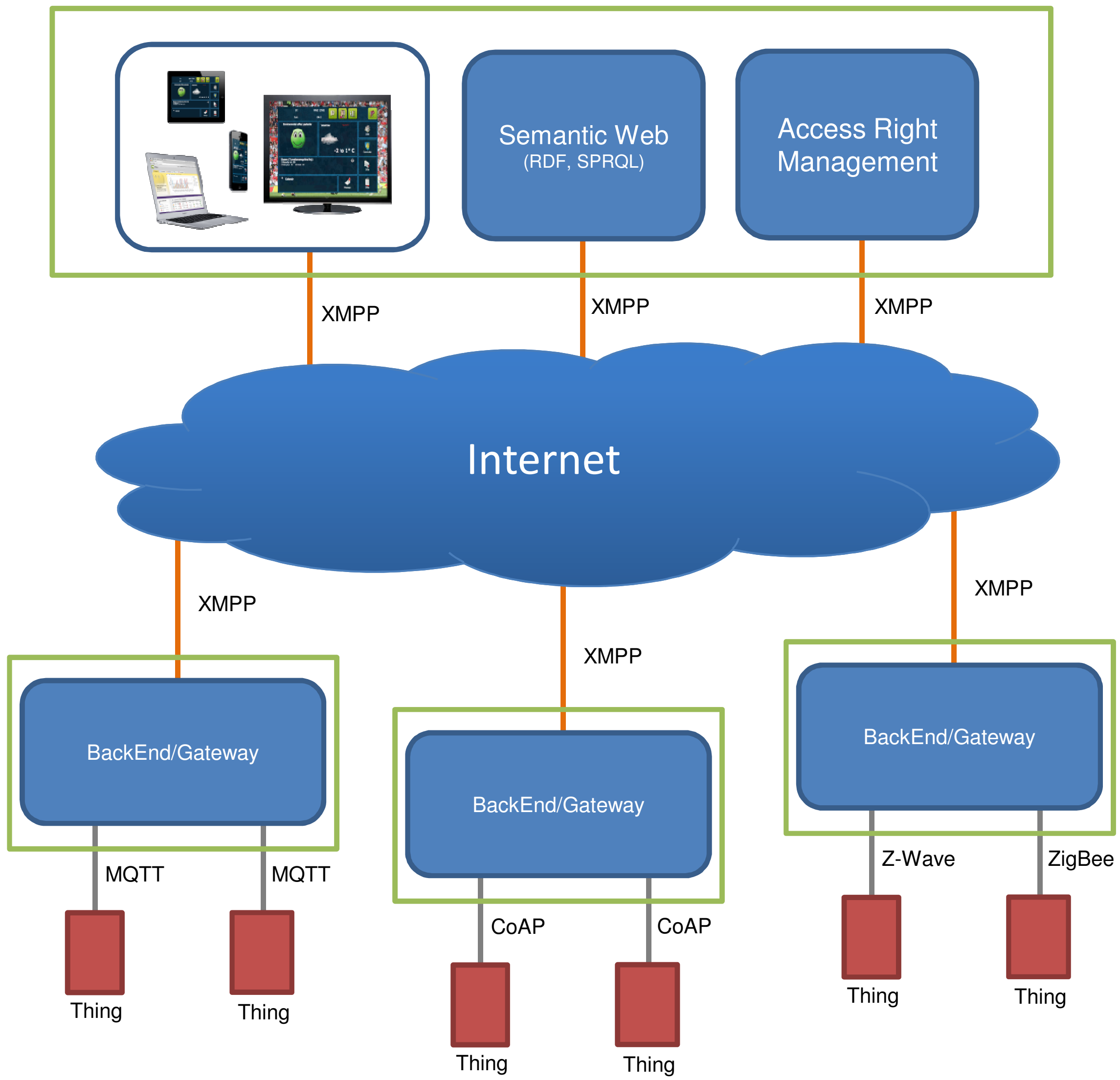
Choice of Platforms – IoT Perspective

- What is the definition of an IoT platform?
- What is driving the business need for IoT platform?
- What security and privacy features are essential?
- What connectivity and device management features are critical?
- How will the platform process, store and integrate data from machines and sensors?
- How will the platform manage software and variant configurations on devices?
- What development and integration tools will be necessary?

XMPP Approach

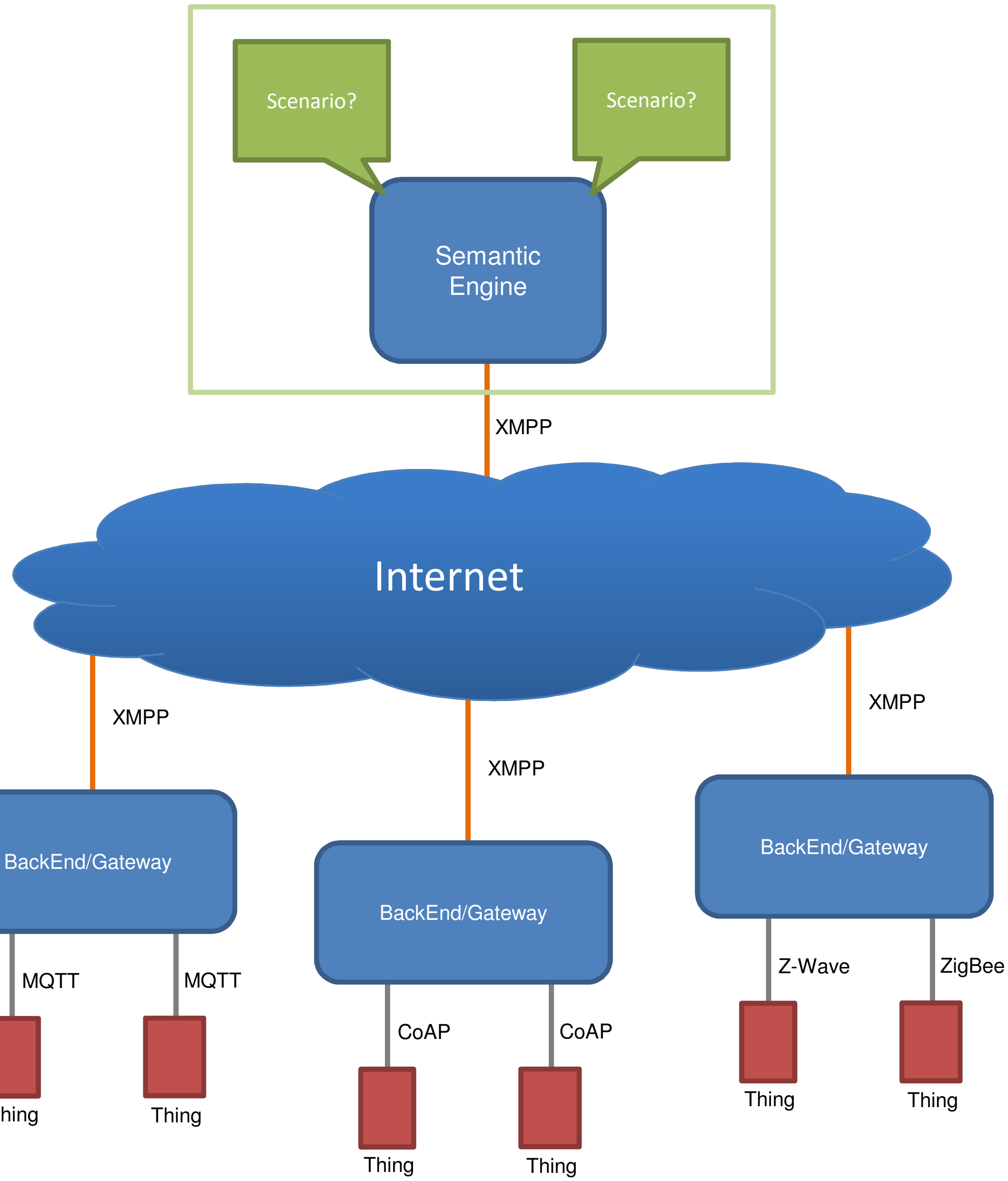
Extensible Messaging and Presence Protocol (XMPP) is a communications protocol for message-oriented middleware based on Extensible Markup Language (XML). The protocol was originally named Jabber. It was developed by the Jabber open-source community (1999) for near real-time, instant messaging (IM), presence information, and contact list maintenance. Designed to be extensible, the protocol has also been used for publish-subscribe systems, signaling for VoIP, video, file transfer, gaming and IoT applications (smart grid, social networking services).

XMPP Approach



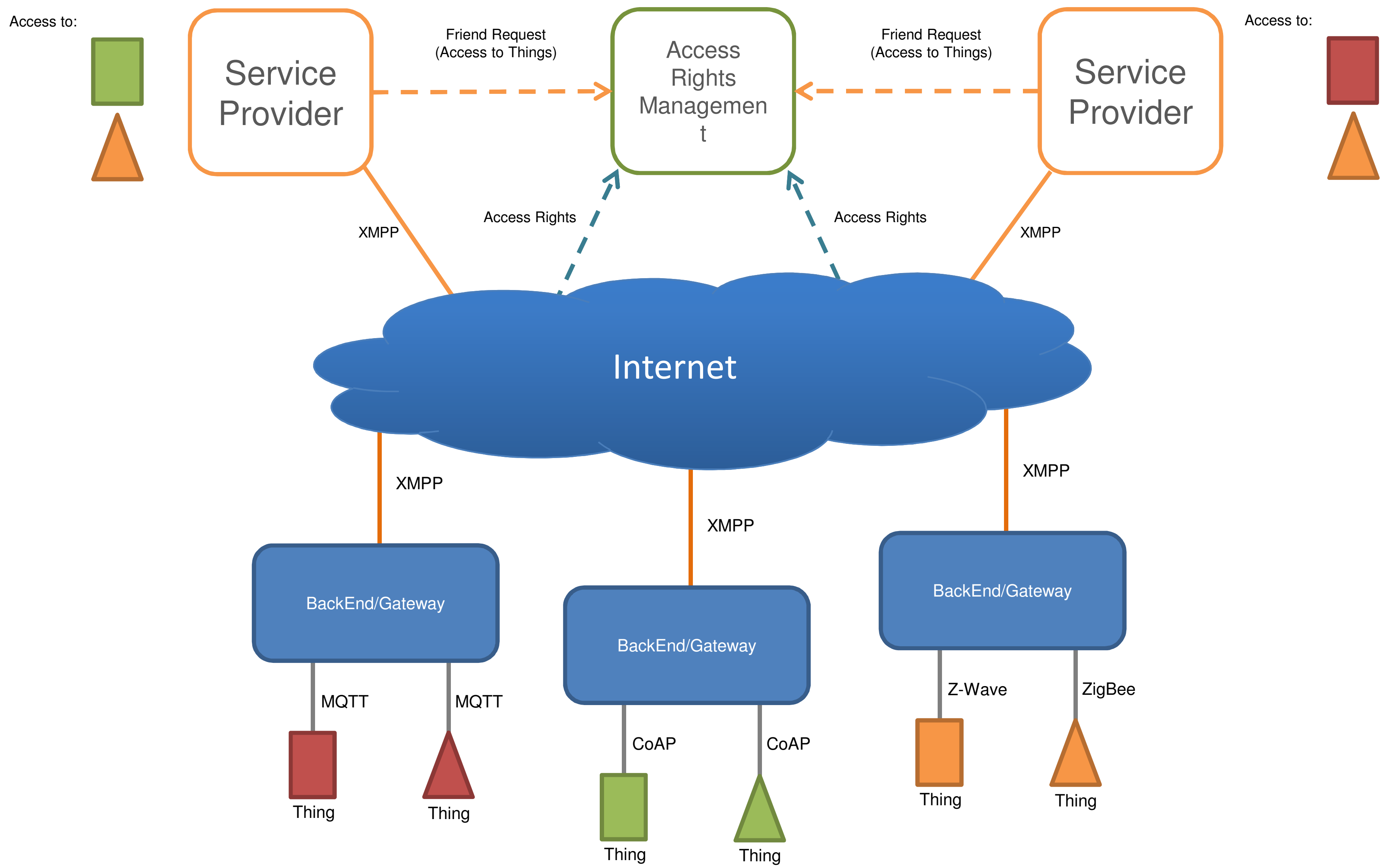
CLAYSTER

XMPP Approach



CLAYSTER

XMPP Approach

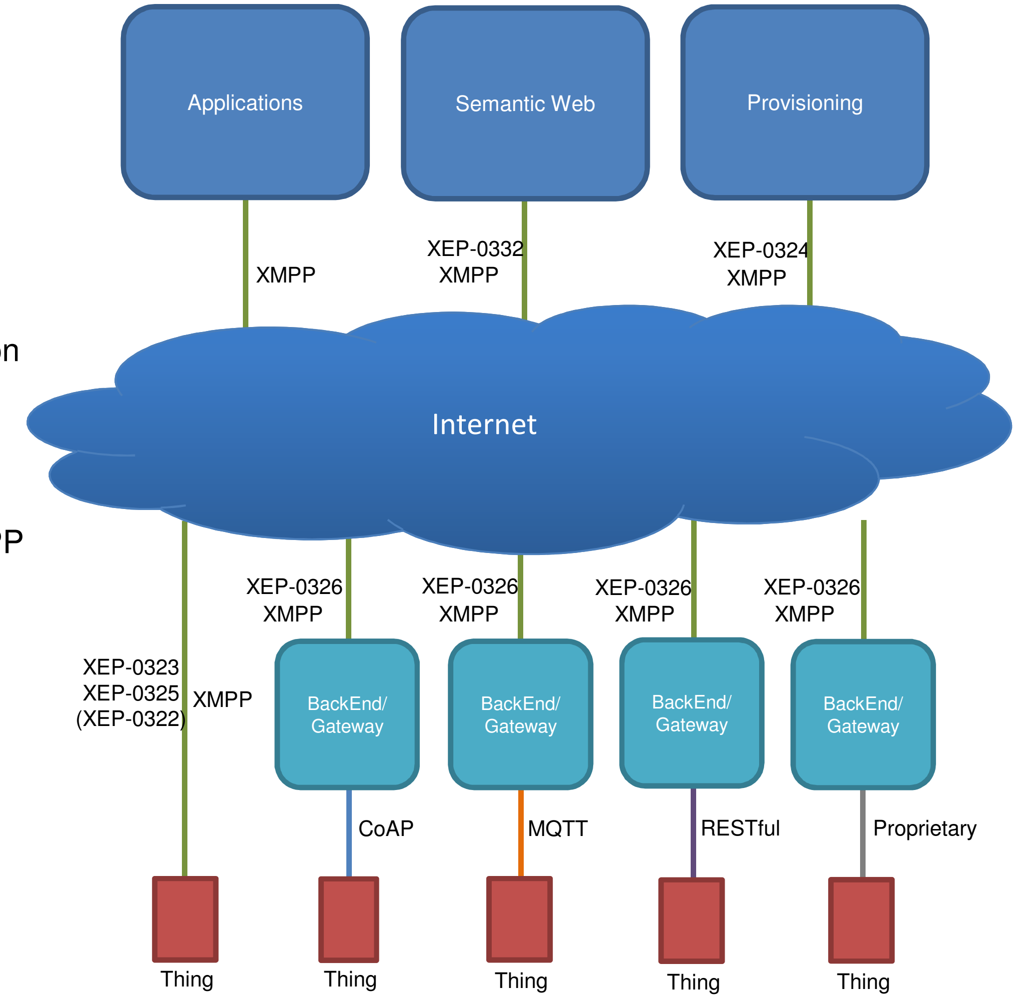


CLAYSTER

XMPP Approach

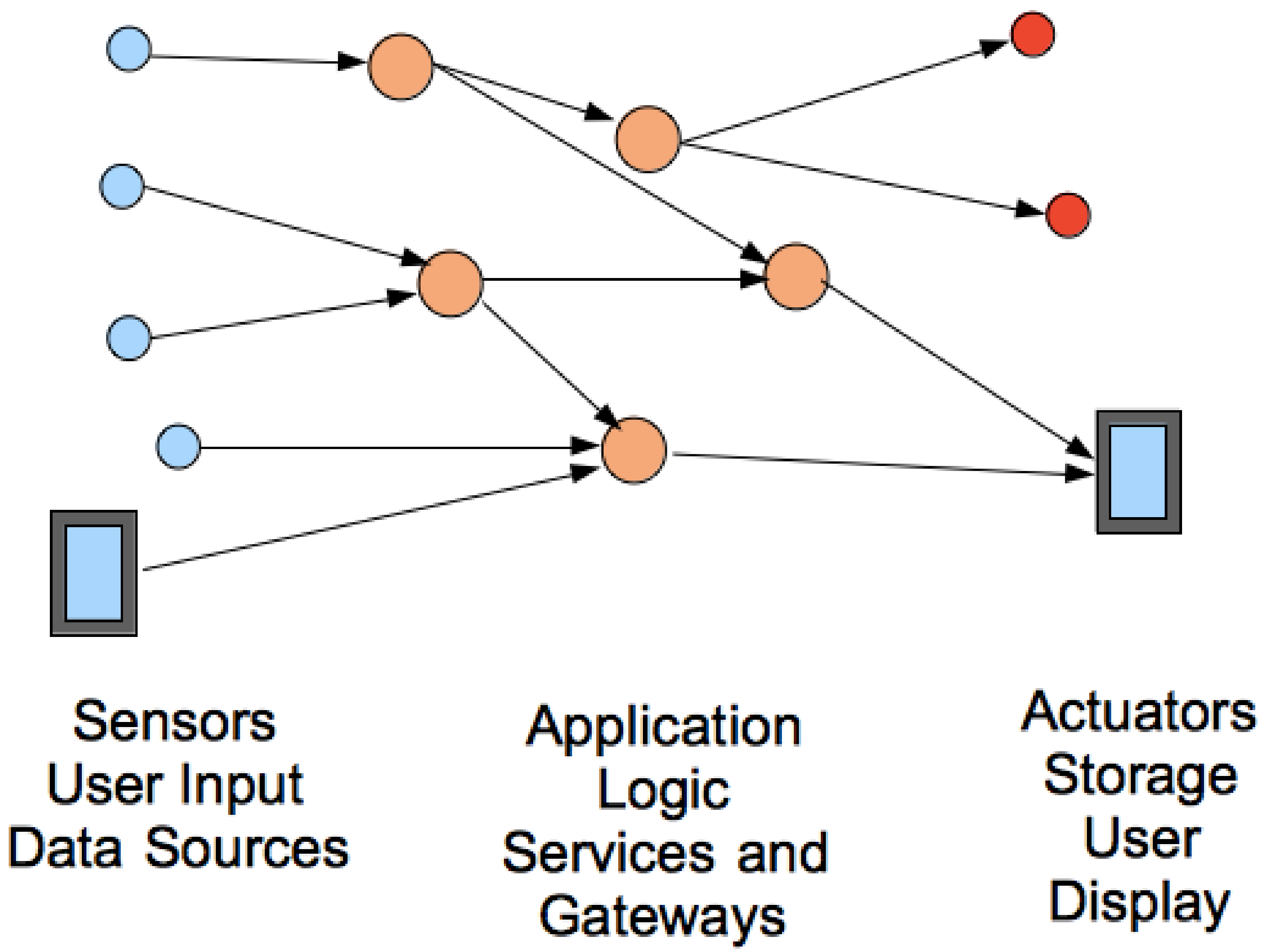
Sensei/IoT P21451-1-4

XEP-0322 – EXI Compression
XEP-0323 – Sensor Data
XEP-0324 – Provisioning
XEP-0325 – Control
XEP-0326 – Concentrator
XEP-0332 – HTTP over XMPP



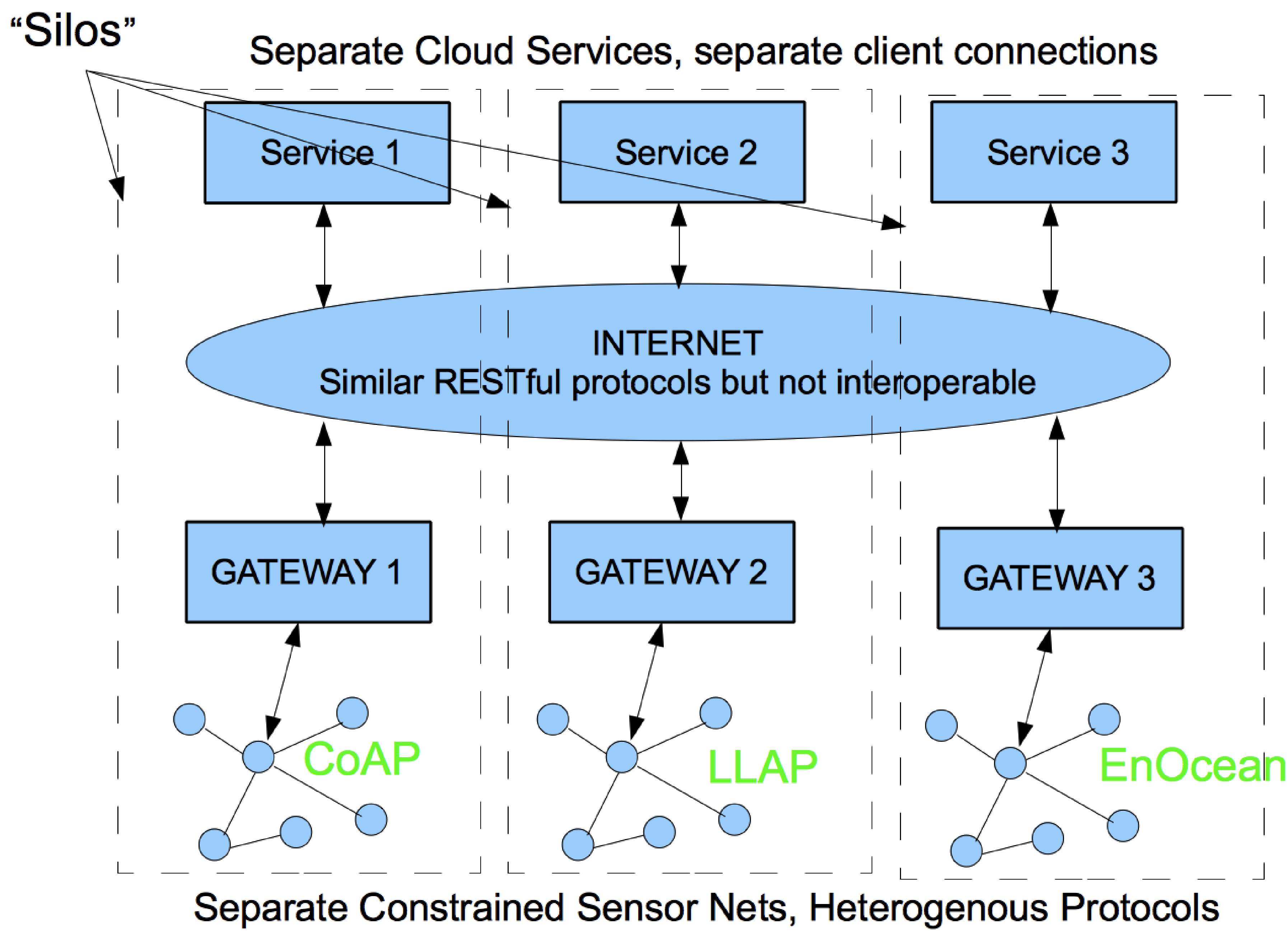
CLAYSTER

IoT Application

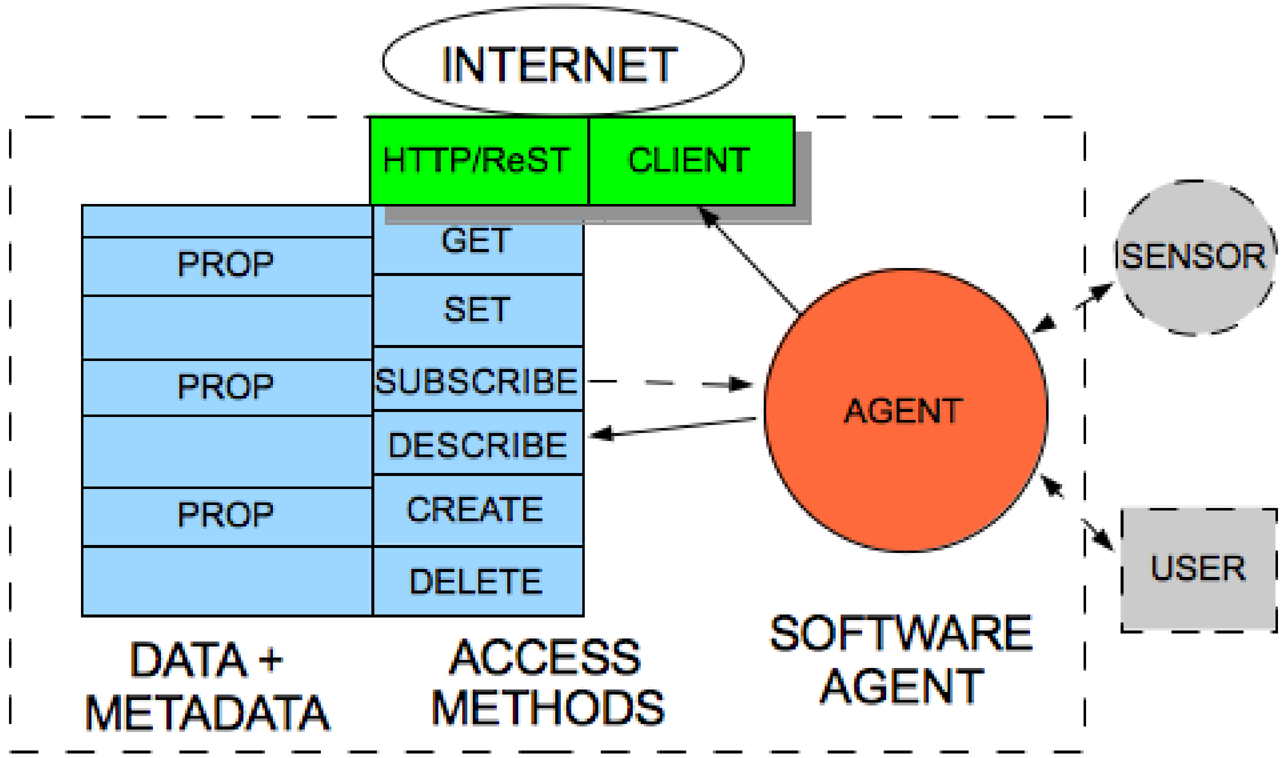


Application as a graph

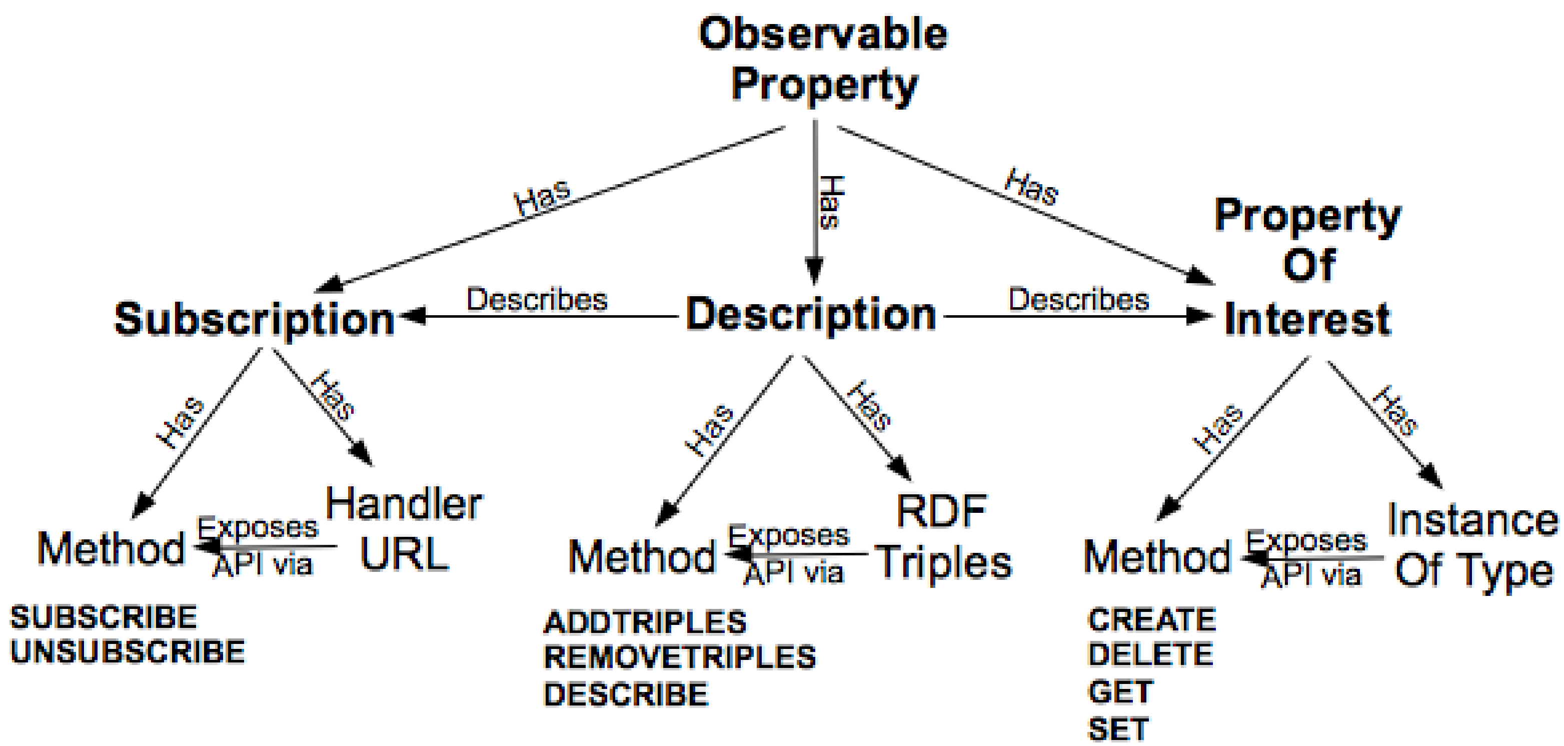
Elements of IoT Architecture



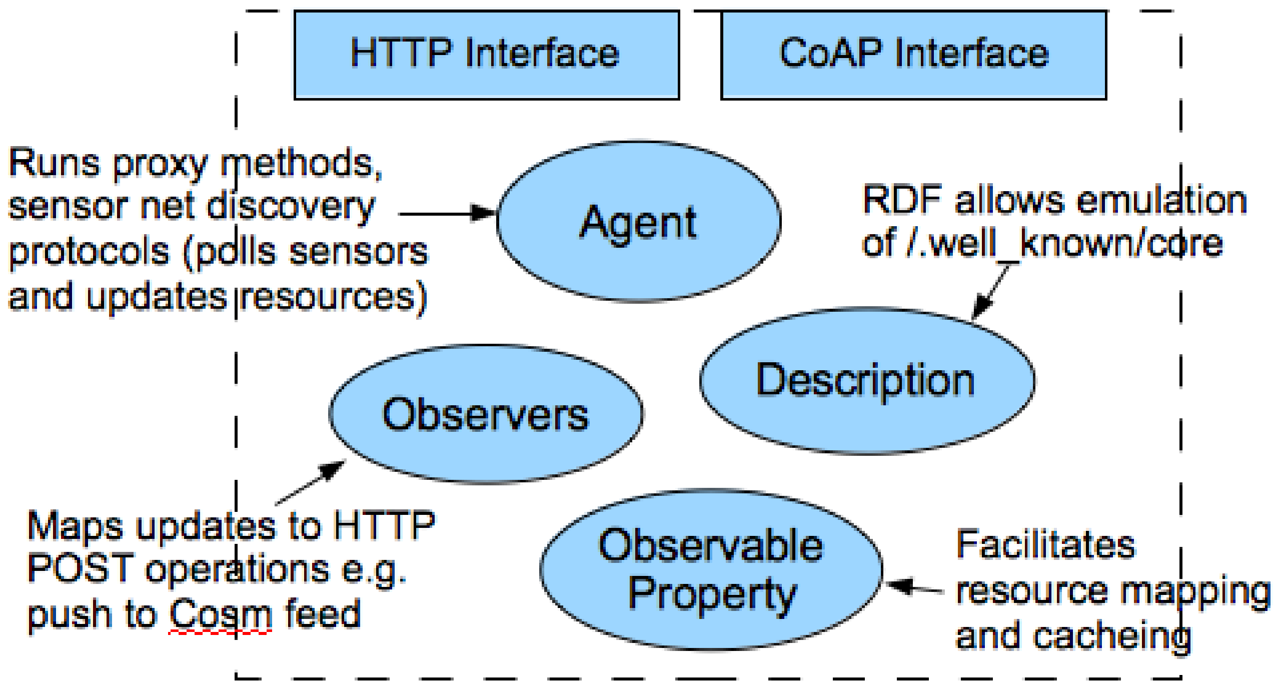
Elements of IoT Architecture



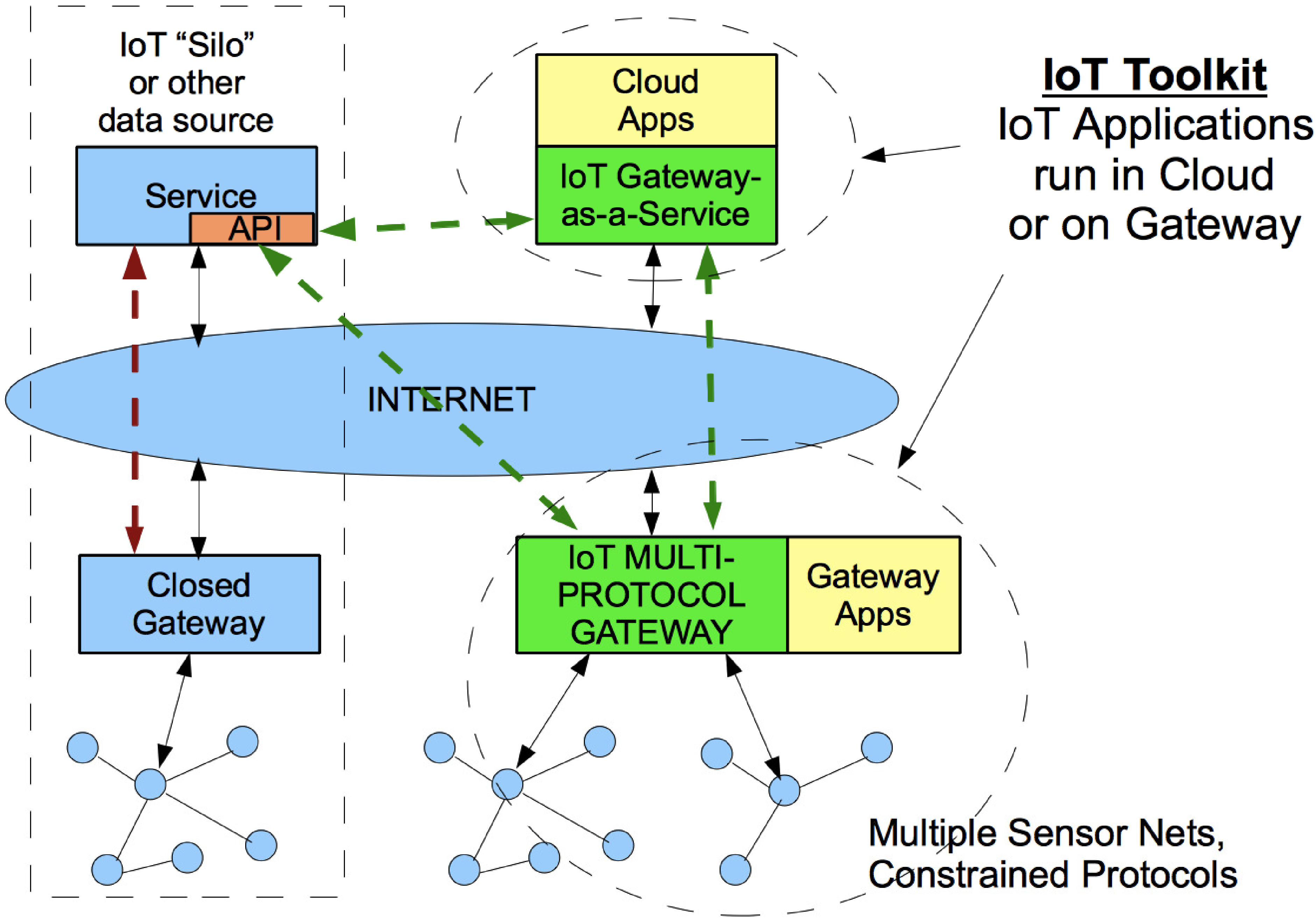
Elements of IoT Architecture



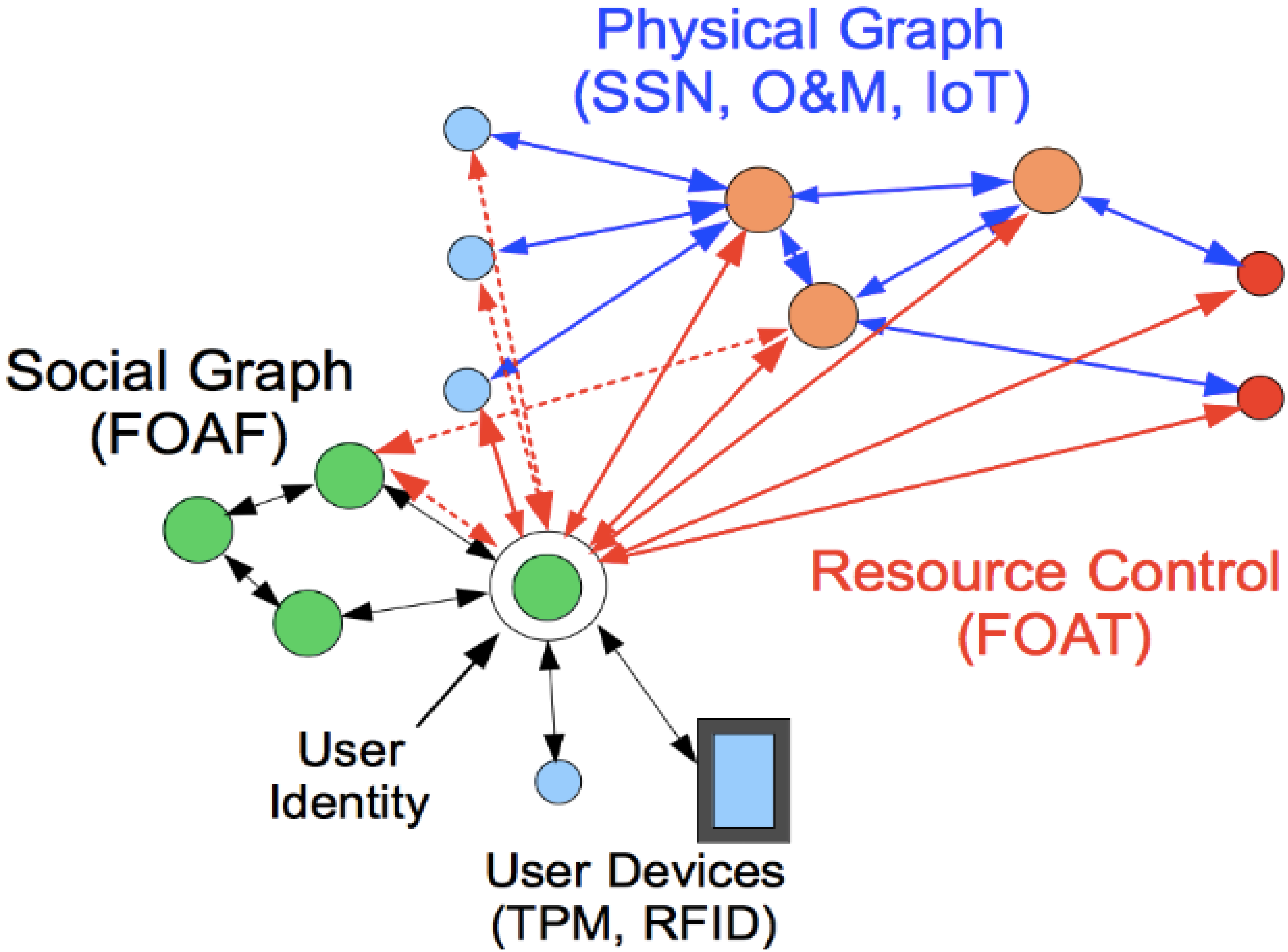
Elements of IoT Architecture



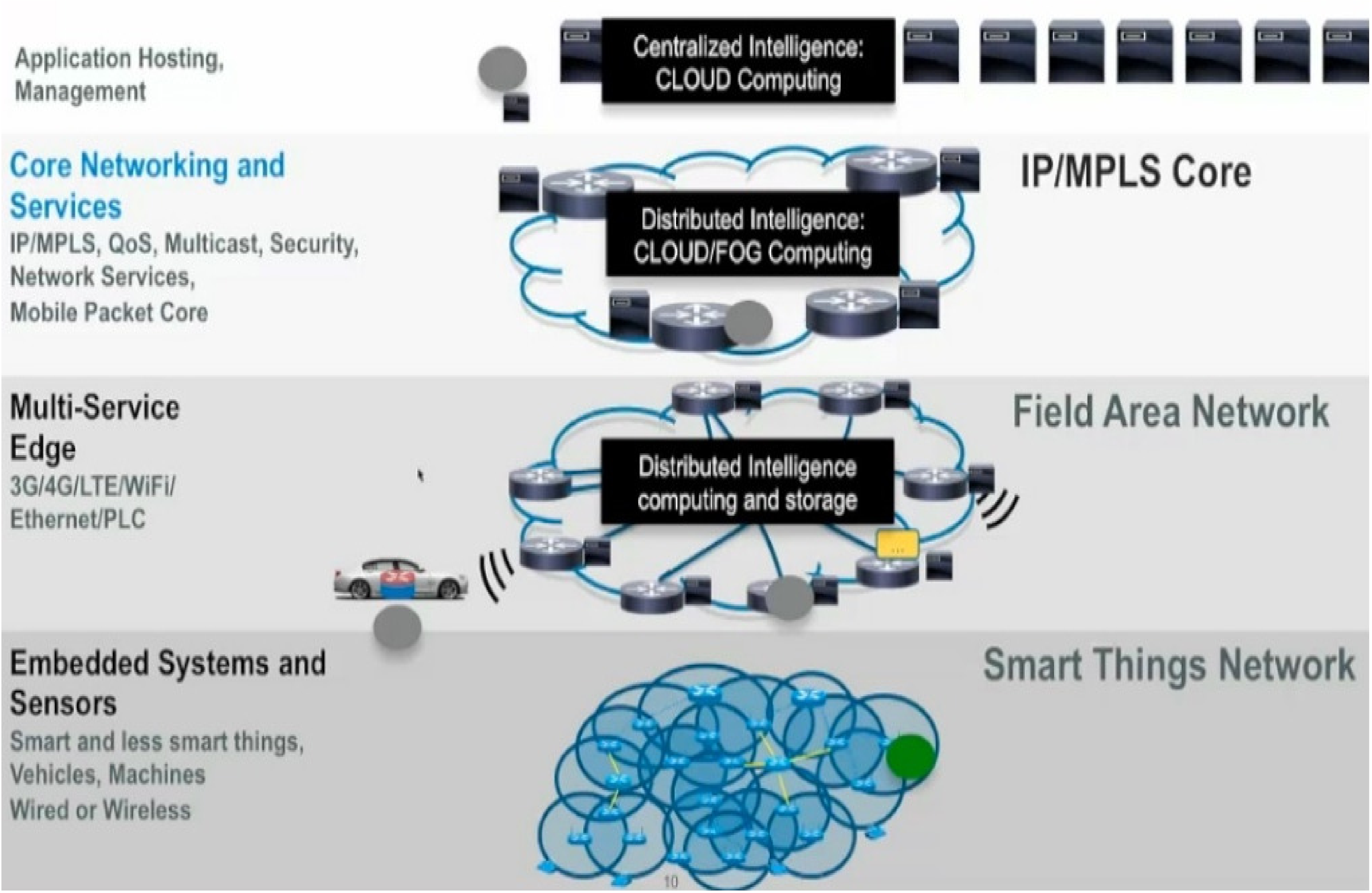
Elements of IoT Architecture



Elements of IoT Architecture

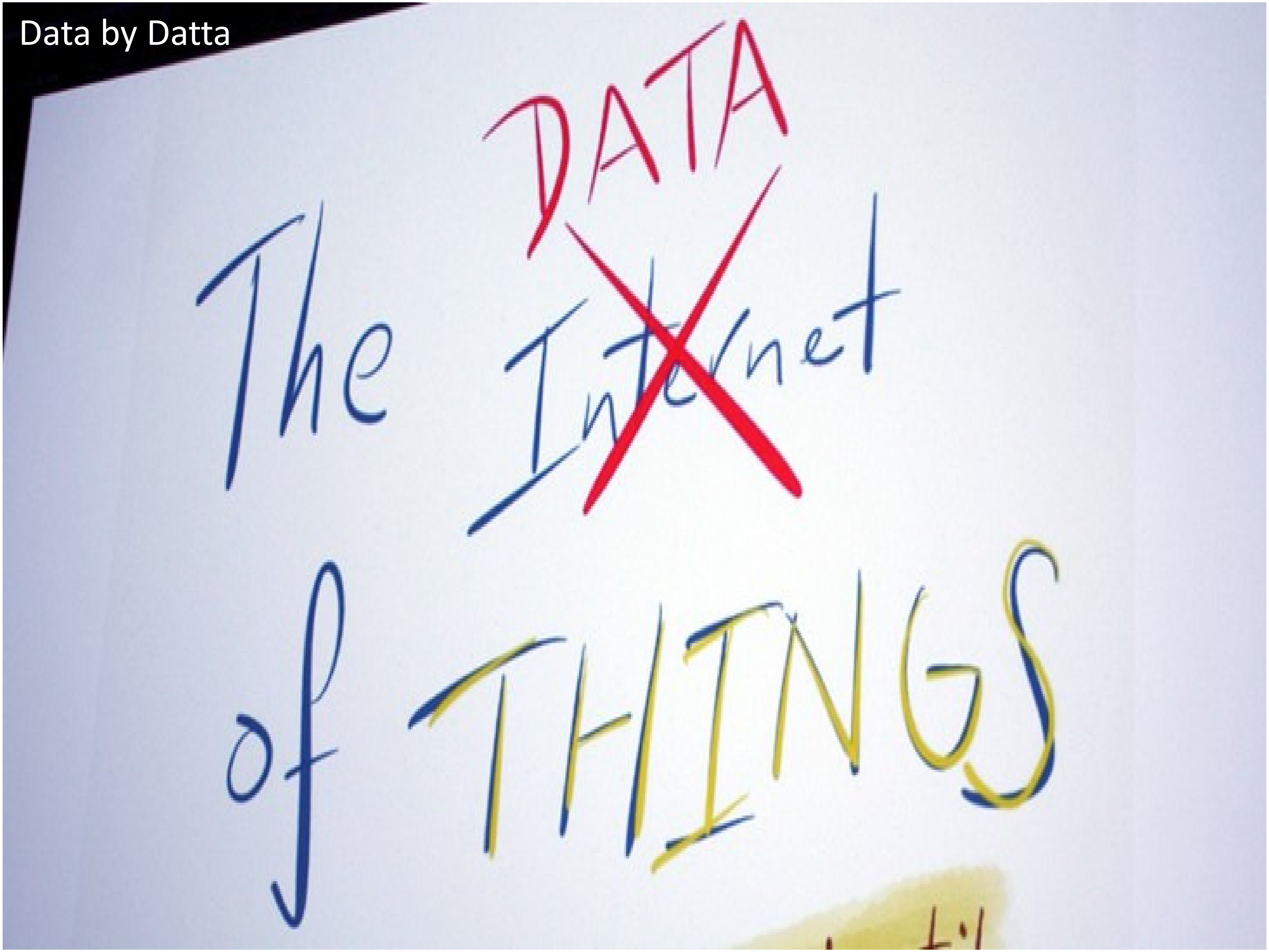


Elements of IoT Architecture – JP Vasseur, Cisco Systems



OK … we have a connected Industrial Internet. It is generating …

DATA

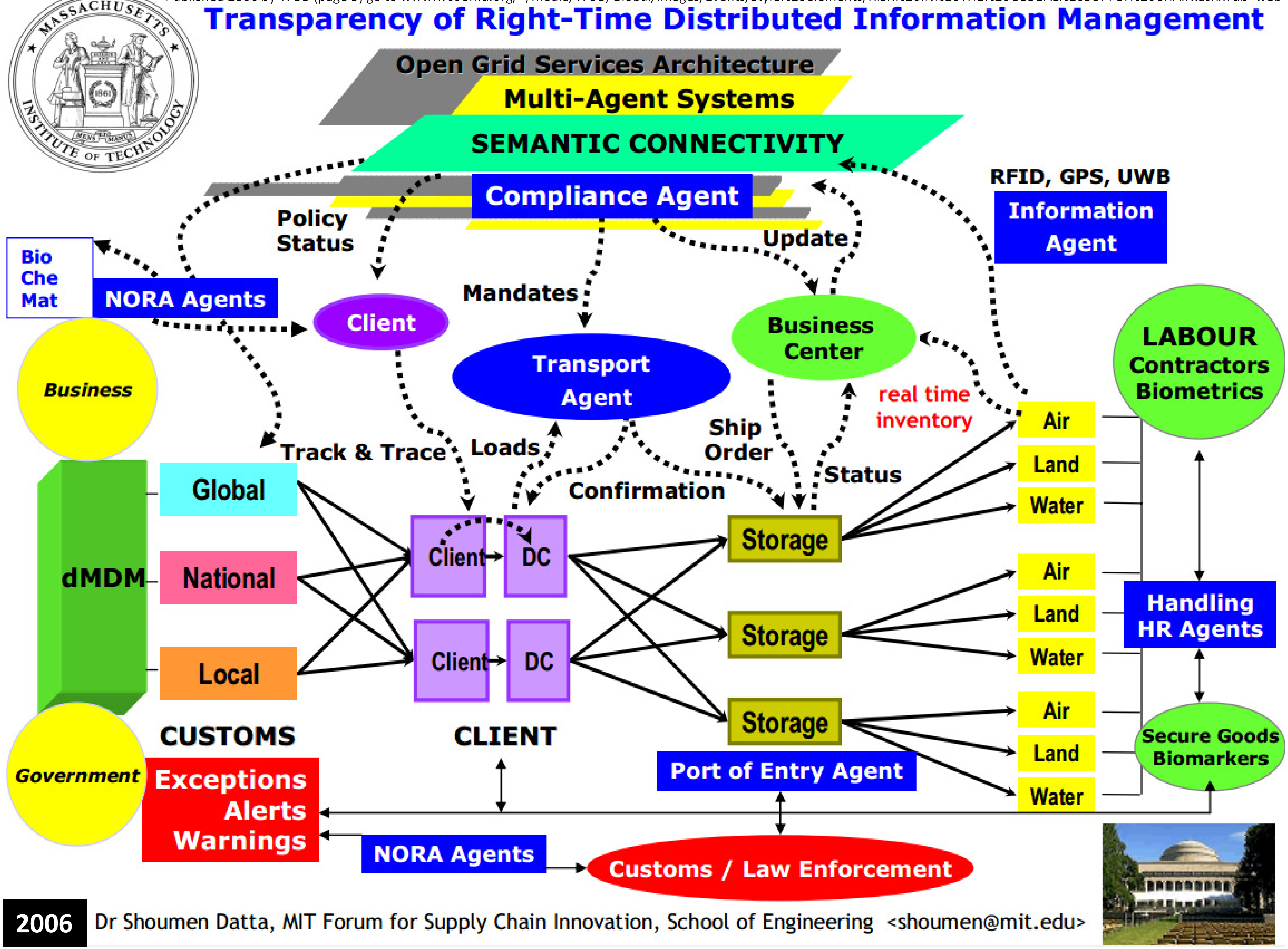

Data by Datta
DATA
The Internet
of THINGS

DATA in an extended ecosystem

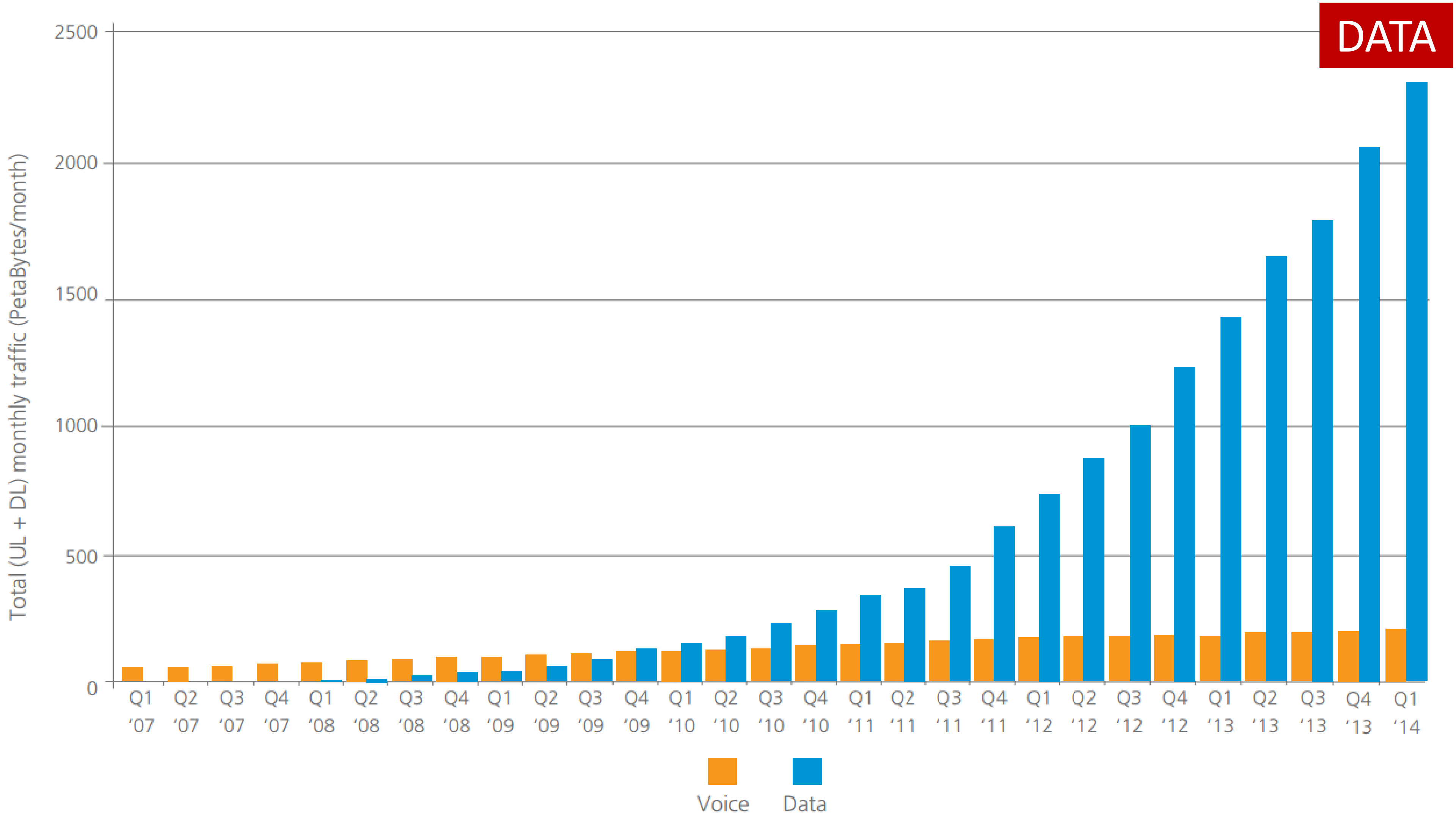
Example of Data → Information, Transparency, Security, Transport

I invented nothing new. I simply assembled into a car the discoveries of other men behind whom were centuries of work ▪ HENRY FORD

Published 2006 by WCO (page 5) go to www.wcoomd.org/~/media/WCO/Global/Images/Events/Style%20elements/RISK%20IN%20THE%20GLOBAL%20SUPPLY%20CHAIN.ashx?db=web

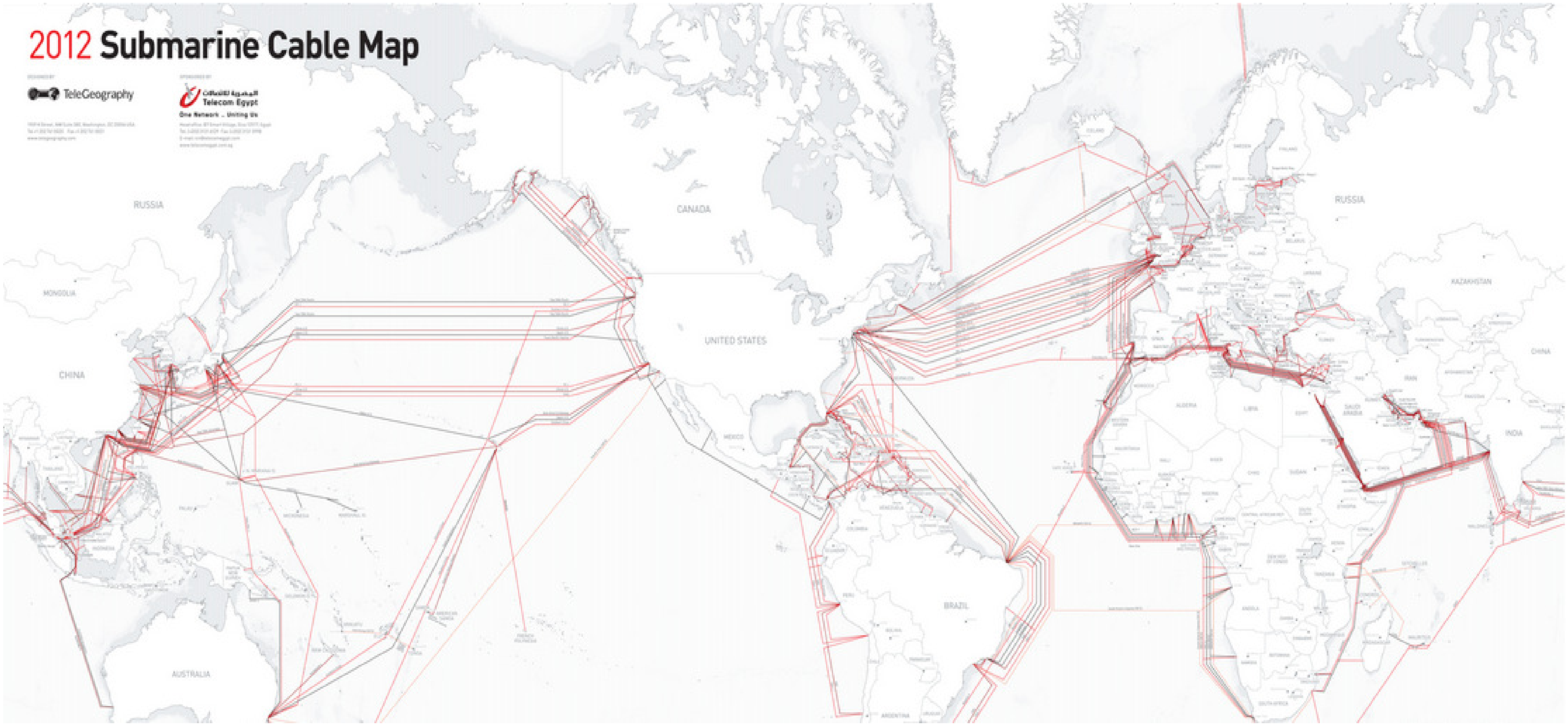


Data is gaining momentum as a "new" dimension for new economic growth

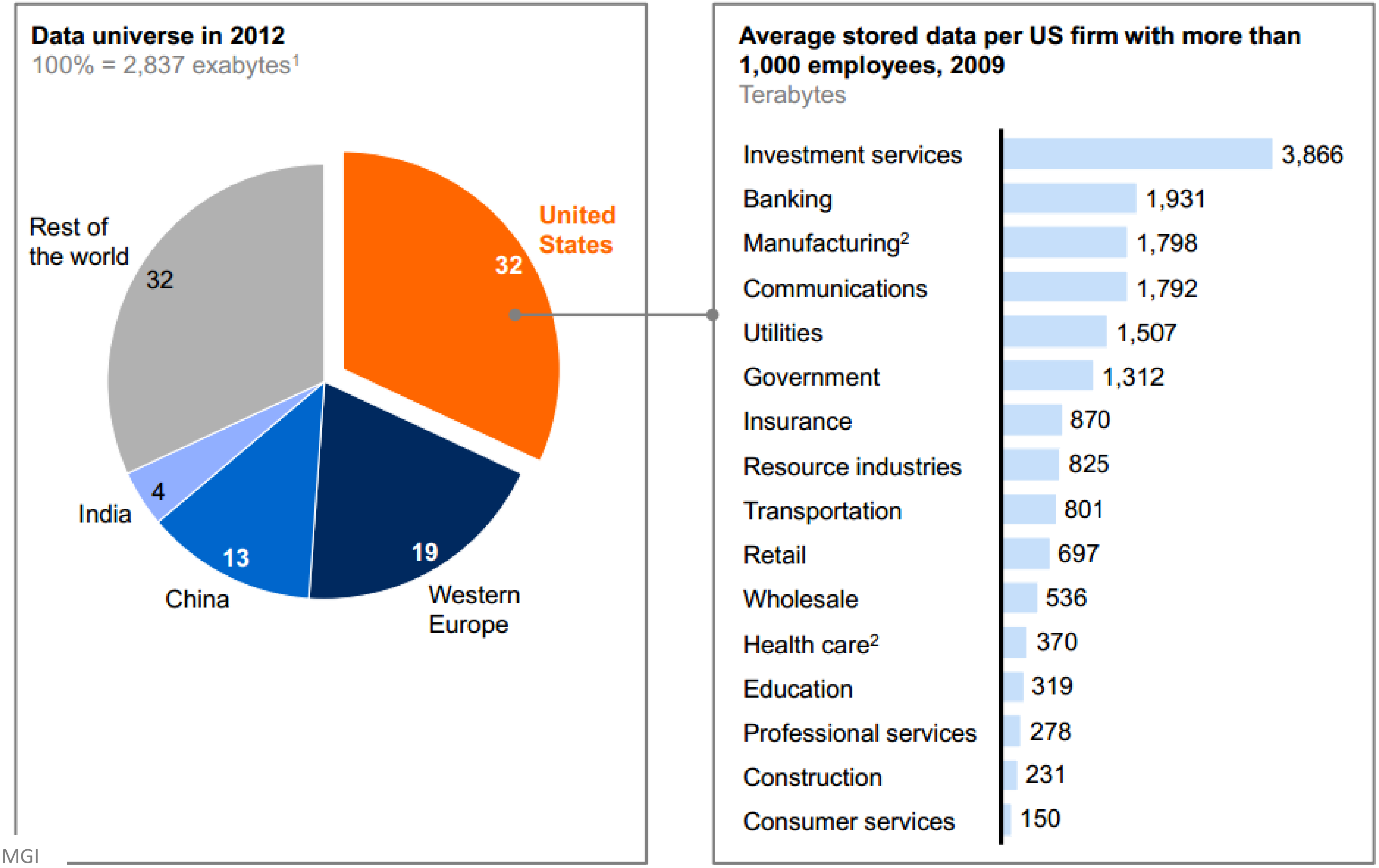


Source: Ericsson

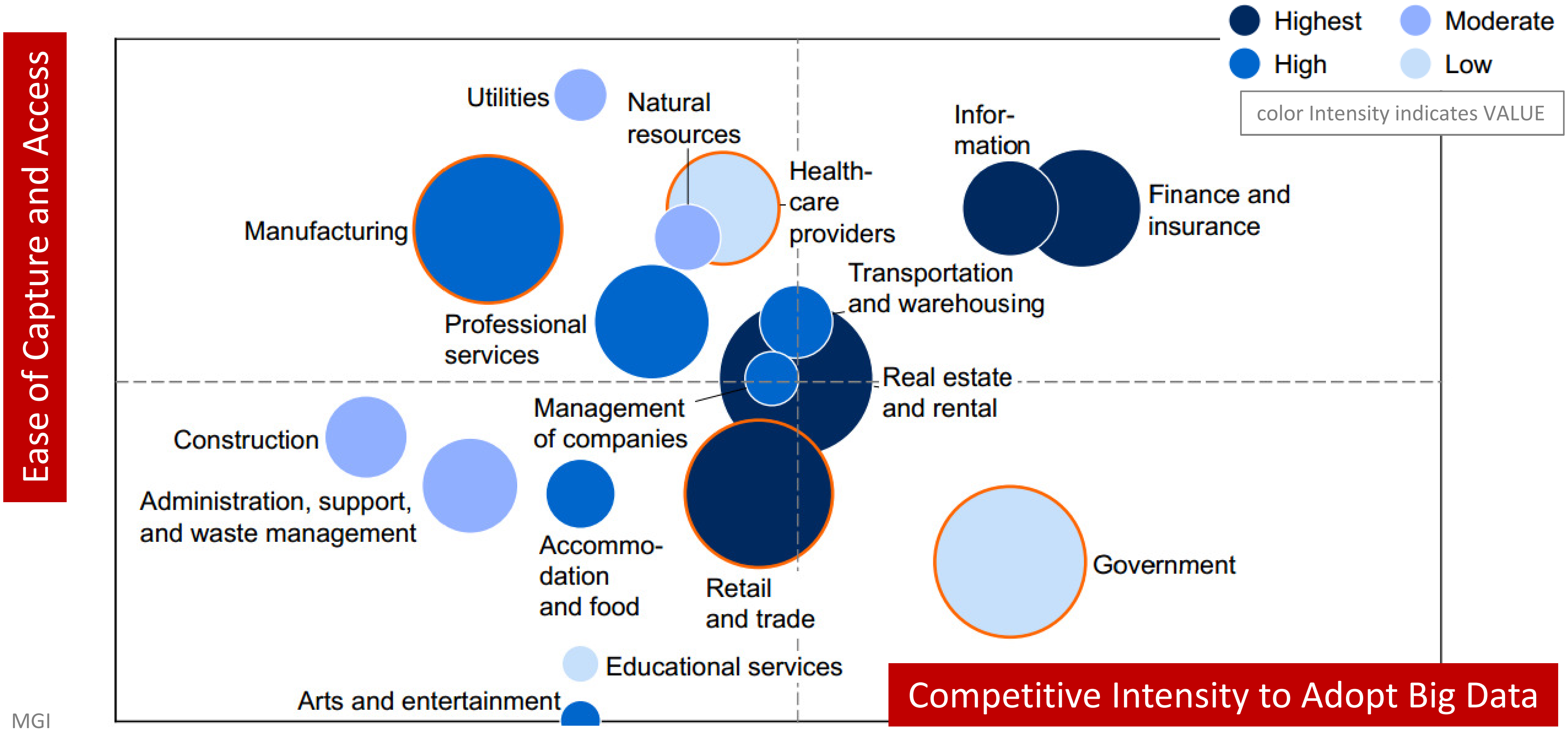
ITU and a number of companies to equip submarine communications cables with sensors to relay data regarding tsunamis or earthquakes.



US has about one-third of the world's data …



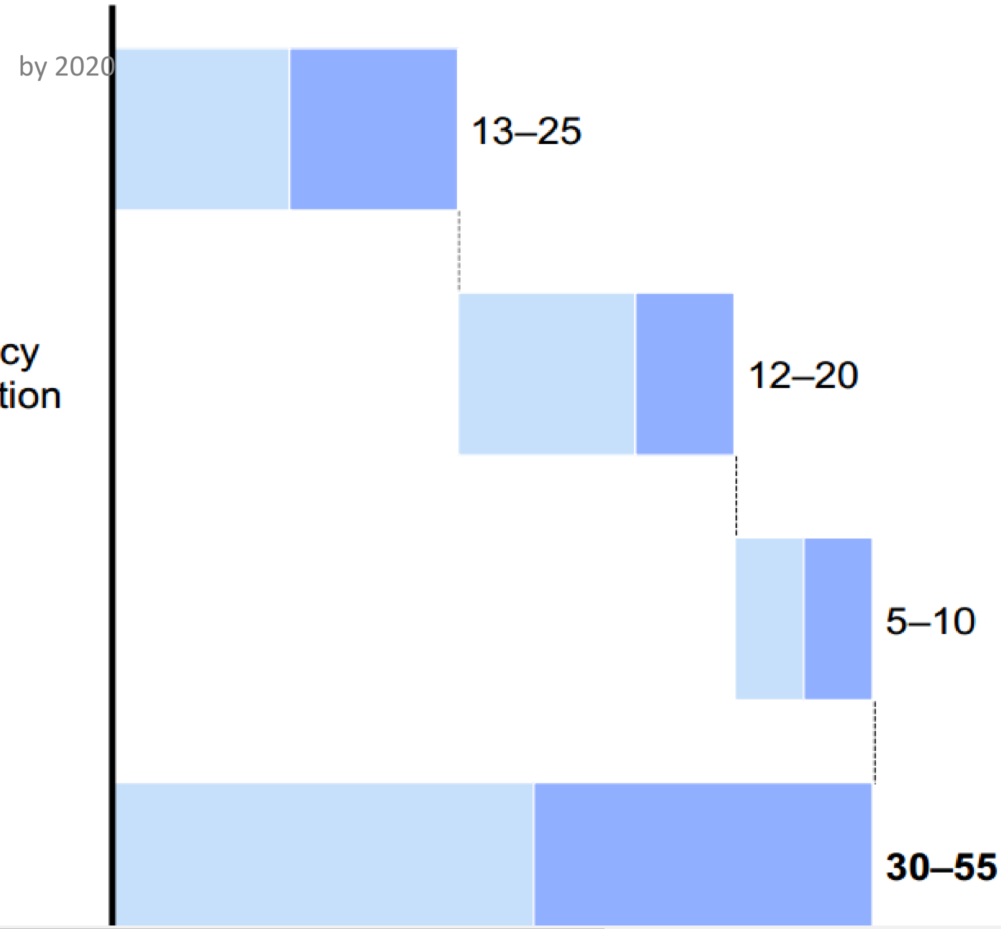
The term "big data" is mired in hype but it has **VALUE** if analyzed in context



MGI

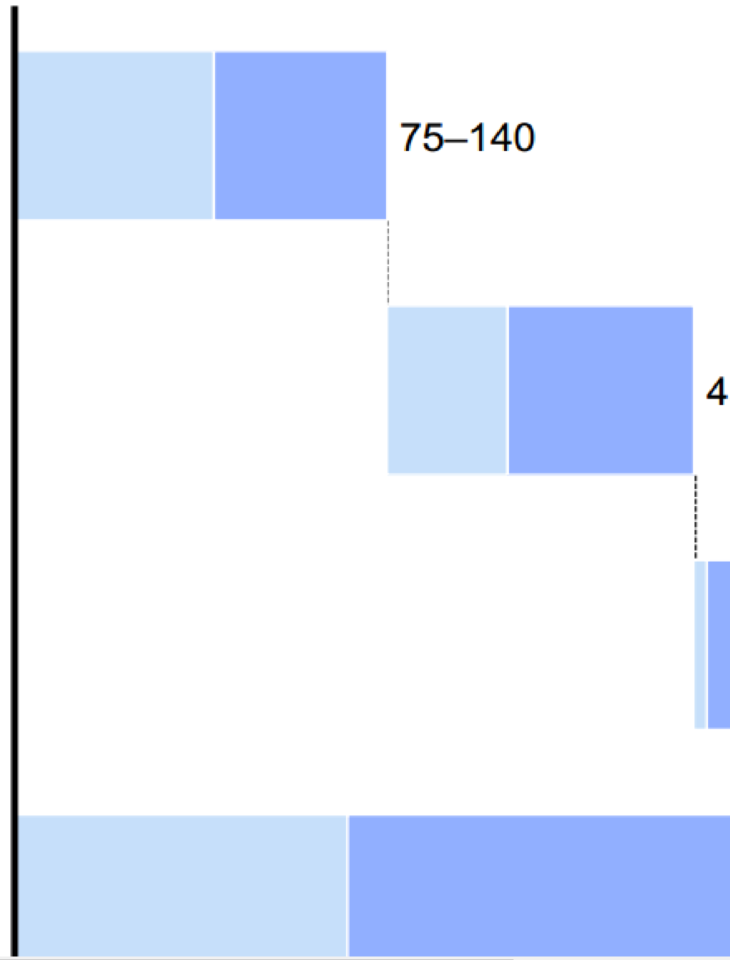
Predicted value of data analytics in the retail supply chain (circa 2020)

Stage of value chain	Area of improvement due to big data analytics	Value of incremental retail GDP $ billion
Supply chain	▪ Inventory management ▪ Transport optimization ▪ Returns management	13–25
Operations	▪ Performance transparency ▪ Labor resource optimization	12–20
Merchandising	▪ Assortment optimization	5–10
Total		**30–55**

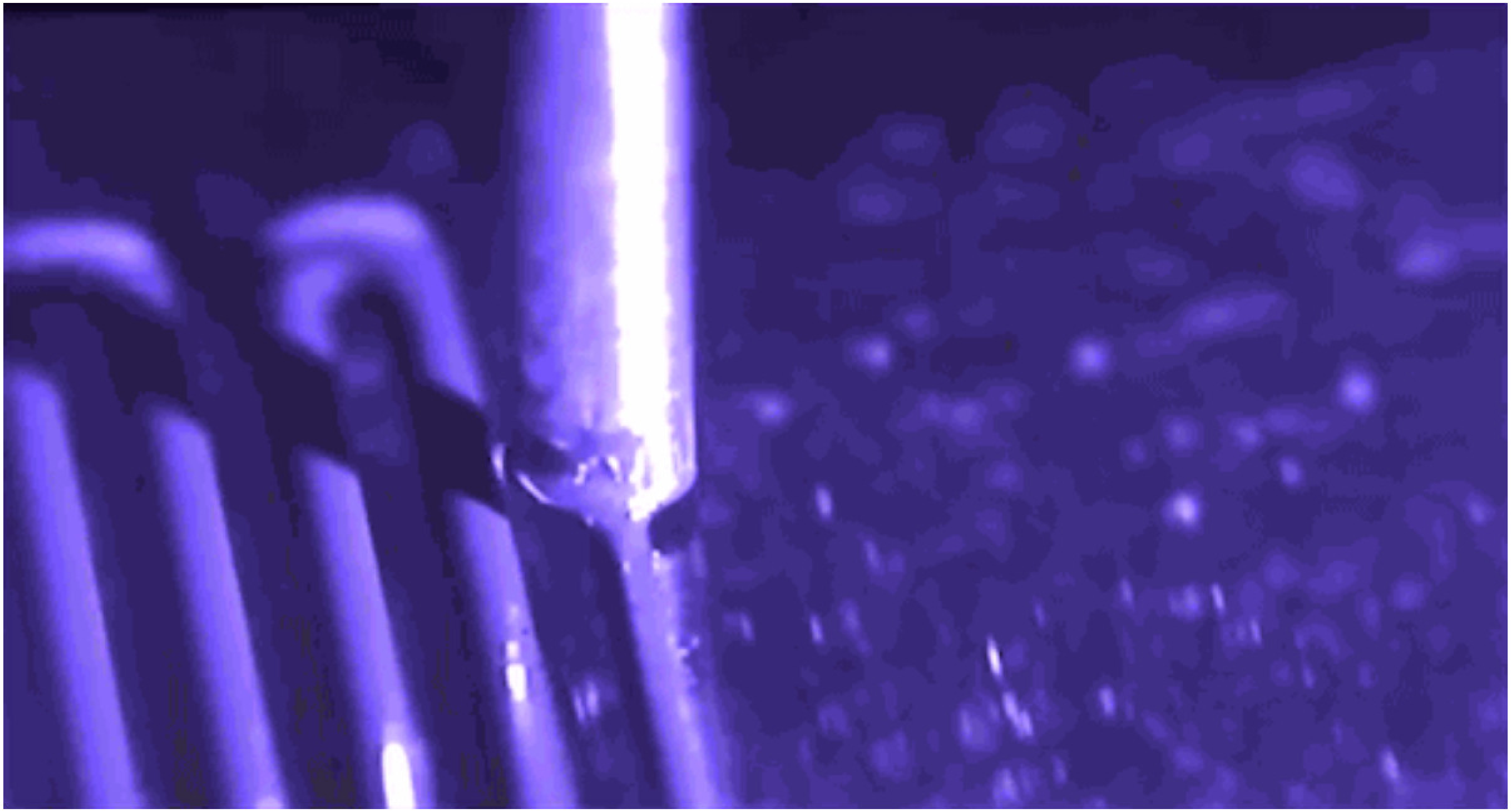


Predicted value of data analytics in manufacturing (circa 2020)

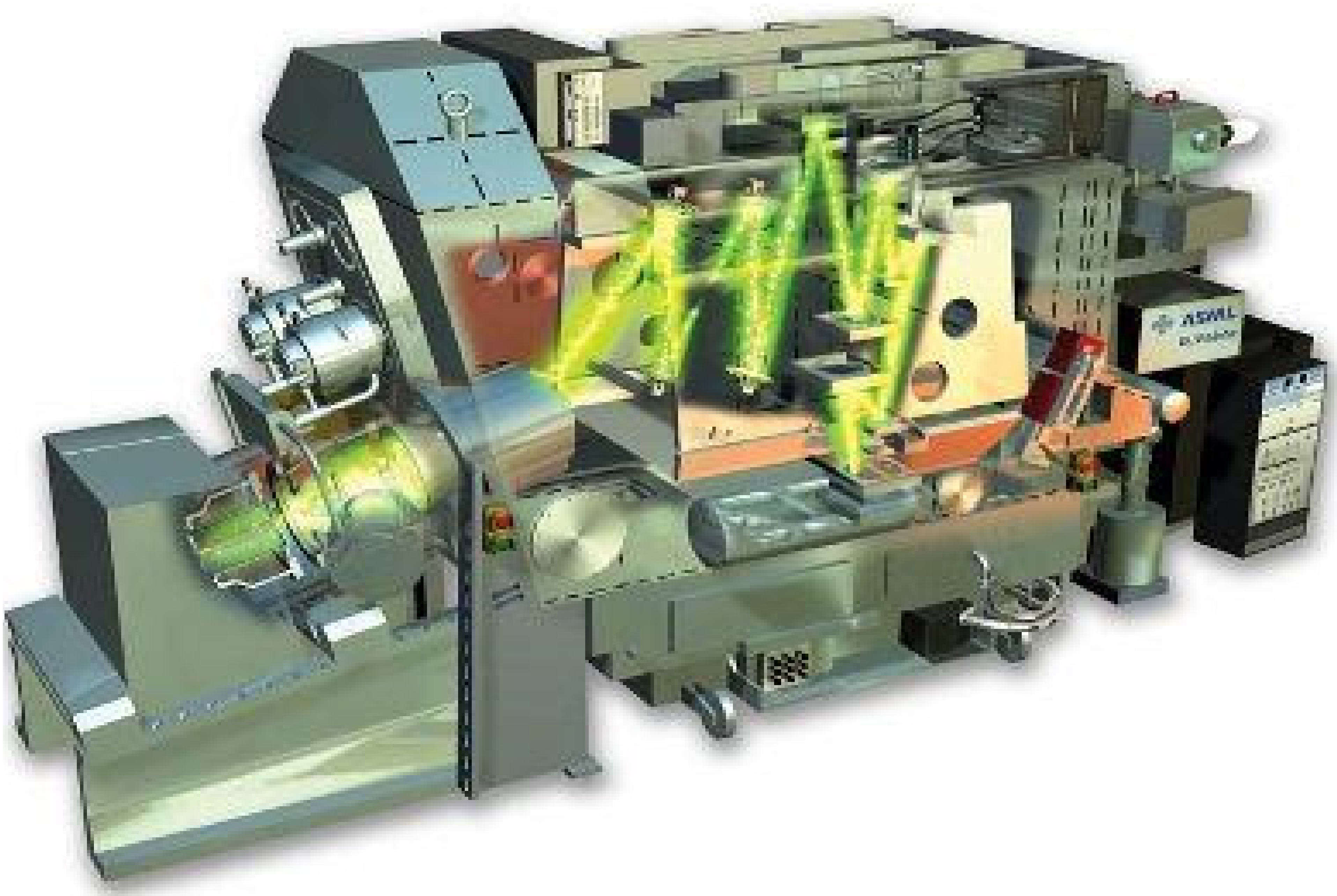
Stage of value chain	Area of improvement due to big data analytics	Potential productivity gains ($ billion)
Research and development	▪ Design to value ▪ Concurrent product life-cycle management ▪ Crowd-sourced R&D	75–140
Production	▪ Sensor analytics ▪ Virtual factories ▪ Predictive maintenance	45–115
Supply chain	▪ Demand forecasting	5–15
Total		**125–270**



Data from inside machines – GE prints sensors deep inside equipment

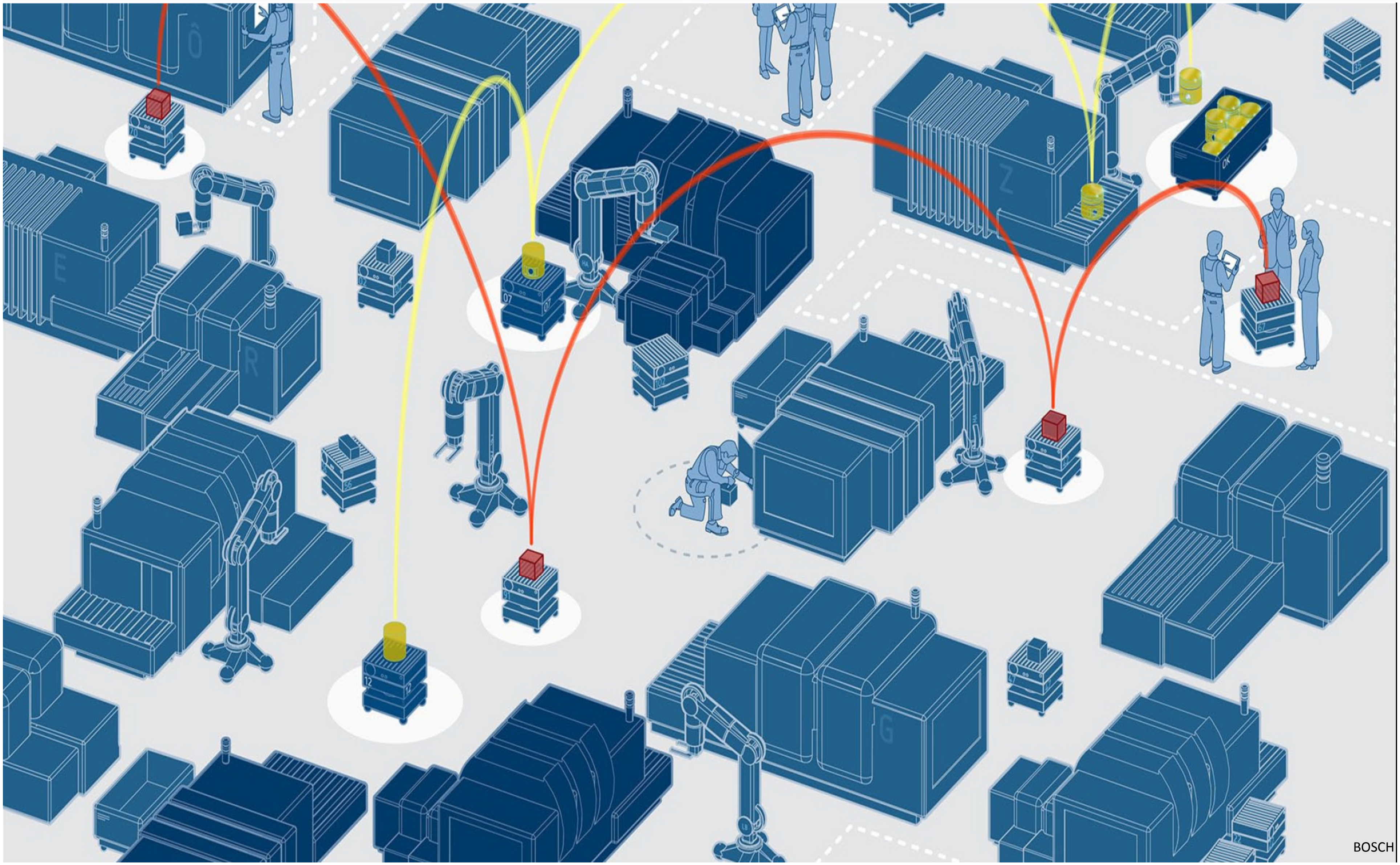


Data from inside machines – sensor networks inside “intelligent” machines



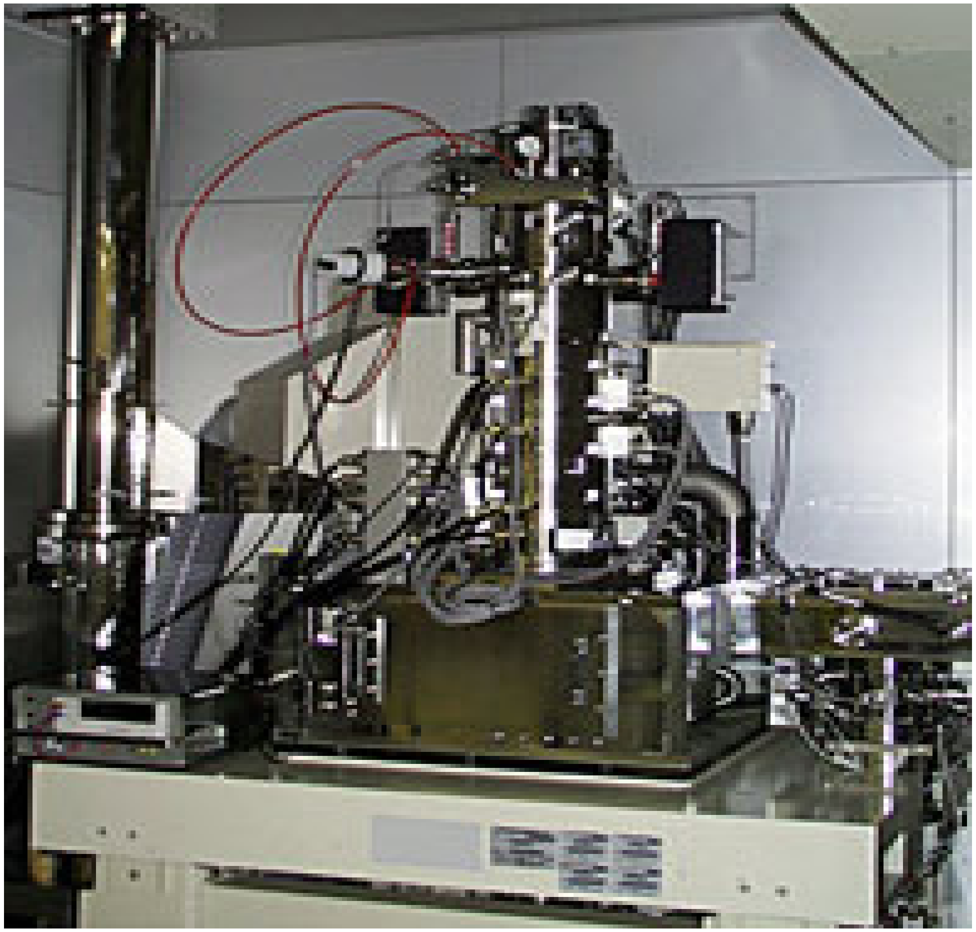
Robotics in manufacturing is nothing new but shop floor data networks?

Data networks improve variant configuration and connects to supply chains



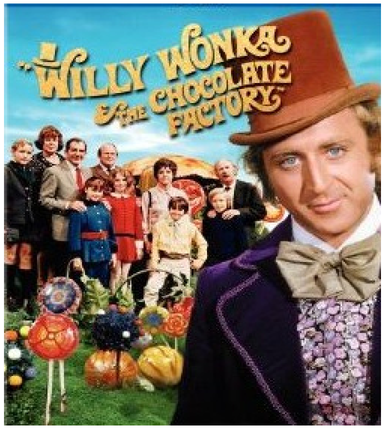
BOSCH

Emma’s Omlette Factory – The Kitchen of the Future – i Print on Demand



Move over…Willy Wonka and The Chocolate Factory

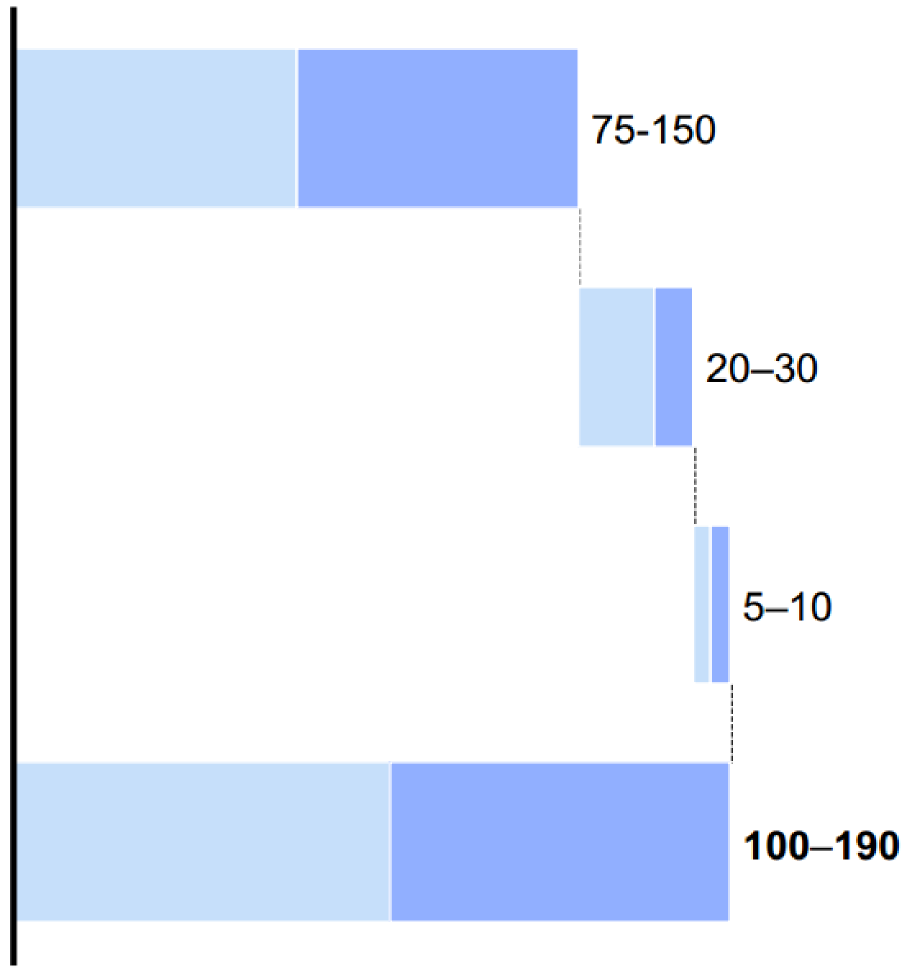
Electron Beam Photo Lithograph from the ancient era modified as a domestic food printer connected to commodity pipelines (milk, cheese, eggs)



Predicted value of data analytics in healthcare (circa 2020)

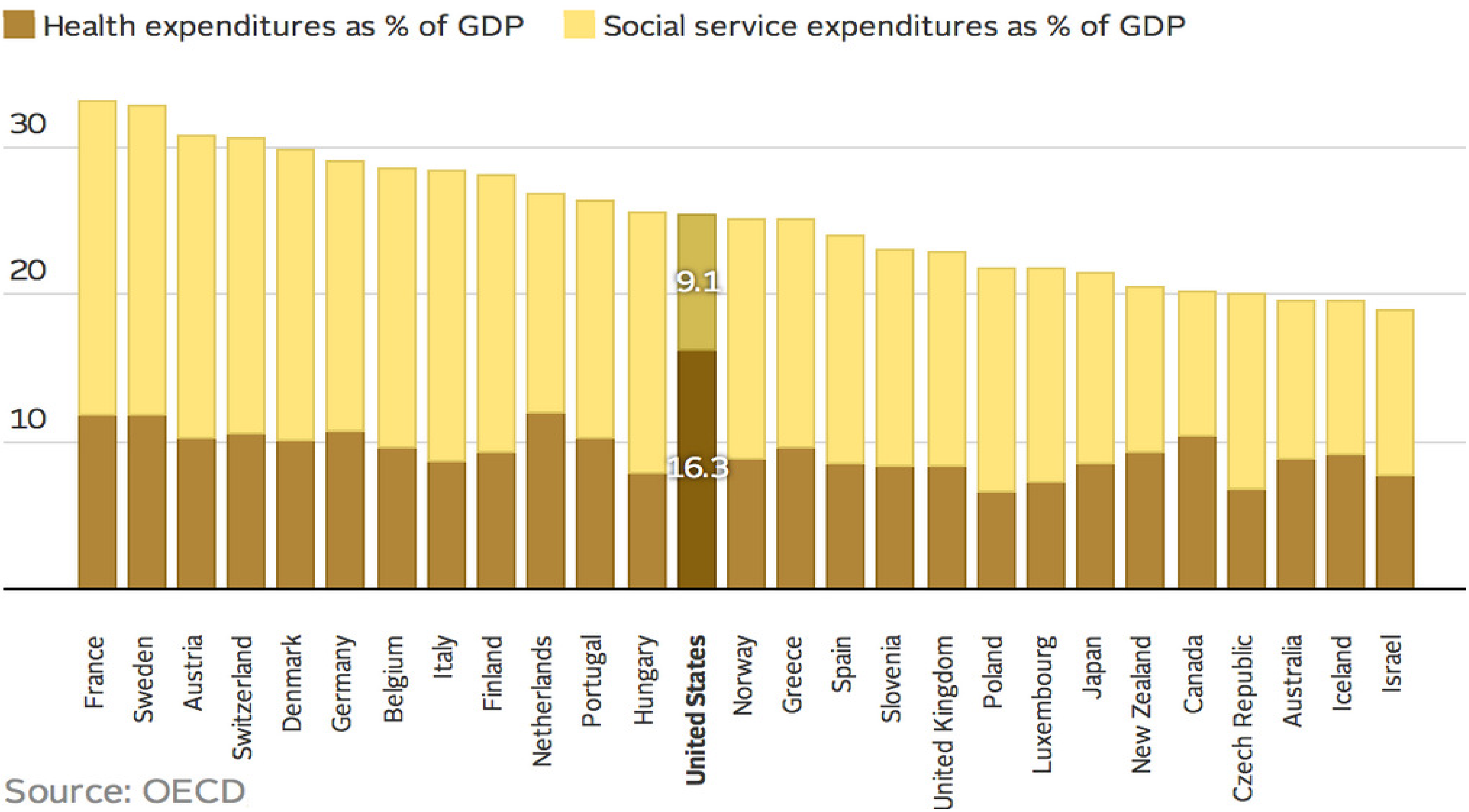
Stage of value chain	Area of improvement due to big data and analytics
Clinical operations	▪ Comparative effectiveness ▪ Clinical decision support ▪ Remote patient monitoring ▪ Performance transparency
Research and development	▪ R&D optimization ▪ Personalized medicine ▪ Pharmacovigilance[1]
Public health	▪ Surveillance and response
Total	

Potential cost savings
$ billion



Laughter is the best medicine but it is not covered by your health insurance

The Paradox of US Healthcare – A Global Anomaly ?



Source: OECD

Proposed value generation ($ billions, due to data) in government by 2020

Category	Lever	Value ($ billions)	Examples
Productivity gains	**Higher operational efficiency**	**35–95**	Automated submissions/processing Monitoring of performance variability Measurement of service outcomes
Reduced expenses	Reduced improper payments	35–85	Systematic, multi-level claim checking Algorithms for decision support
	Lower procurement costs	90–140	Price and service transparency Vendor and provider comparisons
Increased revenue	Improved tax collection	155–235	Identification of collection anomalies Correlation and statistical analyses Higher accuracy of record-keeping

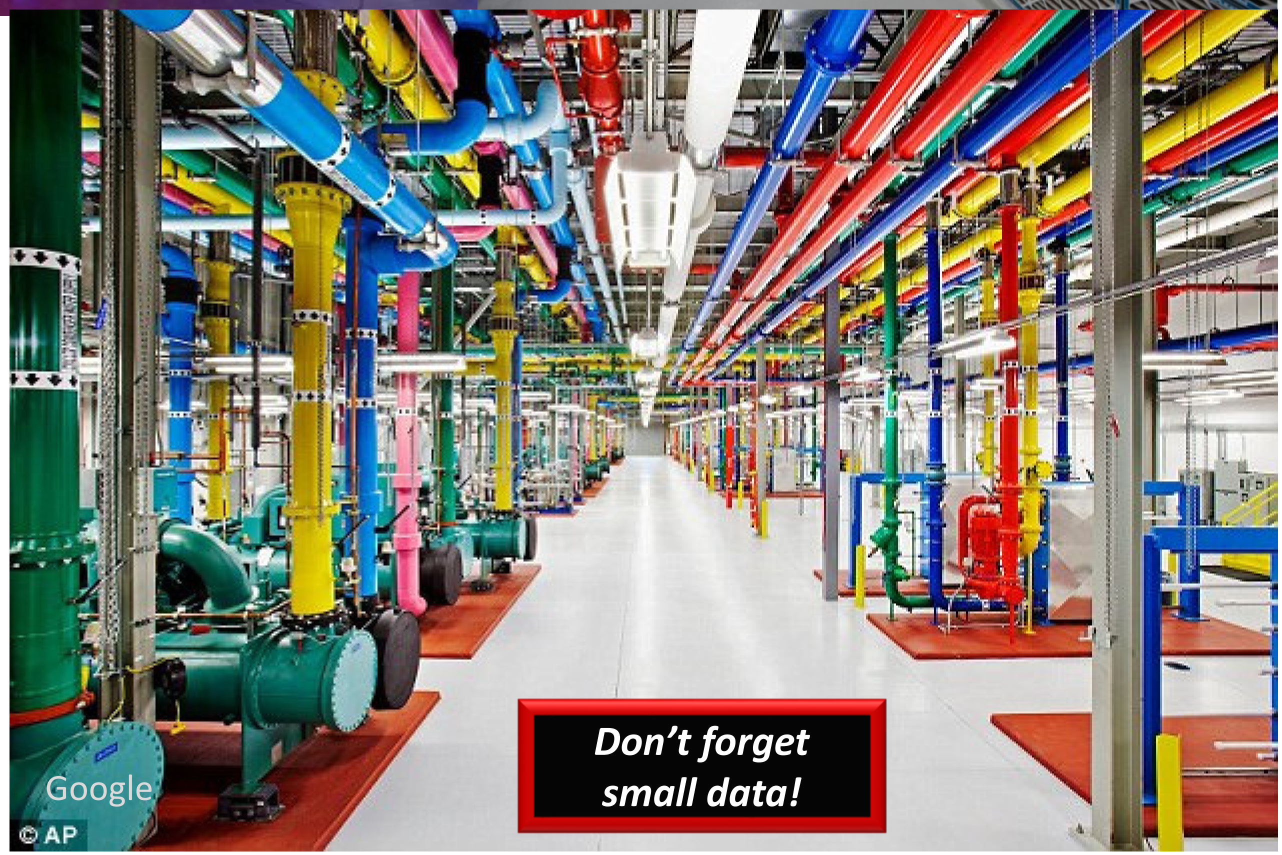
With current technology you can find the haystack but with big data you can find the needle - Nils Herzberg, SAP AG

Hellabyte

10^{27}

[**Petition to Establish "Hella" as the SI Prefix for 10^27**](#)
[October 27, 2013](#)

I can't believe I almost forgot -- today is Hellaween, the best day of the year! In honor of the SI prefix that never was, we've designated 10/27 as the official day to celebrate 10^27. Happy Hellaween everybody!



Big Data	Industrial Internet- IoT

Big Data

- Volume
- Variety
- Velocity
- Volatility
- Veracity

5 V

Industrial Internet- IoT

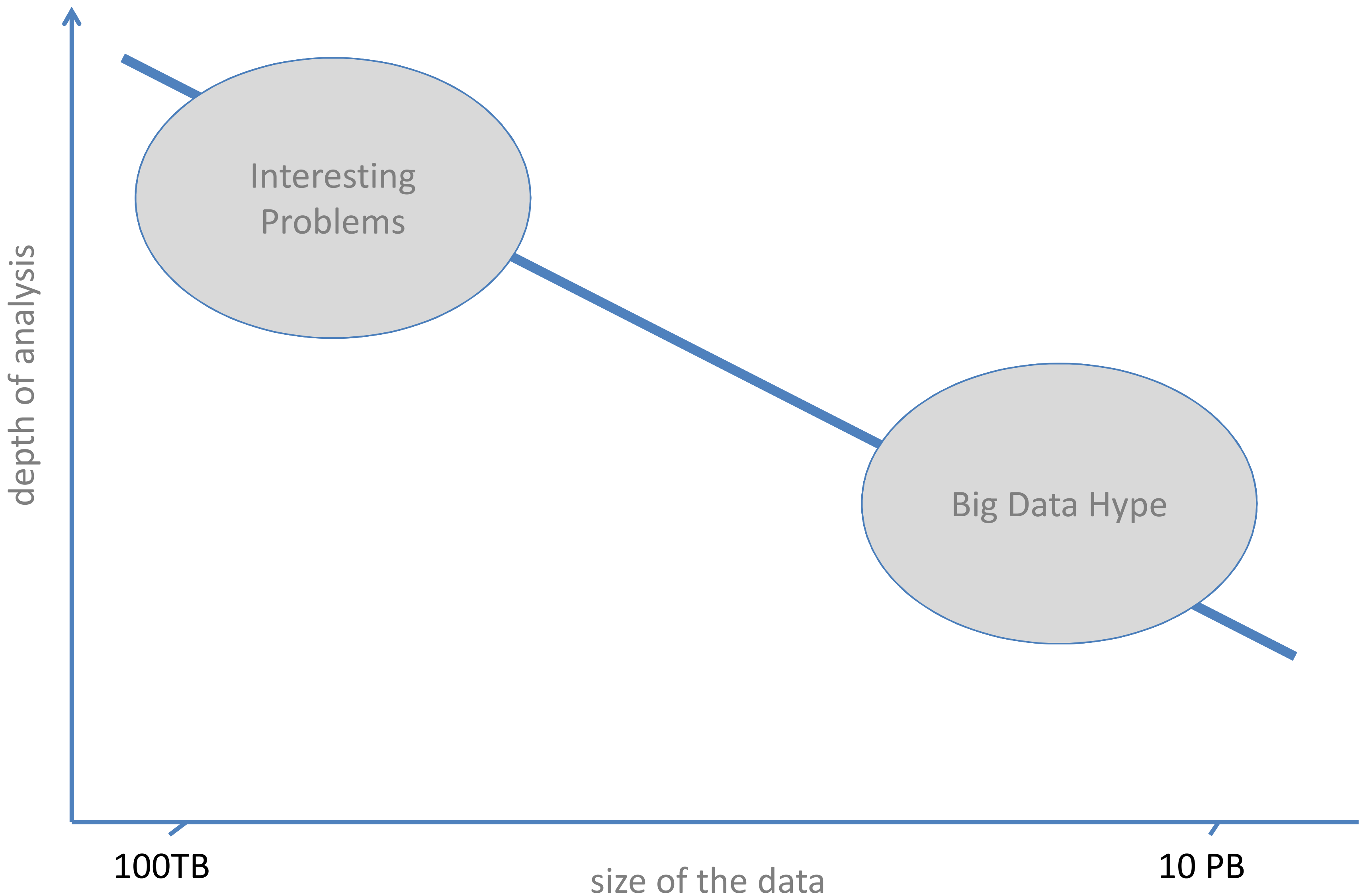
- Components
- Connectivity
- Convergence
- Collaboration
- Community

5 C

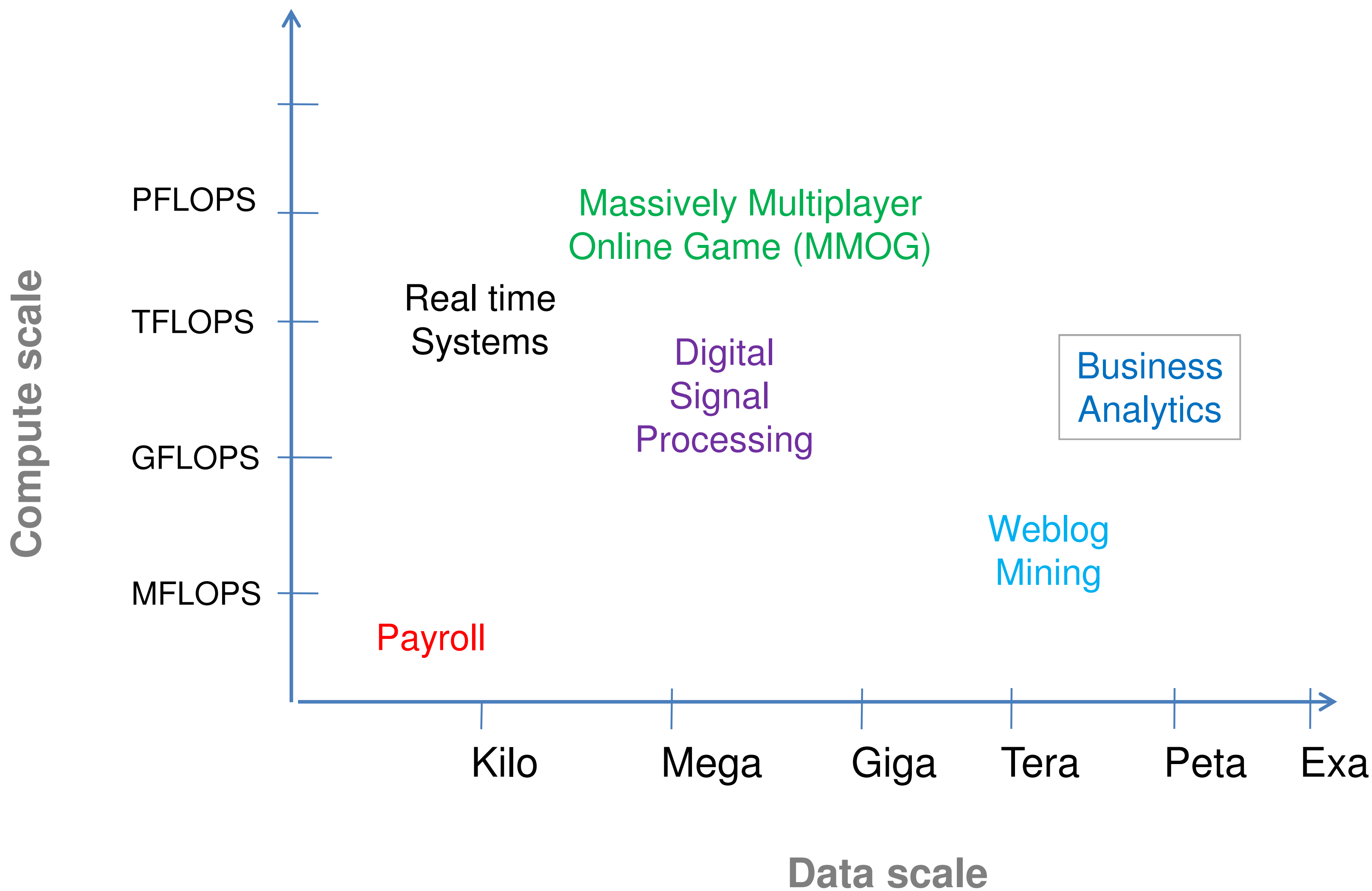
Actions due to the Industrial Internet depend on analyses of

DATA

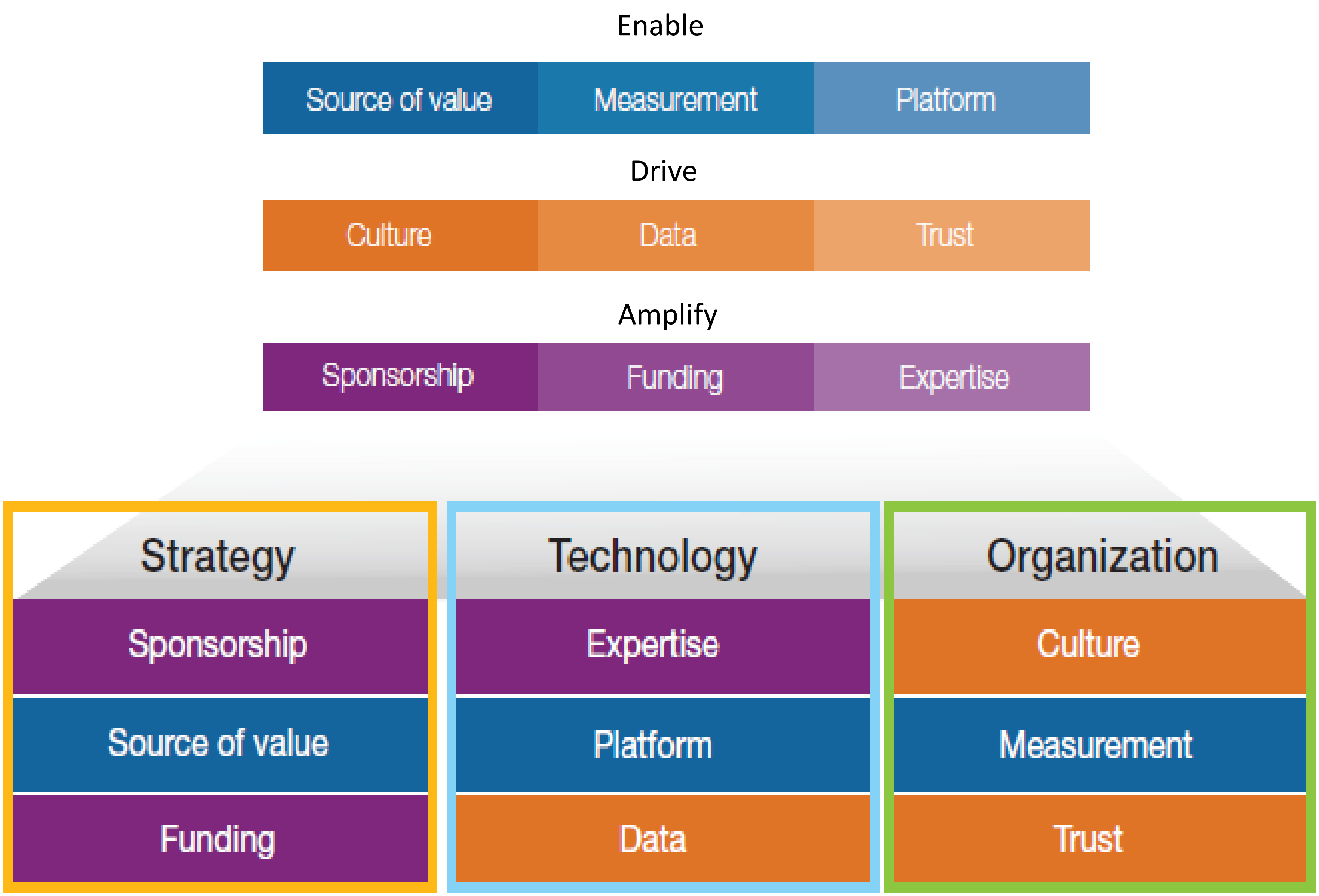
There are interesting and profitable uses of data even if it is not so “big”



Small Data vs Big Data – The Problem Space



The Industrial Internet is Impotent without Data and Data Analytics

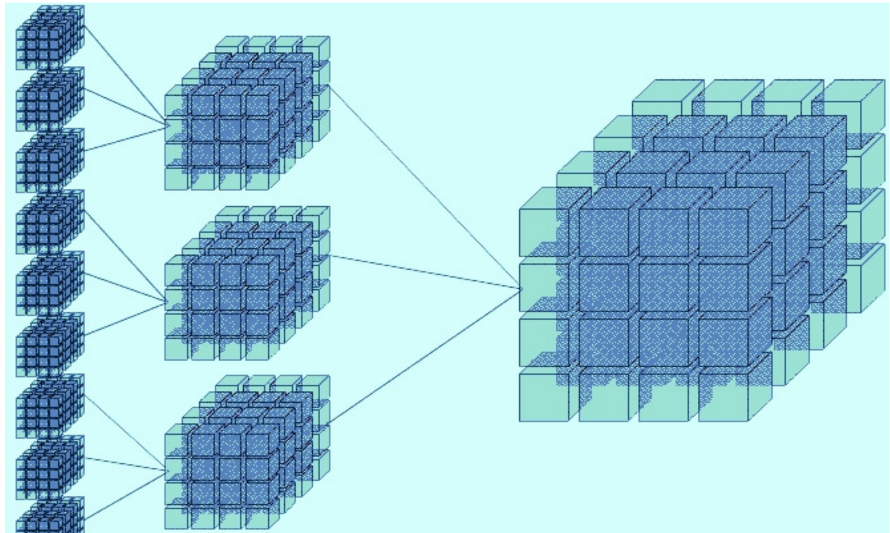


ibm.com/iibv

New tools for handling of

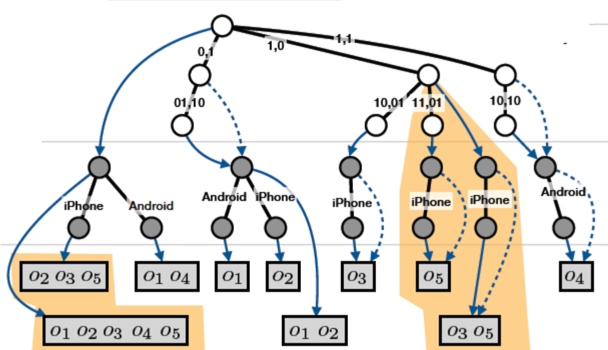
DATA

The Industrial Internet may benefit from a Paradigm Shift

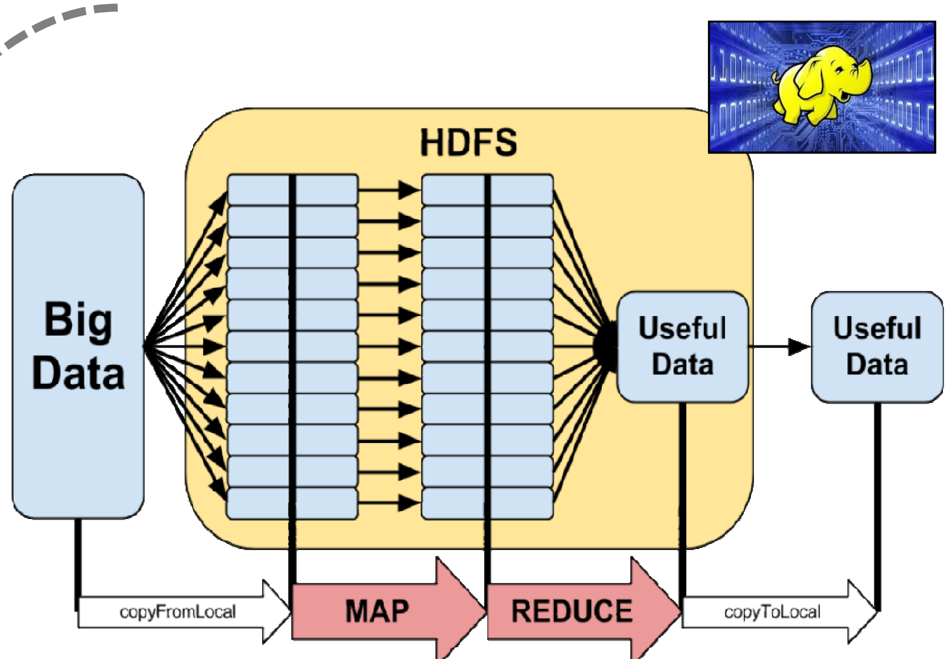


Marvin Minsky “cube on cube” (The Society of Mind, 1959)

nanocubes



www.nanocubes.net/assets/pdf/nanocubes_paper.pdf



http://bit.ly/GFS-2004

Why Hadoop when we have relational databases?

Google File System and Google MapReduce spawned Nutch which led to Hadoop, an open source platform to spread data across thousands of cheap servers prior to analysis. Doug Cutting (formerly with Google) and Mike Cafarella is credited with the creation of Hadoop at Yahoo (some prefer to state that HDFS was reverse engineered from GFS). Google BigTable gave rise to an army of "NoSQL" databases that can process unusually large amounts of information. Google Pregel delivered multiple "graph" databases to map online relationships between people and things. Recently, Impala (based on a sweeping Google database known as F1) was developed at Cloudera by Marcel Kornacker (formerly with Google). Impala enables instant analysis of massive amounts of data (stored in Hadoop) in real time (not possible using Hadoop's ecosystem of tools, Hive and Pig).

How long will it take to do a relational scan on 100TB?

HDFS - Hadoop Distributed File System

- Created by Doug Cutting and Mike Cafarella
  - Process internet scale data (search the web, store the web)
  - Reduces cost by distributing workload on massively parallel system (build with large numbers of inexpensive computers as servers)
- Tolerate high component failure rate
  - Disk fails on average once in 3 years (probability of failures for 1000 disks is about 1 per day)
  - Balance between power consumption and machine failure rates
- Throughput is given higher priority over the response time
  - Batch operation (response will not be immediate, not in real time)
- Large streaming scans (reads) - no random access
- Large files preferred over small
- Reliability provided though replication

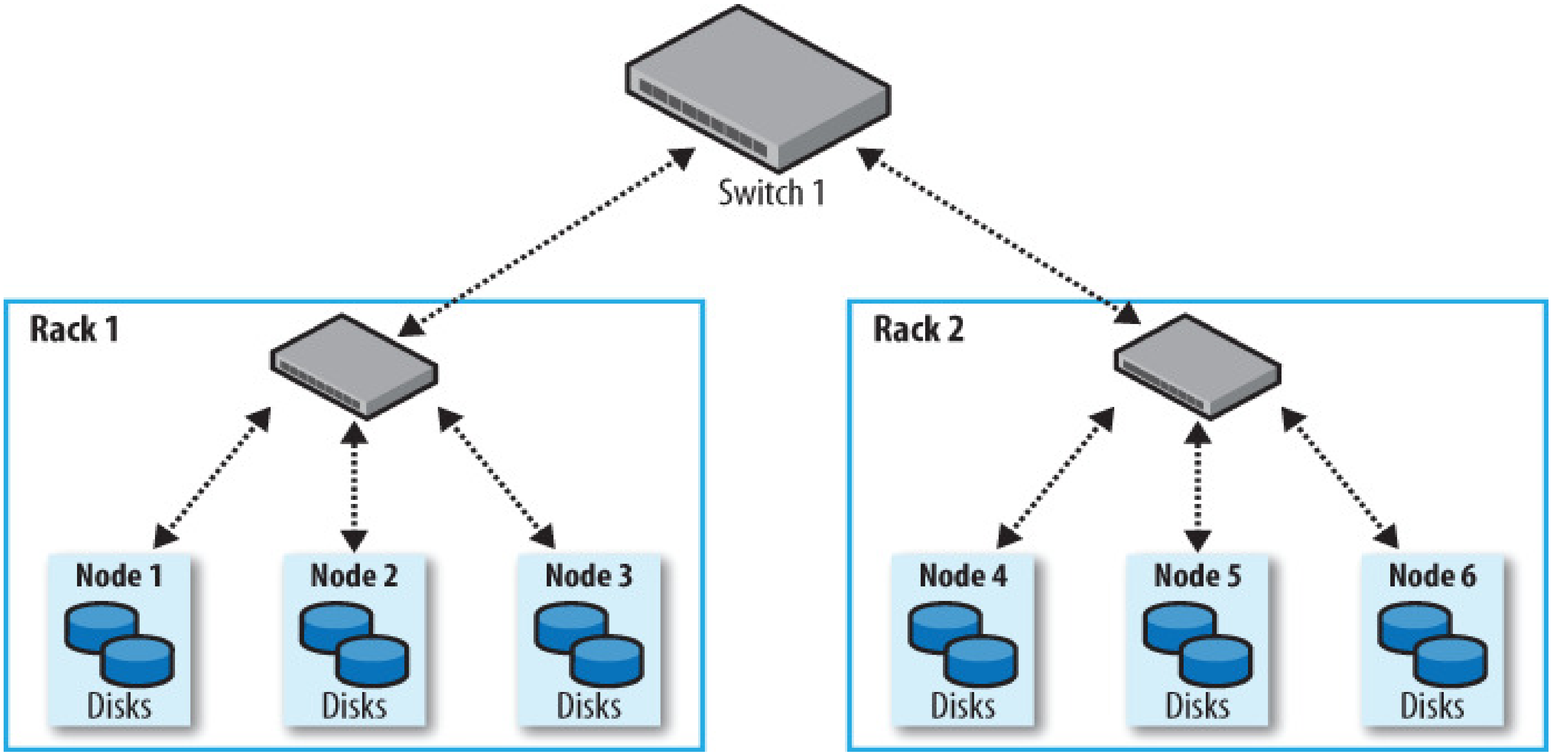
Doug Cutting with Hadoop, the elephant

RDBMS vs Hadoop – complementarity ?

- Structured data with known schemas
- Records, long fields, objects, XML
- Updates allowed
- SQL & XQuery
- Quick response, random access
- Data loss is not acceptable
- Security and auditing
- Encryption
- Sophisticated data compression
- Enterprise hardware
- 30+ years of innovation
- Random access (indexing)
- Large DBA and Application development community, widely used

- Unstructured and structured
- Files
- Only inserts and deletes
- Hive, Pig, Jaql
- Batch processing
- Data loss can happen sometimes
- Not yet
- Not yet
- Simple file compression
- Commodity hardware
- Since 2005
- Access files only (streaming)
- Small number of companies using it in production, many startups

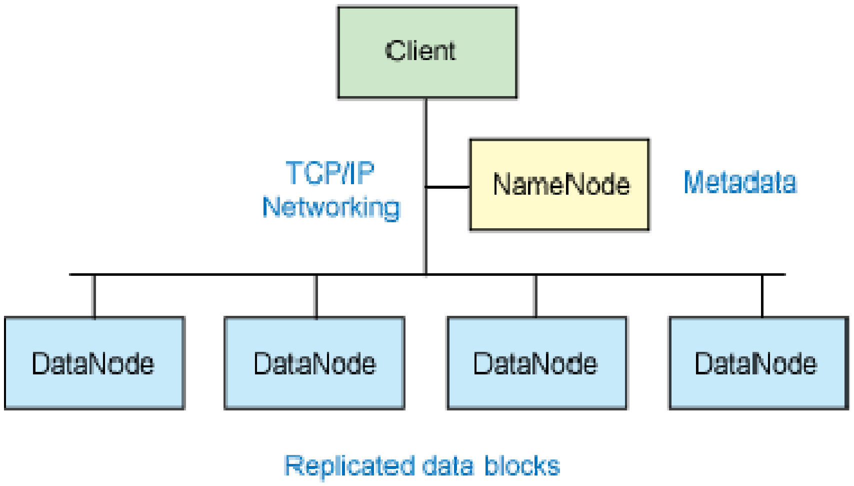
Hadoop Cluster



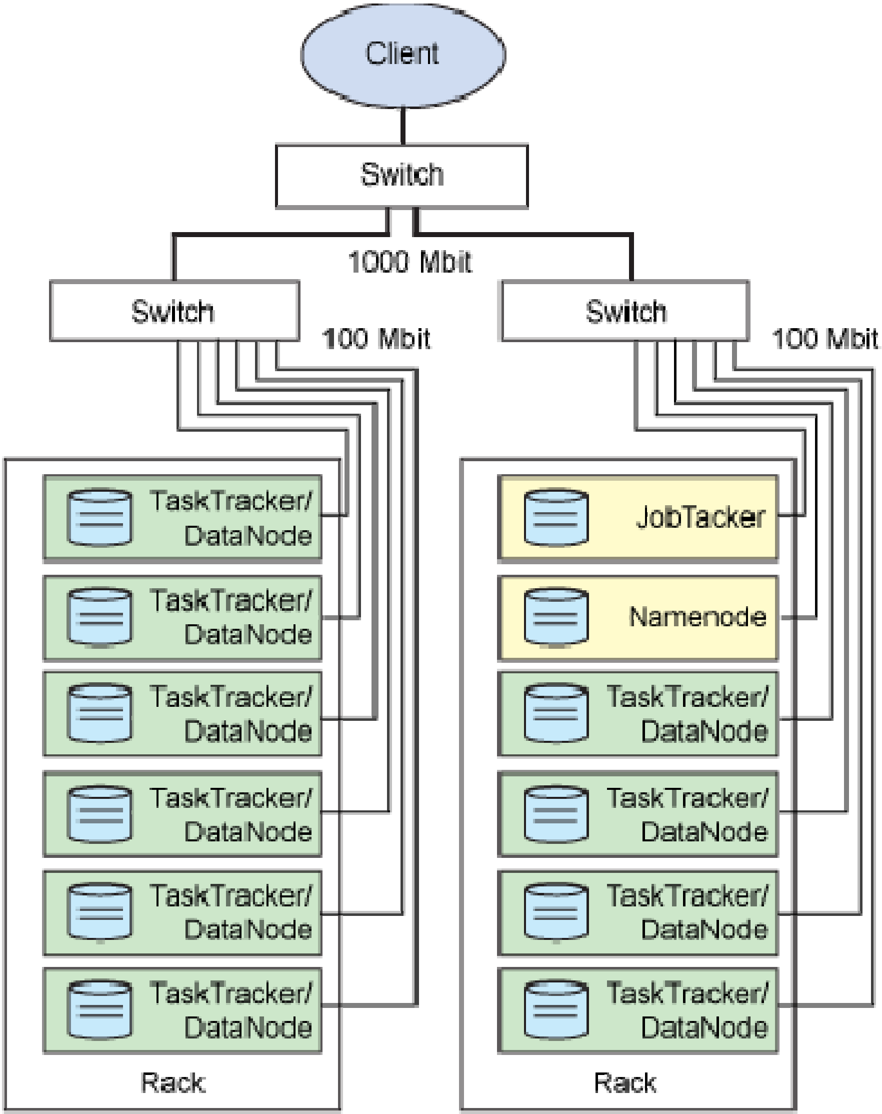
… scale to "n" racks!

Hadoop cluster at Yahoo!

Hadoop Cluster

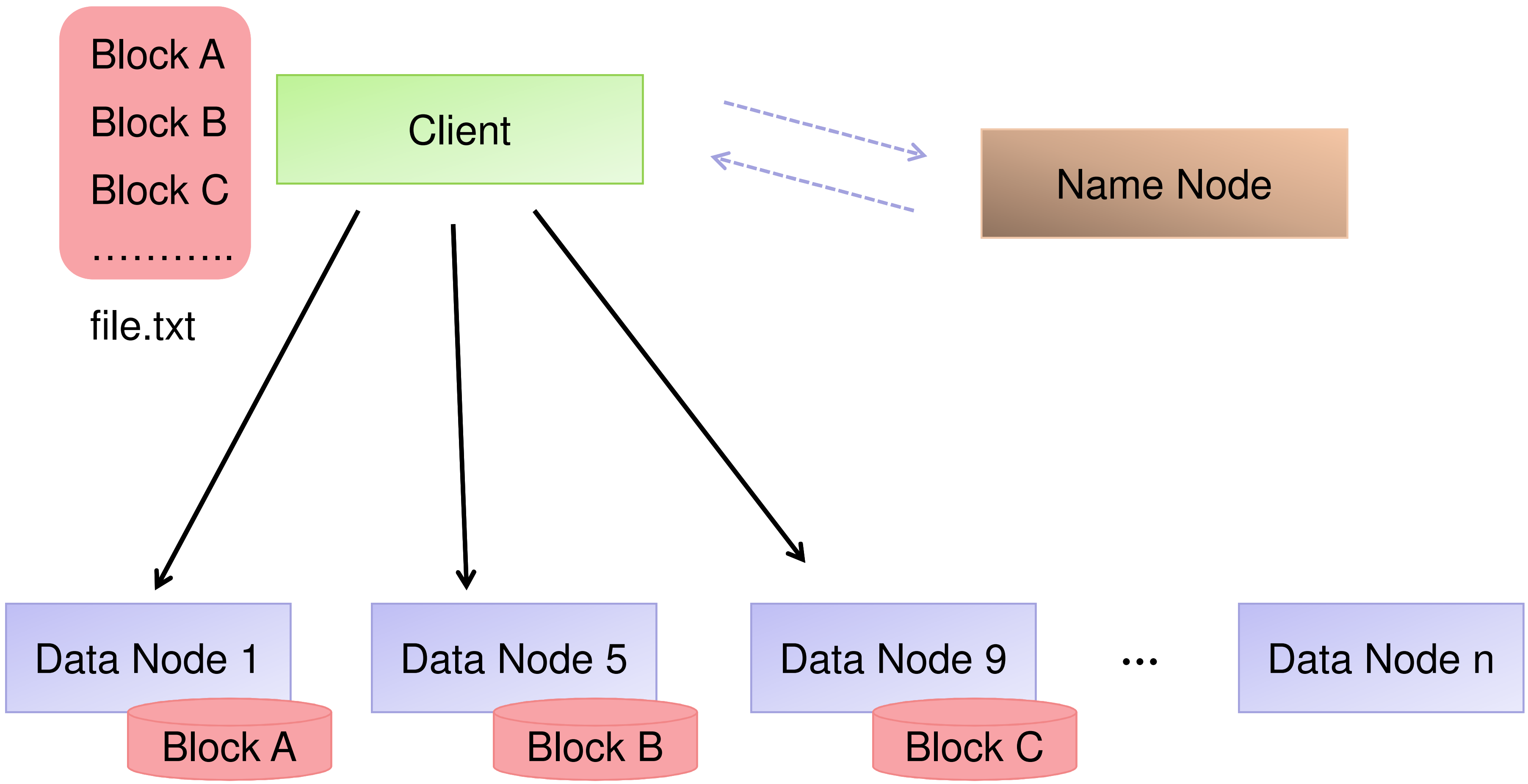


Simplified view of a Hadoop cluster



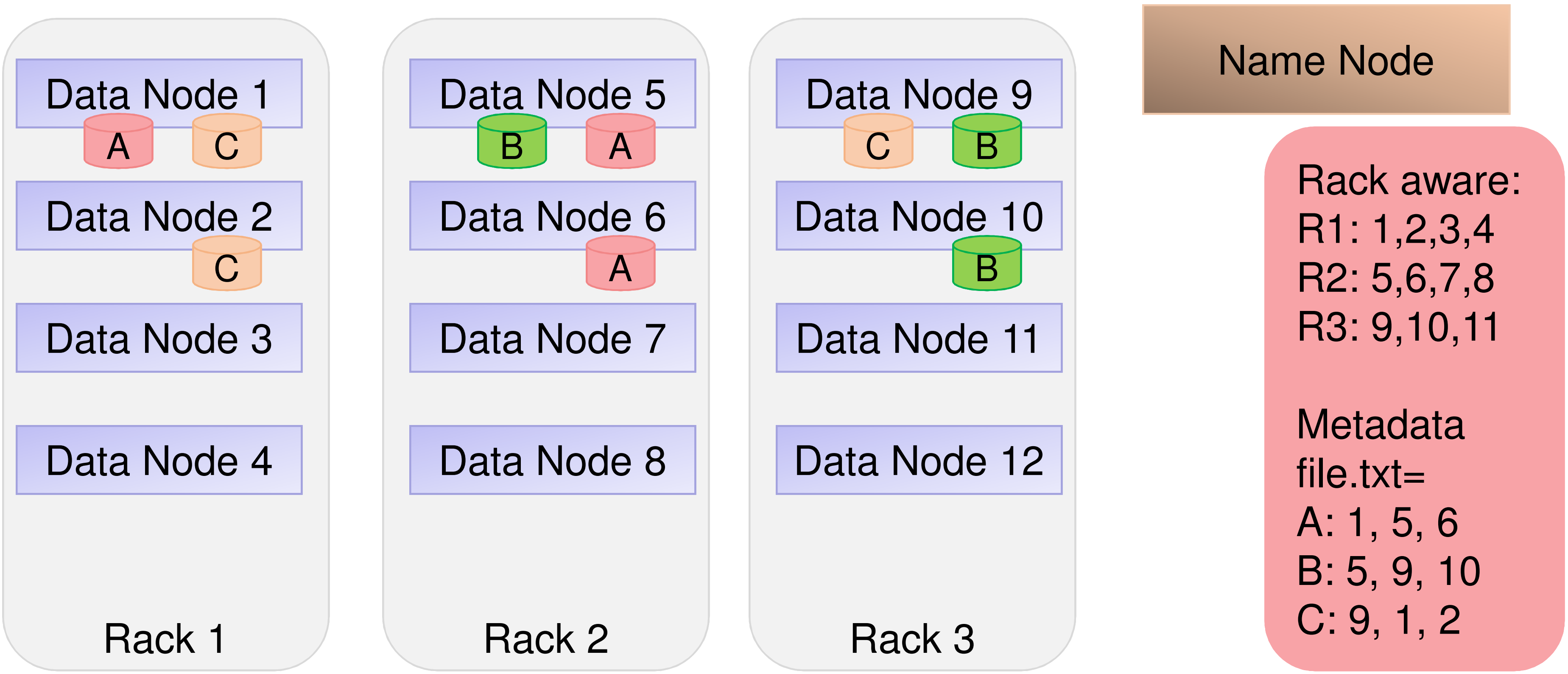
Showing physical distribution of processing and storage

Writing to HDFS



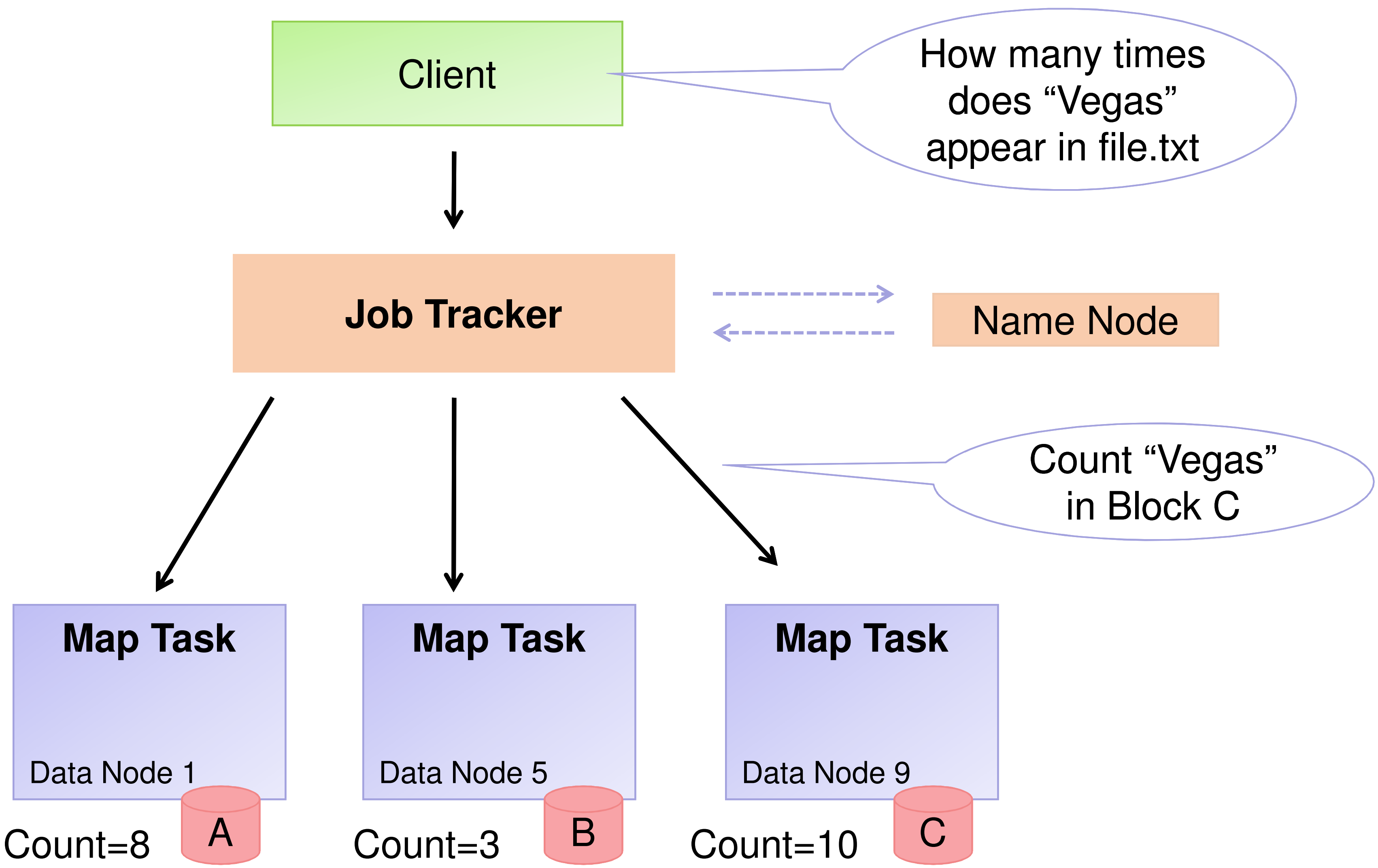
Split file into blocks and write different blocks to different machines → Parallelism

Replication of Data and Rack Awareness

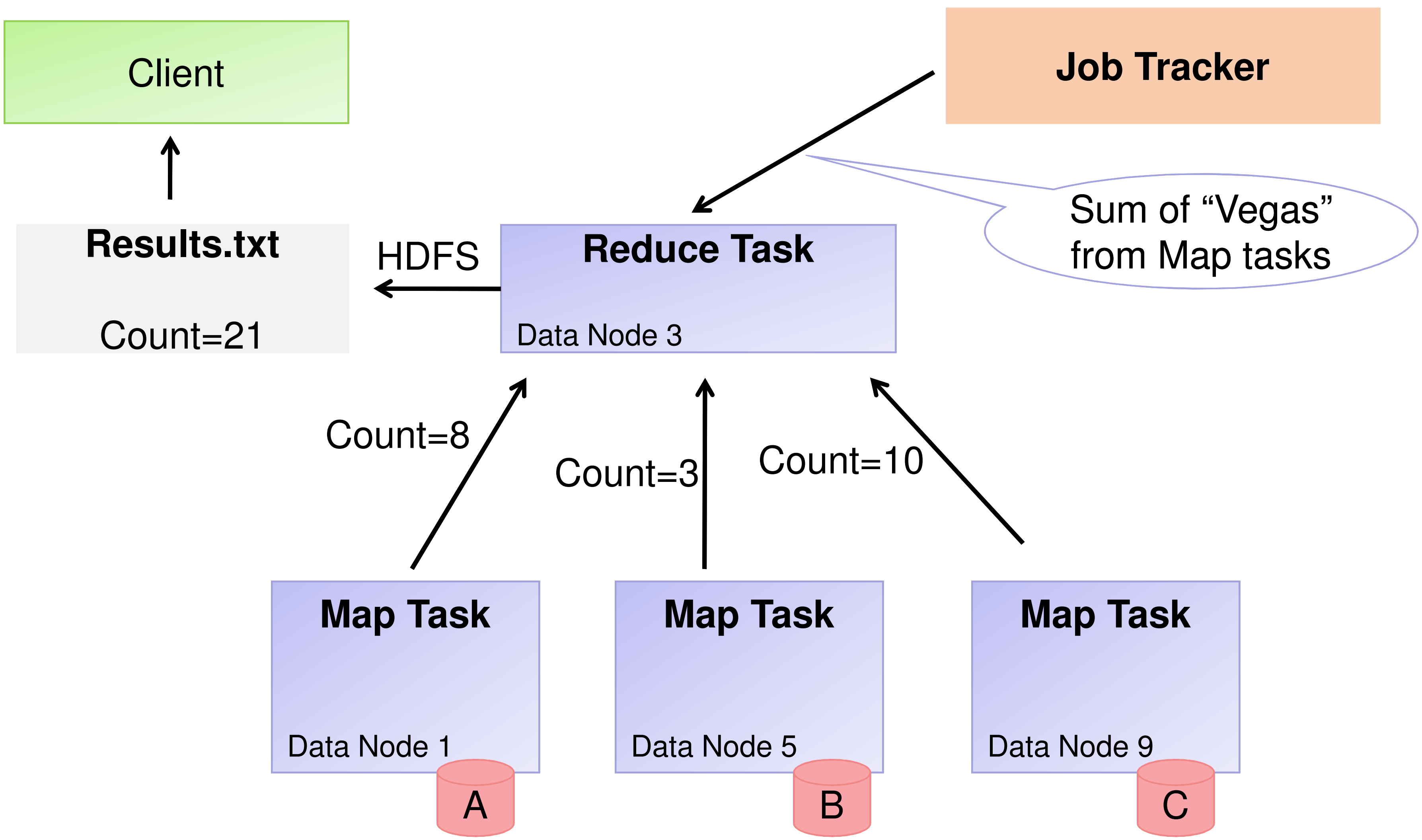


Typically for every block of data, two copies will exist in one rack, another copy in a different rack. Hence, you can never lose all data even if an entire rack fails!

Data Processing: Map



Data Processing: Reduce



Data in Motion (Variety and Velocity) → Stream Computing

Linear Scalability

- Clustered deployments – unlimited scalability

Automated Deployment

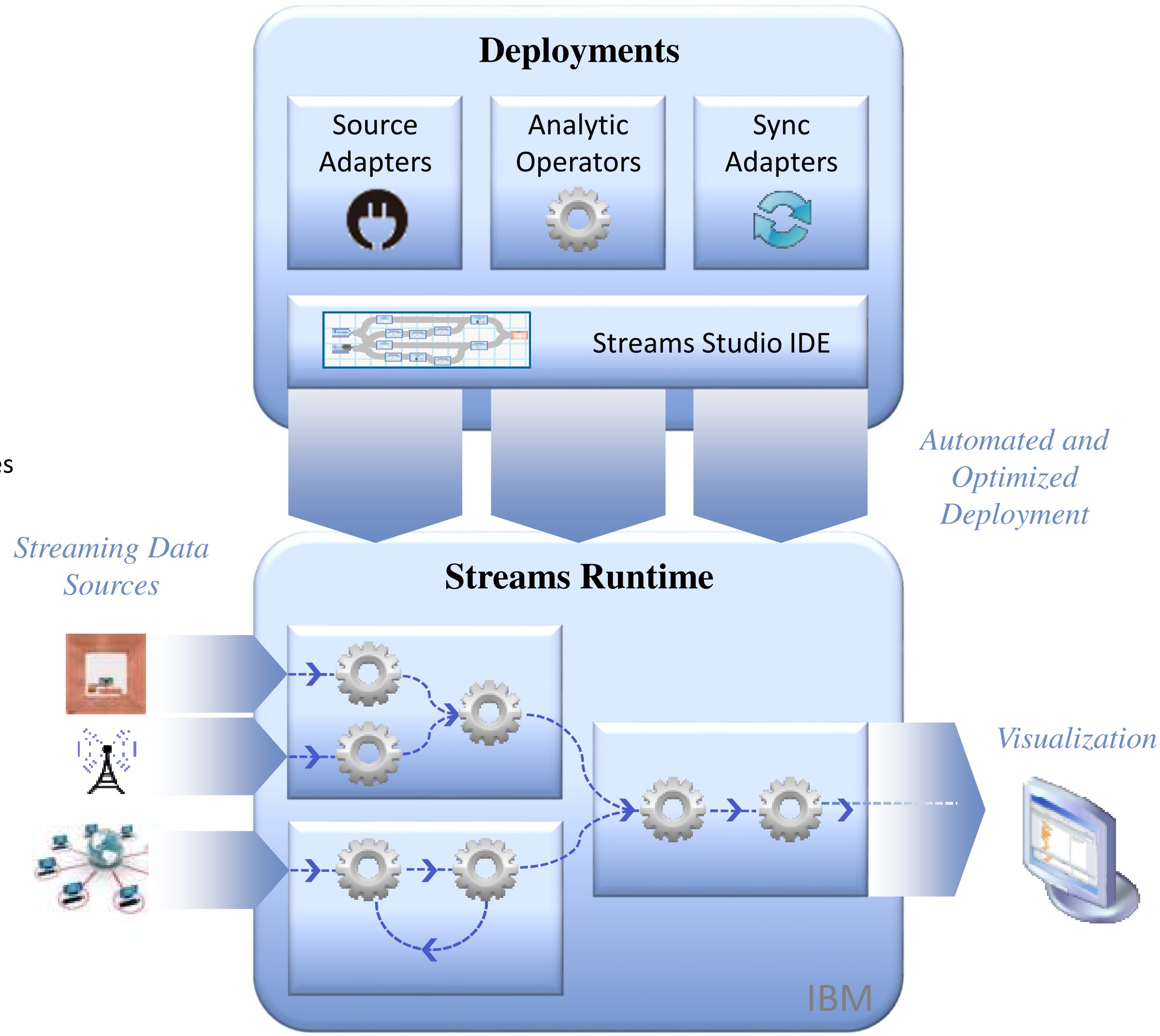
- Automatically optimize operator deployment across clusters

Performance Optimization

- JVM Sharing – minimize memory use
- Fuse operators on same cluster
- Telco client – 25 Million messages per second

Analytics on Streaming Data

- Analytic accelerators for a variety of data types
- Optimized for real-time performance



Massively Scalable Stream Analytics

It is crucial to make sense of

DATA

US Presidential Debates
Making Sense of Sentiments

LIVE DEMO!

USC Annenberg Innovation Lab

TWITTER SENTIMENT ANALYSIS

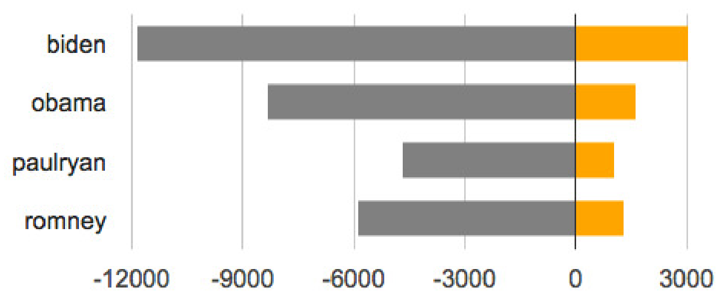
SAIL

19:33
updates every 30s

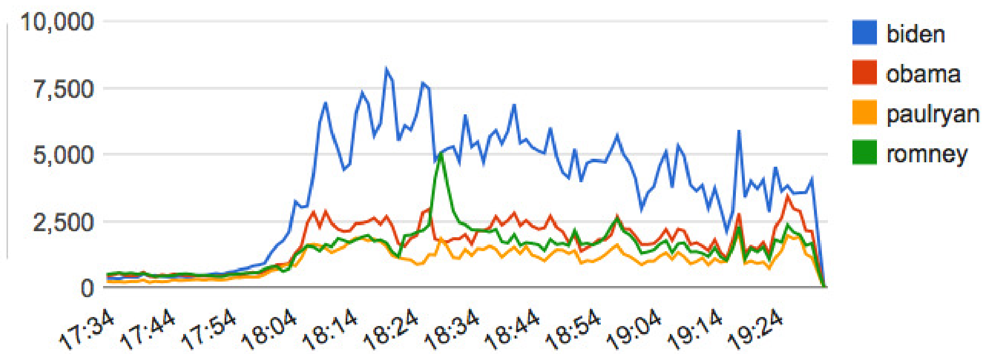
Our unique sentiment model and real-time processing infrastructure allow us to gauge live public sentiments toward the 2012 United States presidential candidates as expressed through Twitter. This live demo is work-in-progress as we continue to refine our sentiment model. More information.

Like 50 Tweet 40 +1 14 Share 104

Sentiment



Tweet Volumes



Trending words

19:28	19:29	19:30	19:31	19:32
Wade	Wade	devoted	closing	
Roe	overturning	chains	momma	
overturning	Roe	they'll	devoted	
#DetailsMatter	abortion	ten	field	
abortion	#DetailsMatter	Wade	chains	

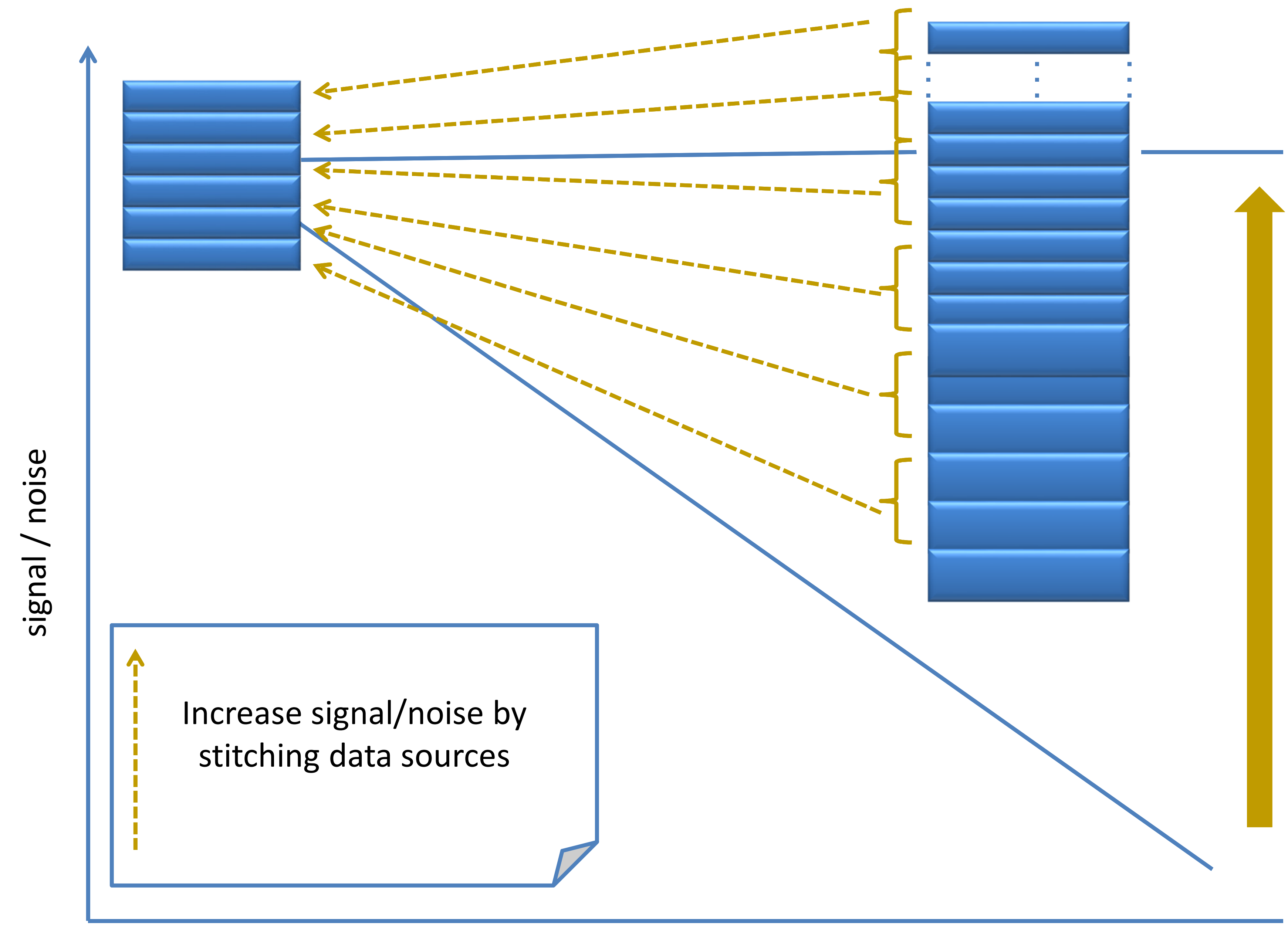
Statistics

Total # tweets processed	1355971
System seconds elapsed	85113
Data rate (tweets/minute)	954

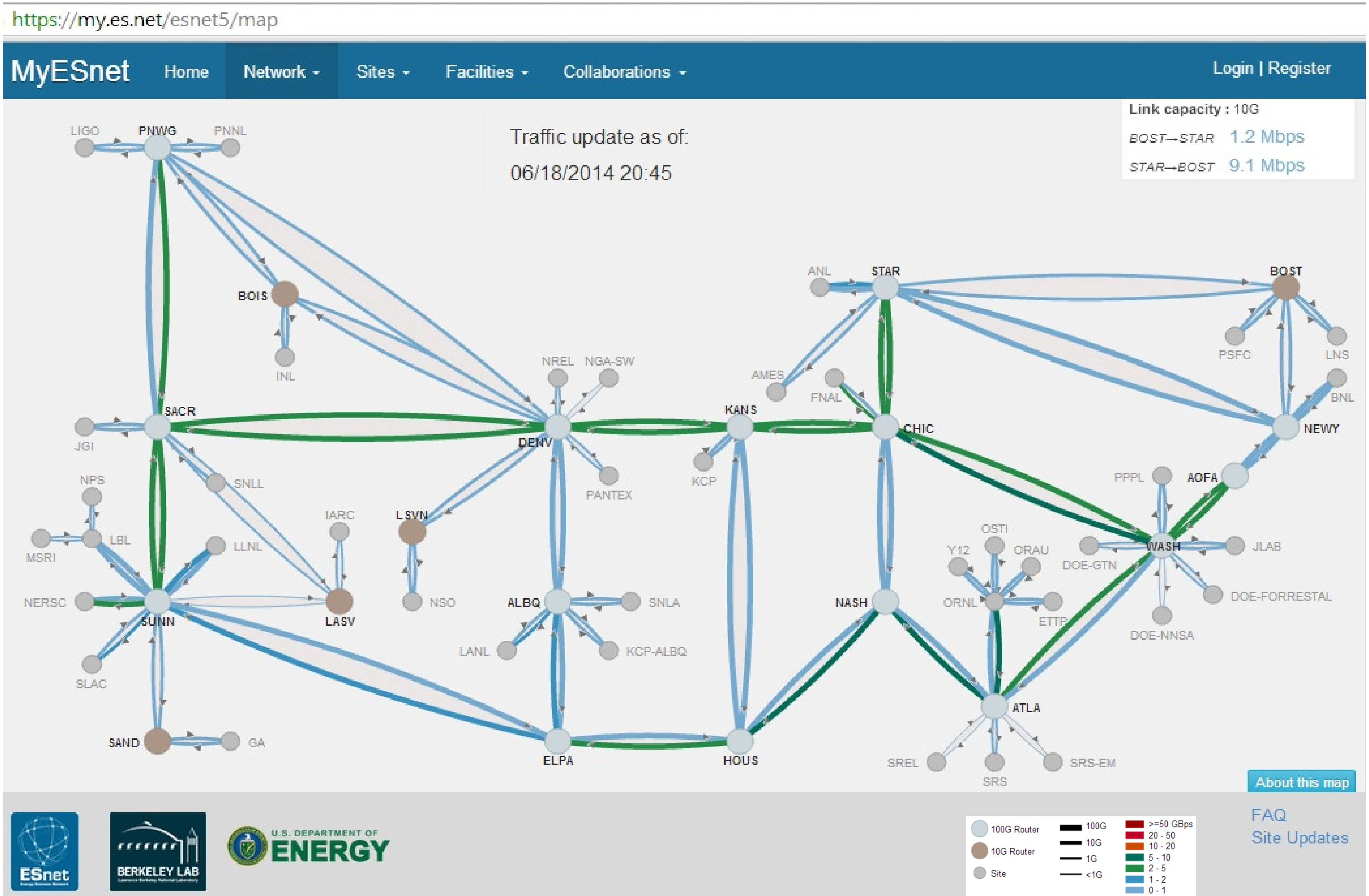
Go To Tweets/Annotation Page

Mirrored site (in case of outage)

Monetization of Perishable Broad Data → extract signal, sanitize, stitch, sell



Speed of Data Transmission in the US – now 100 Gbps (proposed 1 Tbps)



Connection Speed

Global Rank	Country/Region	Q1 '14 Avg. Mbps	QoQ Change	YoY Change
1	South Korea	23.6	8.0%	145%
2	Japan	14.6	12%	29%
3	Hong Kong	13.3	8.5%	24%
20	Taiwan	8.9	6.4%	118%
24	Singapore	8.4	6.1%	28%
42	Australia	6.0	2.6%	39%
45	New Zealand	5.6	5.7%	30%
48	Thailand	5.2	6.8%	31%
69	Malaysia	3.5	16%	30%
79	China	3.2	-6.4%	46%
93	Indonesia	2.4	46%	55%
105	Philippines	2.1	5.7%	49%
107	Vietnam	2.0	12%	47%
118	India	1.7	8.4%	34%

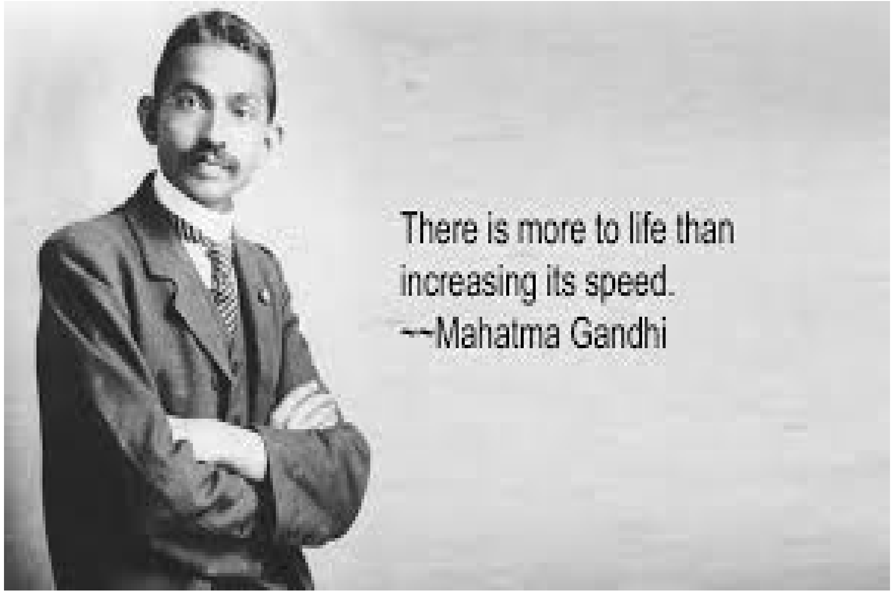
Average Connection Speed
by Asia Pacific Country/Region

Global Rank	Country/Region	Q1 '14 Peak Mbps	QoQ Change	YoY Change
1	South Korea	68.5	6.5%	52%
2	Hong Kong	66.0	-3.3%	0.3%
3	Singapore	57.7	-2.5%	32%
5	Japan	55.6	4.7%	17%
7	Taiwan	52.6	2.1%	61%
30	Thailand	34.4	-11%	14%
41	Australia	31.6	-10%	20%
51	Malaysia	27.9	-6.9%	10%
59	New Zealand	24.3	12%	20%
74	Indonesia	19.4	55%	42%
78	Philippines	18.8	-42%	26%
96	China	13.6	-1.2%	43%
110	Vietnam	12.3	-3.2%	-1.9%
112	India	12.0	-1.5%	7.6%

Average Peak Connection Speed
by Asia Pacific Country/Region

Source: Akamai Report Q1 2014

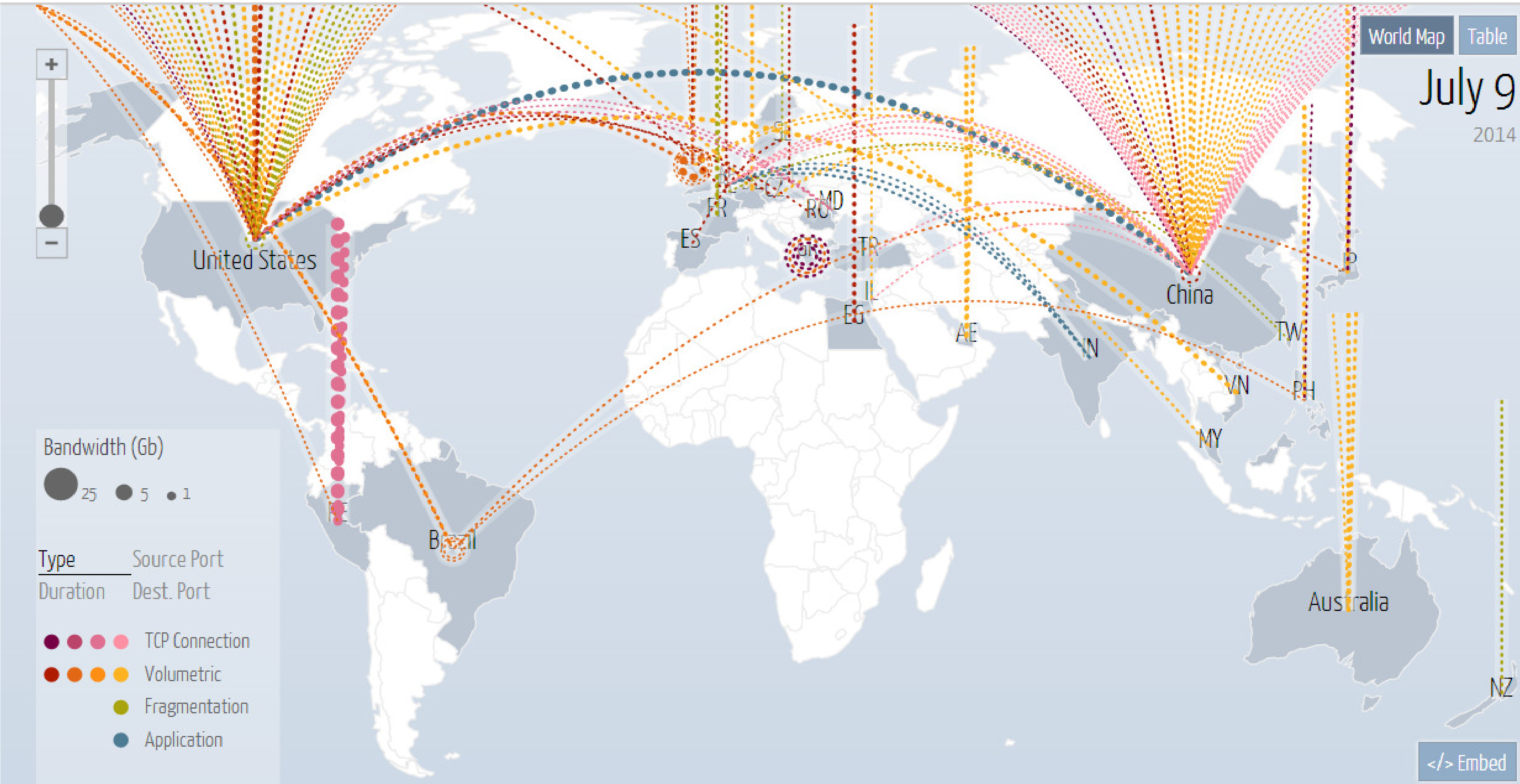
The need for speed?



Is your data secure?

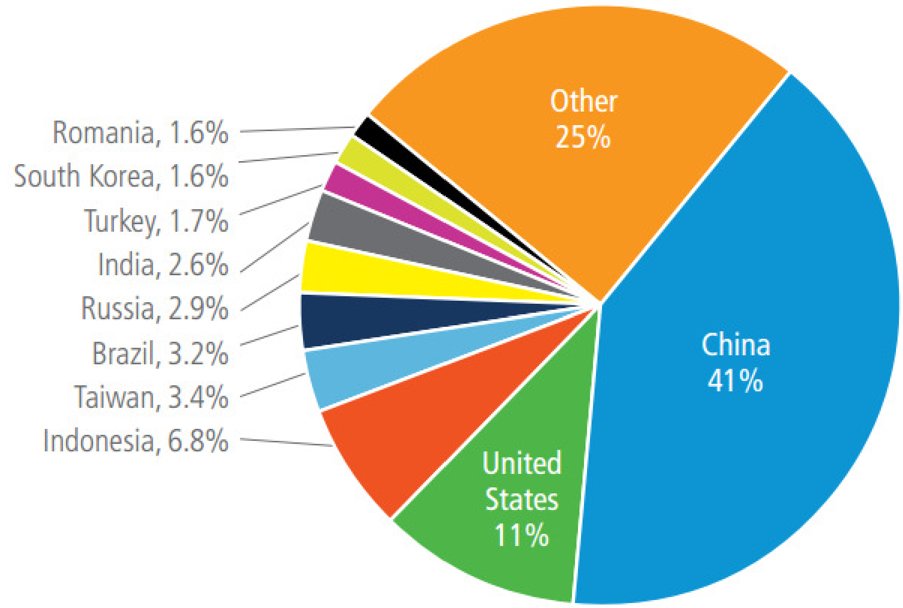
THE ASCENT OF CYBERSECURITY

Digital Attack Map – The Prelude to Cyber Warfare



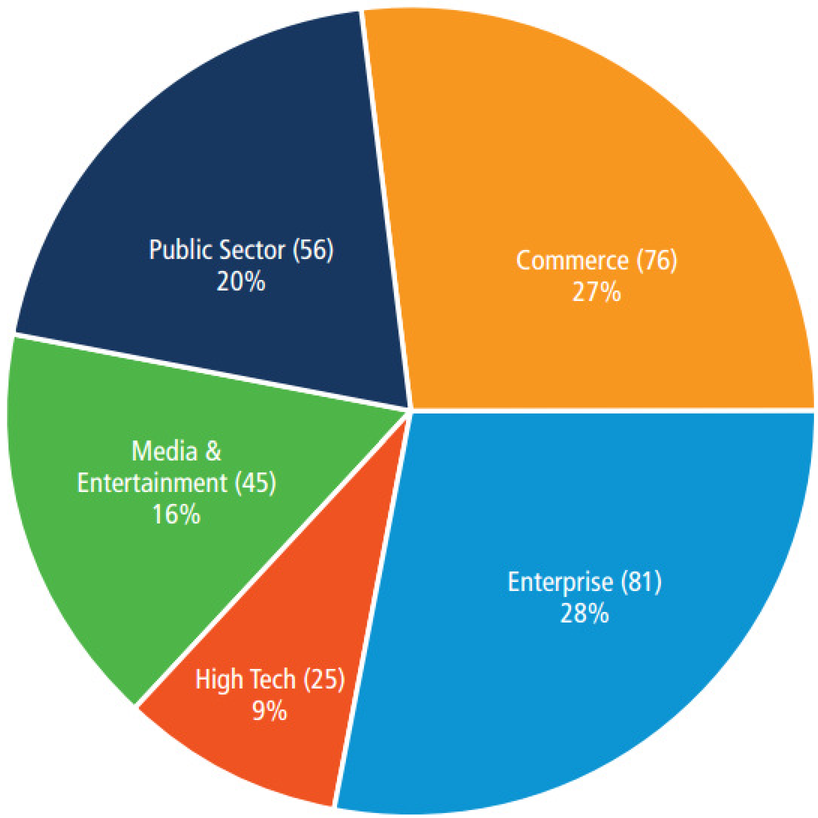
Distributed Denial of Service (DDoS) Attack Traffic (source IP analysis)

	Country/Region	Q1 '14 Traffic %	Q4 '13 %
1	China	41%	43%
2	United States	11%	19%
3	Indonesia	6.8%	5.7%
4	Taiwan	3.4%	3.4%
5	Brazil	3.2%	1.1%
6	Russia	2.9%	1.5%
7	India	2.6%	0.7%
8	Turkey	1.7%	0.4%
9	South Korea	1.6%	0.6%
10	Romania	1.6%	0.9%
–	Other	25%	12%

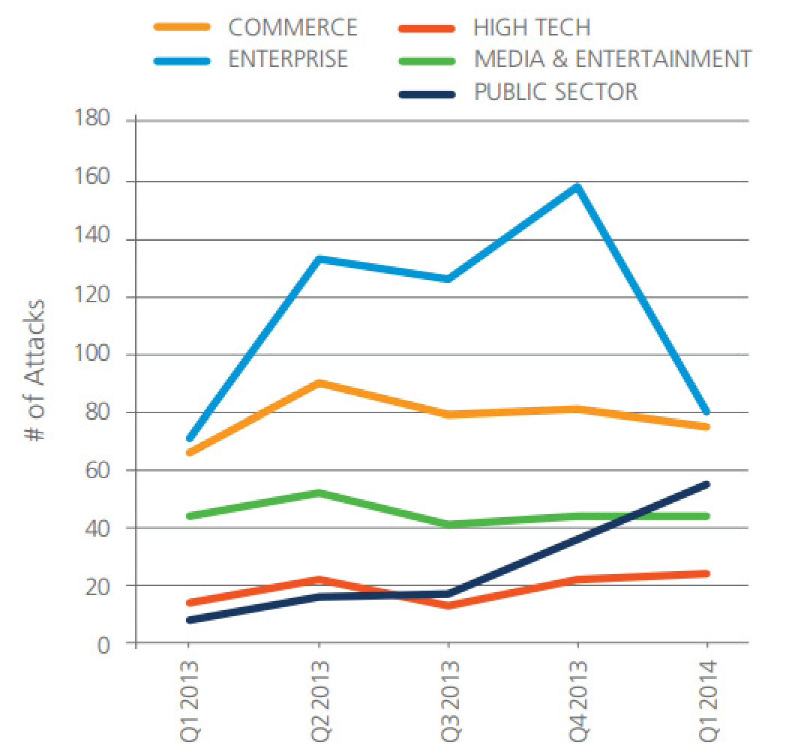


Source: Akamai Report Q1 2014

Distributed Denial of Service (DDoS) Attacks by Sector



Q1 2014 DDoS Attacks by Sector



Attacks by Sector Over Time

Akamai Report Q1 2014

A new competitive sport for the industrial internet era – Car Hacking

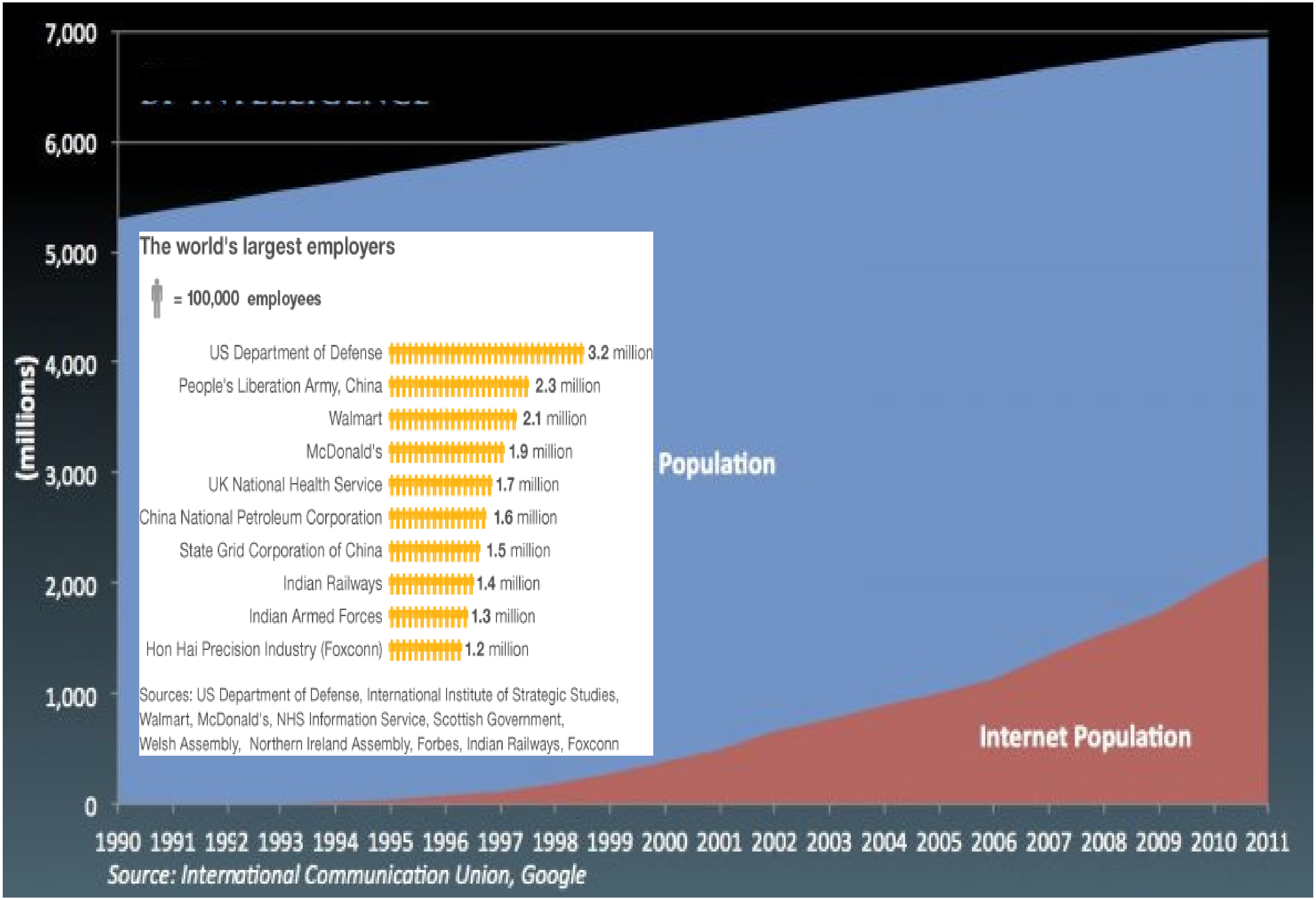
Autonomous objects may be sitting ducks for the teen hacker. **True or False?**

Google Inc. revealed a new operating system for cars, called Android Auto, on Wednesday, laying the groundwork for vehicles to virtually become smartphones on wheels. As more cars become connected to the Internet in some capacity and collect and transmit more data, the question becomes all the more real: Will car-hacking become the new carjacking?

Broad spectrum of data

The range of data related applications will stretch our imagination

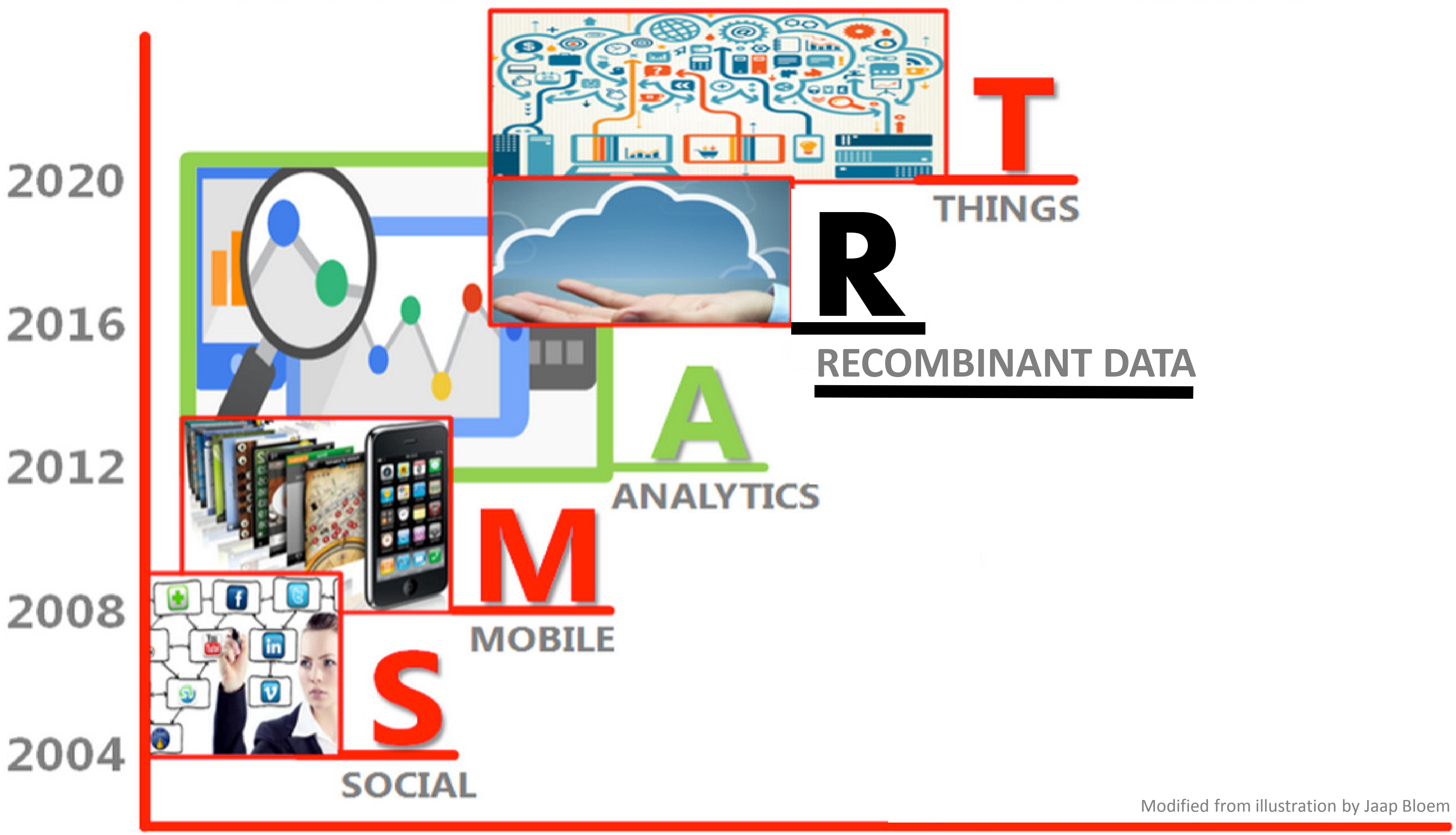
Data – Imagine what happens if 50% of the population were connected



Recombinant Data

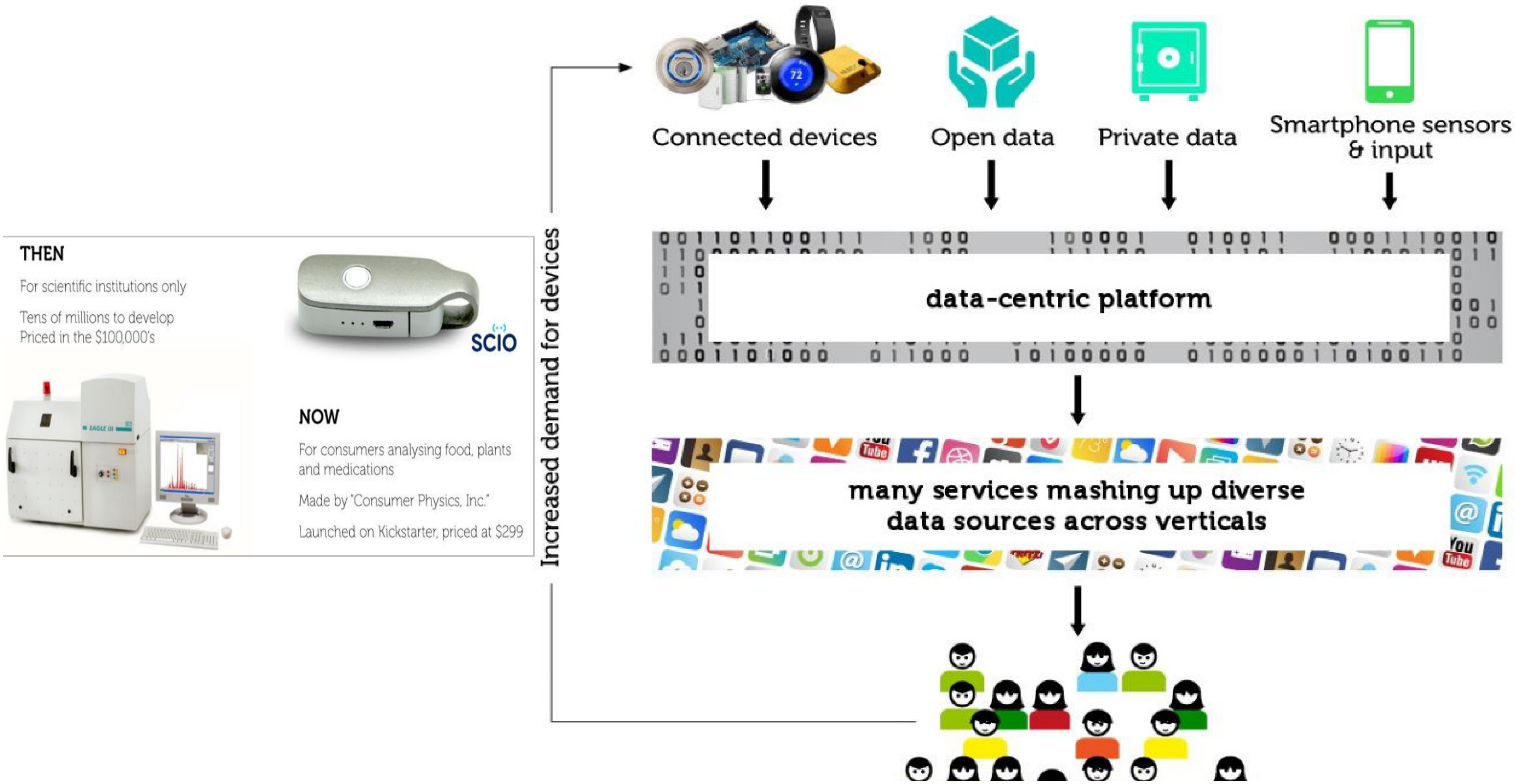
Data (by itself – in one silo) is of limited value unless analyzed in conjunction with other data in context of the application or in context of the problem-question

How smart can you make SMART ?? Depends on Recombinant Data

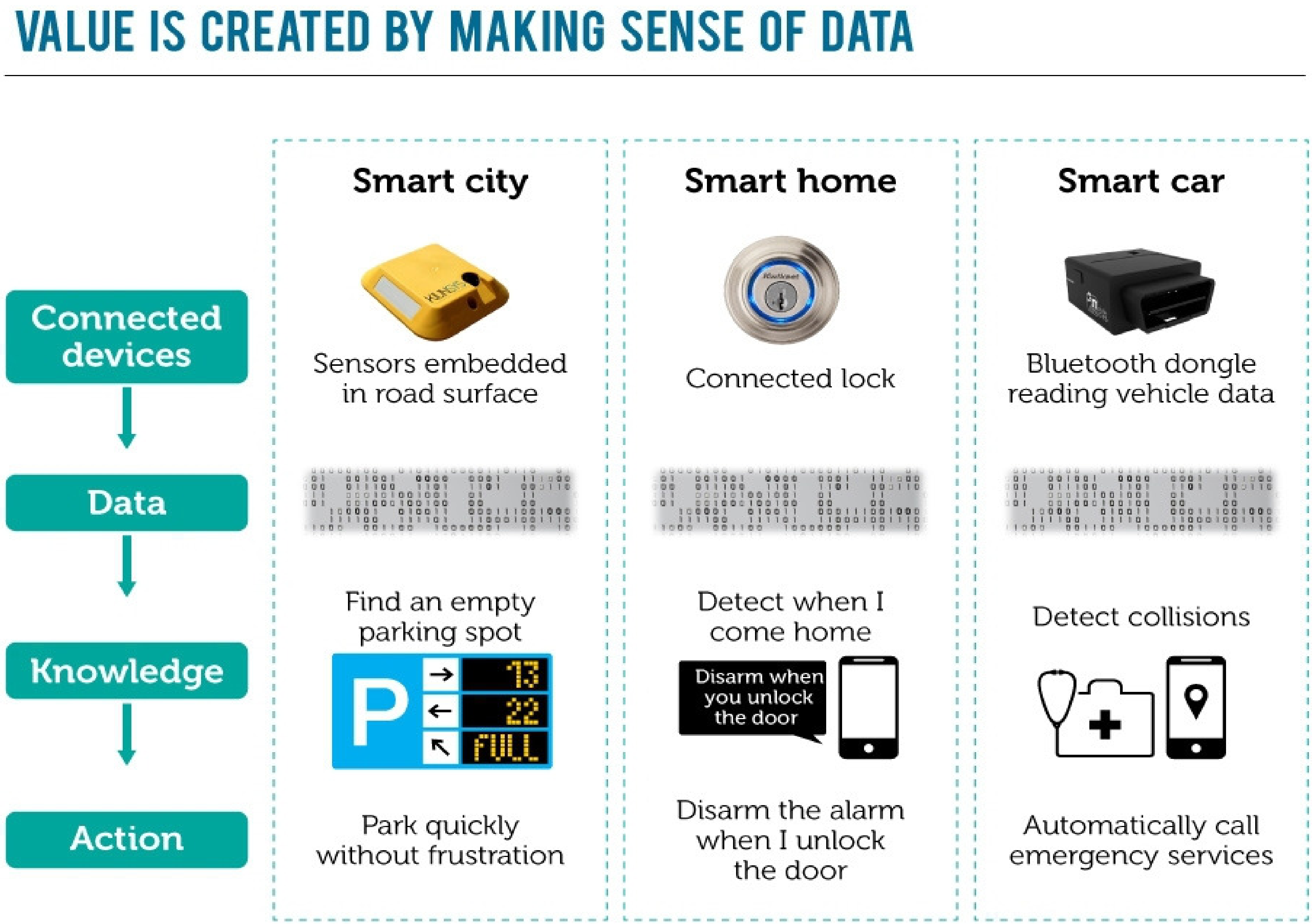


Modified from illustration by Jaap Bloem

Recombinant DNA is so yesterday … the emergence of Recombinant Data

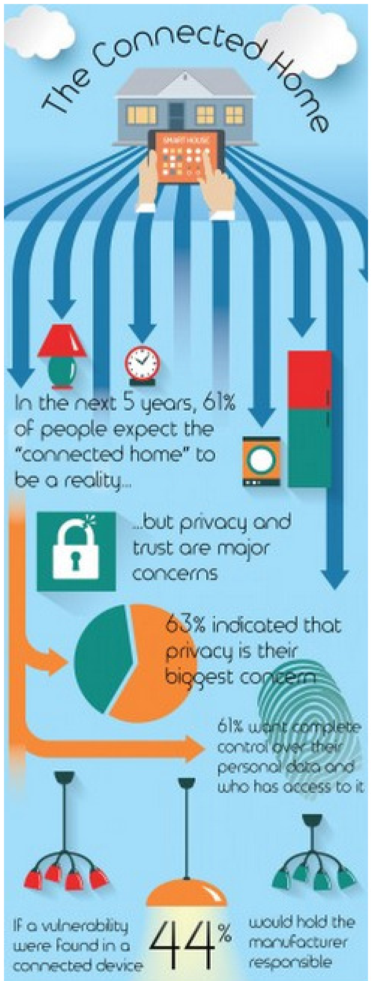


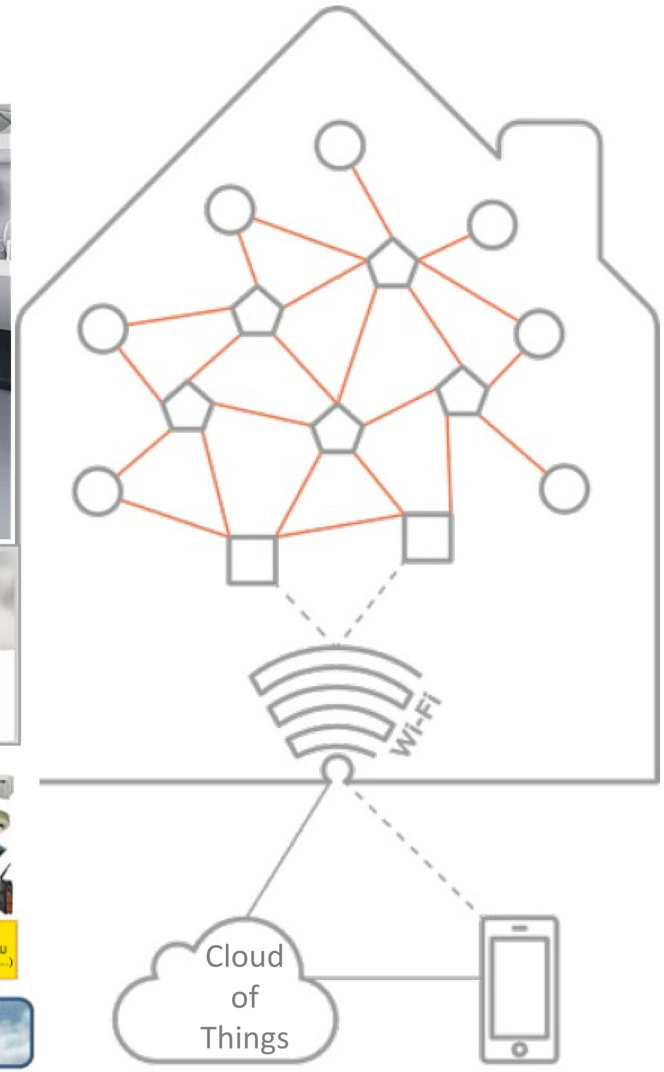
Making Sense of Recombinant Data – unleashing the value cryptic in data



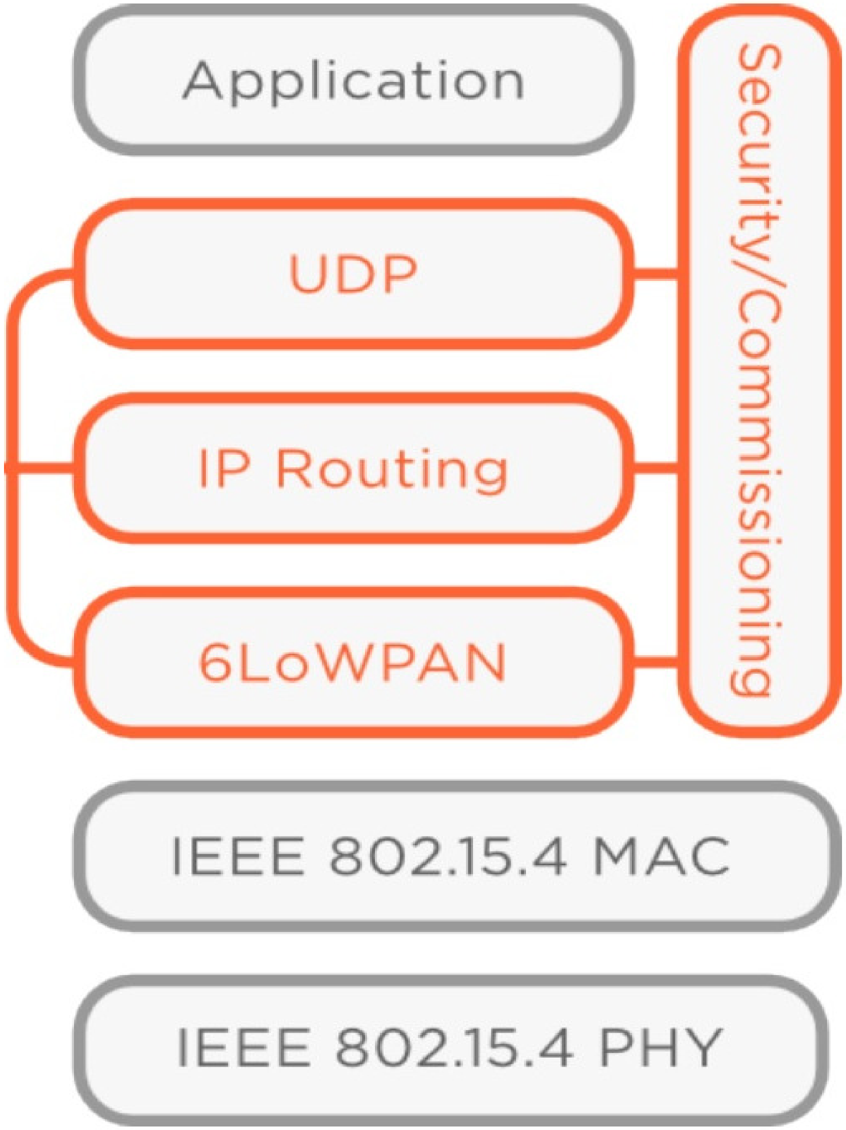
vmob.me

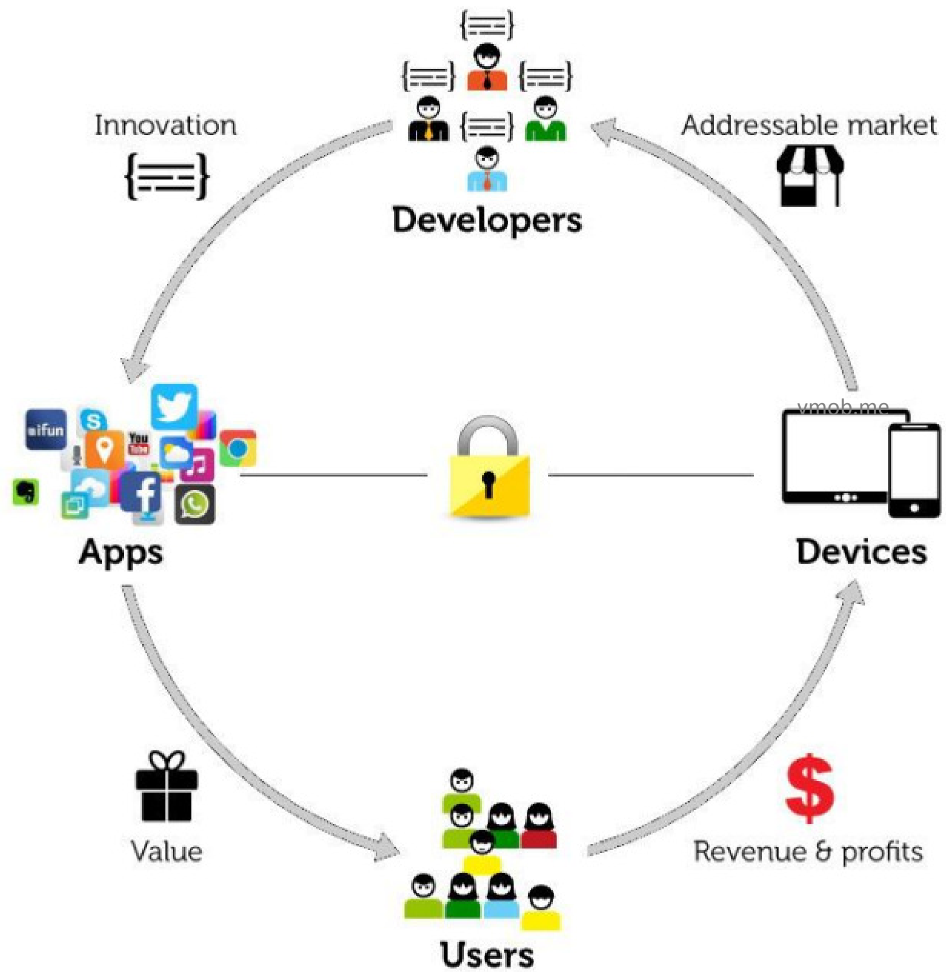
Threading a Home Mesh Network to make every home a smart home?



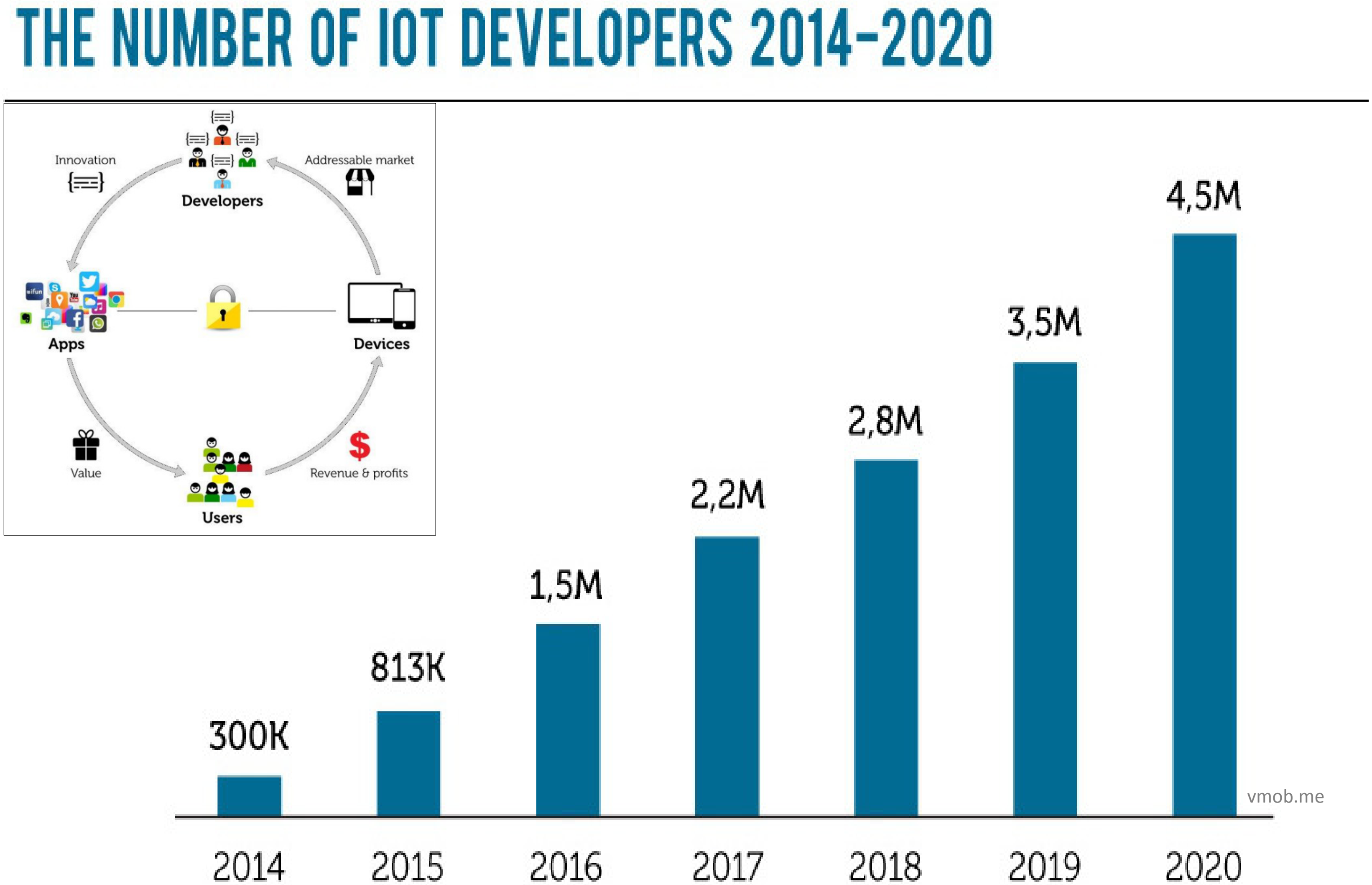


How to thread an emerging business cycle ?



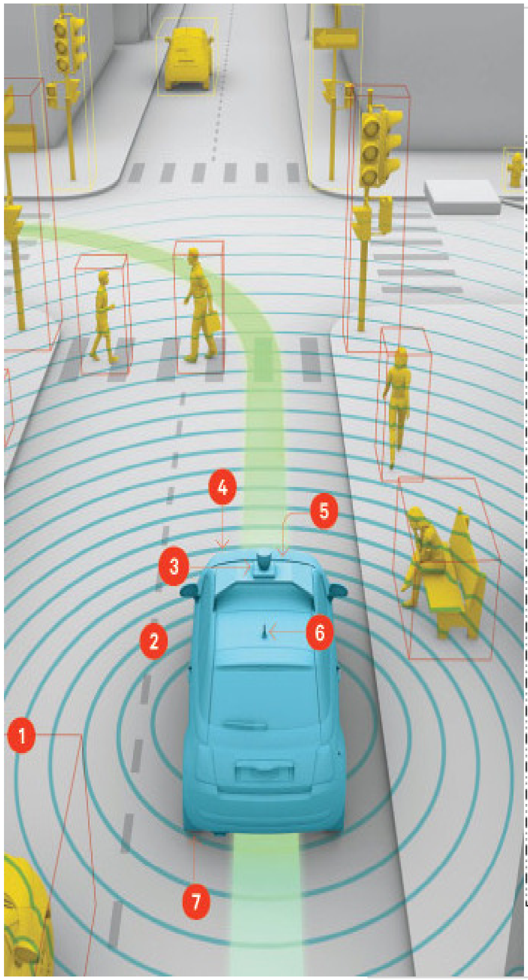


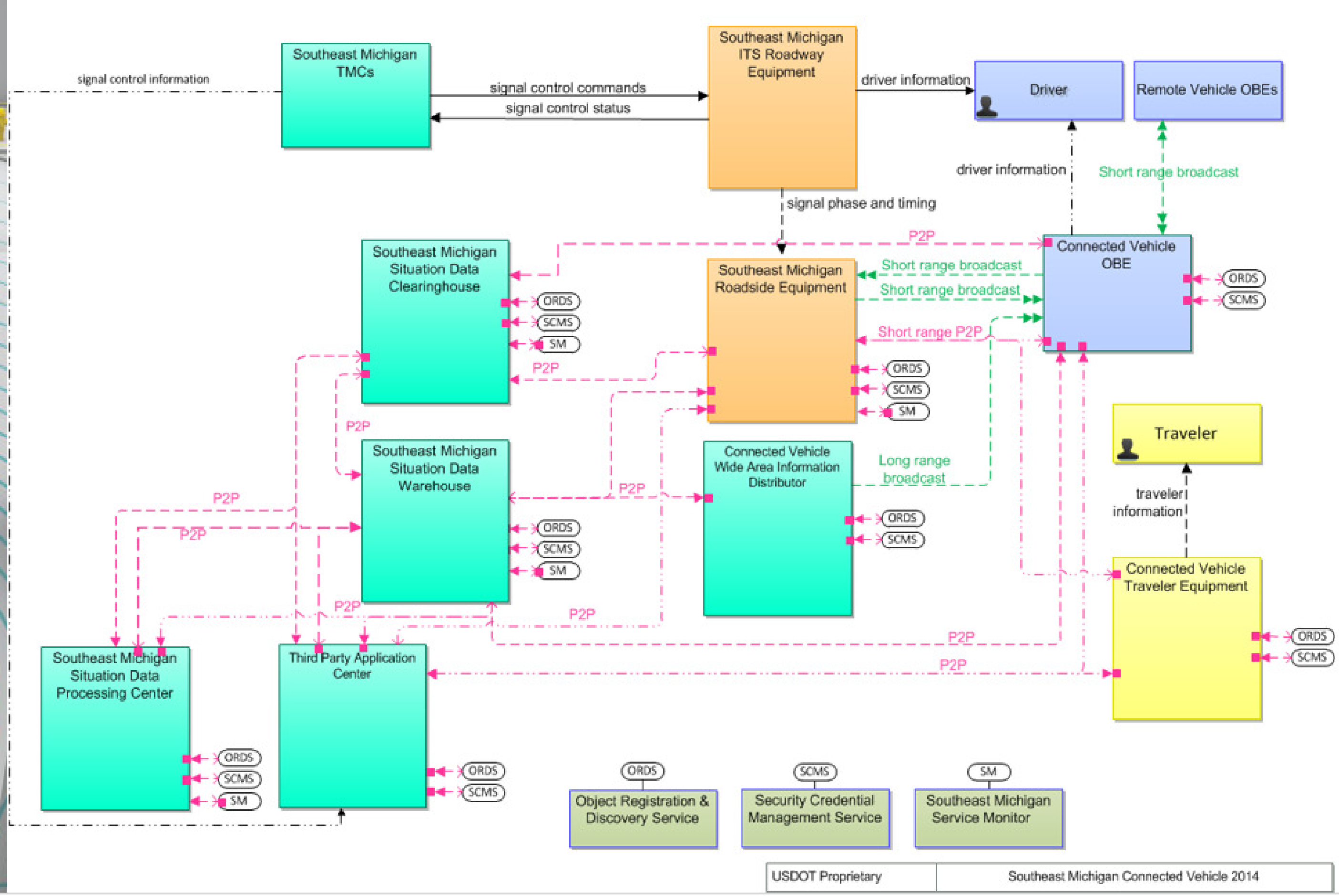
Job creation catalyzed by the industrial internet and internet of things



Demand for 4.5 million developers by 2020 – new jobs for software industry

Exabytes of data per second from deployment of autonomous vehicles

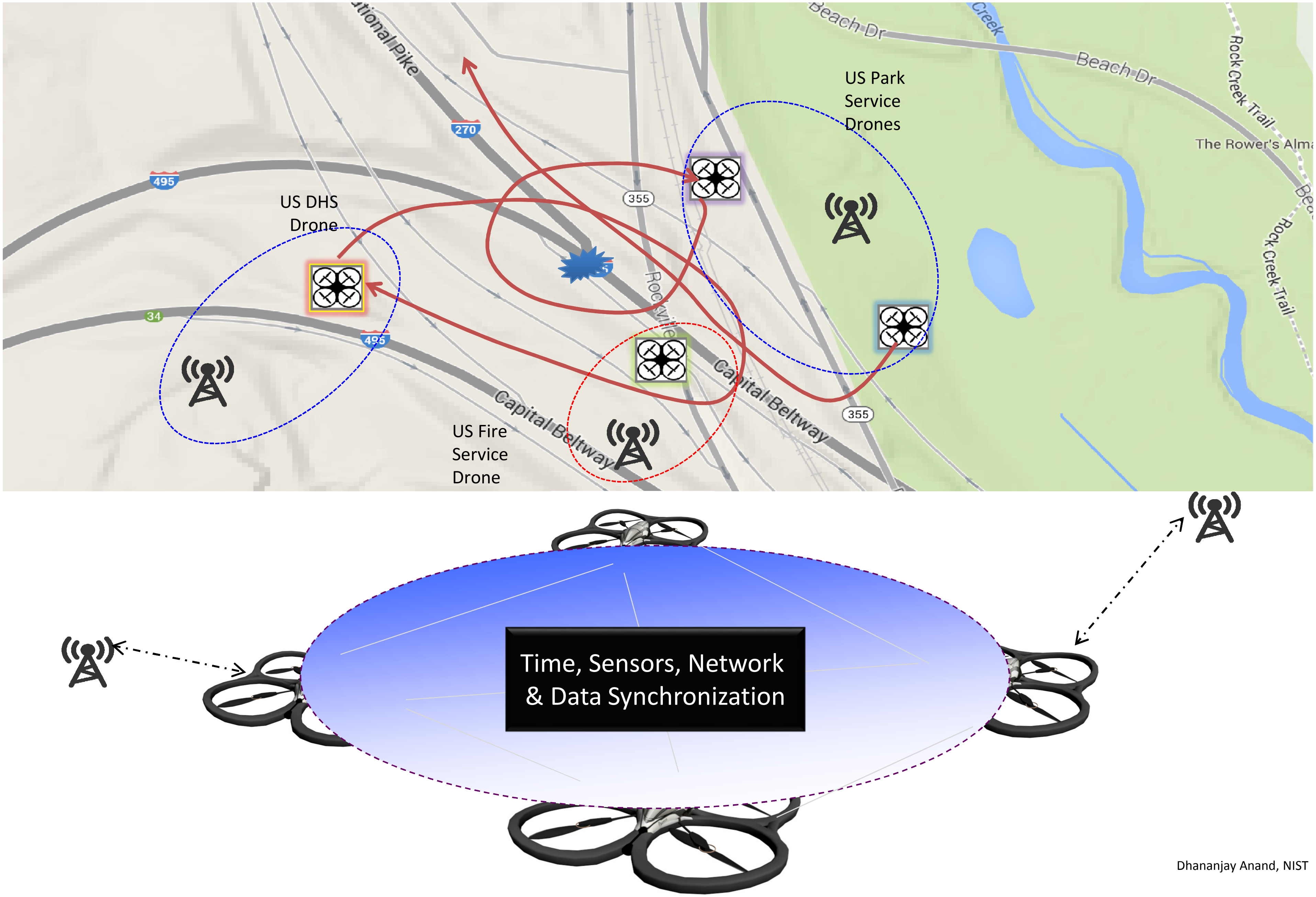




Terrestrial Transportation – Emergency "Crash to Care" Response System




Hellabytes of data from deployment of emergency search & rescue drones



Dhananjay Anand, NIST

Tectonic Paradigm Shift – Data has gone to the Dogs – Internet of Dogs

Computer Scientists Are Building An Internet Of Dogs For Emergency Rescues

K9 ANALYTICS INC – *We are dogmatic about the future of data*

The Lassie of the future will not bark for the sheriff. Instead, a wireless sensor on her harness will detect gas in an earthquake-shattered building, then text the drones and first responders on the scene. Or at least that's one team's idea behind a design from this year's SmartAmerica Challenge, a project launched by the White House Innovation Fellow program.

The Internet of Dogs is just one part of a larger emergency response system, explains Justyna Zander, the SmartAmerica team lead. Together with computer scientists from a range of academic institutions and industries, they developed a process by which drones, robots, dogs, and human first responders could communicate with one another automatically.

Diesel and Simba resting at the feet of Robo-Cop in the Washington DC Convention Center on June 11, 2014 at the SmartAmerica Challenge organized by Presidential Innovation Fellows Sokwoo Rhee and Geoff Mulligan. Has Boeing receded to the background of US innovation?

Tectonic Paradigm Shift – To bee or not to bee – To bee decided

Data, People and Smart Cities – Grand Decarbonization Plan for Chicago

Data may not even fetch basic commodity pricing
Data analytics may evolve as the premium value add

WHAT WILL YOU DO WITH

FREE DATA STORAGE ?

FREE COMPUTATION ?

Google's Big Data IoT Play For Manufacturing

Posted By Paul Tate, June 13, 2014 at 7:02 AM, in Category: Transformative Technologies

"What if storage and compute power were free? How would that change the way you look at Big Data and the Internet of Things?" asked Tom Howe, Google's senior enterprise consultant for manufacturing during last week's 10th Manufacturing Leadership Summit in Palm Beach, Fla.

Addressing the annual gathering of senior industry executives, Howe suggested that Google is acutely aware of many of the key issues facing manufacturing today as the company has become a significant global producer itself – from the racks it uses in its data centers around the world, to Google Glasses, Nexus smart phones and tablets, the Project Loon high-altitude balloon networks that connect remote regions to the internet, and its newly launched self-driving cars. Not to mention its acquisition of eight or more robotics companies over the last few months.

Howe's focus in his talk, however, was not on Google's own manufacturing activities, but on how the Internet of Things (IoT) and Big Data are rapidly becoming strategic game-changers for all types of manufacturing enterprises. Companies must now actively pursue the collection of multiple types of key data about their operations and their products because, he warned the audience, "if you don't collect this data, someone else will!"

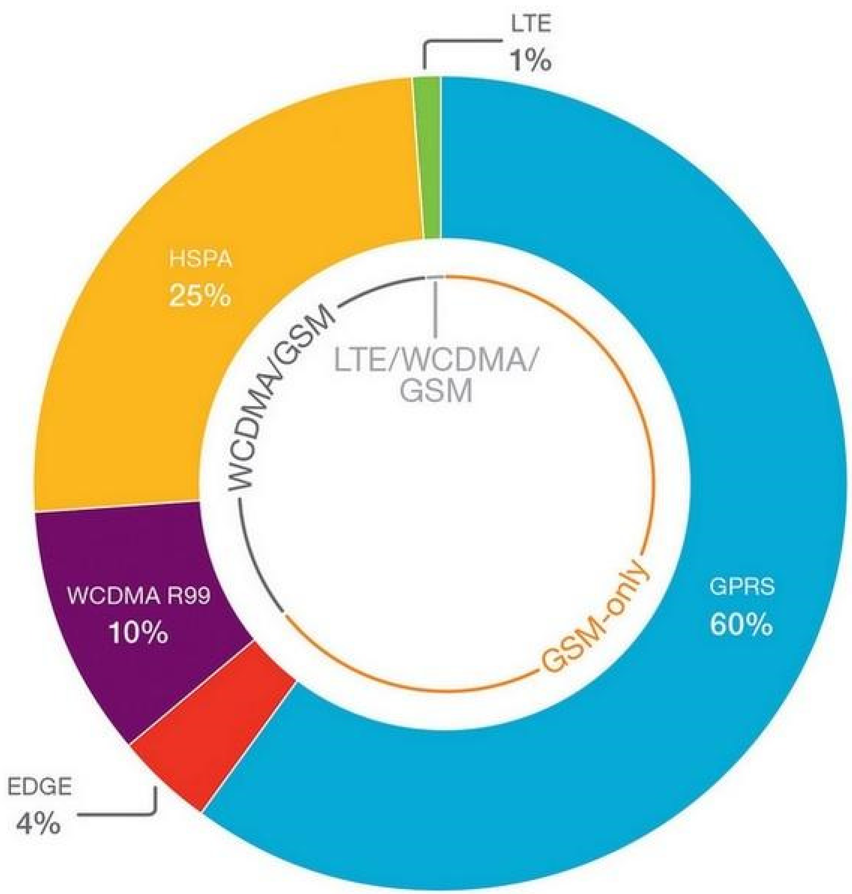
The problem with Big Data, he added, is that 'in our perspective there have been a number of significant blockers to progress in the past." These include the storage costs of massive amounts of information; the cost of crunching the data; the right tools to look at and analyse the data; limitations to network availability and speed; and simply "knowing which questions to even ask", he added.

Google's answer is a 'public cloud' for enterprise IoT. That's where Howe's question to the audience about the potential impact of free storage and compute power comes into play.

He cited different examples of how cloud-based IoT can work in practice - from re-imagining old products such as domestic thermostats that are now connected to the internet, uploading data to the cloud, crunching the results, and sending instructions back down to the device or the owner to create remedial actions; to retrofitting old products like agricultural vehicles that provide real-time location and performance data; to innovative new ideas like smart band aids sending alerts to help to stop the spread of infection in hospitals and medical centers.

answers
not
numbers

Radio capability distribution of M2M devices in measured mobile networks



HELLABYTES

3D

Data Driven Decisionmaking

World Cup star Luminoso scores $6.5M to fund expansion of text analytics business

MIT Media Lab spinoff rolling amidst buzzy World Cup partnership with Sony

By Bob Brown | Follow

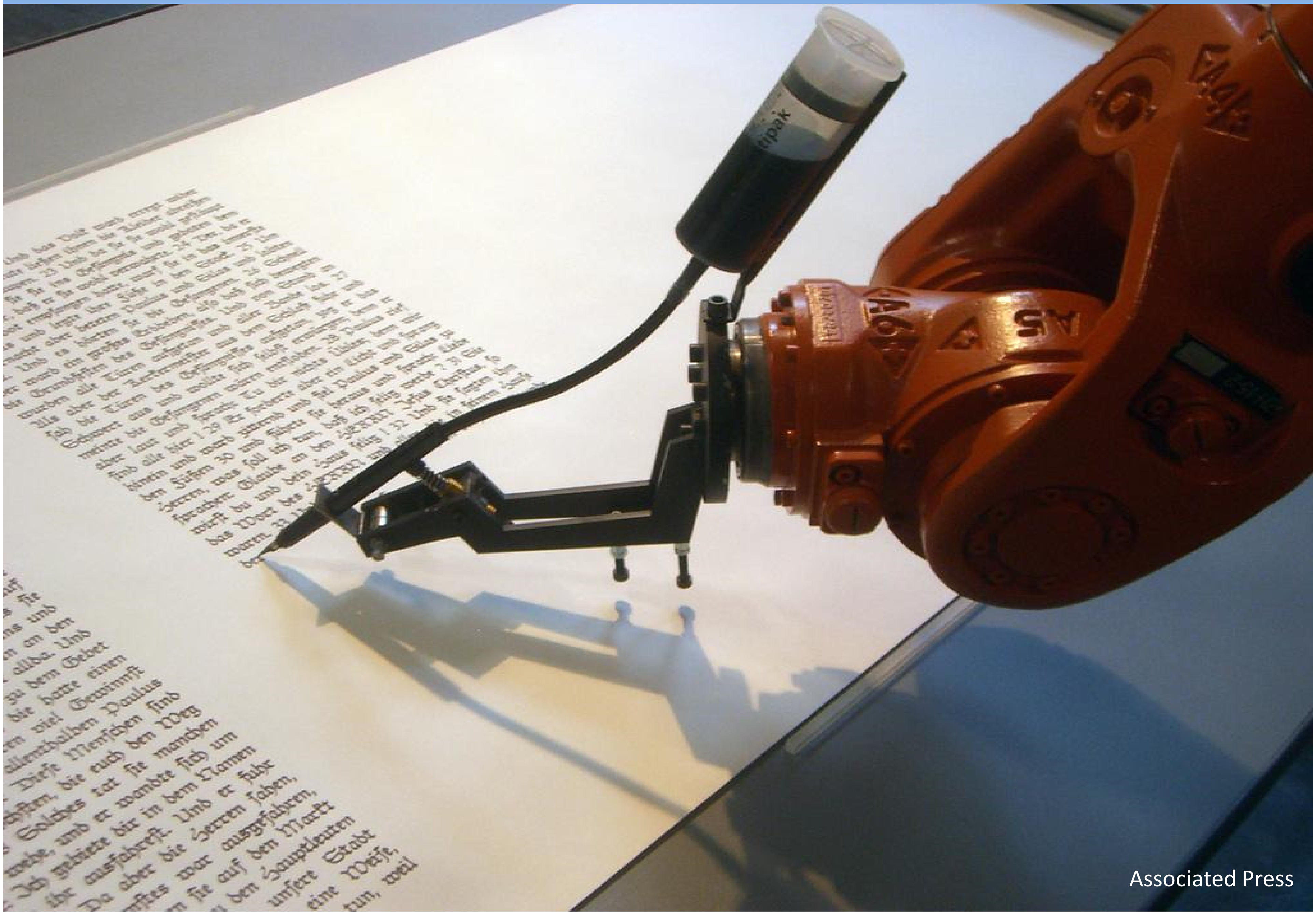
NetworkWorld | Jul 2, 2014 4:30 AM

analytics Startups SaaS

Text analytics company Luminoso, a 2010 MIT Media Lab spinoff that helps its customers make sense out of unstructured data, has raised a $6.5 million Series A round of funding. The 25-person outfit plans to use the funds for new hires in sales, product management and client services as well as to expand its product line.

The fresh funds come via Acadia Woods and Digital Garage, the latter of which is based in Tokyo and was co-founded by MIT Media Lab director Joi Ito. Cambridge, Mass.-based Luminoso, which offers its dashboard service via a software-as-a-service (SaaS) model and also provides APIs that can be incorporated into customers' existing systems, raised $1.5 million in seed funding in 2012.

Articles by Robots - Articles for Robots - Articles about Robots

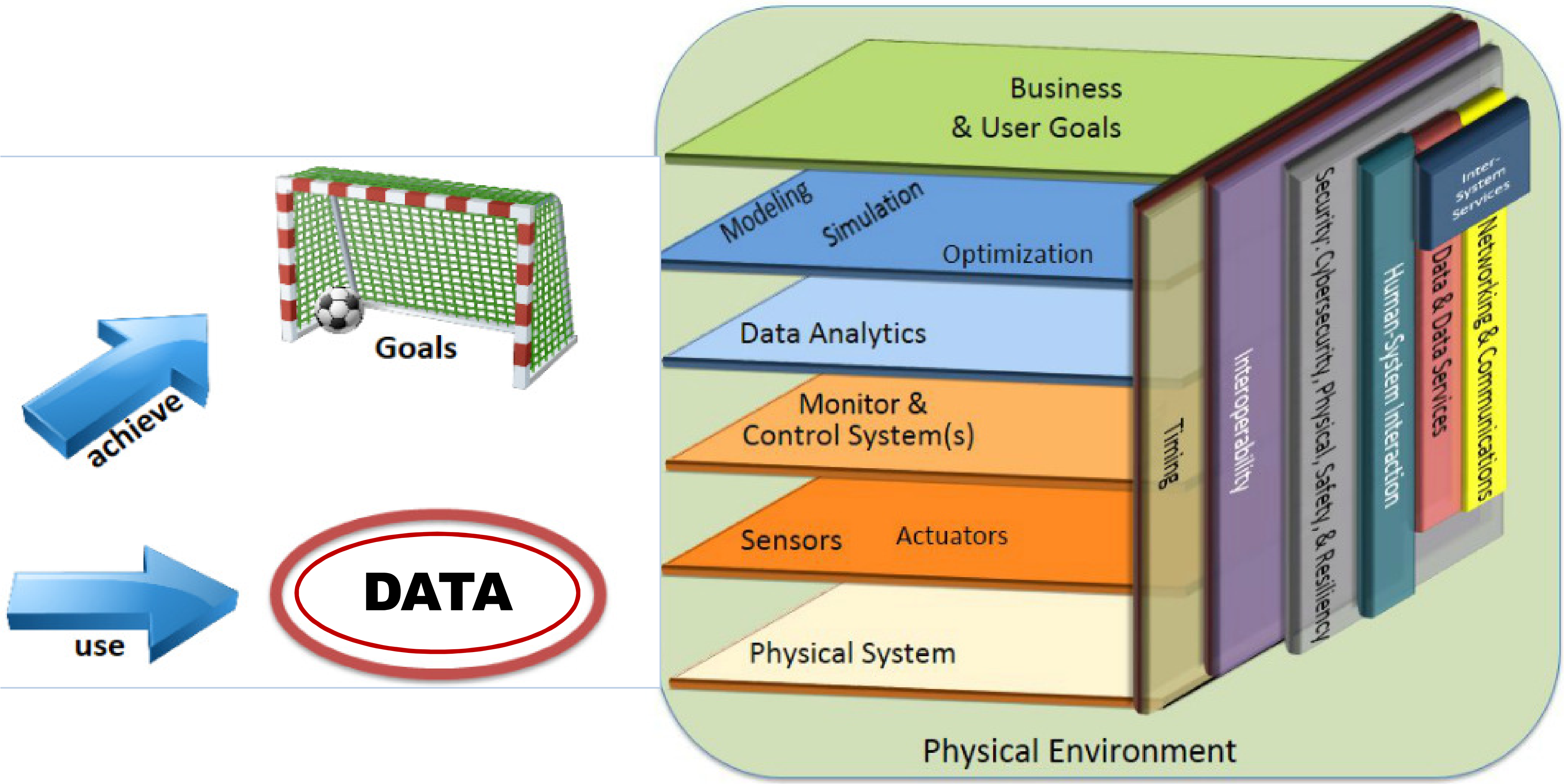


Associated Press

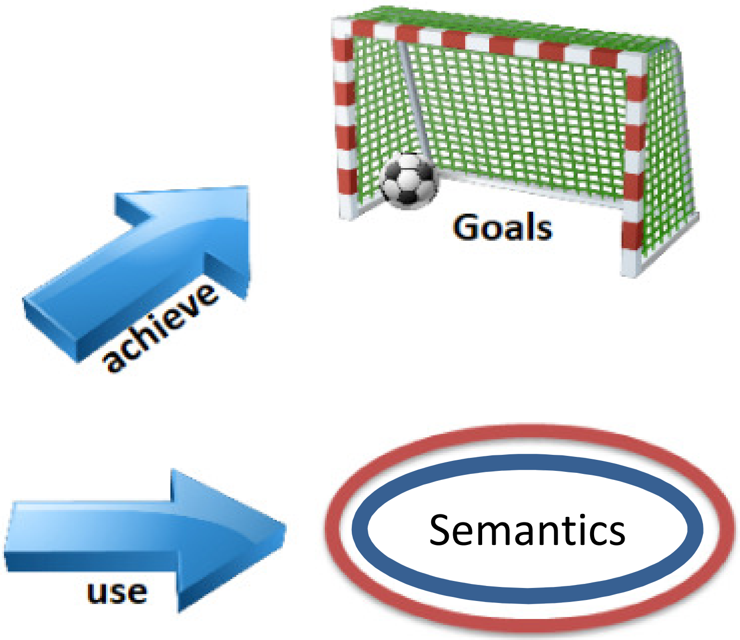
Intelligent Recombinant Data Analytics

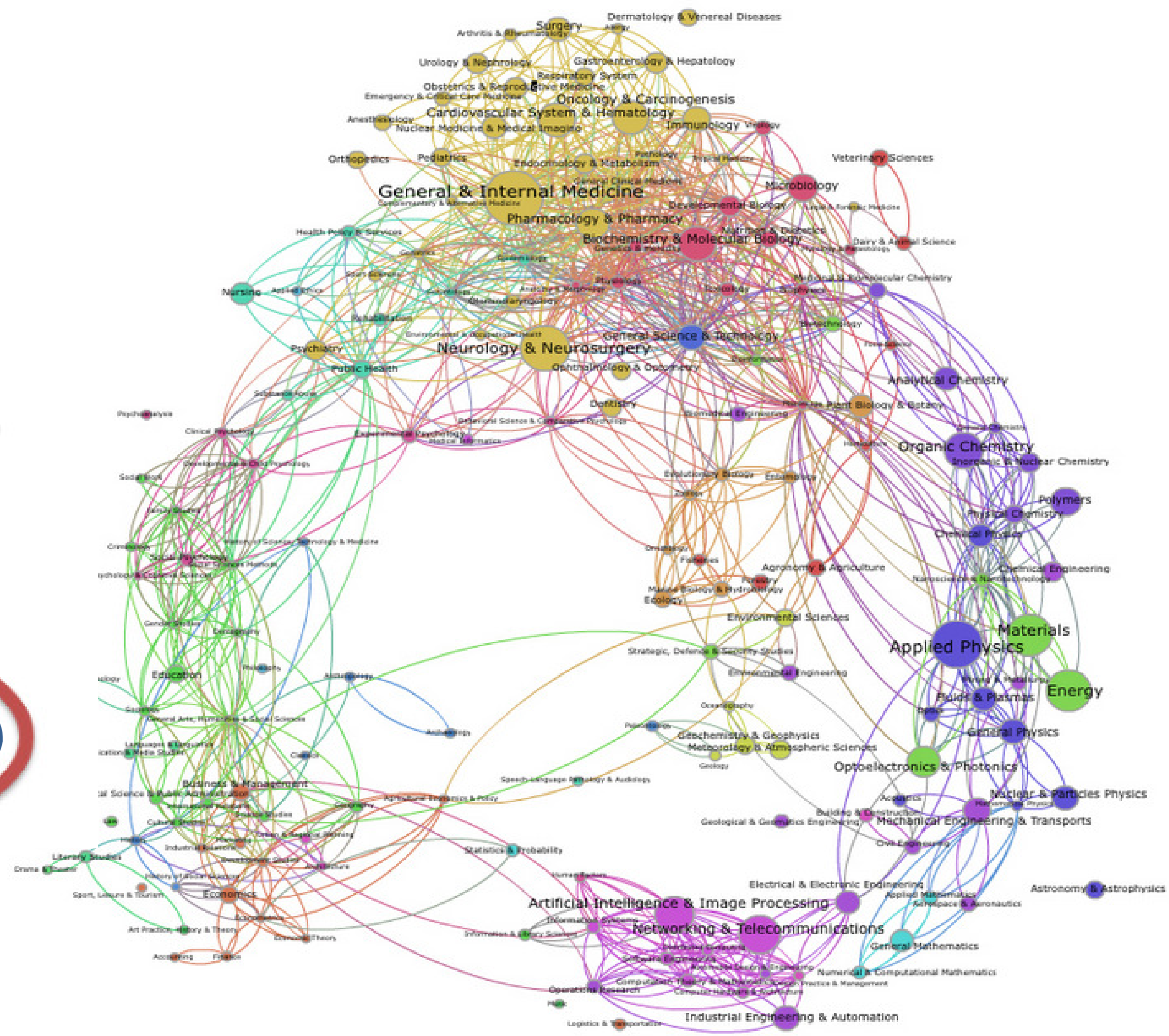
Predictions are very difficult, especially if it is about the future – Niels Bohr (1885-1962)

A staple horizontal for any vertical – IRDA & Data Driven Decision-making

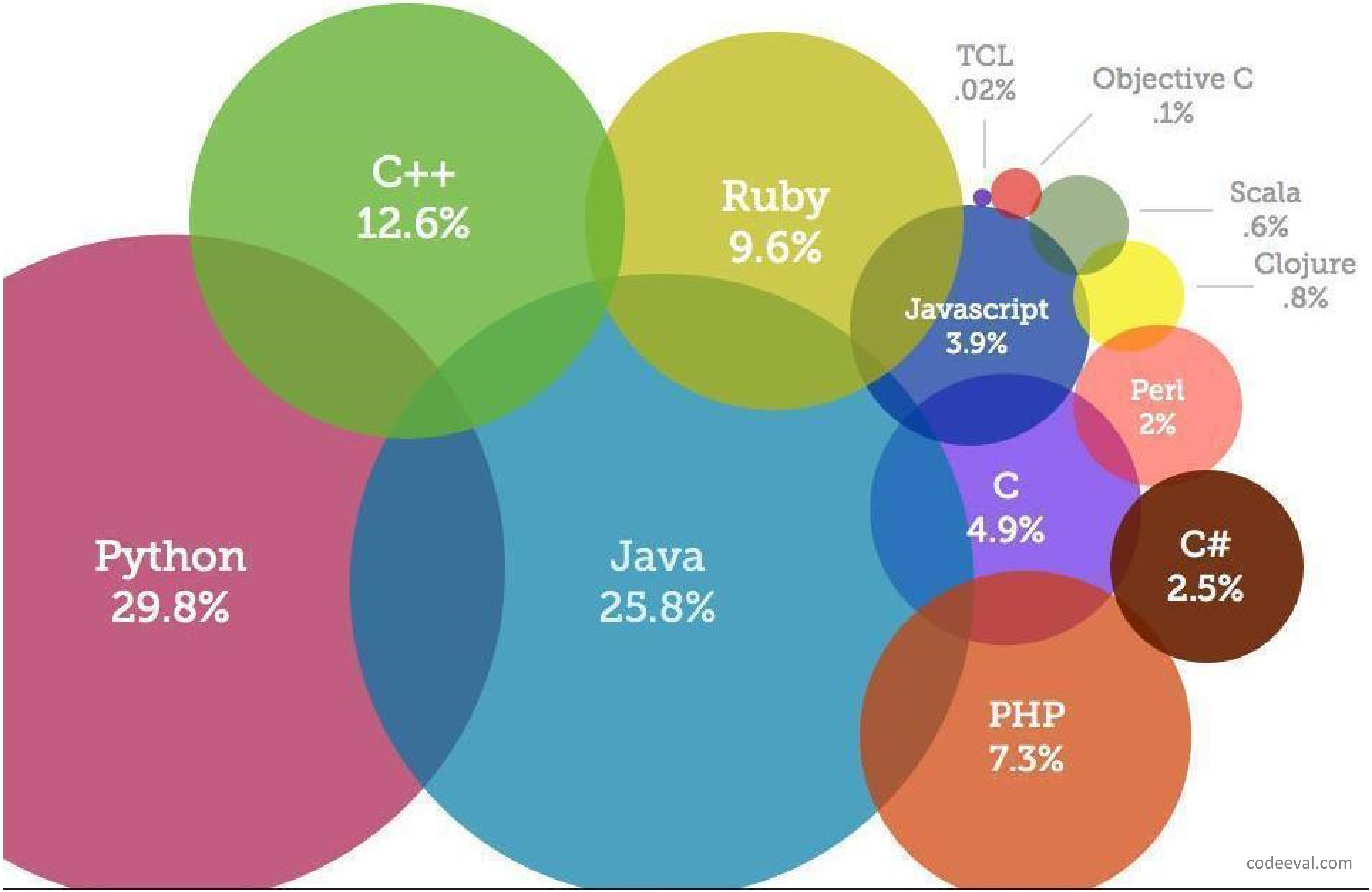


Data without context? Context without semantics? Semantics without ontology?

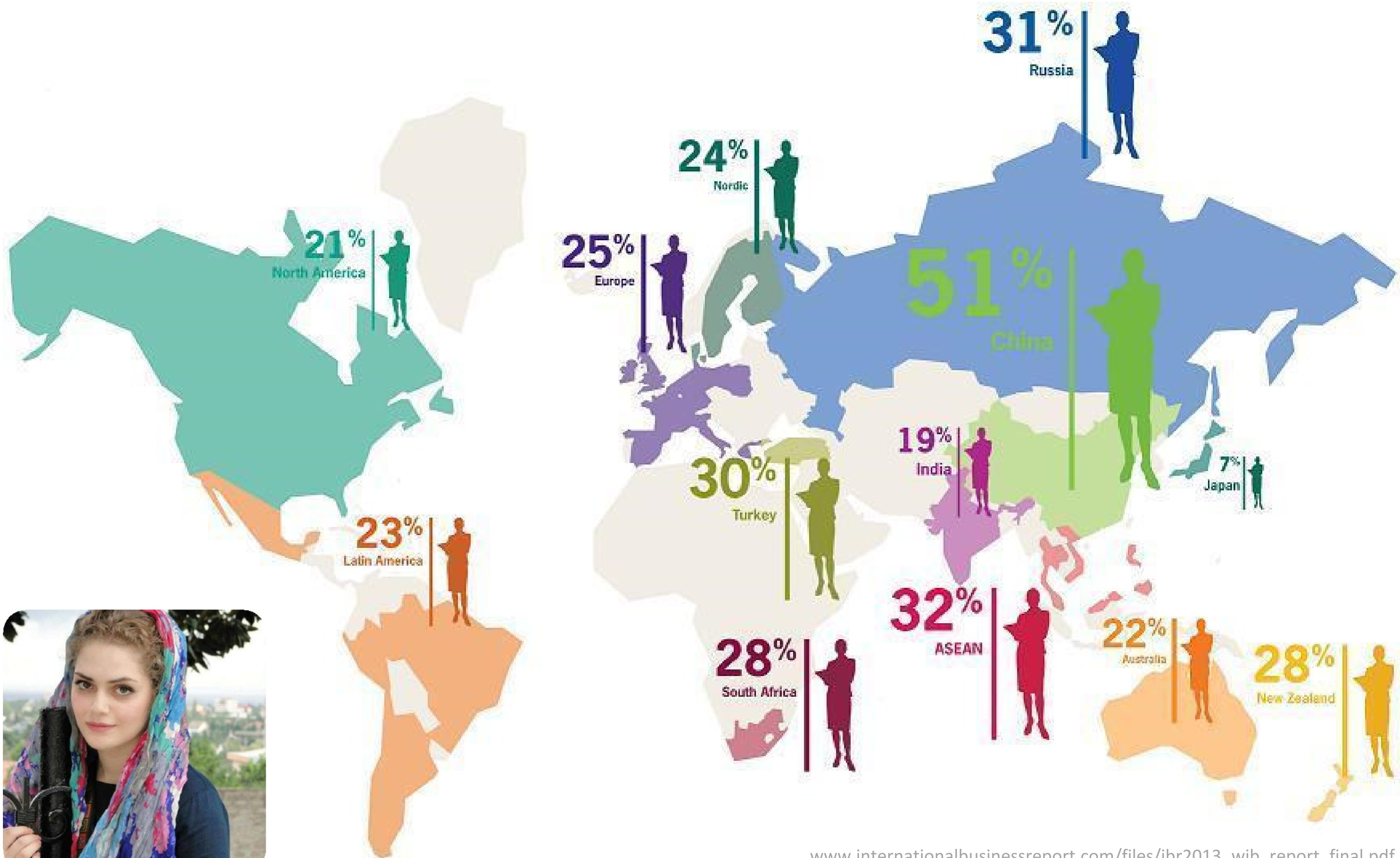




Girls Who Code <> Data without software?



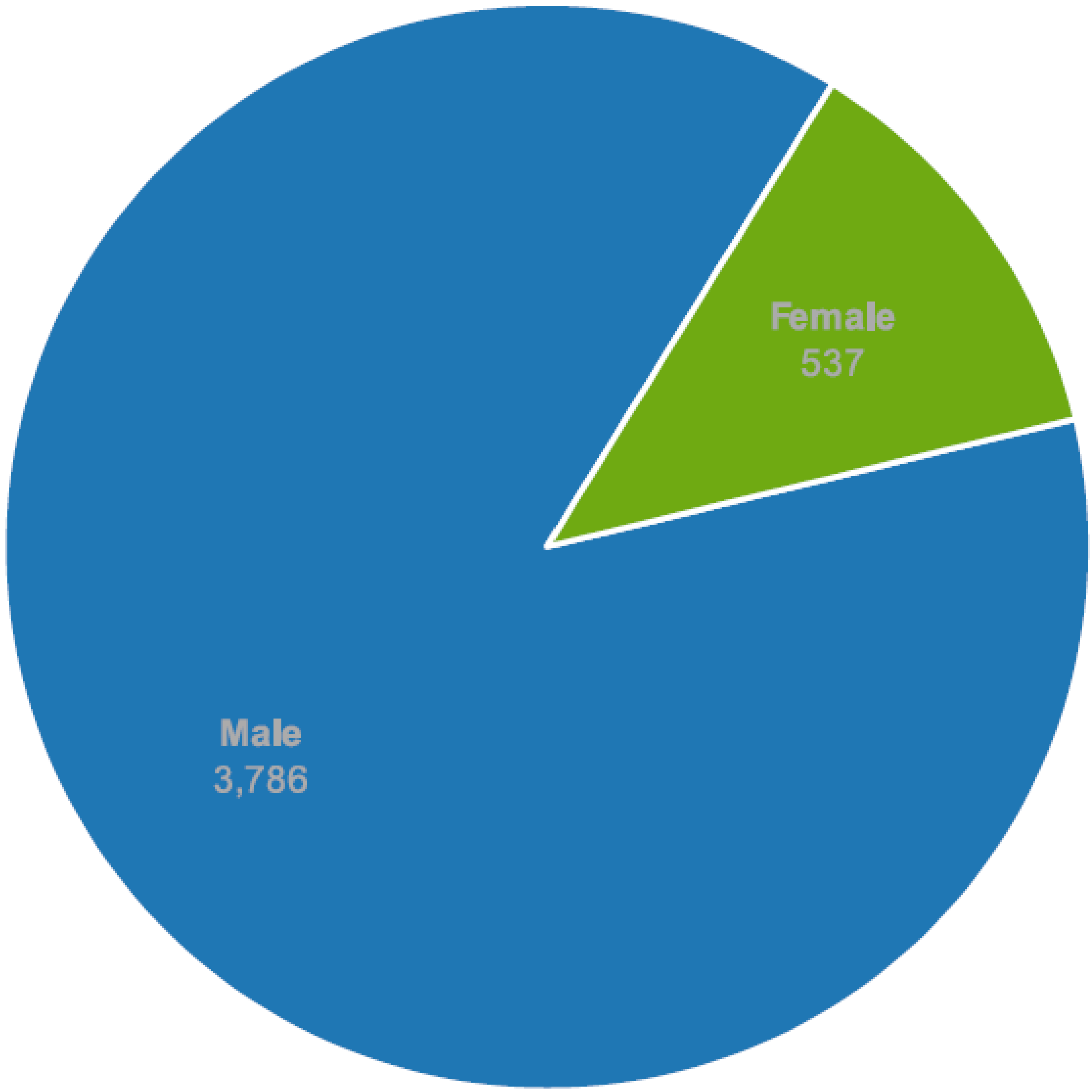
Math-based role: More women pursuing degrees in mathematics may catalyze vision-leadership



www.internationalbusinessreport.com/files/ibr2013_wib_report_final.pdf

Women in Senior Management, 2013

Silicon Valley's Gender Imbalance – The Rate Limiting Factor for Creativity and Entrepreneurship



Women in Engineering Roles in Leadership and/or Management (updated 02-14-2014)

Data, Connectivity, Context, Value – Gulf between Principles & Practice

Transparent and innovative business models are in dynamic state with real-time information, instant price discovery and quick problem resolution. The latter is now a basic expectation of consumers, citizens and business customers. Taken together, these changes will force many companies to rethink elements of their business models which are not in pace with these progressive practices. Leaders will need to make their companies more transparent and elevate rapid responsiveness as a core competency. Business models built on transparency and responsiveness will satisfy customers and help companies become more agile and credible with their stakeholders as long as privacy and security concerns are adequately addressed. The key rate limiting step is the availability of skilled workforce.

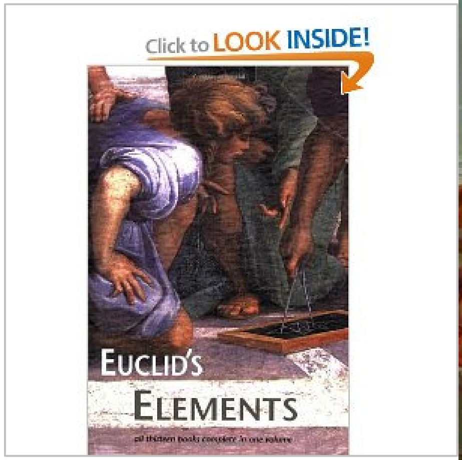
- http://www.ibm.com/analytics/us/en/
- http://hbr.org/2012/10/big-data-the-management-revolution/ar/1
- http://googleblog.blogspot.com/2010/10/what-were-driving-at.html
- http://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century
- http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03575usen/GBE03575USEN.PDF
- http://spectrum.ieee.org/automaton/robotics/artificial-intelligence/how-google-self-driving-car-works

How to deliver value from data? Transform the vision of IRDA into reality?

The rising economic and business impact of information technology means that competition will heat up for graduates in science, technology, engineering and mathematics (STEM) where job growth is likely to be several times faster than in other areas. As the automation of knowledge work gains momentum and computers start handling a growing number of tasks now performed by knowledge workers, some mid-level jobs will disappear. People with higher-level skills will become more important. Providing new forms of training to upgrade knowledge workers' capabilities and rethinking the nature of public education, especially in mathematics, will be critical priorities for businesses to invest in and for government leaders to decrease bureaucracy. Education is our key.

Can MOOC catalyze an educated & IRDA-proficient supply chain of talent ?

Did we arrive at a conclusion we knew almost since the beginning of time?



Born Raffaello Sanzio da Urbino in 1483 (Urbino, IT). Died April 6, 1520 (Rome, IT) Raphael - The School of Athens

How to connect the recombinant data dots in context of applications?

Mathematics

The quintessential denominator

Short supply of mathematically trained talent and workforce during the industrial internet data deluge may be analogous to running out of iron ore in the middle of the industrial revolution.

Assuming we have sufficient workforce trained in computational math

How do we analyze small and big

DATA

The latest US influenza season is more severe and has caused more deaths than usual.

EPIDEMIOLOGY

When Google got flu wrong

US outbreak foxes a leading web-based method for tracking seasonal flu.

BY DECLAN BUTLER

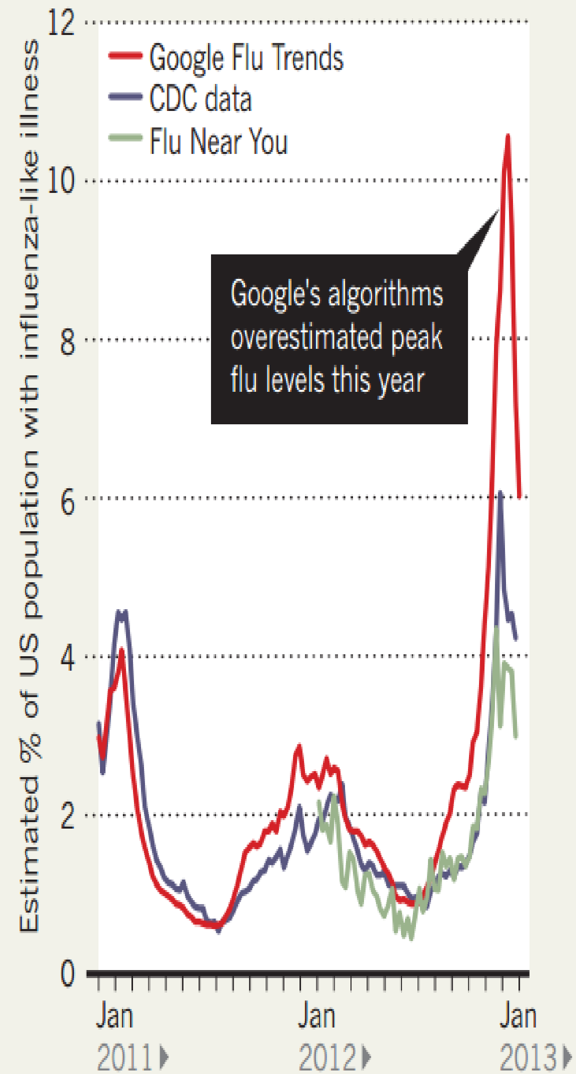
When influenza hit early and hard in the United States this year, it quietly claimed an unacknowledged victim: one of the cutting-edge techniques being used to monitor the outbreak. A comparison with traditional surveillance data showed that Google Flu Trends, which estimates prevalence from flu-related Internet searches, had drastically overestimated peak flu levels. The glitch is no more than a temporary setback for a promising strategy, experts say, and Google is sure to refine its algorithms. But as flu-tracking techniques based on mining of web data and on social media proliferate, the episode is a reminder that they will complement, but not substitute for, traditional epidemiological surveillance networks.

"It is hard to think today that one can provide disease surveillance without existing systems," says Alain-Jacques Valleron, an epidemiologist at the Pierre and Marie Curie University in Paris, and founder of France's Sentinelles monitoring network. "The new systems depend too much on old existing ones to be able to live without them," he adds.

This year's US flu season started around November and seems to have peaked just after Christmas, making it the earliest flu season since 2003. It is also causing more serious illness and deaths than usual, particularly among the elderly, because, just as in 2003, the predominant strain this year is H3N2 — the most

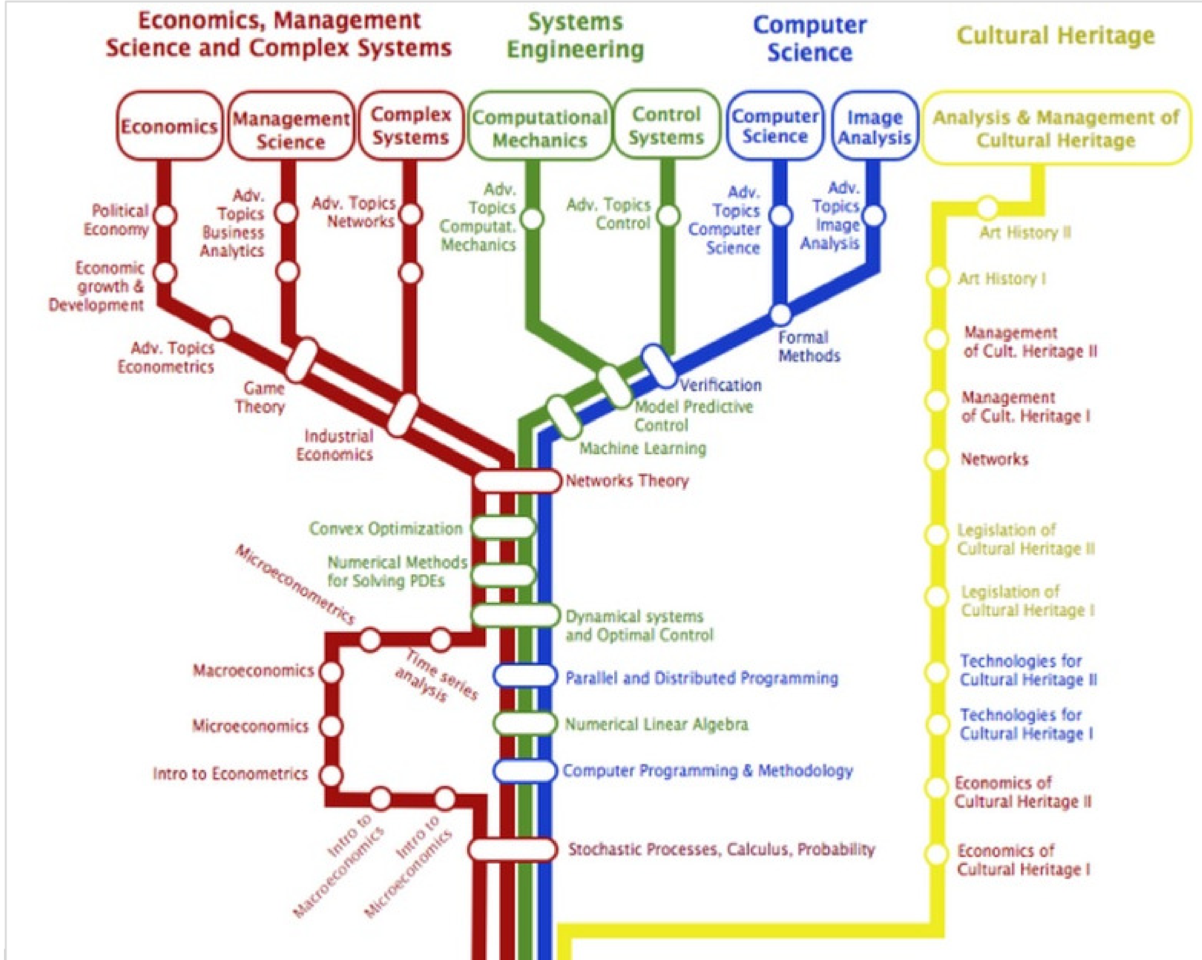
FEVER PEAKS

A comparison of three different methods of measuring the proportion of the US population with an influenza-like illness.



The bottom line – Data must be analyzed in context

Data science without context is noise. Context without relevant data is impotent.



Essential Context of Data Analytics – Environment, Dependencies & Ecosystems

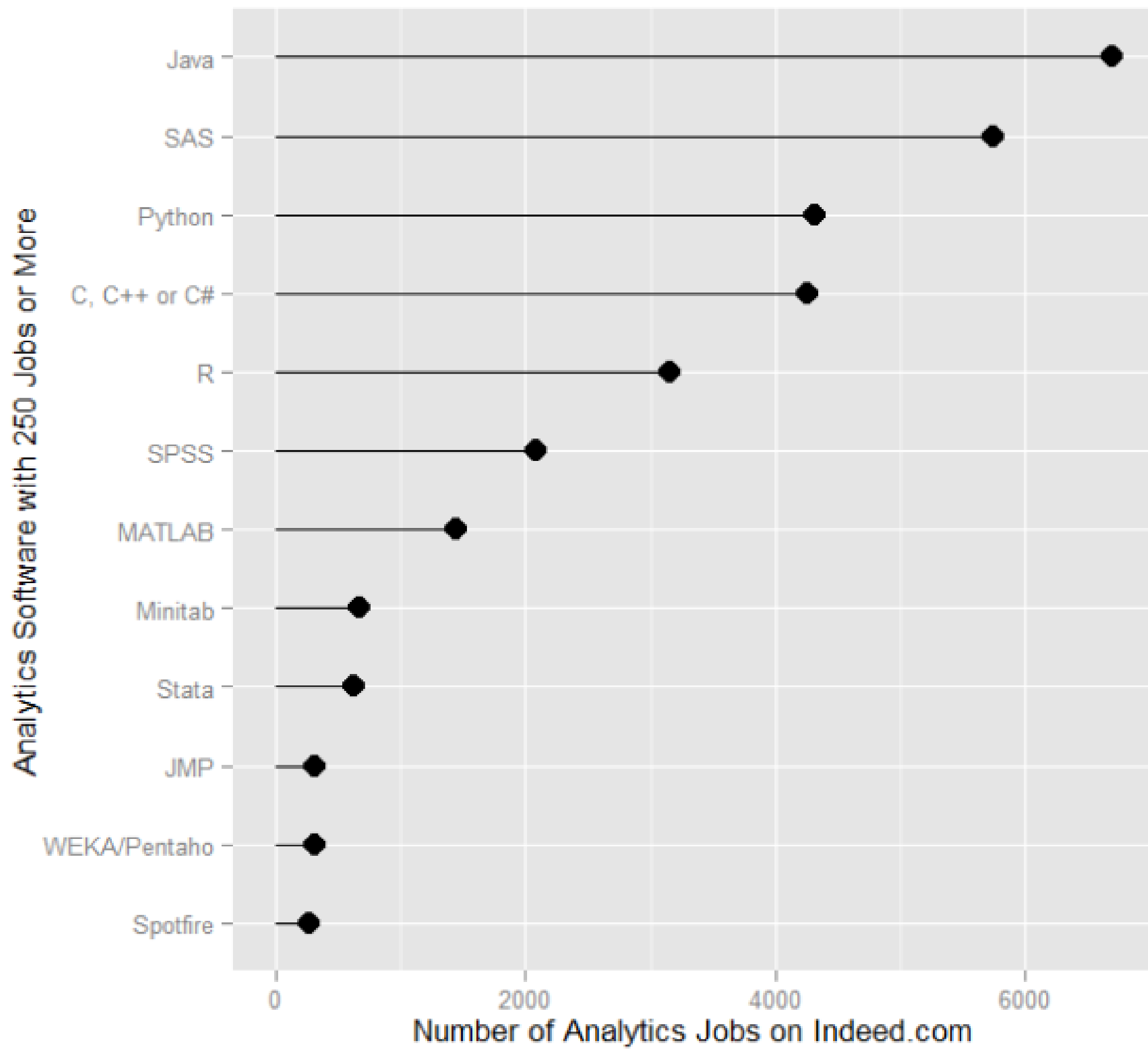
Science without religion is lame, religion without science is blind – Albert Einstein

Assuming we have sufficient domain knowledge to analyze in context

Plethora of software packages for

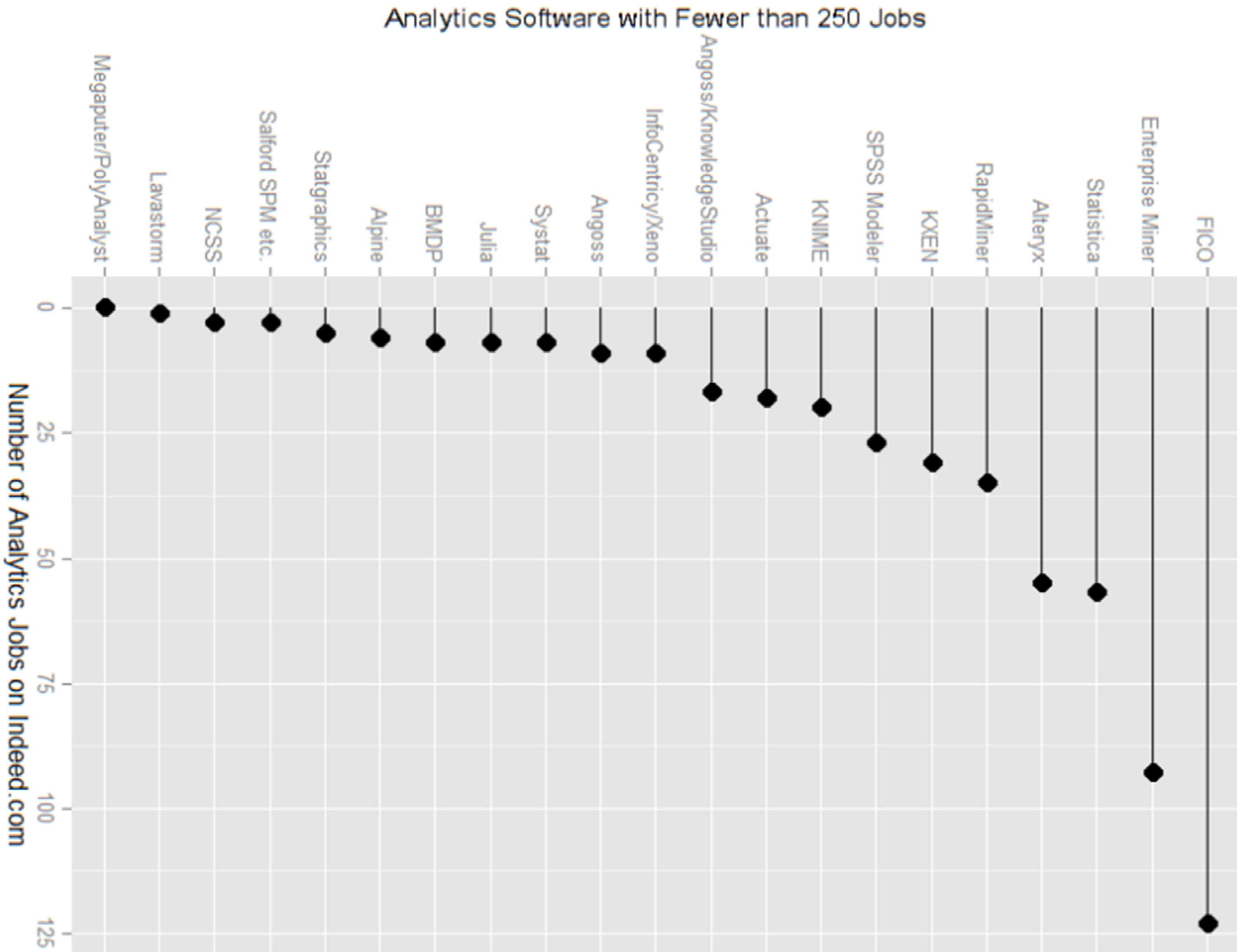
DATA ANALYTICS

The number of analytics jobs by software (as of 2/2014)

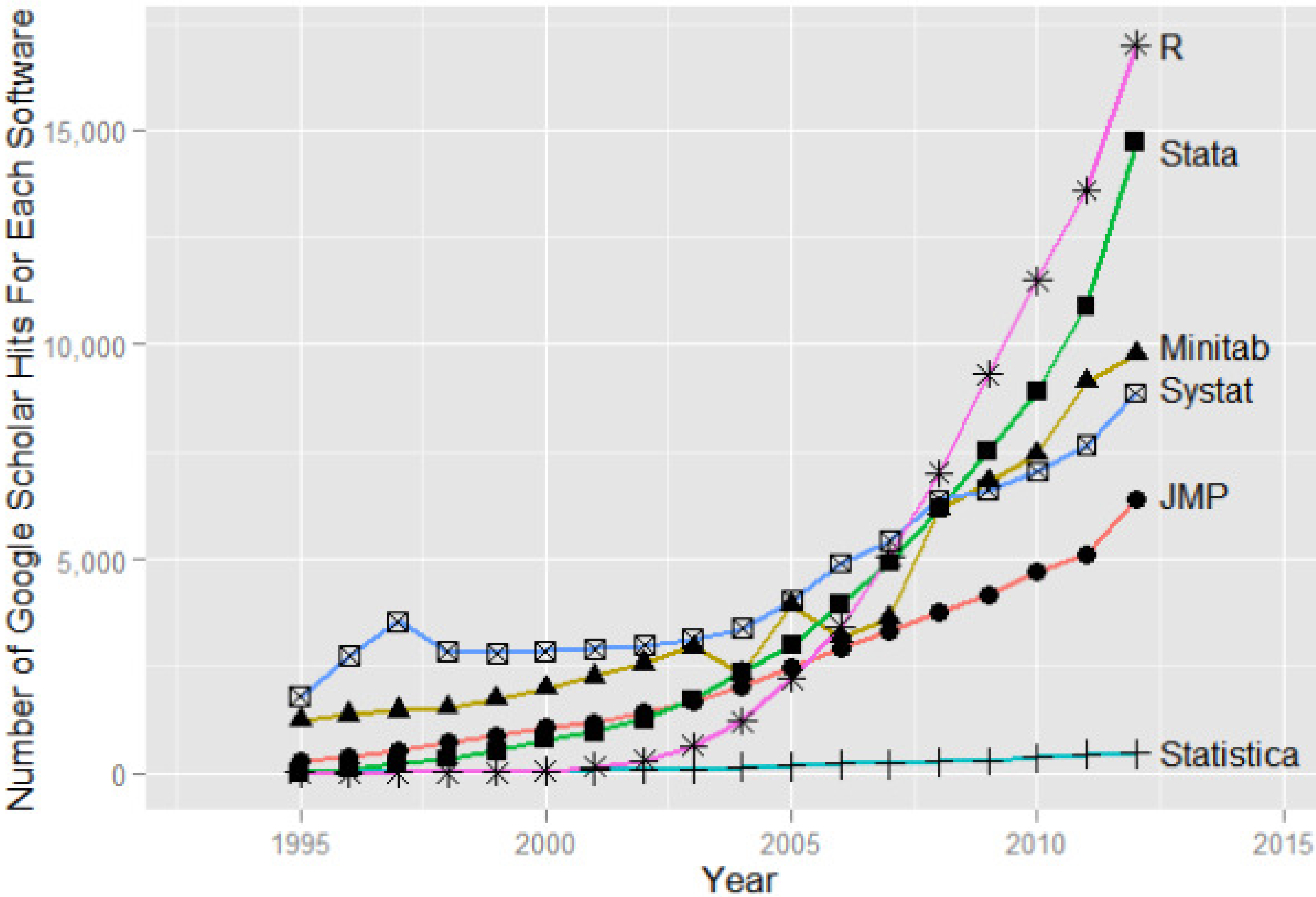


Specific to analtyics (MATLAB has many engineering jobs which were not counted in this total as of 2/2014)

The number of analytics jobs by software – under 250 jobs (as of 2/2014)

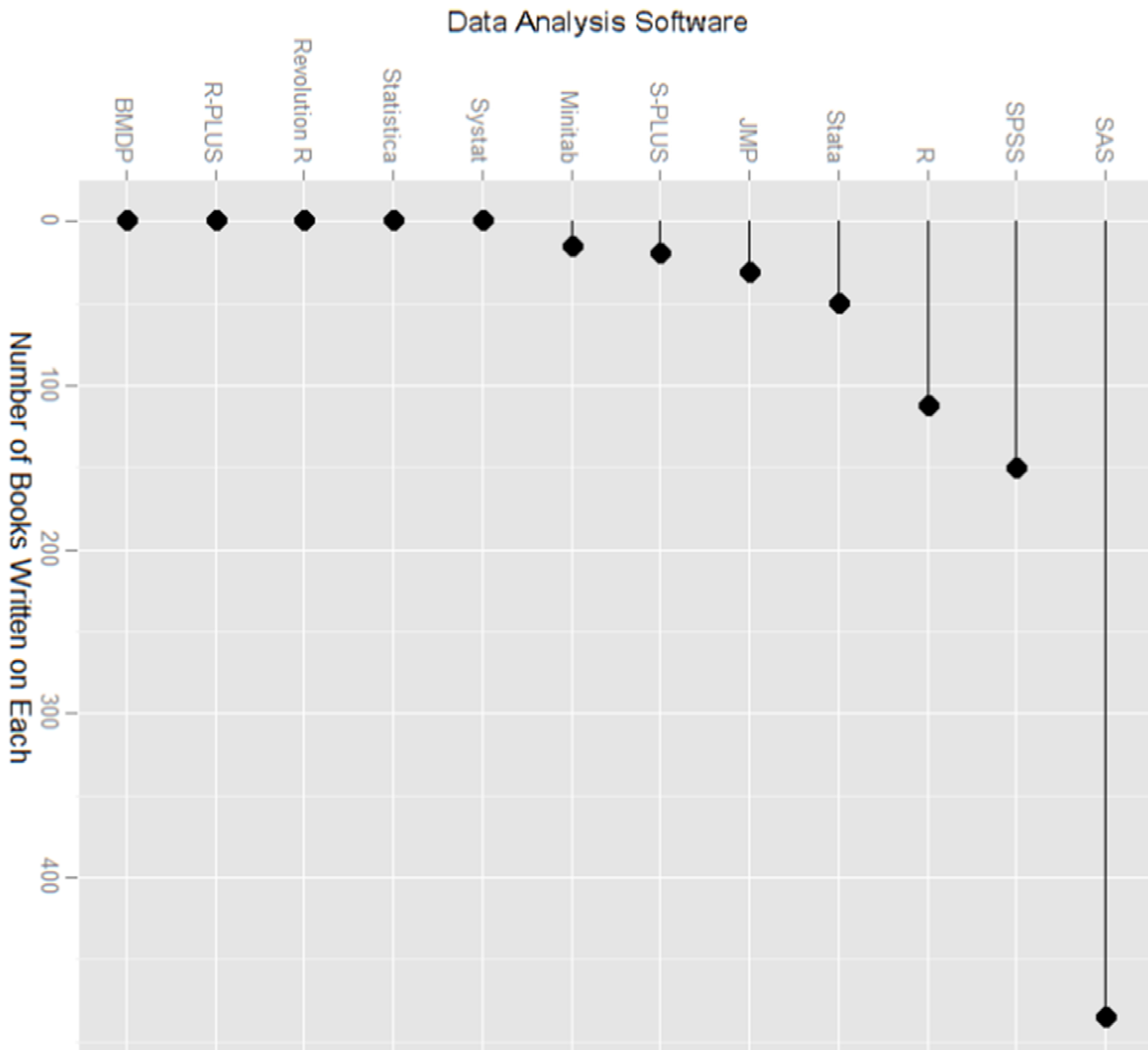


Number of scholarly articles that reference each software

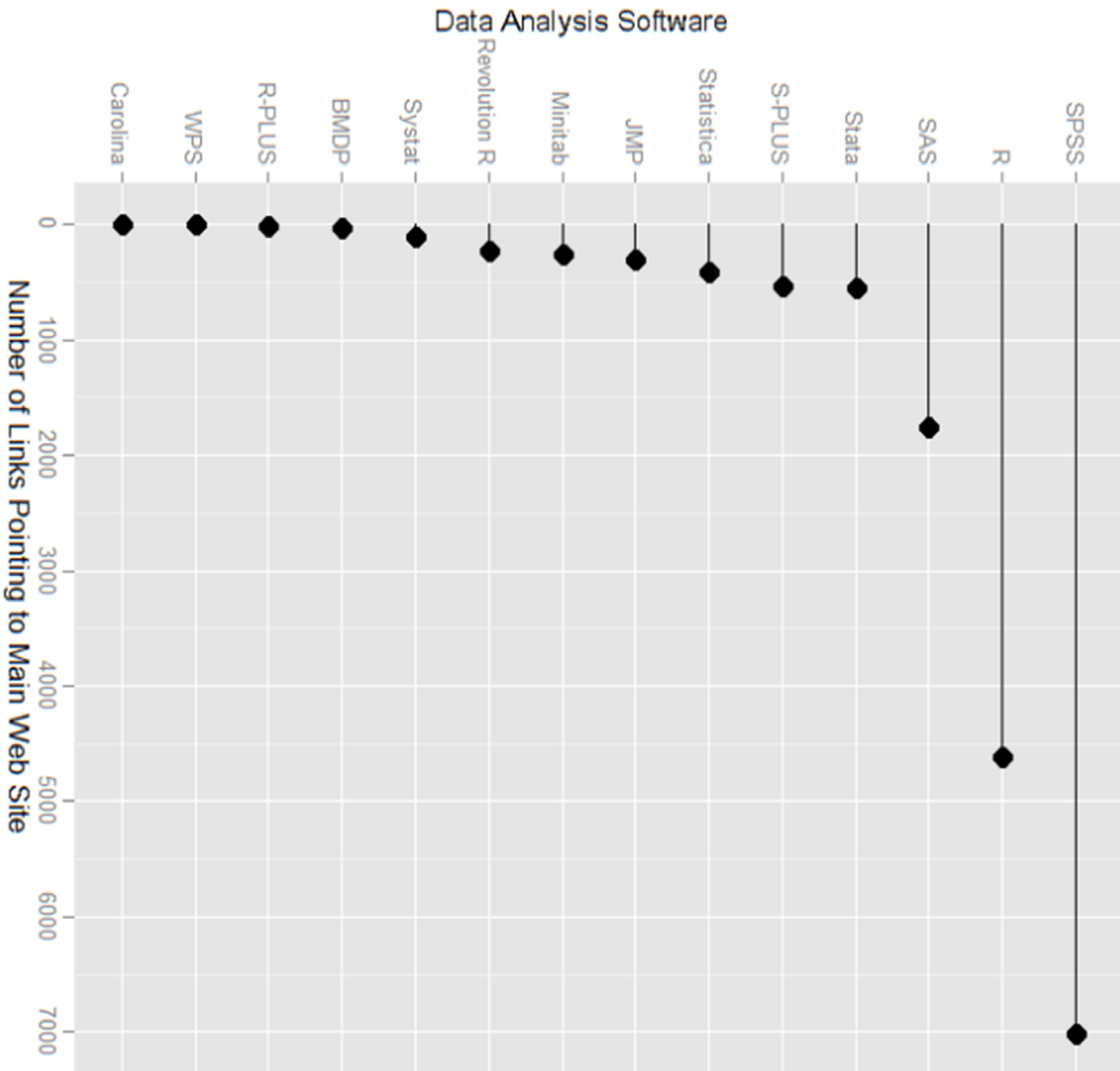


After removing the top two (SPSS and SAS)

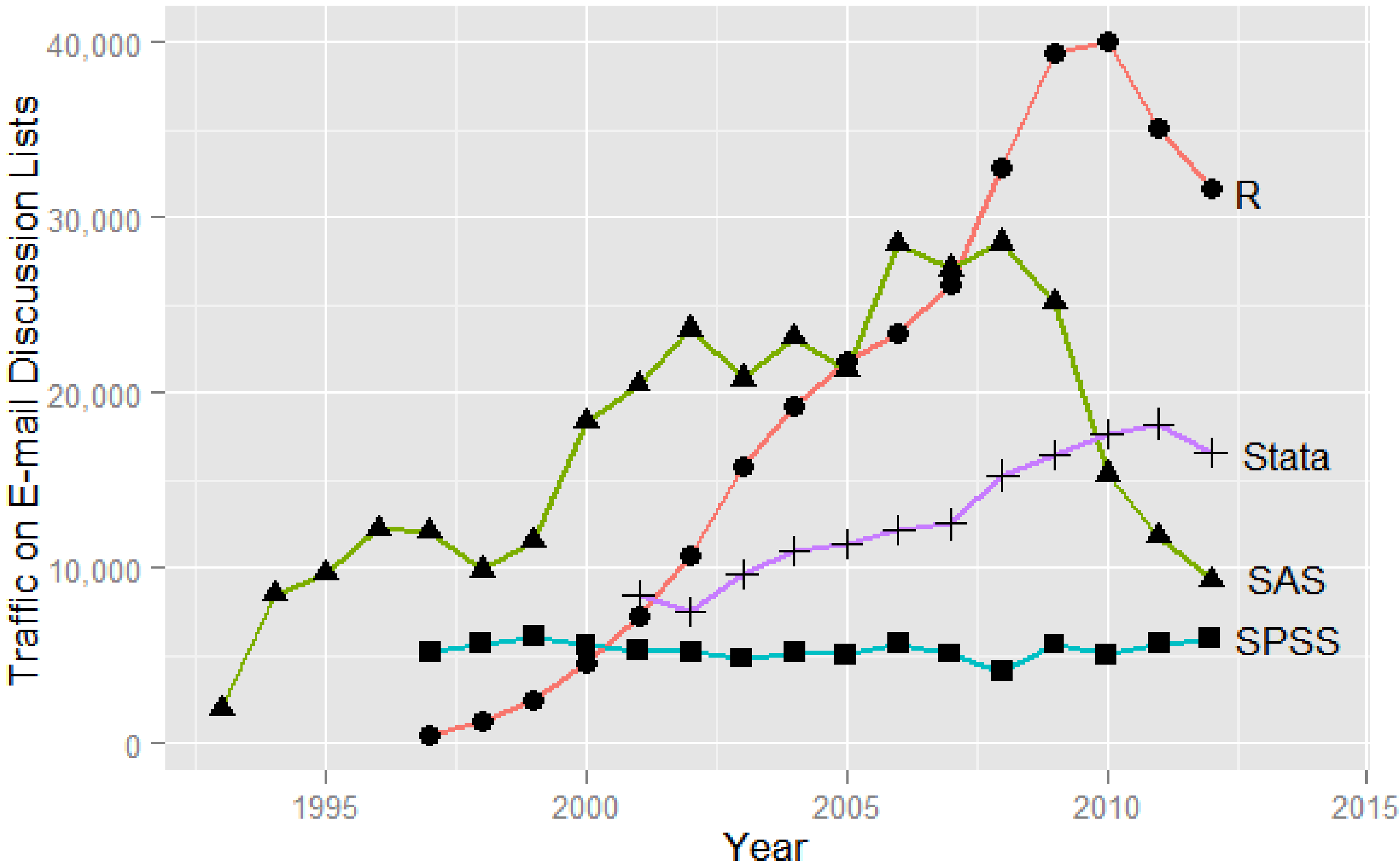
Books that contain the name of software in the title



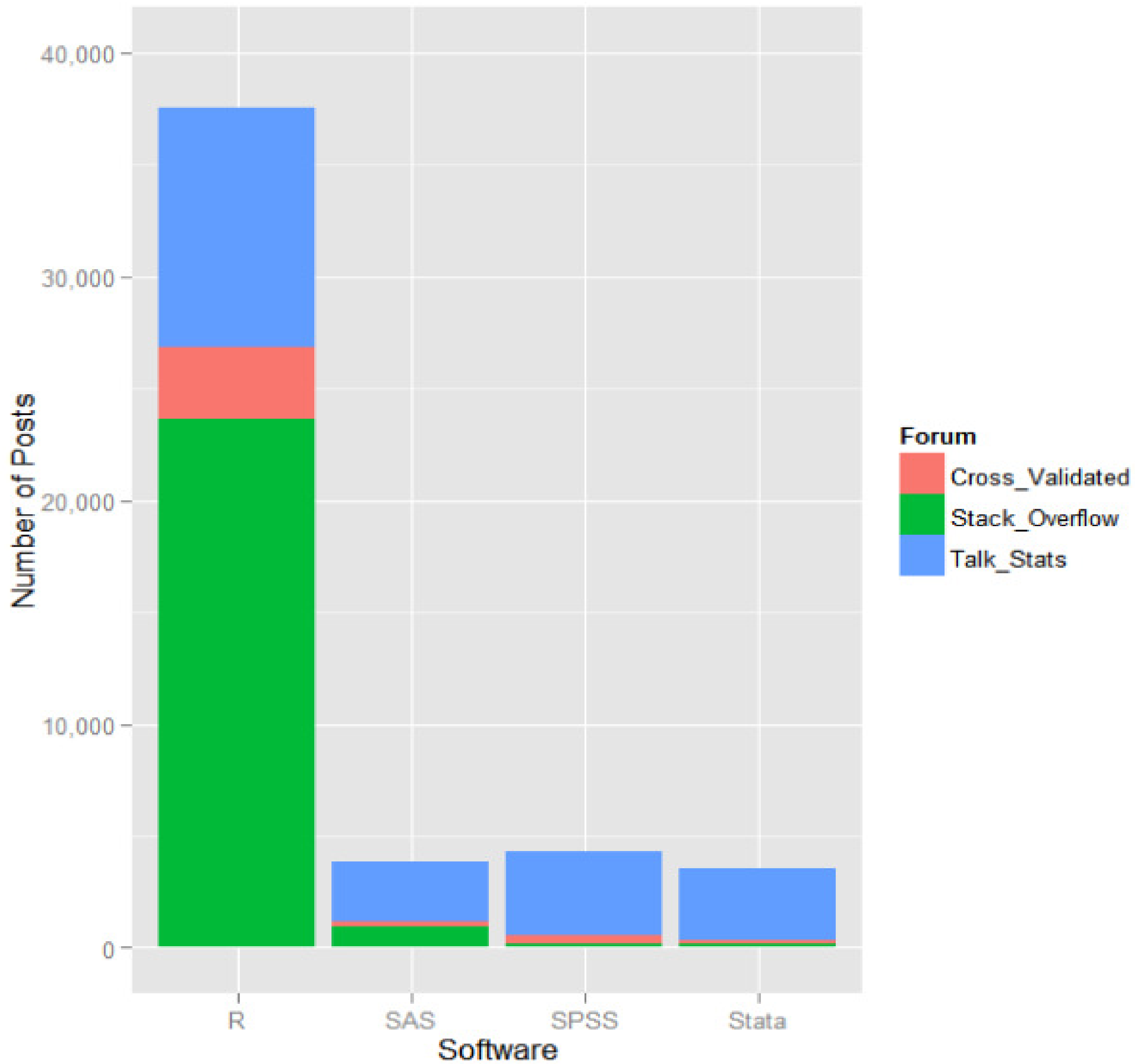
Number of web site links that point to the main web site of each software package



Monthly email traffic on each software's main listserv discussion list

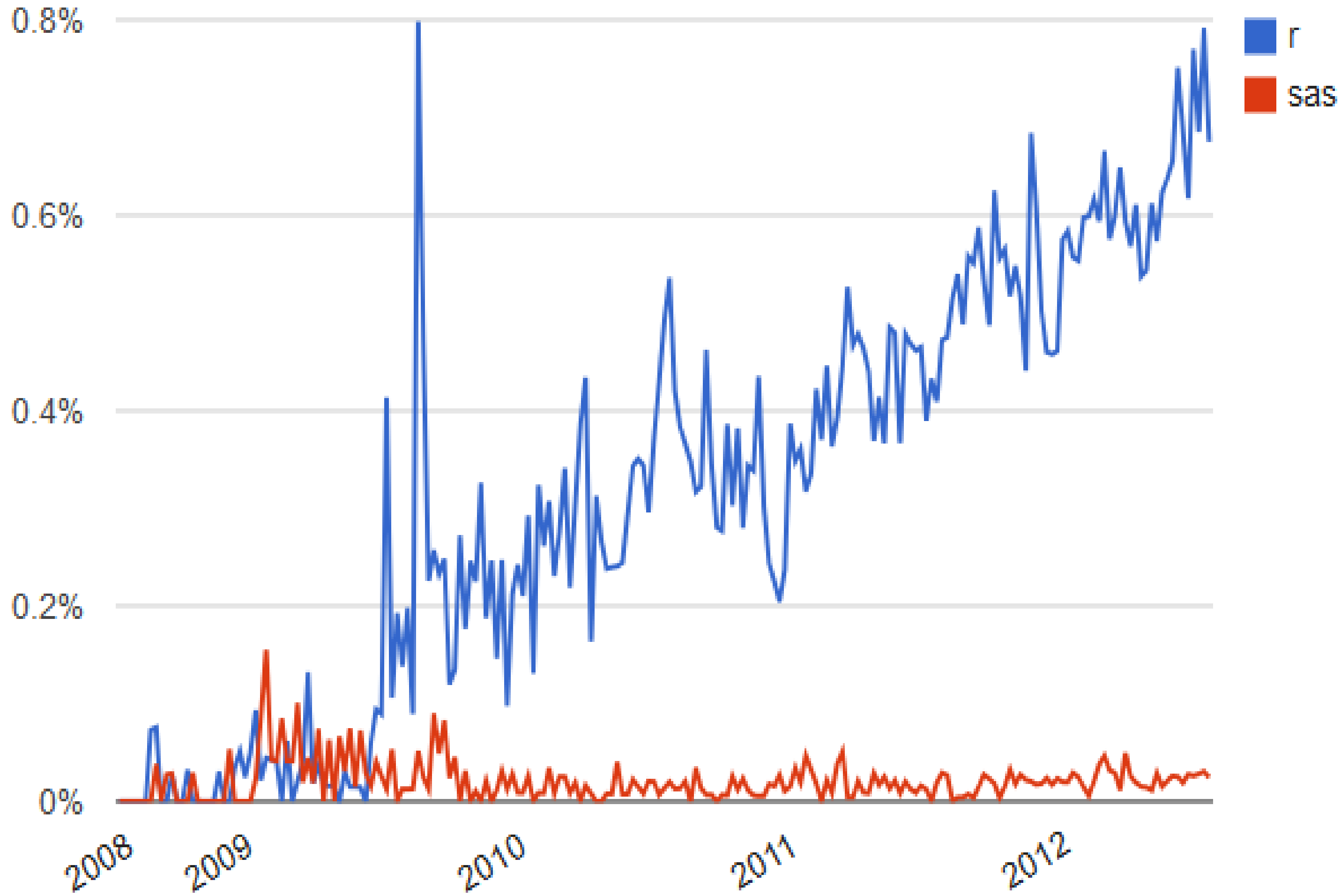


Number of posts per software on each forum



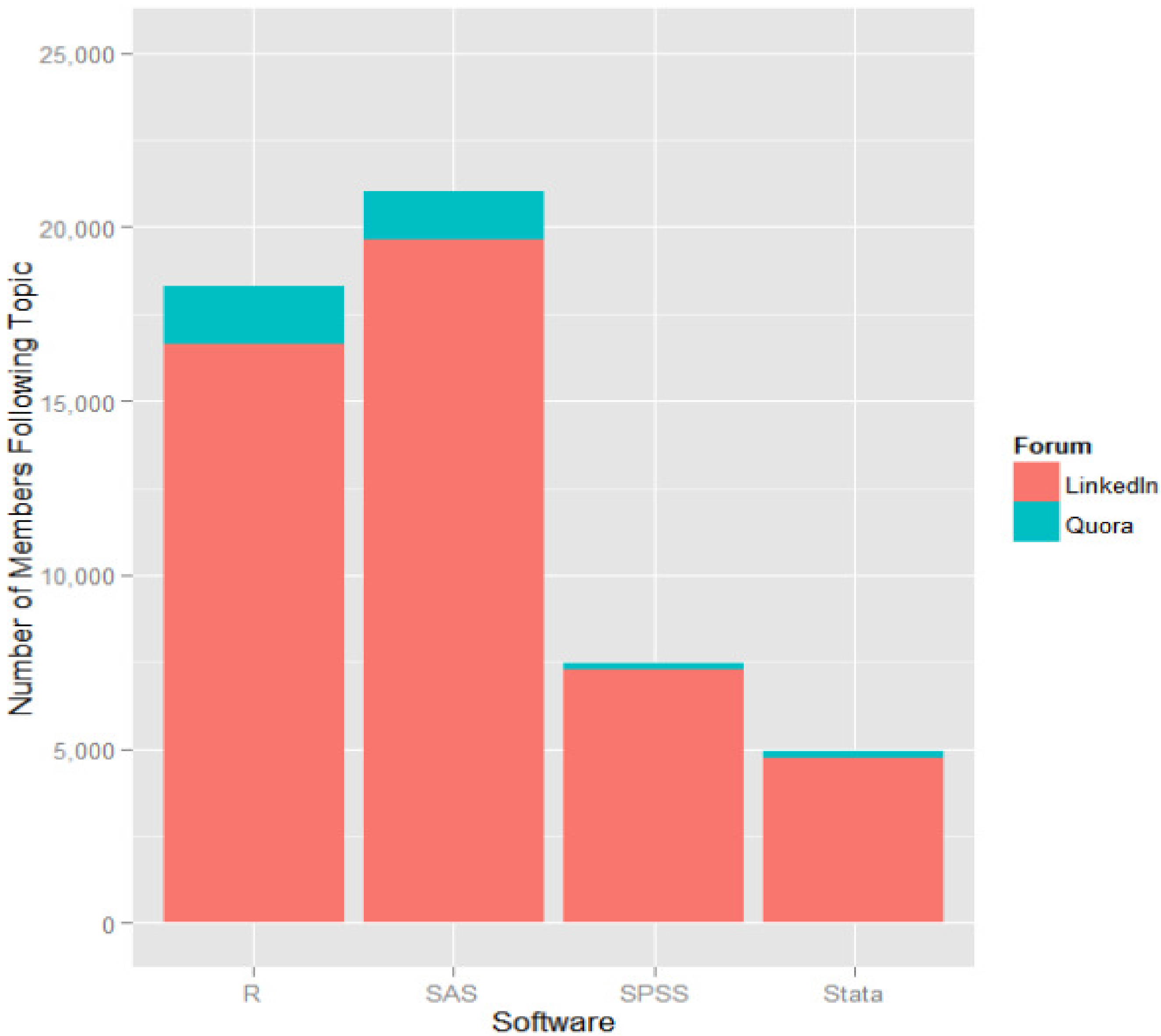
Data as of 10/2013

Number of R- or SAS-related posts to Stack Overflow



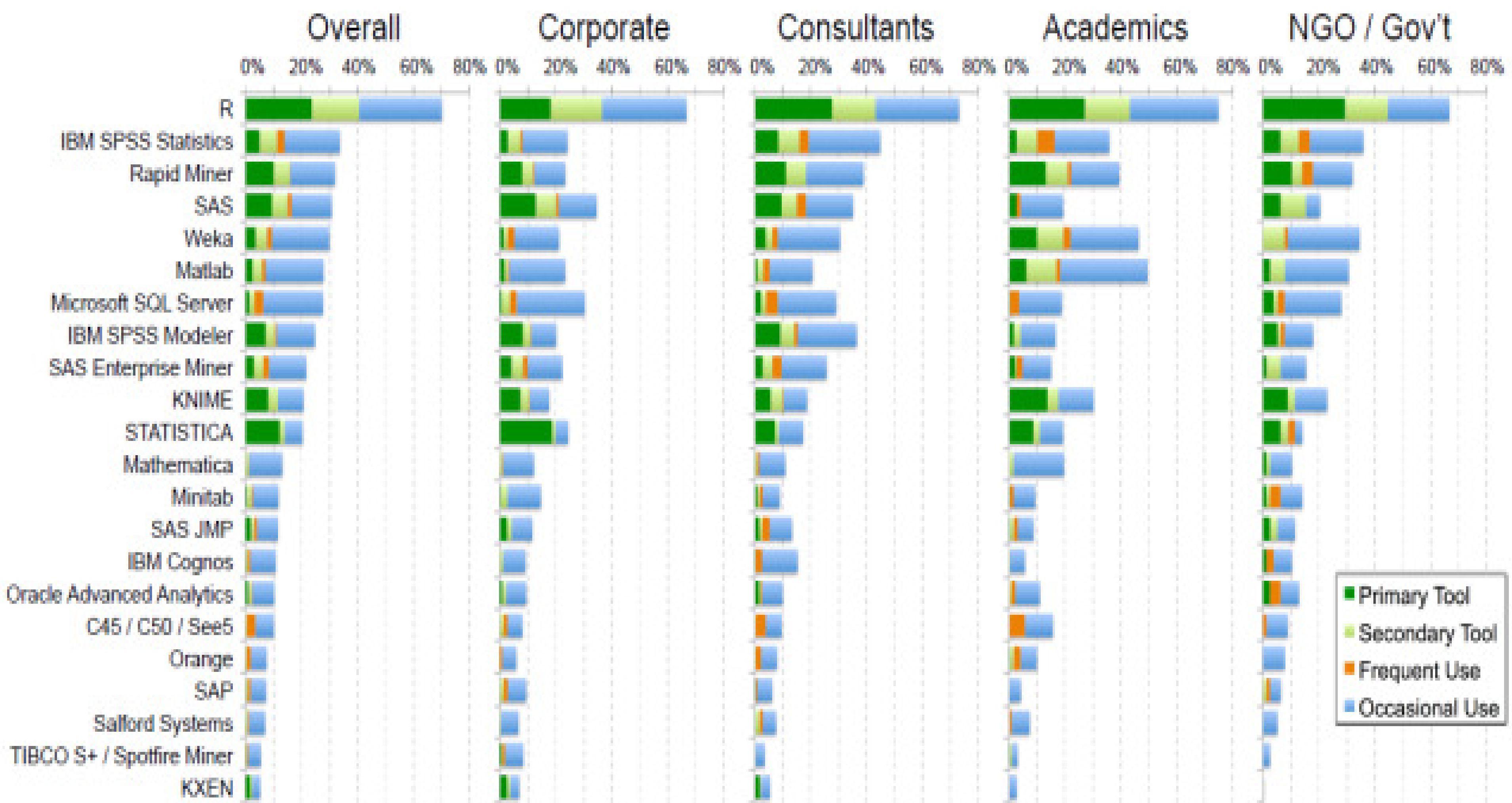
Weekly data points

Number of people registered in the main discussion group for each software



Data as of 10/2013

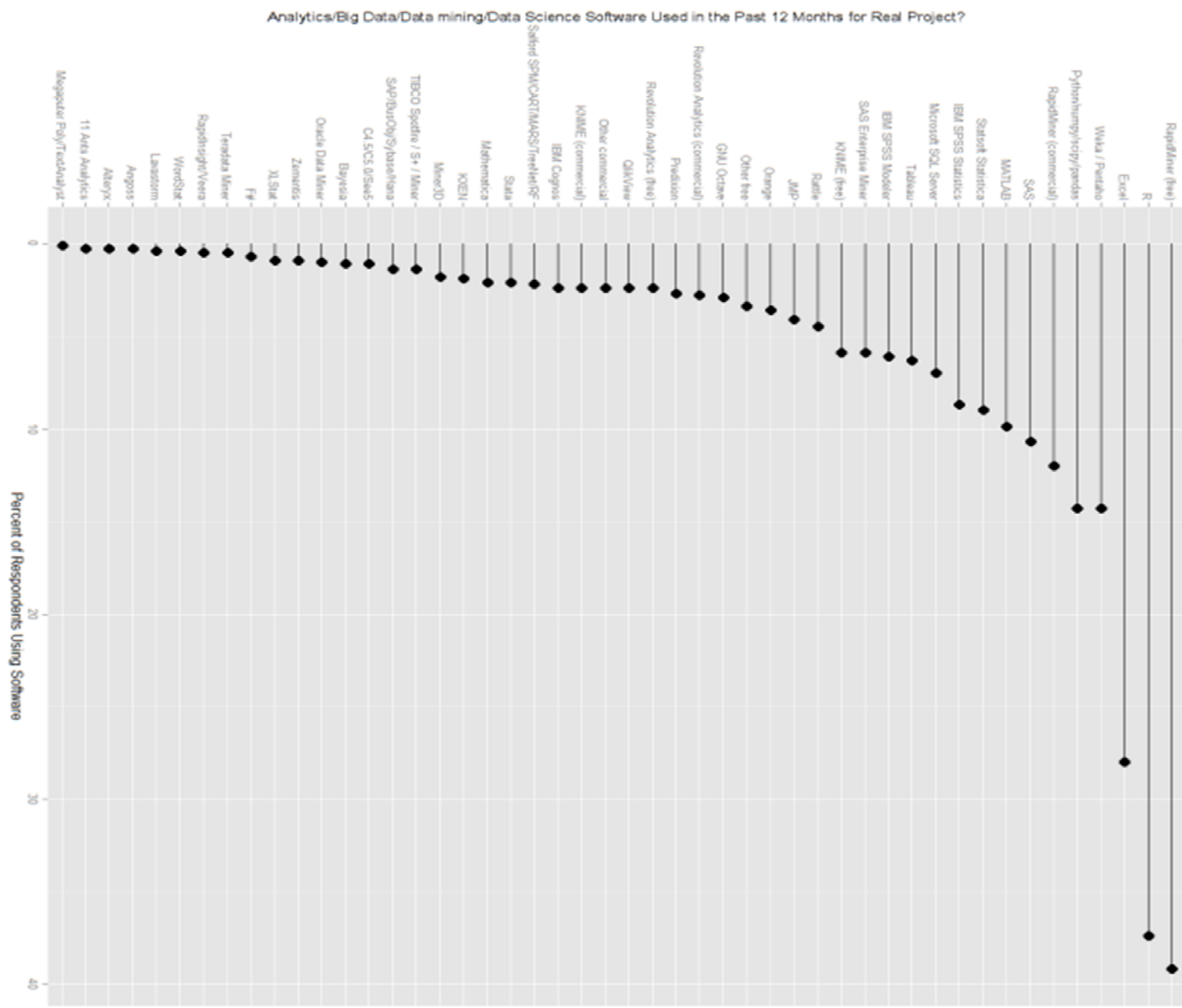
Rexer Analytics Data Miner Survey 2013



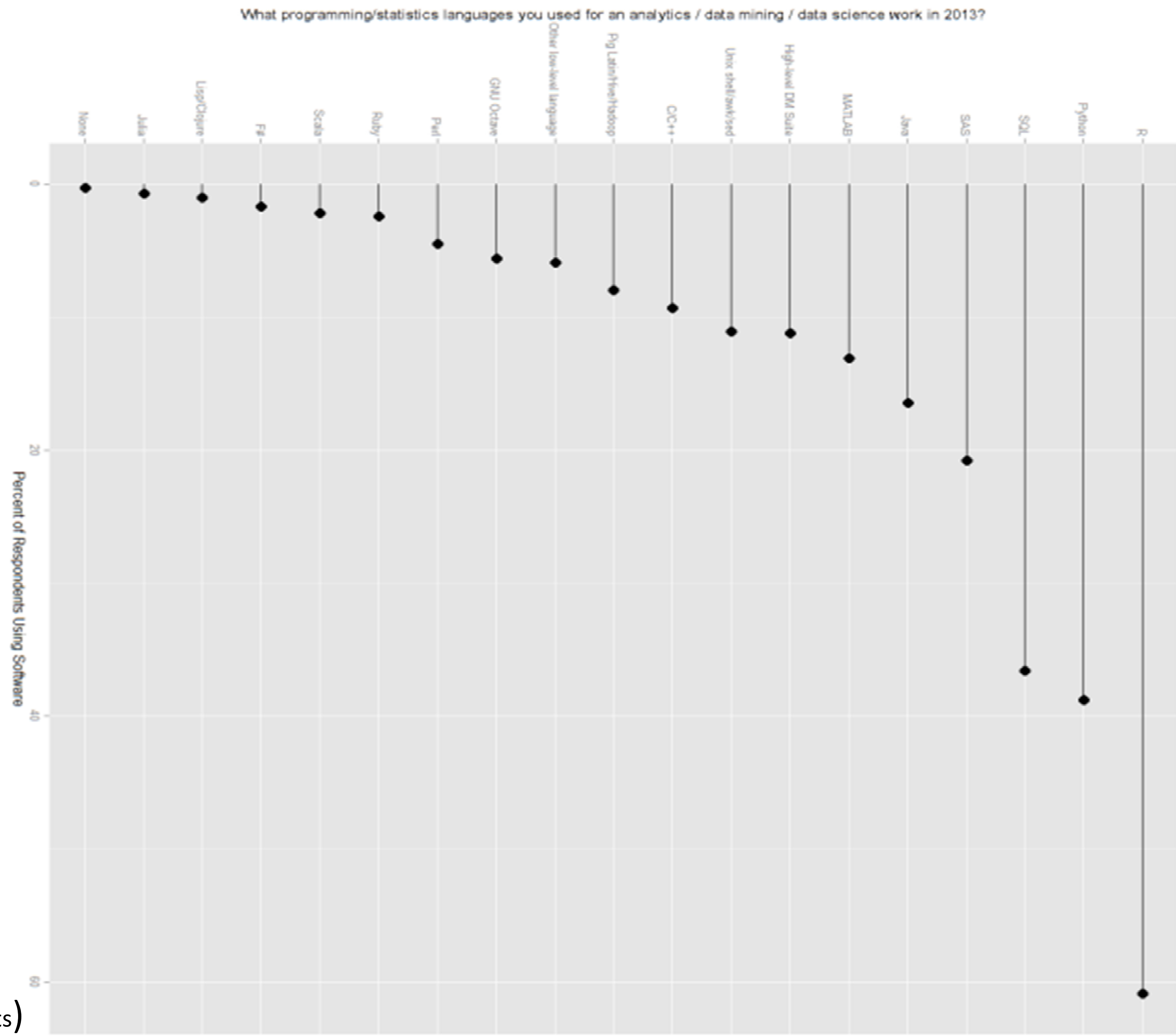
"What data mining software you have used in the past 12 months?"

1. Rapid Miner
2. R
3. Excel
4. Weka
5. Python

(all open source)

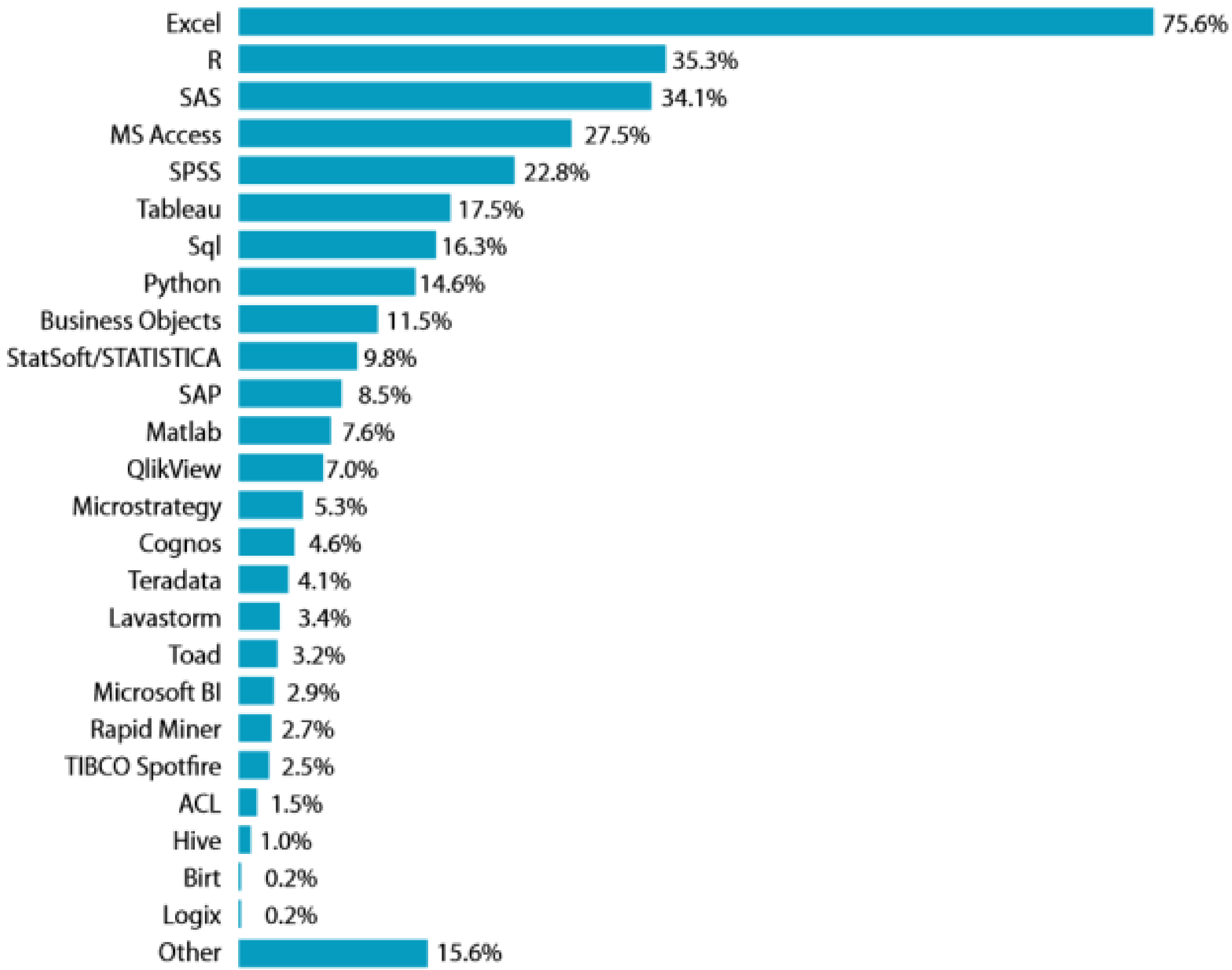


Programming languages used for data analysis / mining in the past 12 months

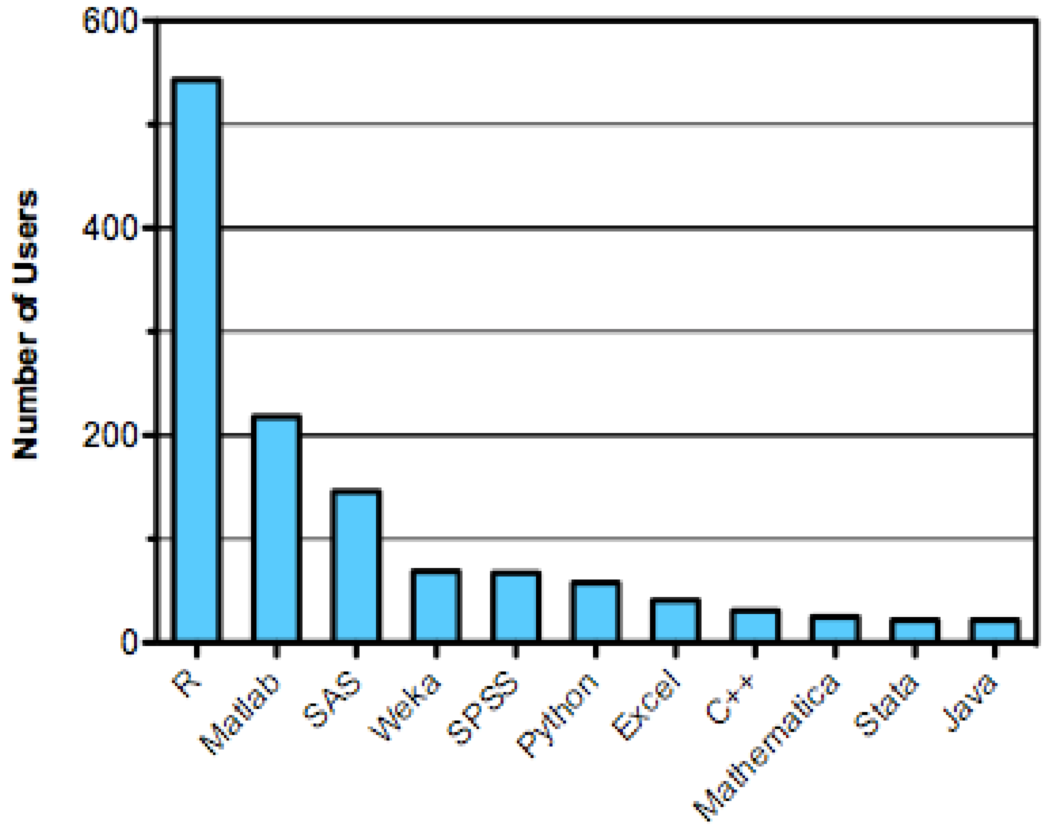


R (> 60% of respondents)

Self-service analytic tool in current use



Software used in data analysis competitions



Data from 2011 but still current for 2014.

Predictions are always difficult but especially for predictive analytical software packages

It may change in weeks or months ahead, but the temporary advantage may be due to …

R

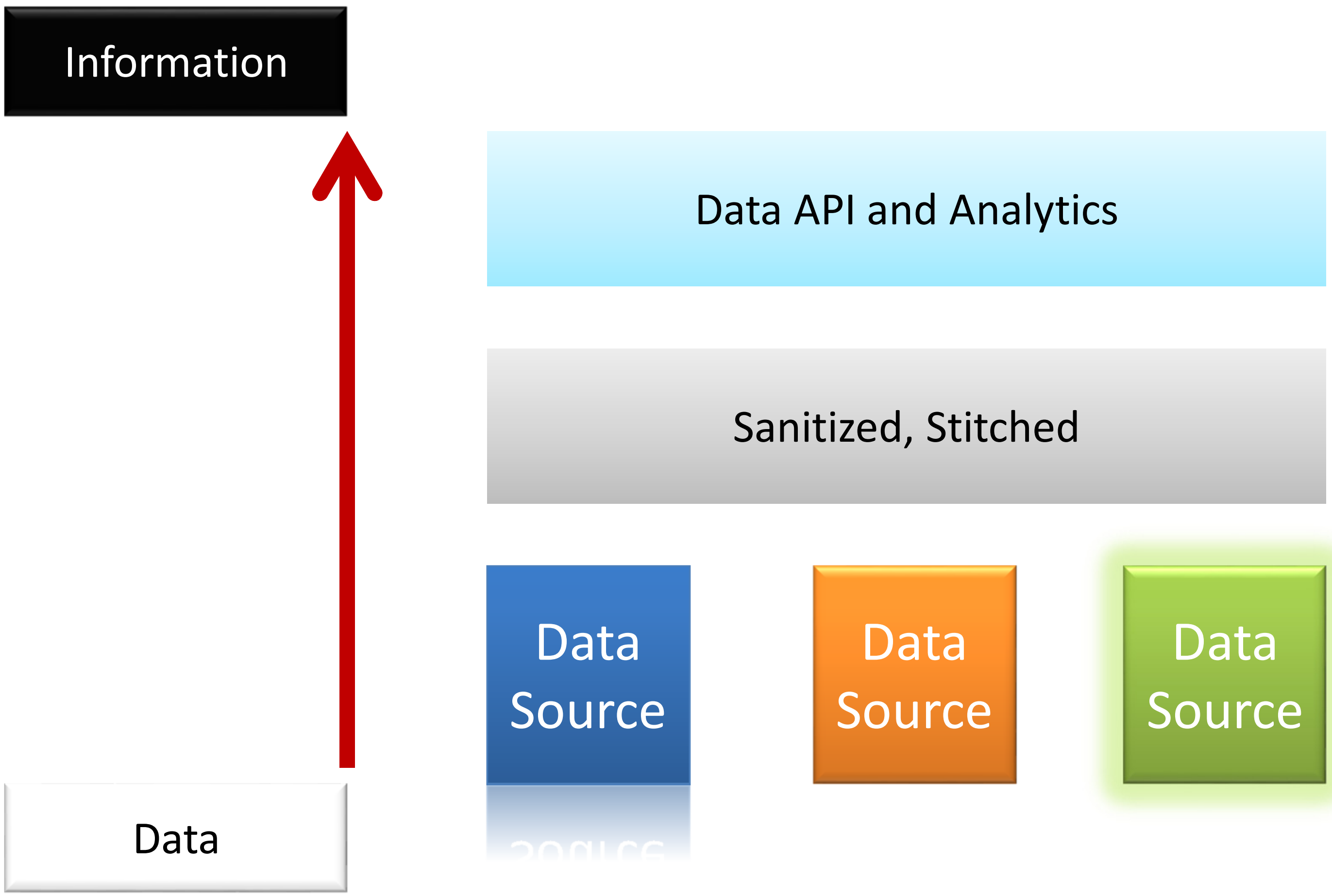
for Robert

Data Analytics is not enough.

Extract

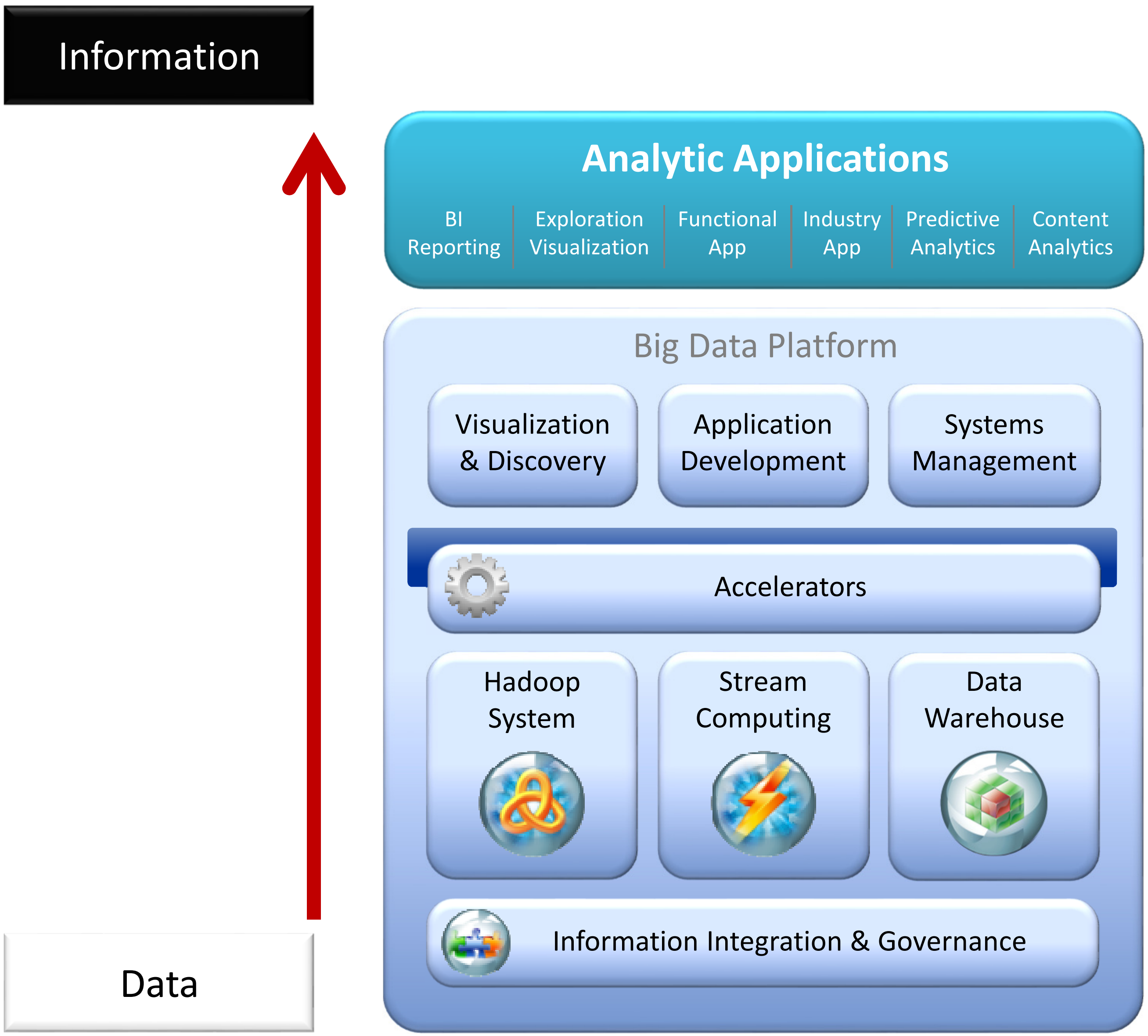
INFORMATION

Monetization of Perishable Broad Data → Transform Data to Actionable Information



apigee.com

Monetization of Perishable Broad Data → Transform Data to Actionable Information



IBM

Are computers necessary for the design of data analytics?

"Computers are useless. They can only give you answers."

Pablo Picasso

Value from data analysis depends on the ability to craft the *contextually relevant*

QUESTION

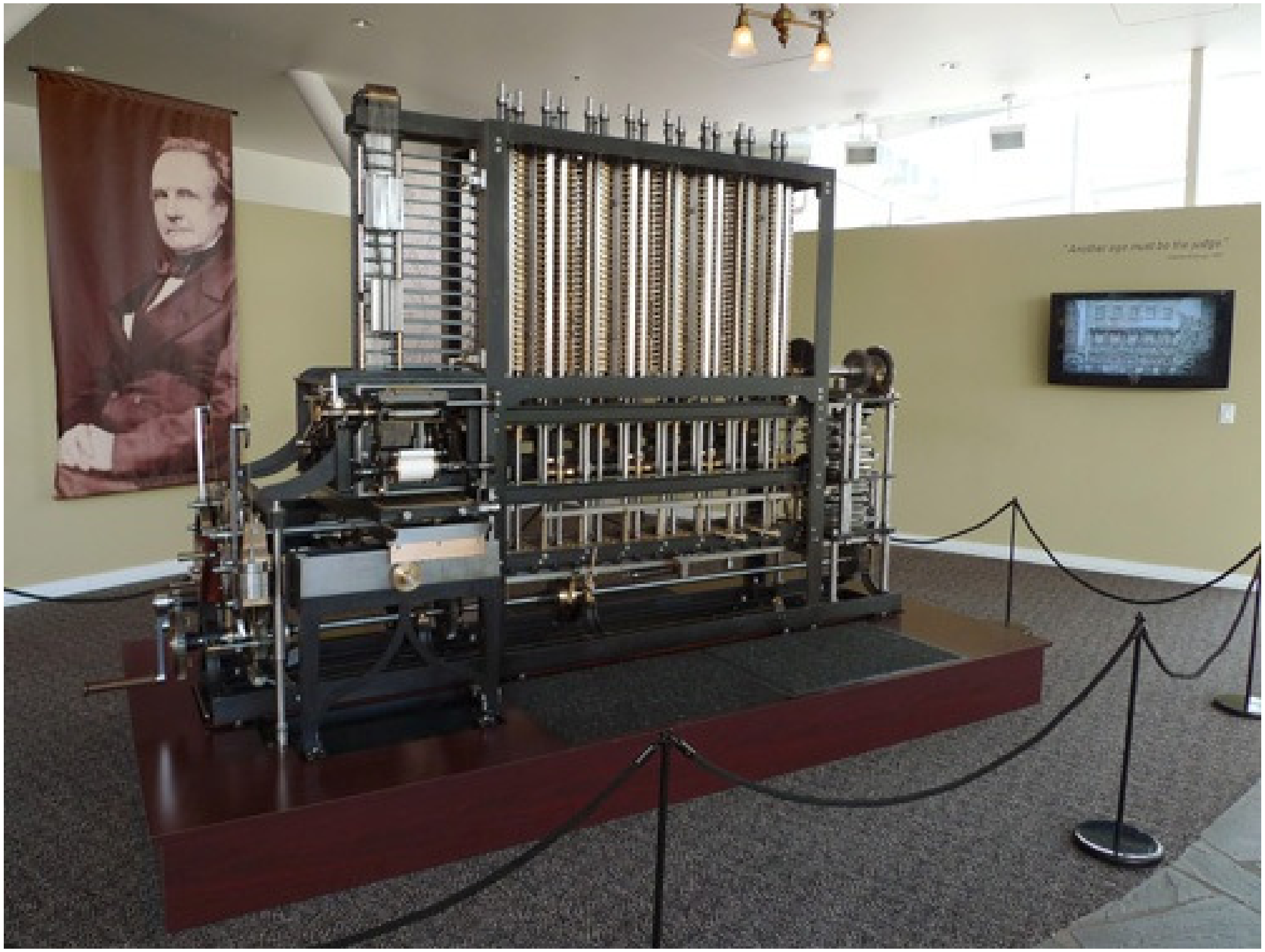
On two occasions I have been asked [by members of the British Parliament],

'Pray, Mr. Babbage, if you put in the machine the wrong figures, will the right answers come out?'

I am not able to apprehend the kind of confusion of ideas that could provoke such a question.

CHARLES BABBAGE

Babbage Engine



Charles Babbage (1791-1871), computer pioneer, designed the first automatic computing engines. He invented computers but failed to build them. The first complete Babbage Engine was completed in 2002 in London, 153 years after it was designed. Difference Engine No 2, built faithfully to the original drawings, consists of 8,000 parts, weighs 5 tons and measures 11 feet long. The photograph (above) is an identical Engine completed in March 2008 which is on display at the Computer History Museum at 1401 N Shoreline Blvd, Mountain View, CA 94043.

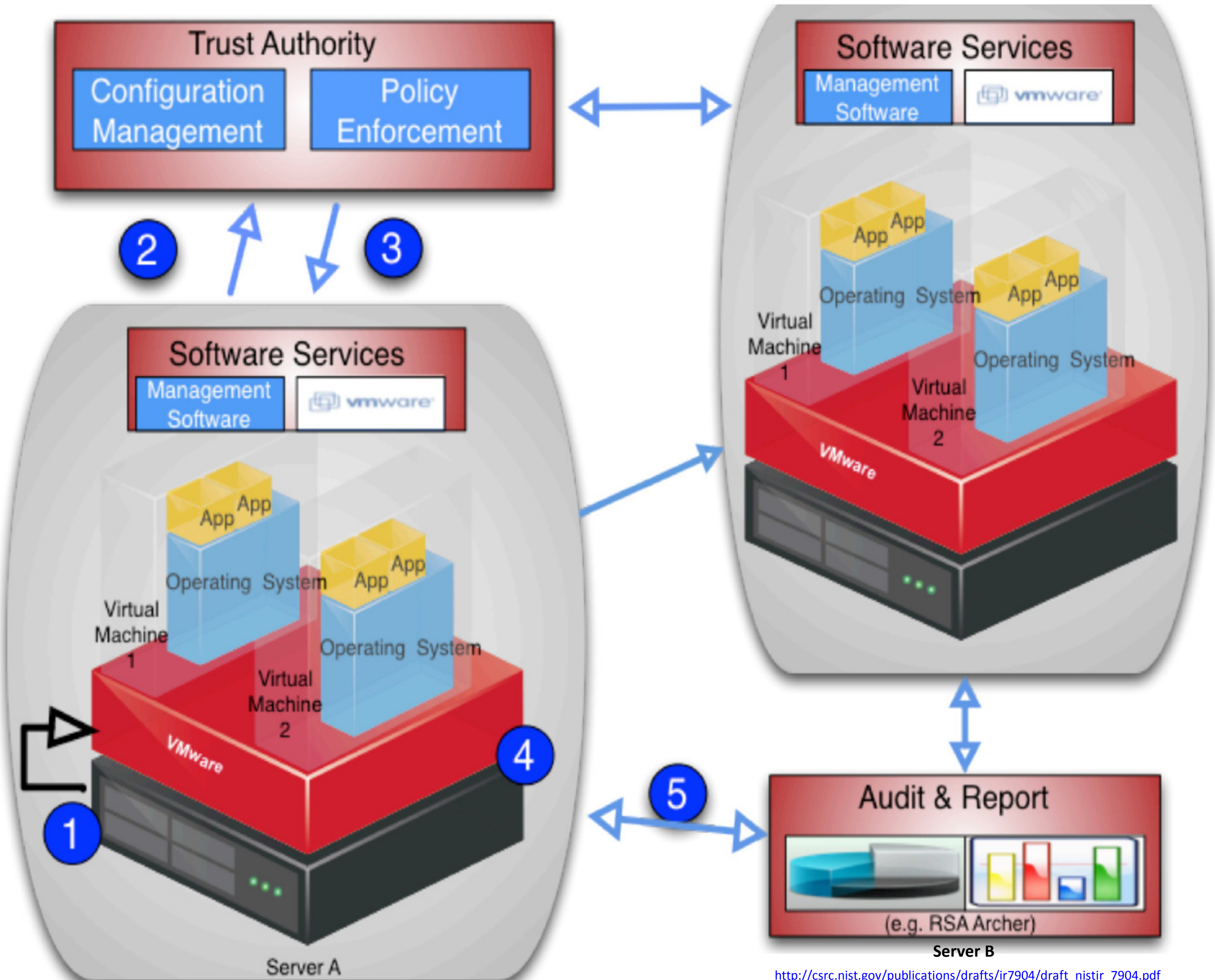
All data are not created equal

DON'T USE MY DATA

"Before I write my name on the board, I'll need to know how you're planning to use that data."

De-Identified Data

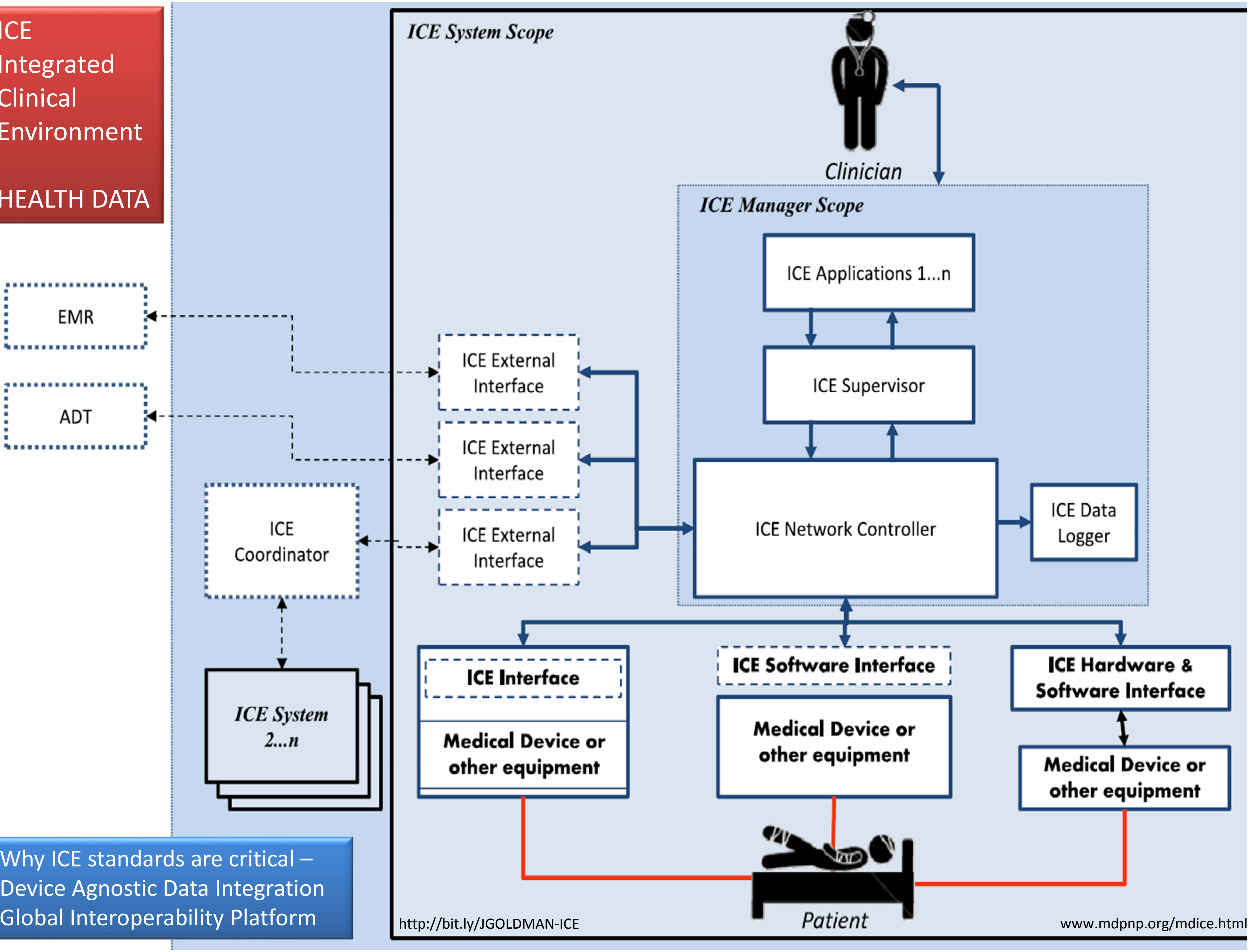
Trusted GeoLocation in the Cloud (NIST NCCOE) – Is this an adequate solution for health data?



http://csrc.nist.gov/publications/drafts/ir7904/draft_nistir_7904.pdf
http://csrc.nist.gov/nccoe/health-it/index.html

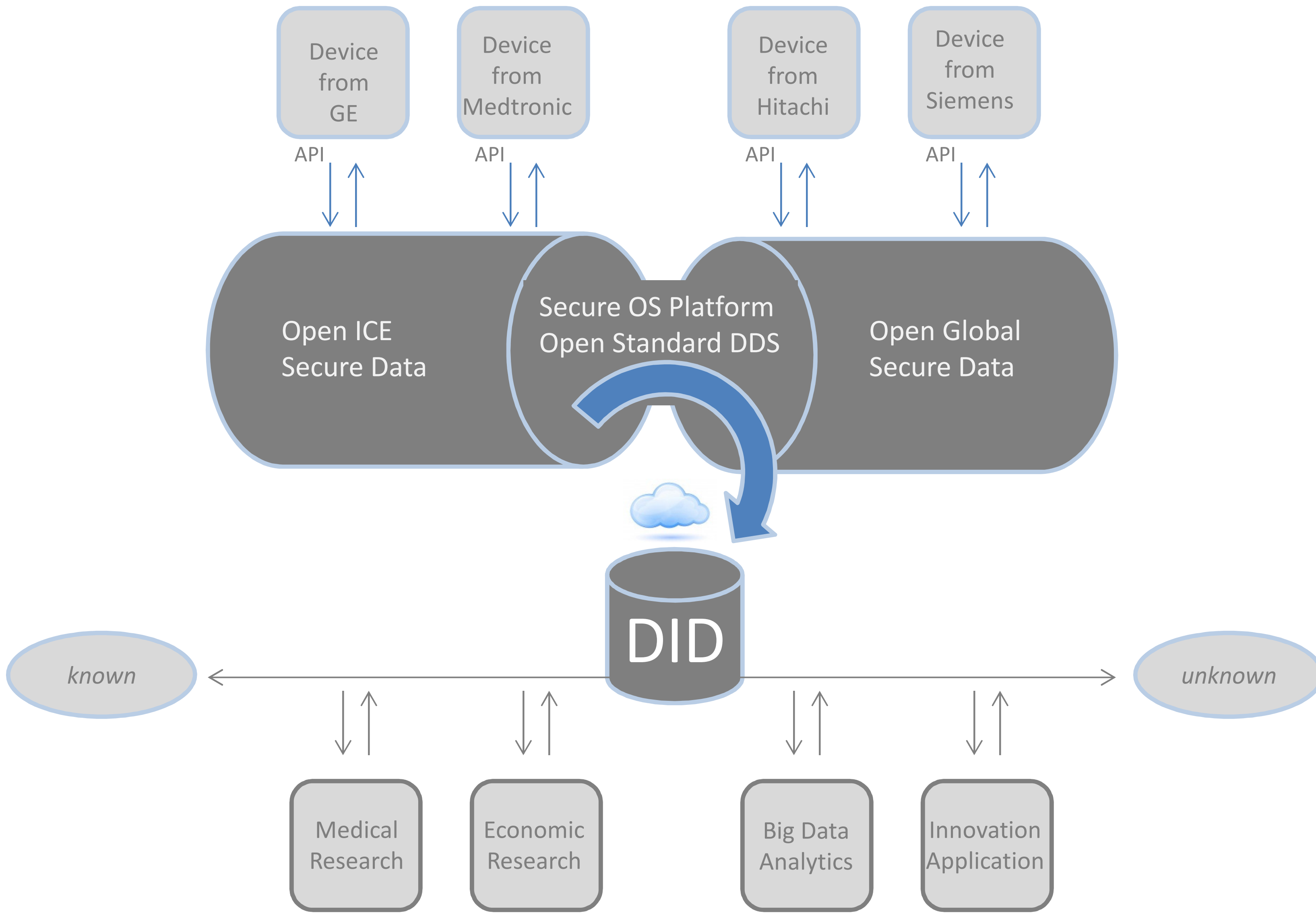
ICE
Integrated
Clinical
Environment

HEALTH DATA



Why ICE standards are critical –
Device Agnostic Data Integration
Global Interoperability Platform

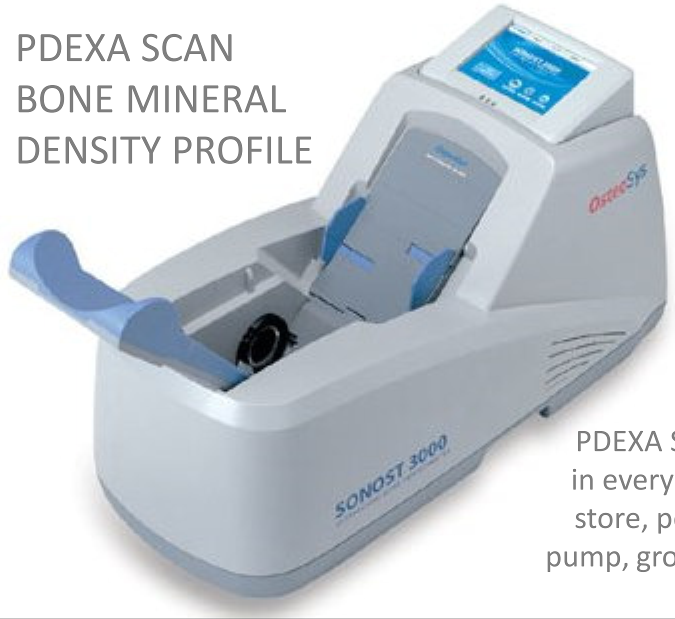
De-identified Data (DID) will drive Research – Management Science – Policy – Funding



Note: In certain instances, CPS related time constraints may render traditional cloud based D2D architecture unacceptable [QoS] due to latency.

CVS Specials - $0.99 for 1-quart Milk • $1.99 for Bone Density • $2.99 Mammogram

PDEXA SCAN
BONE MINERAL
DENSITY PROFILE



PDEXA SCAN
in every drug
store, petrol
pump, grocery

Osteoporosis

EU → 28 million in 2010 to 34 million in 2025 (increase of 23%)

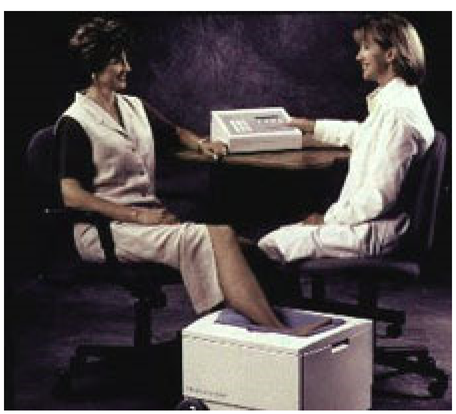
US → 44 million (represents 55% of people aged 50+)

Brazil → 10 million (1 in every 17)

India → 36 million (2013)

China → 70 million (50+). Cost of treatment USD1.5 billion in 2006.
Estimated US$12.5 billion in 2020 and US$265 billion in 2050.

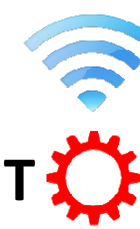
In 2008, Indonesia had 34 DXA machines, half of them in Jakarta (population 237 million) which translates to 0.001 machine per 10,000 population. The equivalent recommended number for Europe is 0.11 (per 10,000)



http://bit.ly/BONE-HEALTH

Health data without de-identification

CONNECT



GROCERY STORE
PURCHASE LOG

Integrated system detects fall in bone density and correlates with reduced purchase of milk. Prevention for osteoporosis starts early. Avoids trauma and/or morbidity from broken bones. Connected healthcare data.

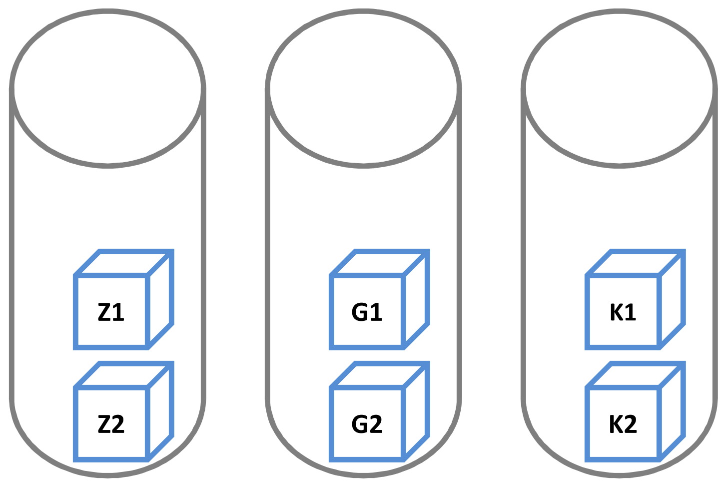
Data Dissociation using meta data to identify/label data type

Clinic VIEW

Name	SSN-UID	Street Address	Zip Code	Blood Glucose	Weight in kg
Jane Does Tag N1	123-45-6789 Tag S1	77 Mass Ave Tag A1	02139 Tag Z1	190 mg/dl Tag G1	190 Tag K1
John Does-Not Tag N2	123-45-6790 Tag S2	86 Brattle St Tag A2	02138 Tag Z2	109 mg/dl Tag G2	159 Tag K2

DID VIEW

Name	SSN-UID	Street Address	Zip Code	Blood Glucose	Weight in kg
			02139 Tag Z1	190 mg/dl Tag G1	190 Tag K1
			02138 Tag Z2	109 mg/dl Tag G2	159 Tag K2



Data Re-association using De-Identified Data (DID) Stack

Same data but ask a different

QUESTION

Same Data ← Different Questions → Extracting Information from DID

Epedimiologists

What is the distribution of potential diabetics by zip code?

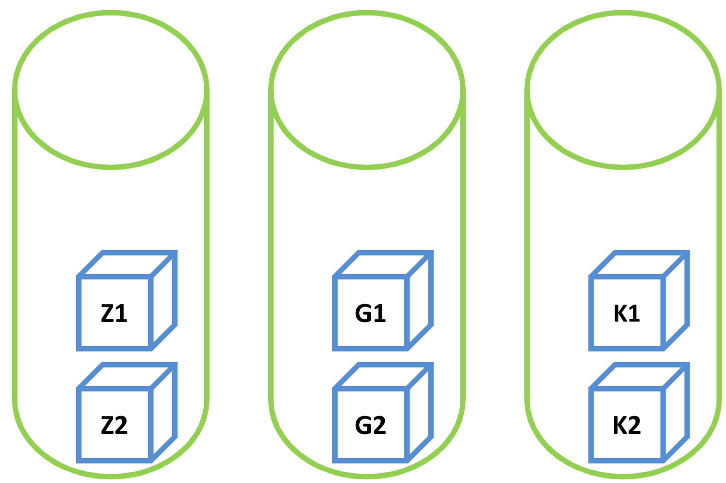
Economists

Is there a relationship between per capita income and body fat?

Physician

Can we correlate high blood glucose with increased body weight?

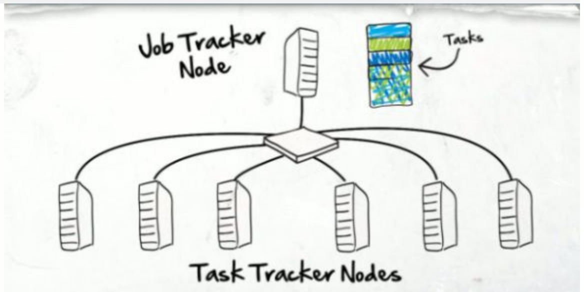
Name	SSN-UID	Street Address	Zip Code	Blood Glucose	Weight in kg
			02139 Tag Z1	190 mg/dl Tag G1	190 Tag K1
			02138 Tag Z2	109 mg/dl Tag G2	159 Tag K2

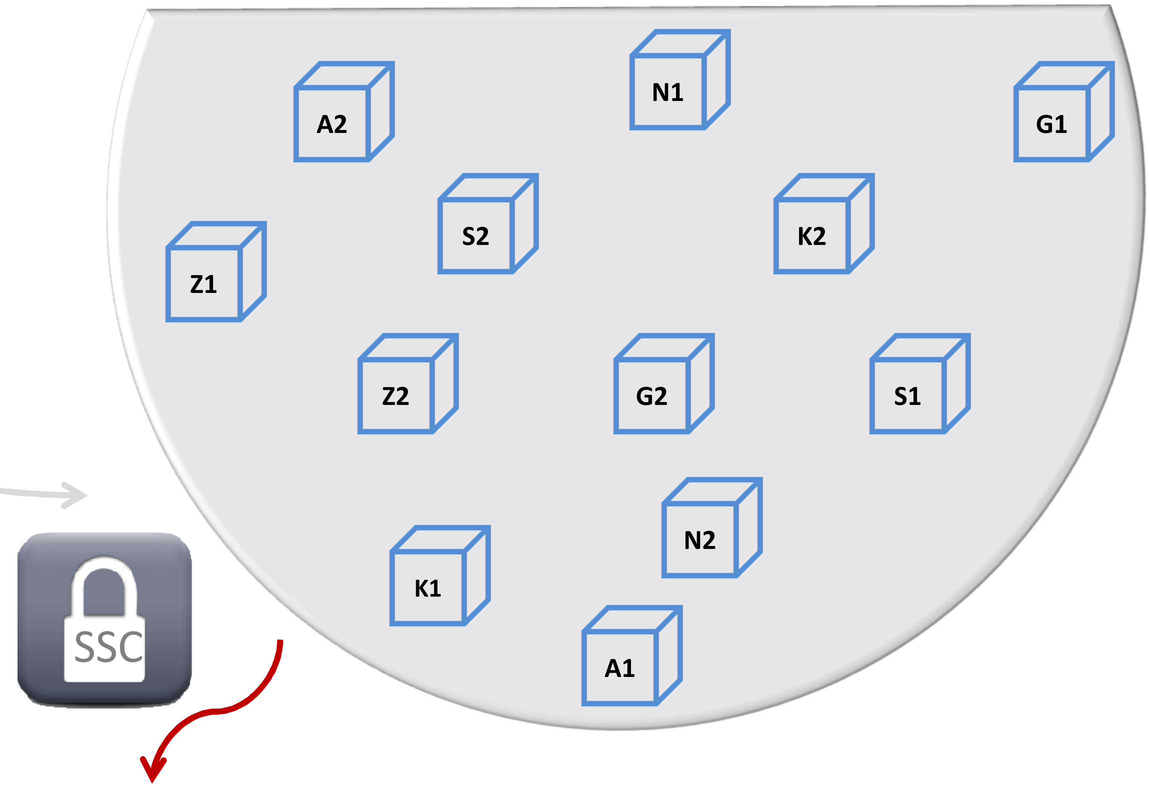


This is a suggestion by the author. Not a proven concept in practice.

Secured Data <> Re-association of De-Identified Data (DID)

Re-sequence DID → HADOOP-esque concept ?





Name	SSN-UID	Street Address	Zip Code	Blood Glucose	Weight in kg
Jane Does Tag N1	123-45-6789 Tag S1	77 Mass Ave Tag A1	02139 Tag Z1	190 mg/dl Tag G1	190 Tag K1
John Does-Not Tag N2	123-45-6790 Tag S2	86 Brattle St Tag A2	02138 Tag Z2	109 mg/dl Tag G2	159 Tag K2

This is a suggestion by the author. Not a proven concept in practice.

Re-stitch De-Identified Data - create Secure Sequencing Code (SSC)

New approaches and innovation cycles are necessary to deal with the big data deluge

- Data is now doubling approximately every 20 months
- Number of internet-connected devices may have exceeded 10 billion
- Payments by mobile phone are hurtling toward $1 trillion
- We are generating 2.5×10^{18} (exabytes) of data each day
- Stored information in the world ~ 1200 exabytes
- If printed on CD-ROMs and stacked up – it will stretch to the Moon in 5 separate piles
- In the 3rd century BC, the Library of Alexandria represented all the knowledge in the world
- Digital deluge offers every person living on Earth 320 times as much information as above

Can detection of data in an application trigger in-network analytics, routing, security check?

Application Aware Networking – visualizing an old concept with new eyes

Cisco Systems

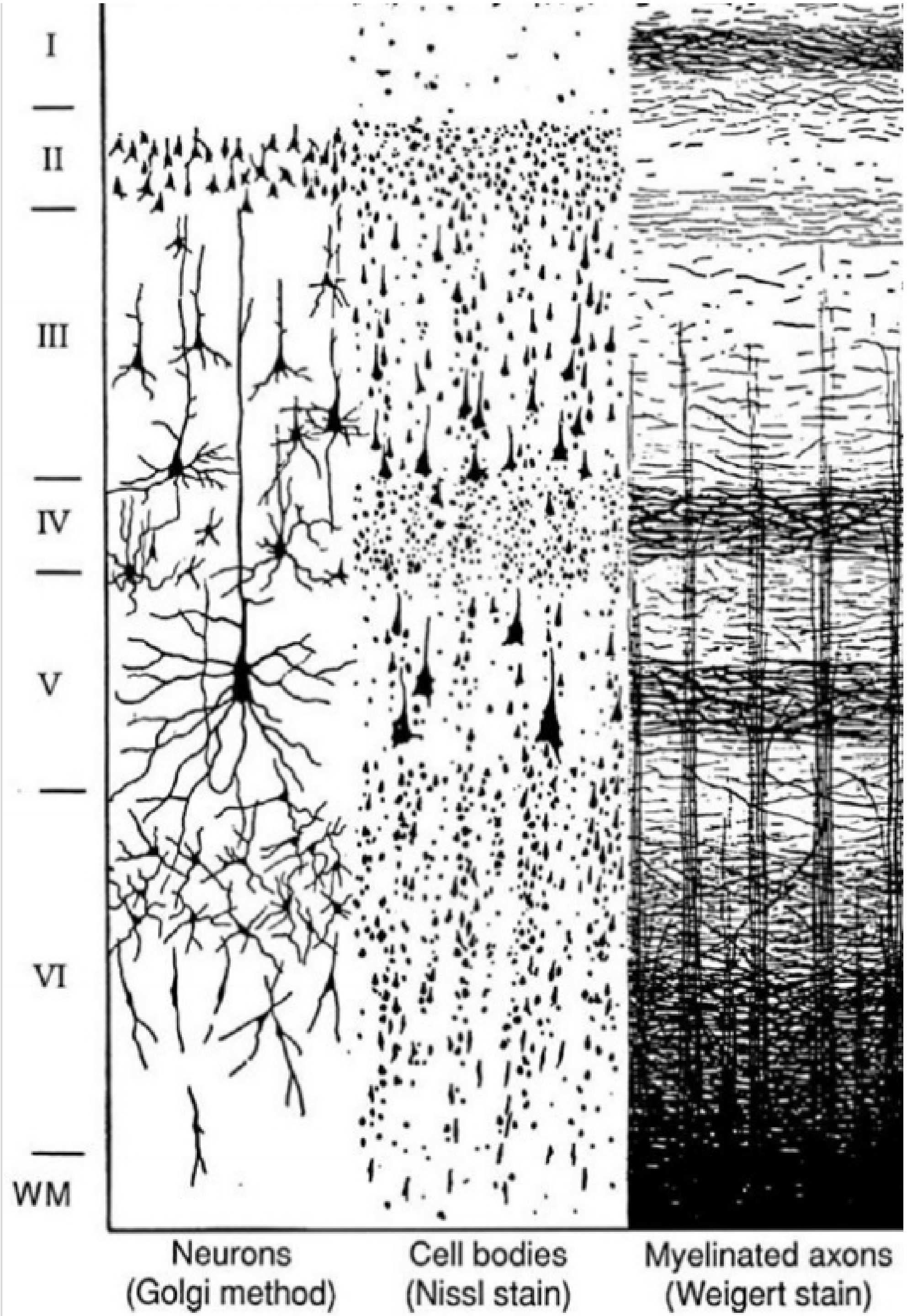
Think and Connect like a Neuron

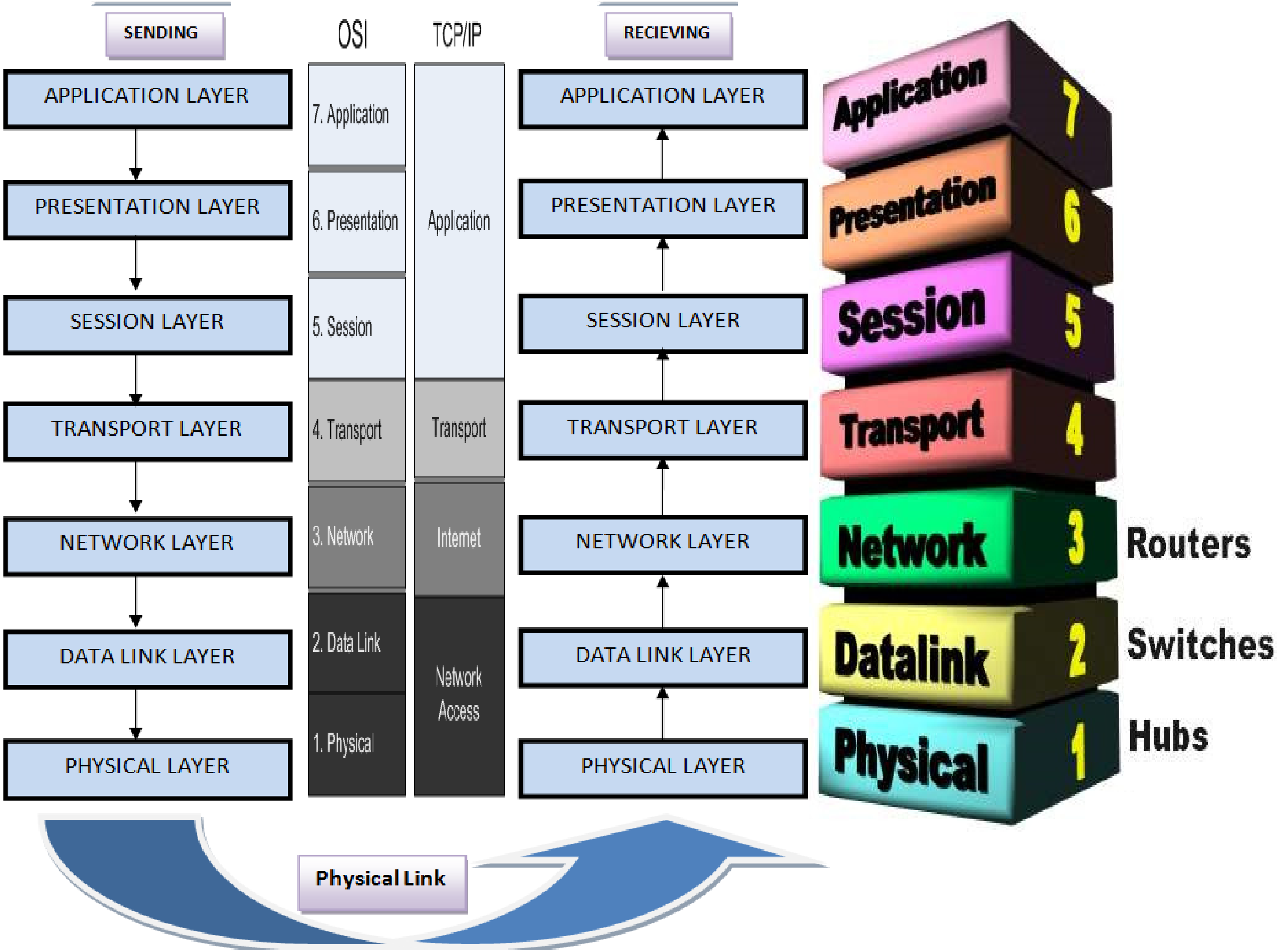
Extracting value from data to generate information

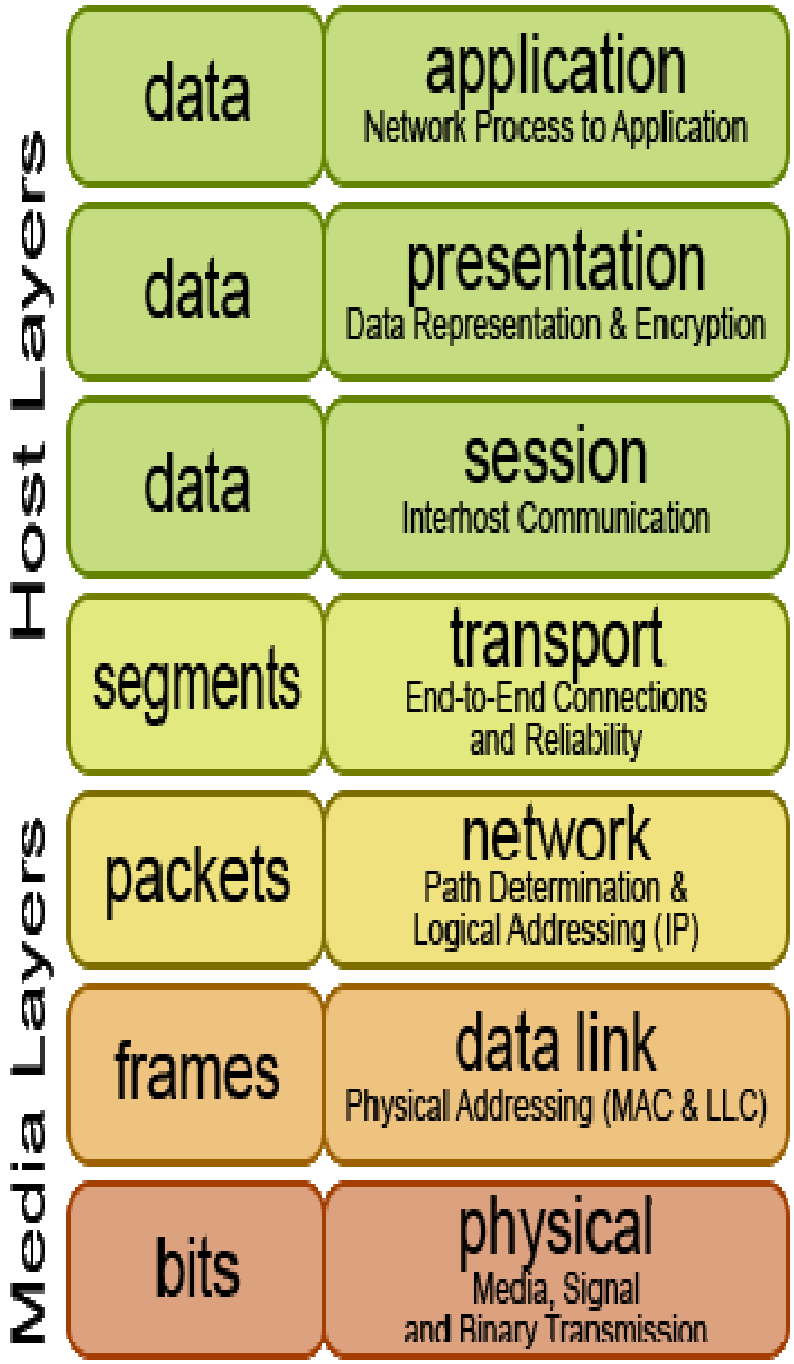
Santiago Ramón y Cajal

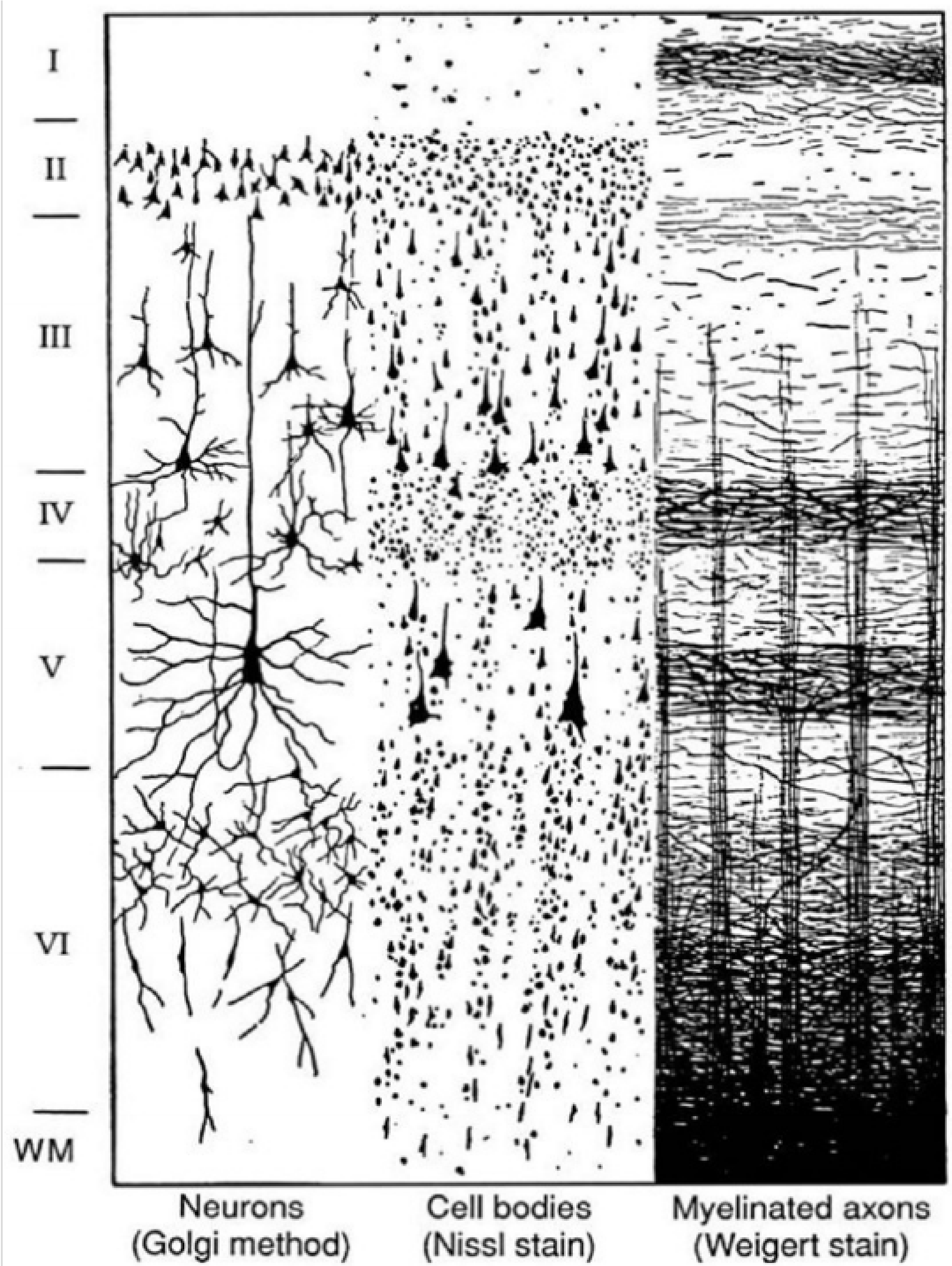
Slice of neo-cortex, as identified by Cajal. Every cubic mm contains about 100,000 neurons and 2-4 km of axons and dendrites. Layers I-VII on the right = 2mm vertical distance.

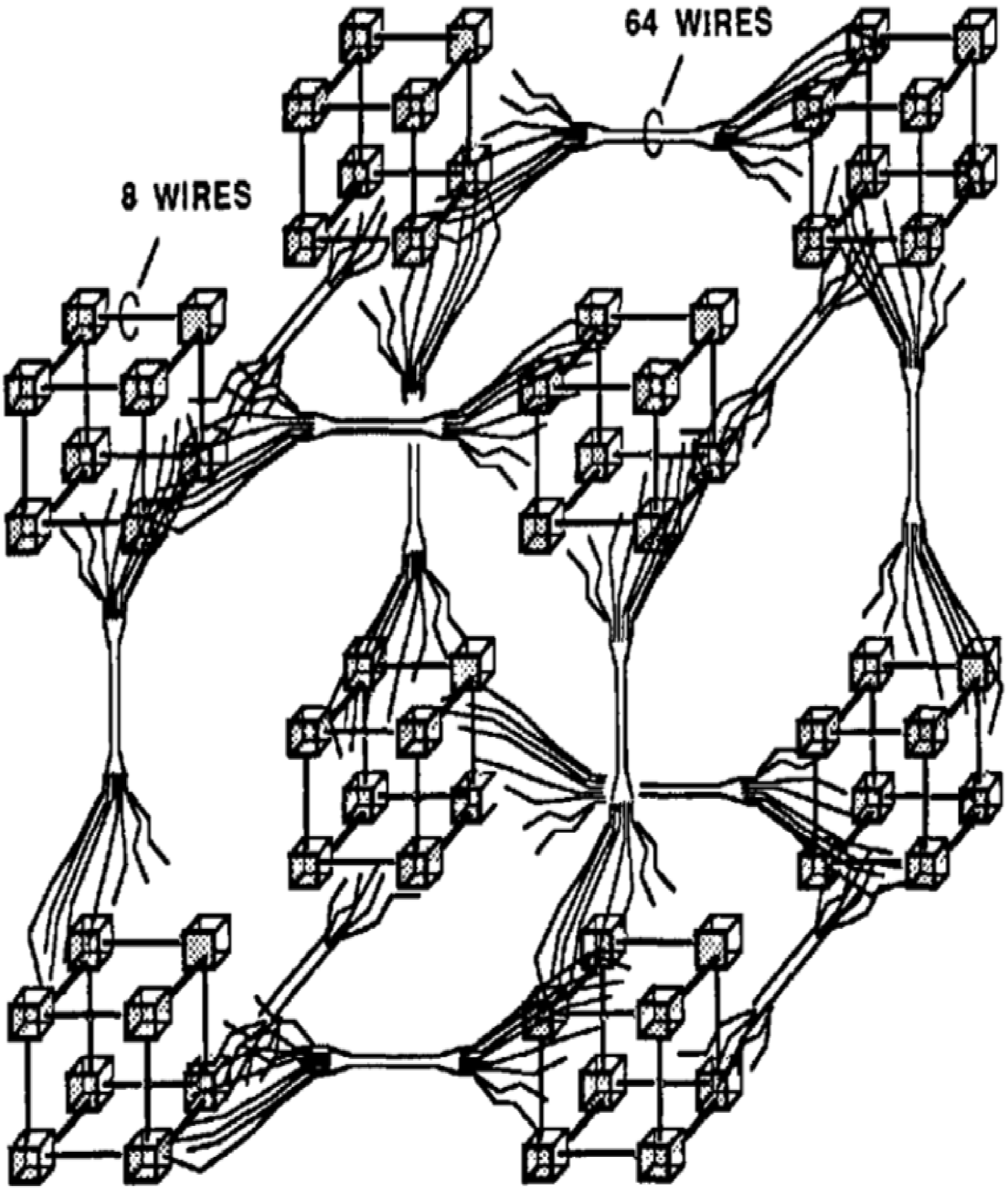
Born	1 May 1852 Petilla de Aragón, Navarre, Spain
Died	18 October 1934 (aged 82) Madrid, Spain




SENDING
OSI
TCP/IP
RECIEVING
APPLICATION LAYER
PRESENTATION LAYER
SESSION LAYER
TRANSPORT LAYER
NETWORK LAYER
DATA LINK LAYER
PHYSICAL LAYER
7. Application
6. Presentation
5. Session
4. Transport
3. Network
2. Data Link
1. Physical
Application
Transport
Internet
Network Access
APPLICATION LAYER
PRESENTATION LAYER
SESSION LAYER
TRANSPORT LAYER
NETWORK LAYER
DATA LINK LAYER
PHYSICAL LAYER
Application 7
Presentation 6
Session 5
Transport 4
Network 3
Datalink 2
Physical 1
Routers
Switches
Hubs
Physical Link


Host Layers
Media Layers
data
application
Network Process to Application
data
presentation
Data Representation & Encryption
data
session
Interhost Communication
segments
transport
End-to-End Connections and Reliability
packets
network
Path Determination & Logical Addressing (IP)
frames
data link
Physical Addressing (MAC & LLC)
bits
physical
Media, Signal and Binary Transmission


I
II
III
IV
V
VI
WM
Neurons (Golgi method)
Cell bodies (Nissl stain)
Myelinated axons (Weigert stain)



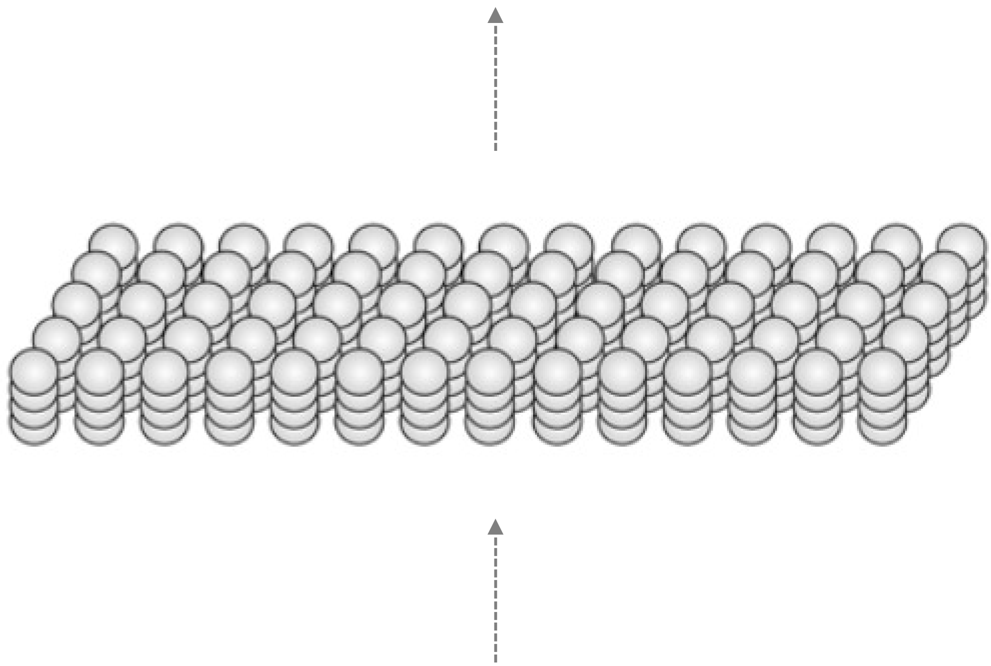
Here, 8 agents make a little cube, and 8 such cubes make a 64-agent supercube.

If we join 8 of these supercubes, we'll have 512 agents. And if we repeat this cube-on-cube pattern ten times, the resulting supercube will contain a billion agents!

But if we link each agent to 30 others instead of only 6, then each agent could communicate with a billion others in only 6 steps.

THE SOCIETY OF MIND
Marvin Minsky (1959)

Hierarchical Temporal Memory (HTM), a form of ANN



Section of a HTM region, equivalent to 1 layer of neurons in the neocortical region (layer 3). Each 4-cell column connects to a subset of the input and each cell connects to other cells in the region (connections are not shown). The principle of this connectivity was abstracted in Minsky's cube-on-cube.

Numenta

HTM (CLA) attributes include time and context – essential for many CPS (cyberphysical systems) applications and data analytics (context)

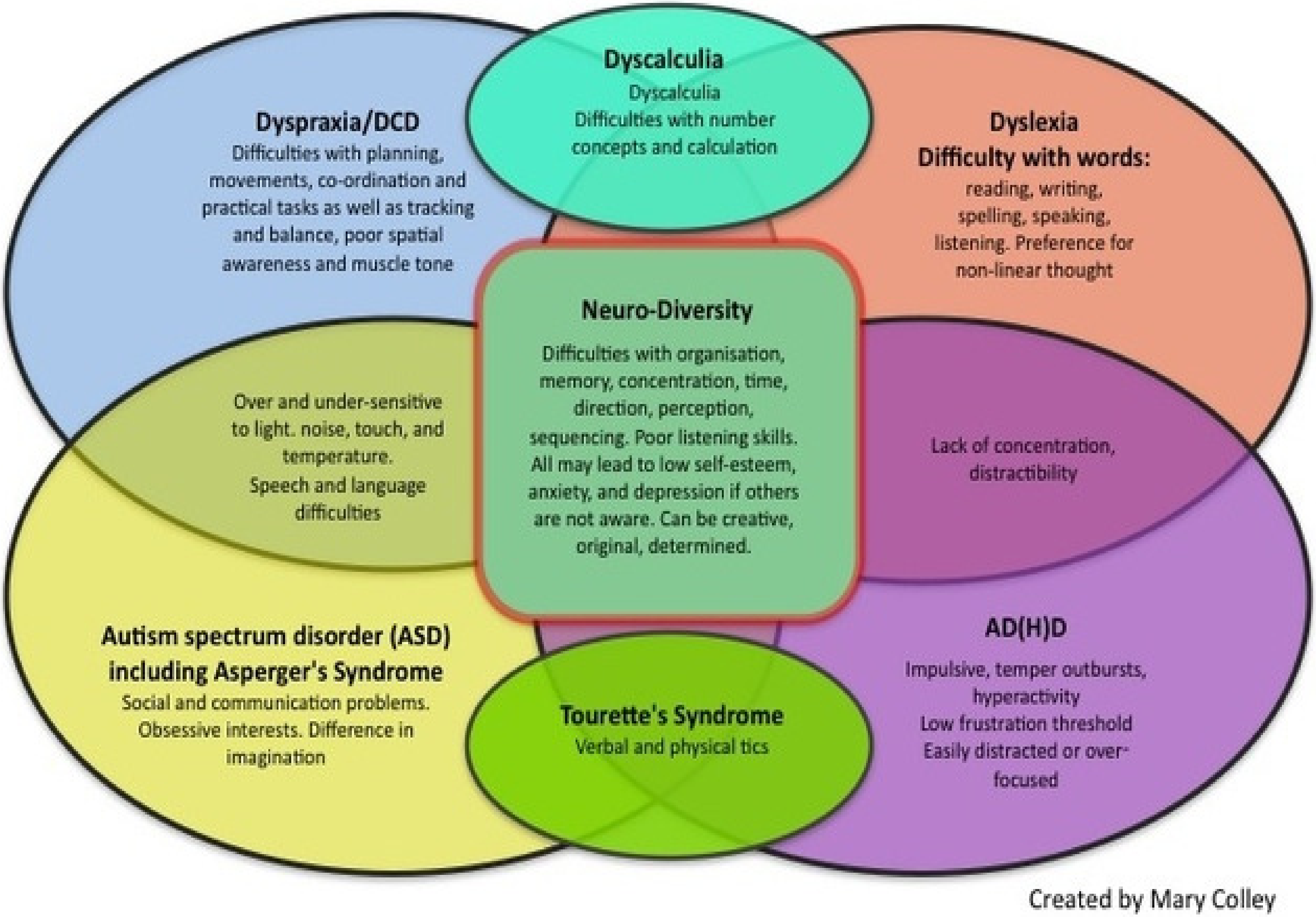
Hierarchical Temporal Memory (HTM) is a machine learning tool to capture the structural and algorithmic properties of the neocortex which is the seat of intelligent thought in the mammalian brain. High level vision, hearing, touch, movement, language and planning are performed by the neocortex. Given such a diverse suite of cognitive functions, the neocortex may be expected to implement an equally diverse suite of specialized neural algorithms. In reality, the neocortex displays a remarkably uniform pattern of neural circuitry. In other words, the neocortex implements a common set of algorithms to perform many different intelligence functions. It may be analogous to an abstraction which is used in a systemic context.

Programming HTM cortical learning algorithms require training through exposure to a stream of sensory data (capabilities are determined largely by exposure). HTM is a memory based ANN system. HTM networks are trained on time varying data and rely on storing a large set of patterns and sequences. A crucial distinction of HTM is embedded in the semantics of time which is an important element in applications relating to cyberphysical systems (CPS). Classic computer memory has a flat organization and does not have an inherent notion of time because the semantics of time are not available in the ISA (instruction set architecture). Therefore, in the classical programming environment, we can implement any kind of data organization and structure on top of the flat computer memory and control how and where information is stored.

HTM memory is more restrictive. HTM memory has a hierarchical organization and is inherently time based. Information is always stored in a distributed fashion. HTM user is expected to specify the size of the hierarchy and what to train the system on but the HTM controls where and how information is stored (data, patterns, text, sequences). Hence, HTMs are learning and prediction machines that can be applied to many types of problems through the inherent abstractions in the system. Although an HTM region is equivalent to only one portion of a neocortical region (layer 3), it can perform inference and prediction on complex data streams. Hence the significance of HTMs in data analytics in multiple domains or verticals.

Although neurons in the neocortex are highly interconnected, inhibitory neurons guarantee that only a small percentage of the neurons are active at one time. Thus, information in the brain is always represented by a small percentage of active neurons within a large population of neurons. This kind of encoding is called a “sparse distributed representation” where a small percentage of neurons are active at one time. “Distributed” refers to the characteristic that the activation of many neurons are required in order to represent something. A single active neuron conveys some meaning but it must be interpreted within the context of a population of neurons to convey the full or complete meaning relevant to the context.

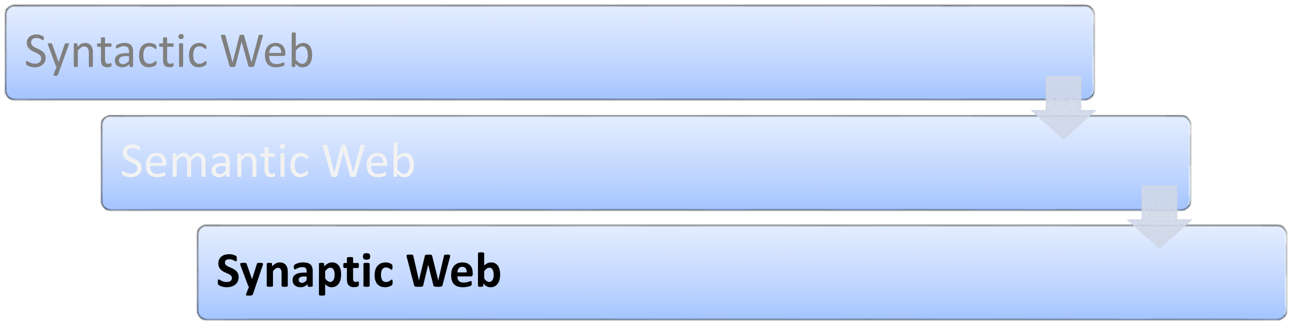
Understanding the neurological basis of certain anomalies provides clues to information/data processing

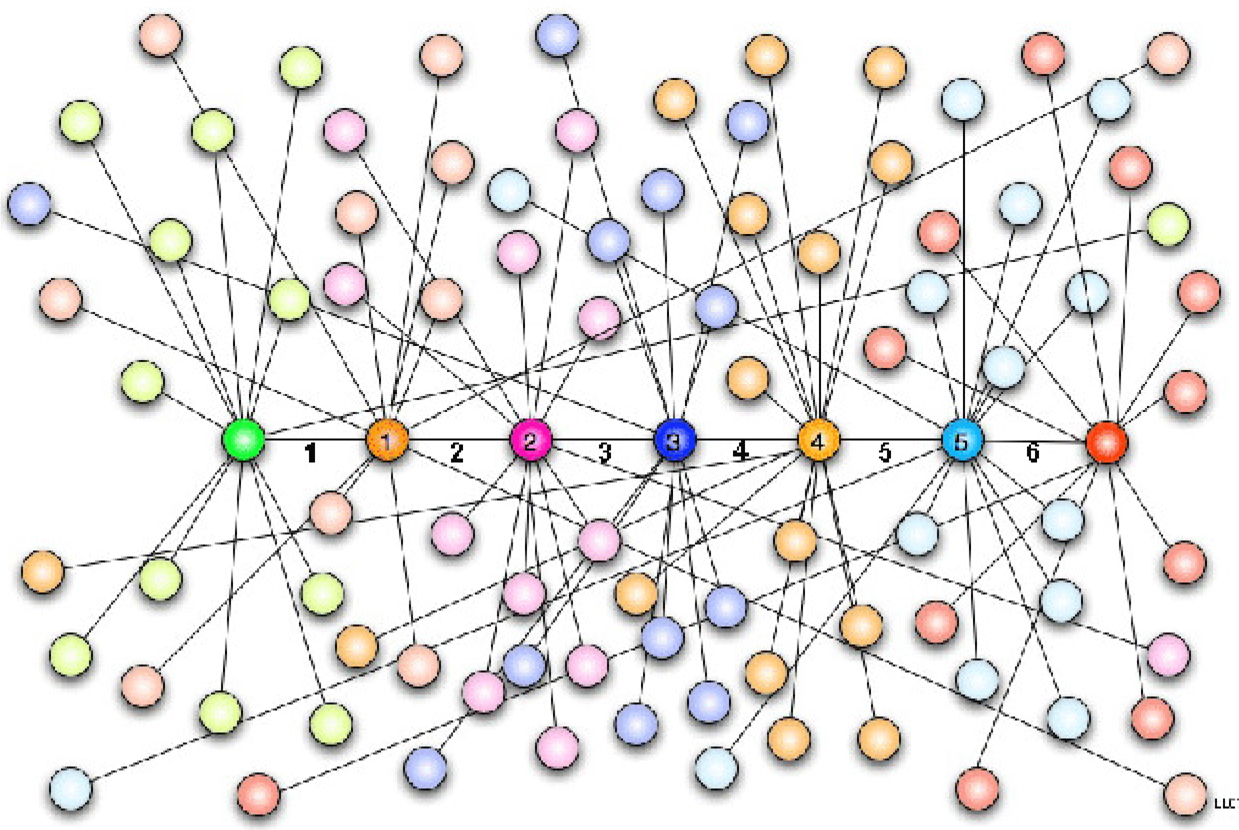


Neurons connect to process data and information using the mechanism of pattern recognition as a tool

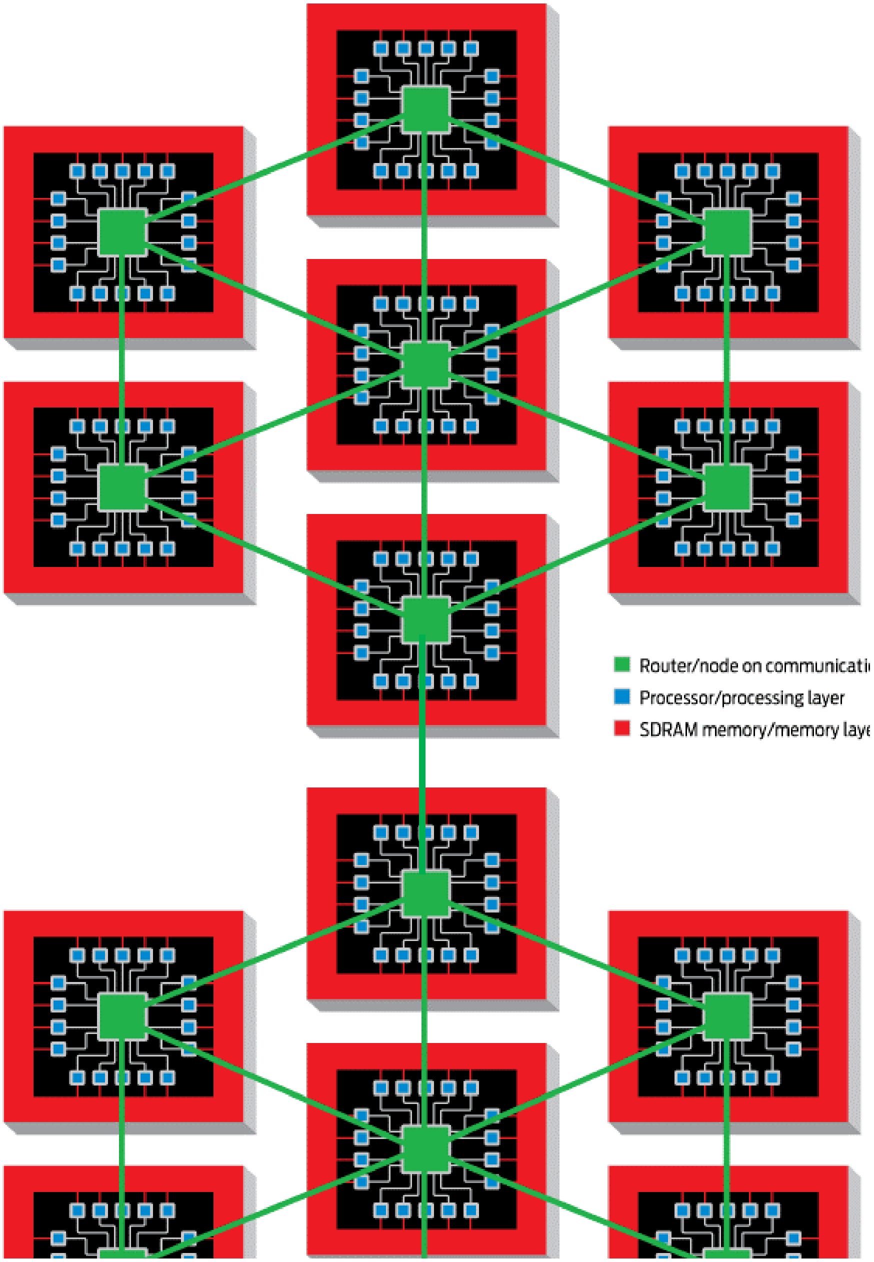
- Syntactic Web
- Semantic Web

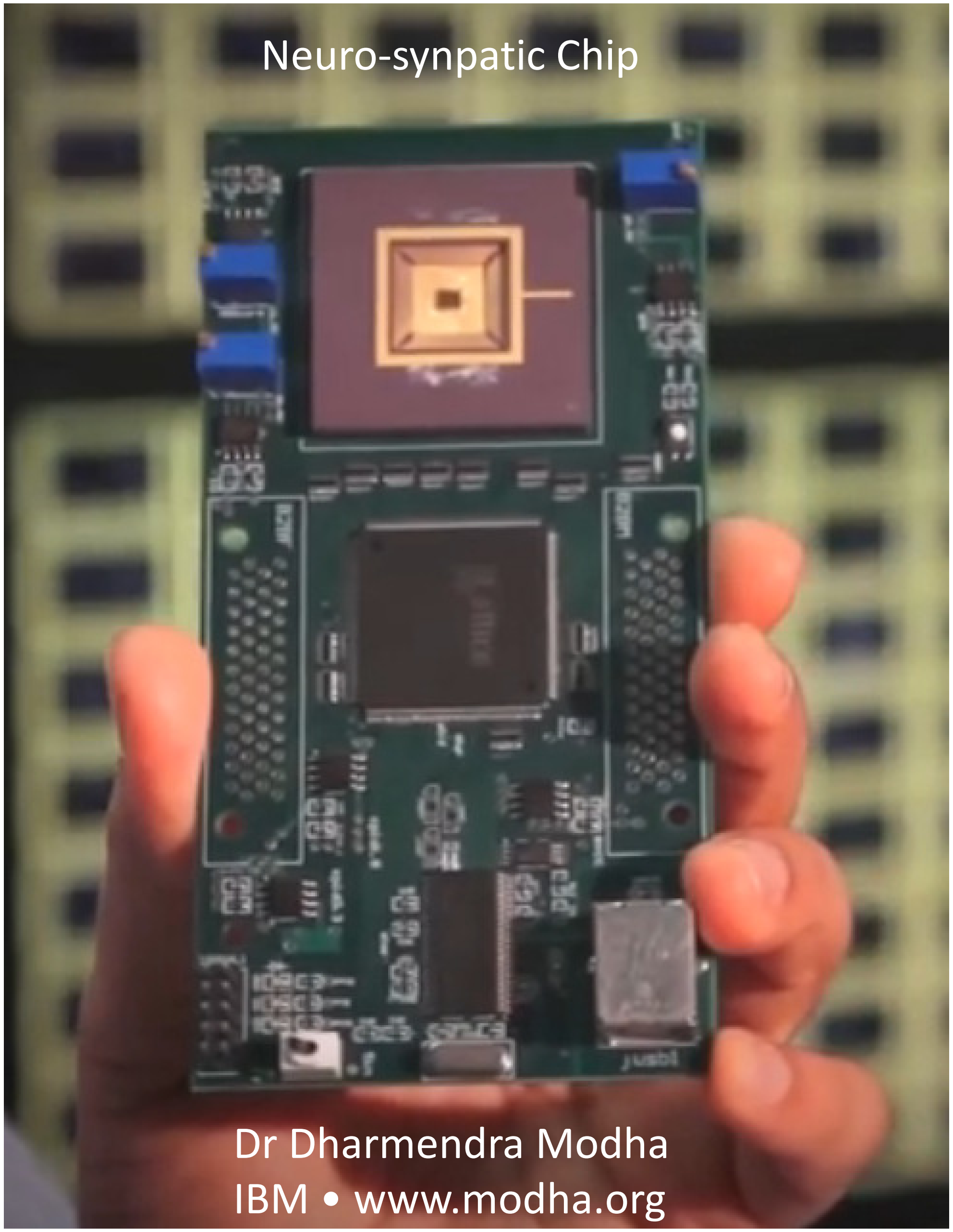
Synapses can connect, converge and coalesce data from various regions to generate the precise response





Neuro-Synaptic Chips & Multi-core platforms for parallel processing of noisy, multi-modal, unstructured data



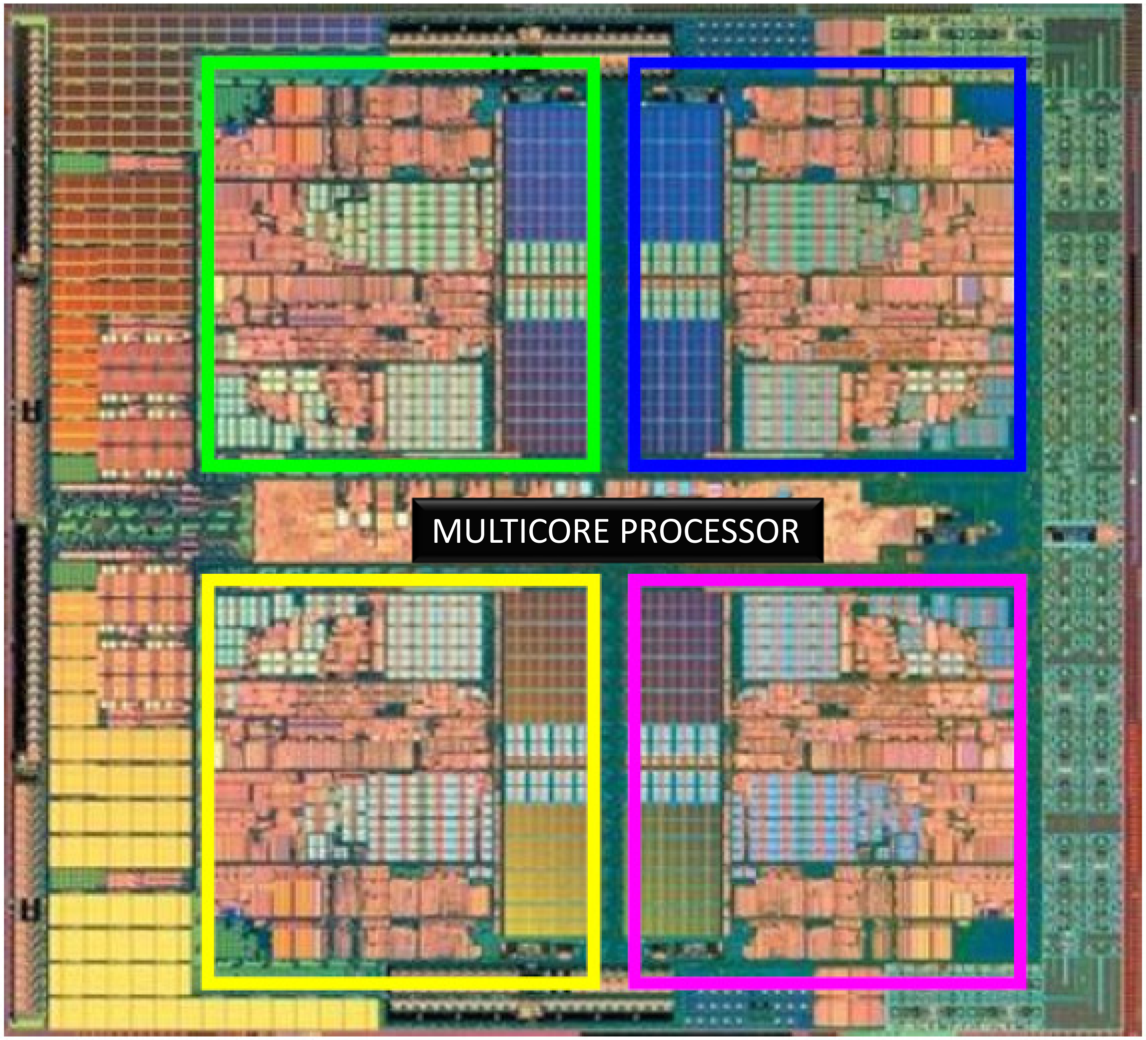


Industrial Internet applications of multi-core platforms: Embedded Fault Detection for Safety-Critical Systems

without reliance on the need for physical redundancy

Data Driven
Anomaly Detection

Model Based
Fault Detection



Software Monitors
FDI Supervisor

Control Algorithms
Signal Processing

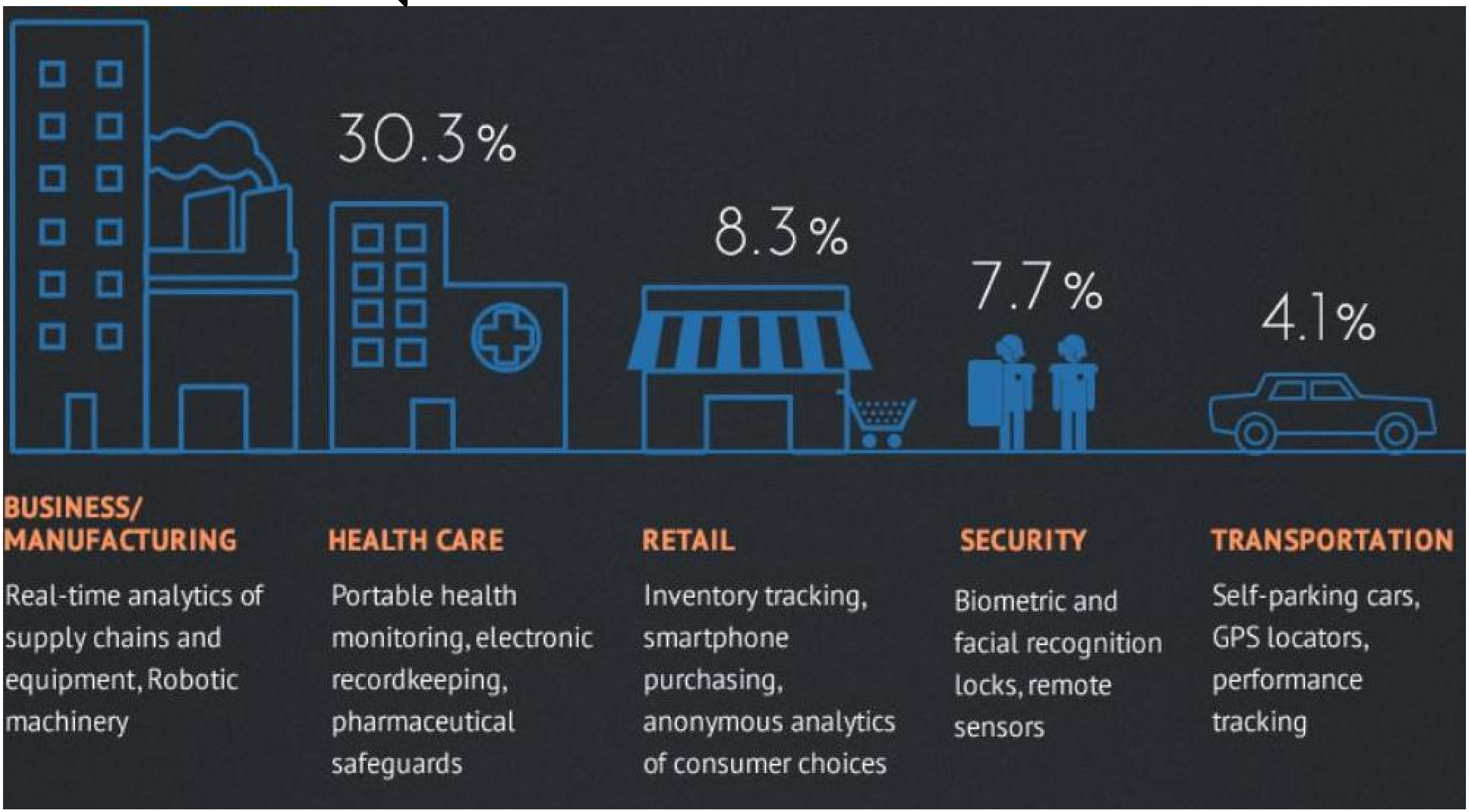
Aviation Industry • in-flight monitoring data and aircraft maintenance based on data analytics

Heart of the Industrial Internet

Economic value from business and manufacturing data

40.2%

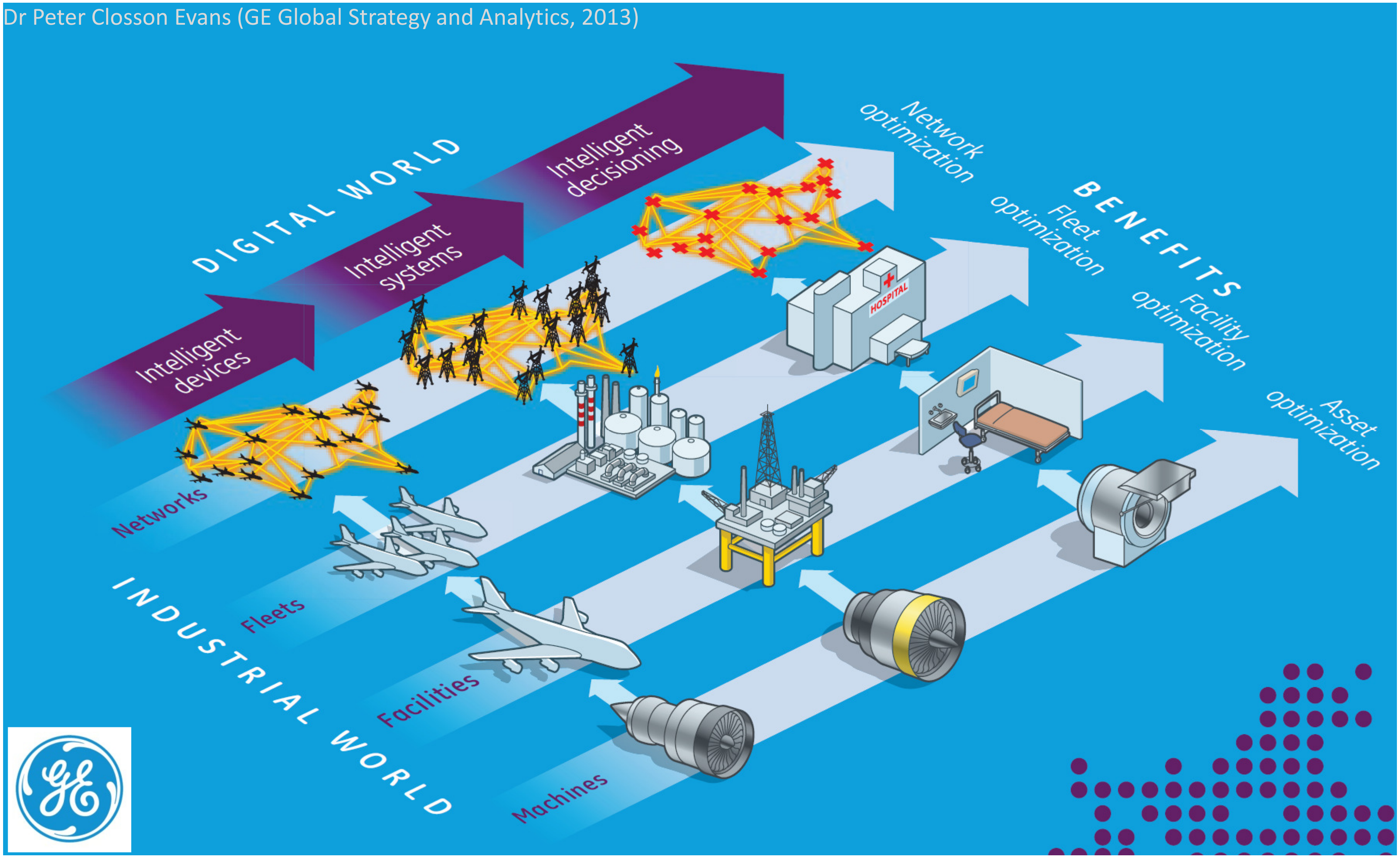
Think BIG DATA – Think Industrial Internet
Think adding $15 trillion to the economy



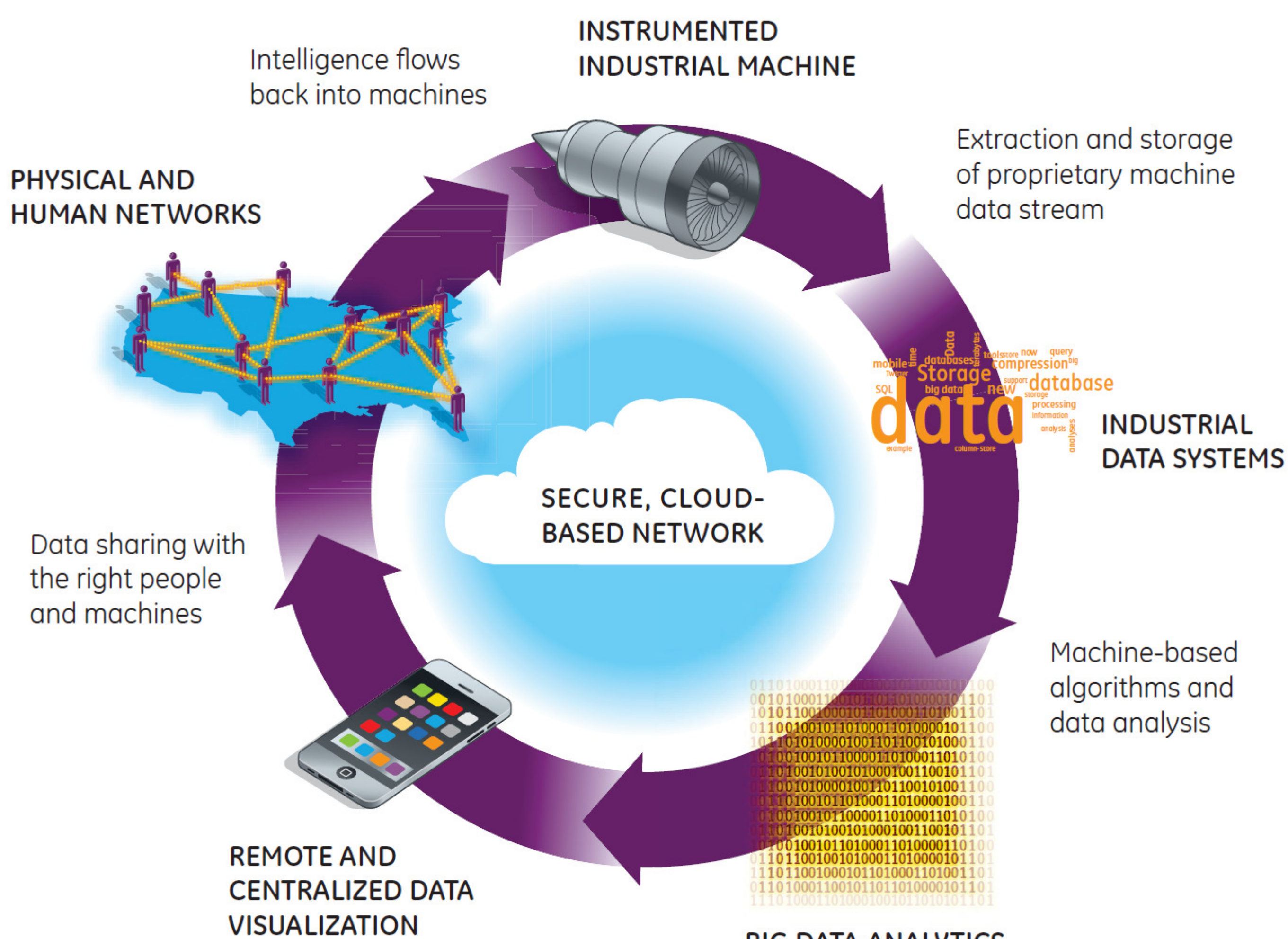
Connected Domains Converge

Synthesizing the Industrial Internet

Industrial Internet



Industrial Internet



Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

Why this mad pursuit ?

The quest for economic growth

Plight to Improve Global Economy - Penchant to Improve Lives of People

Almost half are jobless

About half are H2M

The richest 300 people are worth as much as the poorest 3 billion in terms of global wealth

Diffusion of Economic Impact

Much more than transaction cost analysis

•

One unconventional example of value

Is there any relation between toll collection and low birth weight ?

Is there a relation between electronic toll payments and health of the fetus?

YES

Electronic toll collection (EZ Pass) may improve the quality of life of newborns

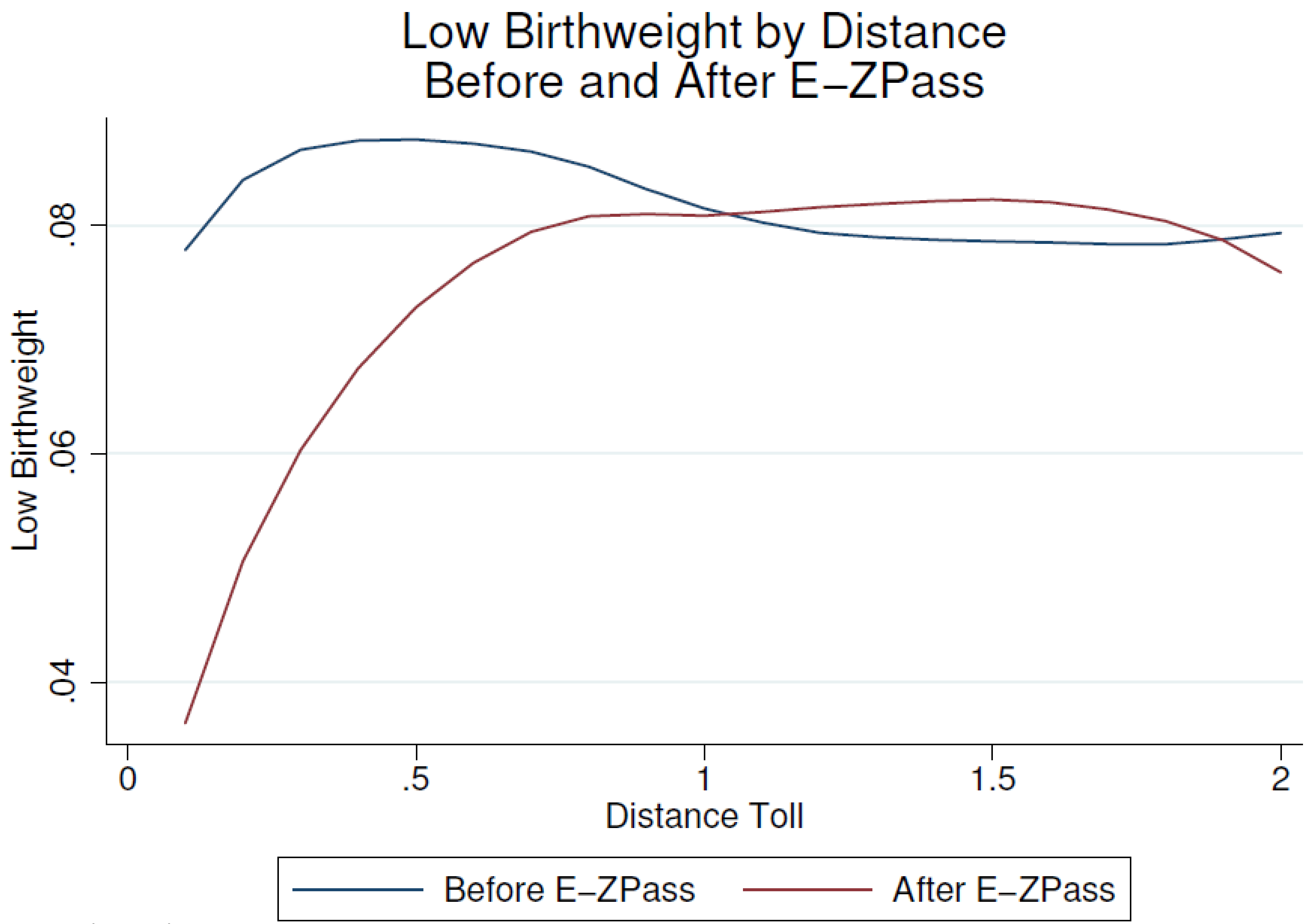
Traffic Congestion and Infant Health: Evidence from E-Z Pass

Introduction of E-Z Pass (the electronic toll collection system for stop-less toll plaza) reduced prematurity and low birth weight among mothers within 2km of a toll plaza by 10.8% & 11.8%, respectively, relative to mothers 2-10km from a NJ-PA toll plaza.

NBER Working Paper 15413 http://www.nber.org/papers/w15413
Janet Currie, Princeton University and Reed Walker, Columbia University
National Bureau of Economic Research, 1050 Massachusetts Avenue, Cambridge, MA 02138
Supported by the John D. and Catherine T. MacArthur Foundation (http://www.macfound.org)

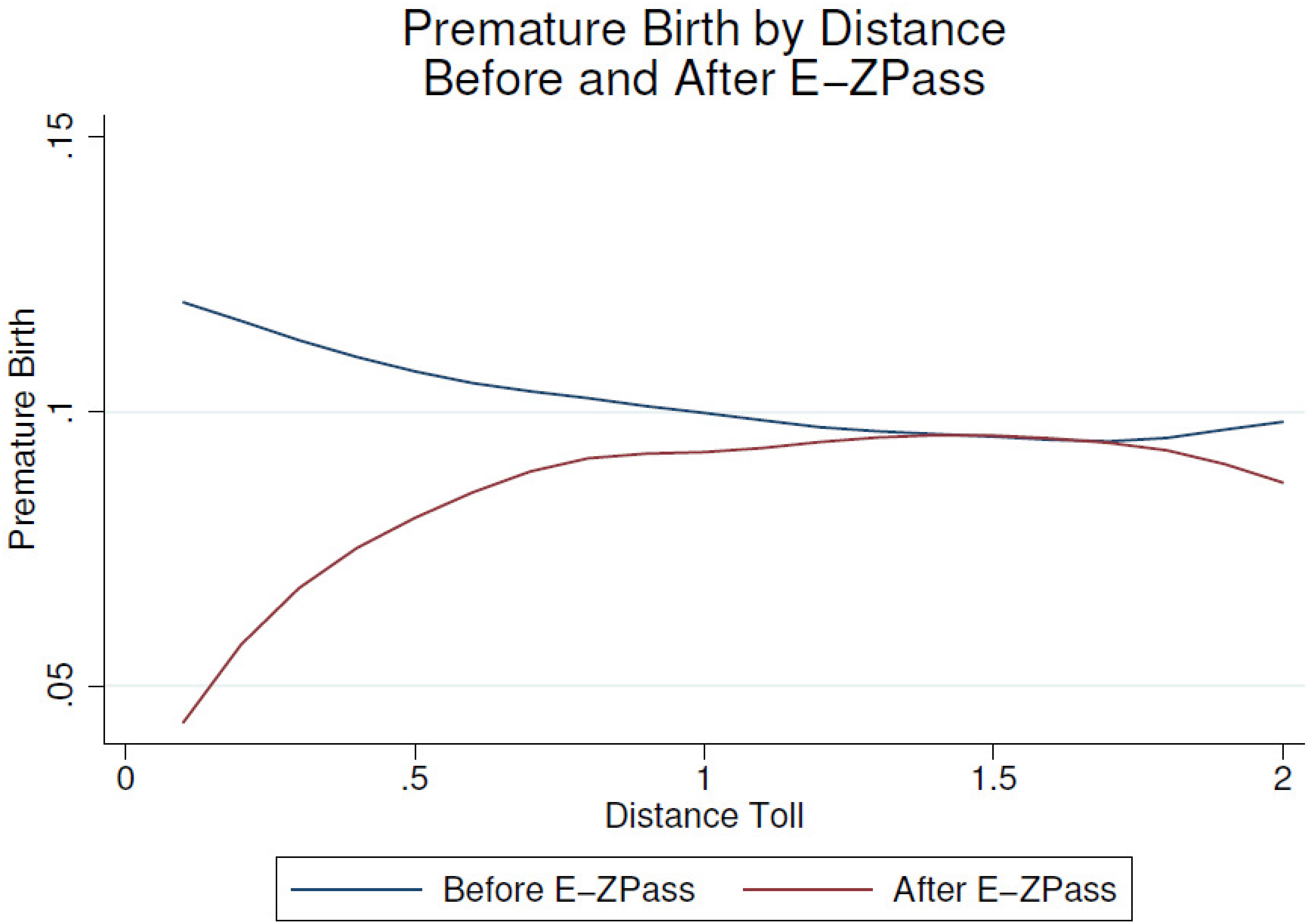
Traffic congestion contributes significantly to poor health among infants. What is the economic impact?

Traffic Congestion and Infant Health: Evidence from E-Z Pass



www.nber.org/papers/w15413

Traffic Congestion and Infant Health: Evidence from E-Z Pass

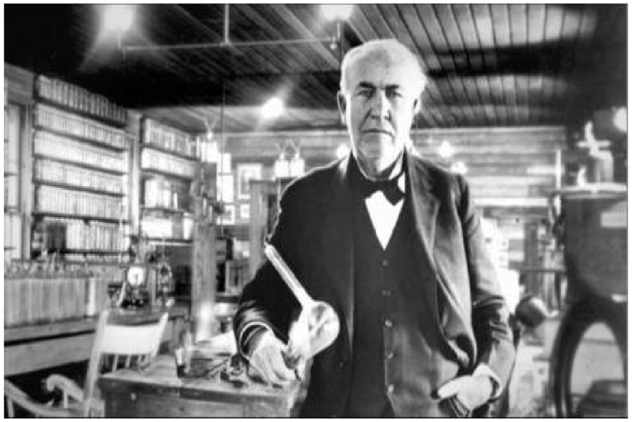


www.nber.org/papers/w15413

Economic Impact

la raison ultime

The Economic Impact of The Industrial Internet – The Energy Under The Curve

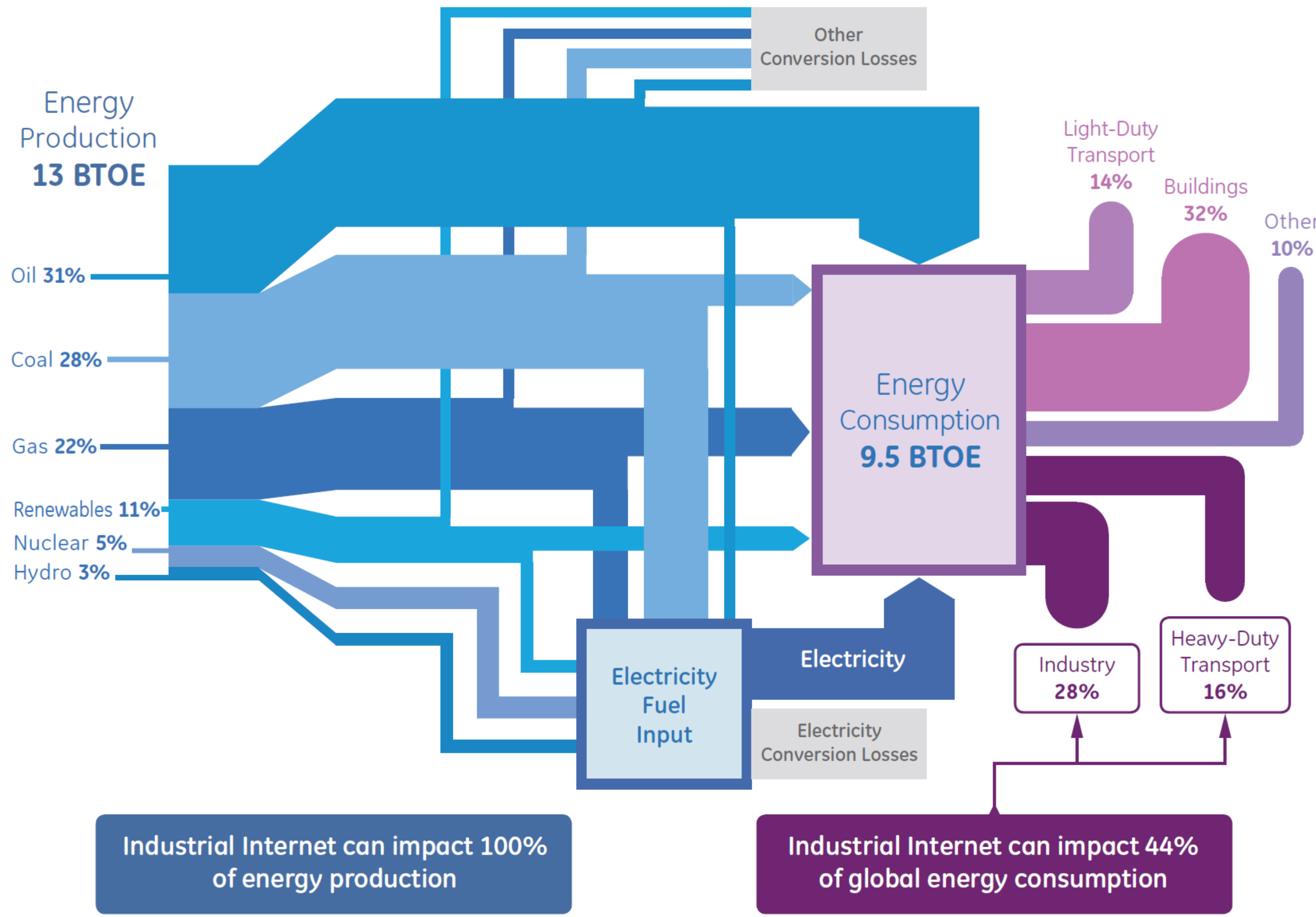


The concept of energy under the curve is directly analogous to an economy's money supply at a given time. Both the energy and the money supply are known amounts. The money is going to be spent by someone (device is going to output its energy). The key is for the money to be spent where it has the most benefit (the light bulb must produce visible light).

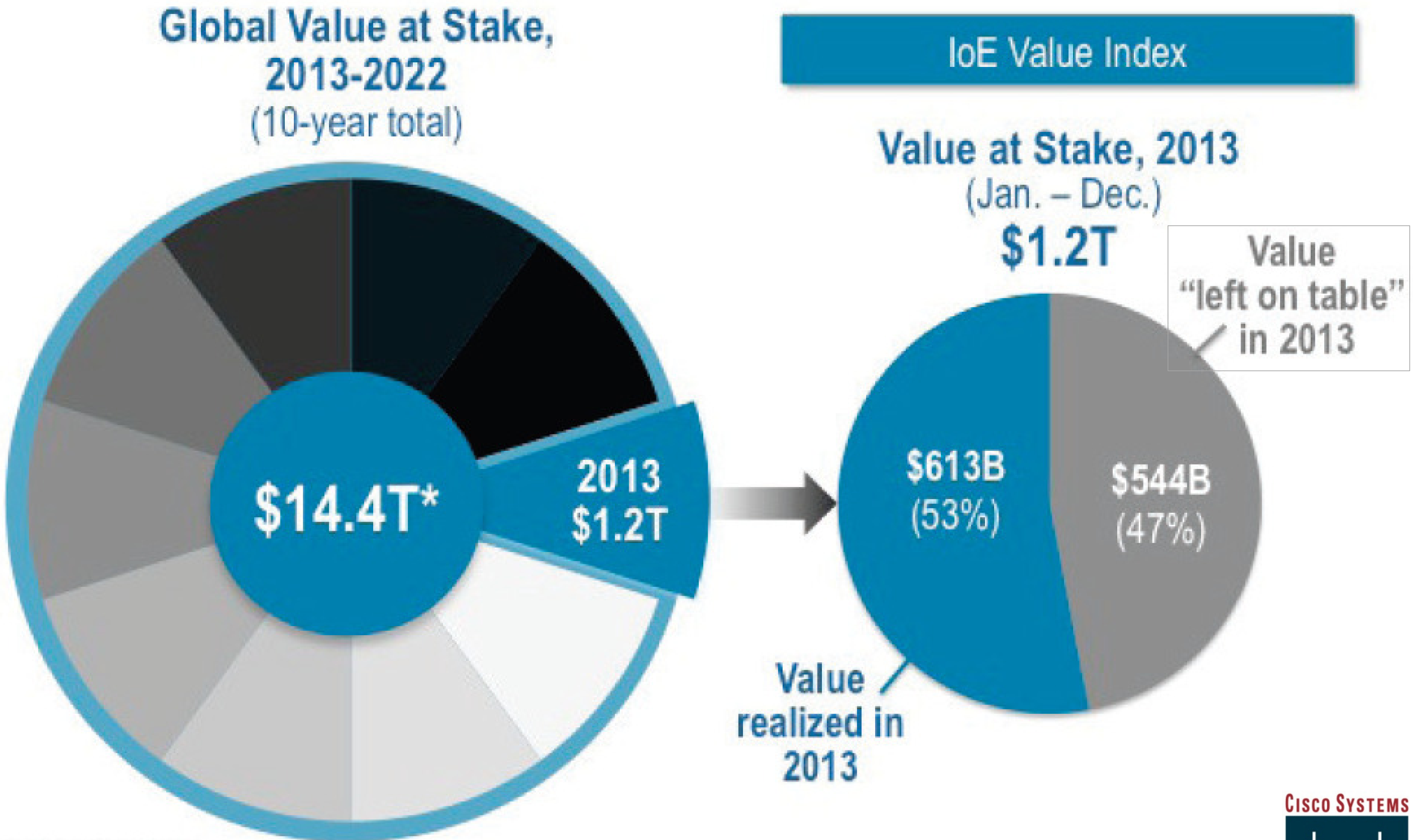
In engineering parlance, there is a phrase called 'energy under the curve.' This refers to the total energy output of a device—light bulb, acoustic transducer —as measured on a graph across a range of frequencies. While every effort is made to maximize the amount of energy output from that device, in the end it's still a finite amount. The key to best performance is getting the device to deliver energy that is ***usable***. A light bulb may produce x lumens of energy, but it won't do much good if its output is predominately at ultraviolet frequencies that are invisible to the human eye. An acoustic transducer (speaker) can be modified to produce more or less energy at different frequencies, but the total acoustic energy produced by that specific speaker is finite. The engineers can move the energy output from one frequency region to another, but the 'total energy under the curve' remains the same. The key to a speaker's useful performance, of course, is for it to produce its energy at frequencies that are audible and useful to humans, not bats.

www.americanthinker.com/2004/09/the_light_bulb_economy.html

The Economic Impact of The Industrial Internet – The Energy Under The Curve

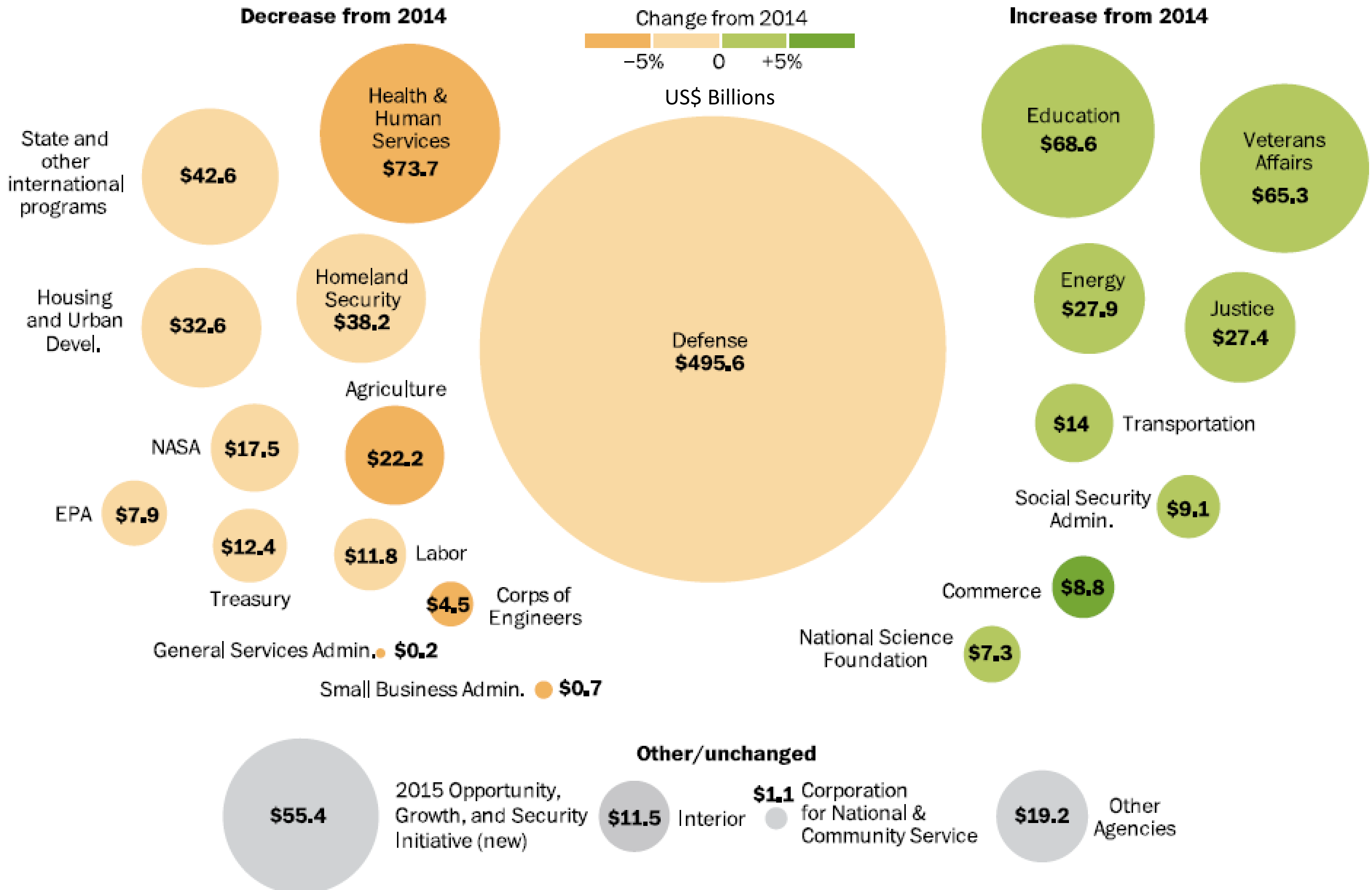


The Economic Impact of The Industrial Internet – The Energy Under The Curve



Cisco Systems

The Economic Impact of The Industrial Internet – Dwarfs the US DoD Budget



The Economic Impact of The Industrial Internet – Driving Efficiencies

Industry	Segment	Time to Service (Labor-hours per year)	Estimated Value (Billion US dollars)
Power	Steam & Gas Turbines	52 Million	$7B
Aviation	Aircraft Engines	205 Million	$10B
Rail	Freight	52 Million	$3B
Healthcare	CT + MRI Scanners	4 Million	$250M

Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

Different Spin on Objects

Industrial Internet of 3 Million Spinning Components → Improve Efficiency and Prevent Failure of Parts

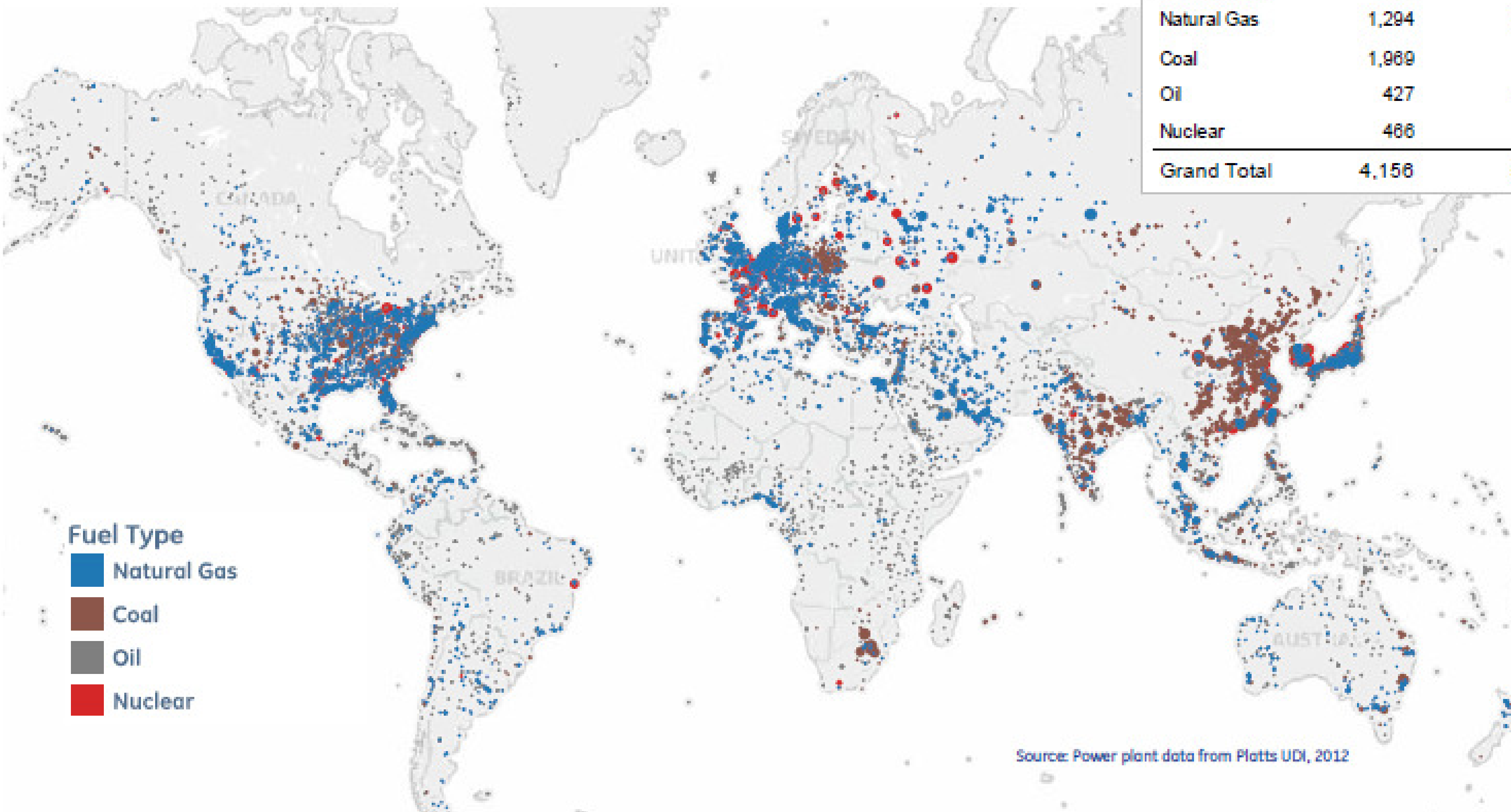
Transportation	Rotating Machinery	# of Assets	# of Things That Spin
Rail: Diesel Electric Engines	Wheel Motors, Engine, Drives, Alternators	120,000	2,160,000
Aircraft: Commercial Engines	Compressors, Turbines, Turbofans	43,000	129,000
Marine: Bulk Carriers	Steam Turbines, Reciprocating Engines, Pumps, Generators	9,400	84,600
Oil and Gas	**Rotating Machinery**		
Big Energy Processing Plants (1)	Compressors, Turbines, Pumps, Generators, Fans, Blowers, Motors	990	36,900
Midstream Systems (2)	Engines, Turbines, Compressors, Turbo Expanders, Pumps, Blowers	16,300	63,000
Drilling Equipment: Drillships, Land Rigs etc.	Engines, Generators, Electric Motors, Drilling Works, Propulsion Drives	4,100	29,200
Power Plants	**Rotating Machinery**		
Thermal Turbines: Steam, CCGT, etc.	Turbines, Generators	17,500	74,000
Other Plants: Hydro, Wind, Engines, etc. (3)	Turbines, Generators, Reciprocating Engines	45,000	190,000
Industrial Facilities	**Rotating Machinery**		
Steel Mills	Blast and Basic Oxygen Furnace Systems, Steam Turbines, Handling Systems	1,600	47,000
Pulp and Paper Mills	Debarkers, Radial Chippers, Steam Turbines, Fourdrinier Machines, Rollers	3,900	176,000
Cement Plants	Rotary Kilns, Conveyors, Drive Motors, Ball Mills	2,000	30,000
Sugar Plants	Cane Handling Systems, Rotary Vacuums, Centrifuges, Cystalizers, Evaporators	650	23,000
Ethanol Plants	Grain Handling Systems, Conveyors, Evaporators, Reboilers, Dryer Fans, Motors	450	16,000
Ammonia and Methanol Plants	Steam Turbines, Reformer and Distillation Systems, Compressors, Blowers	1,300	45,000
Medical Machines	**Rotating Machinery**		
CT Scanners	Spinning X-Ray Tube Rotors, Spinning Gantries	52,000	104,000

Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

Anything that spins or rotates can break (downtime). Mounted sensors may detect fault or create alerts using MTBF (example of a common metric) to schedule preventative maintenance or replacement of part to avoid breakdowns.

Millions of Parts Spin or Rotate to Deliver Power

Technology	GW	Number of Power Plants
Natural Gas	1,294	23,436
Coal	1,969	8,574
Oil	427	24,102
Nuclear	466	507
Grand Total	4,156	56,620



www.iea.org/etp/

4-5% net revenue (~$775,000 pa) lost due to unplanned outages for the 250MW F-class plant

http://gasturbinespower.asmedigitalcollection.asme.org/article.aspx?articleid=1661517
http://proceedings.asmedigitalcollection.asme.org/proceeding.aspx?articleid=1694319

Rail Transportation

120,000 locomotives globally

52 million man-hours to service annually*

GE Evolution Series locomotive

According to a joint statement released after talks in New Delhi between Japanese Prime Minister Shinzo Abe and Indian Prime Minister Manmohan Singh on Saturday (25 January 2014) Manmohan Singh was appreciative of Japan's high level of expertise and technology of High Speed Railway (Shinkansen) system and noted its interest in introducing it in India. (IANS – 1/25/14 11:28 PM IST)

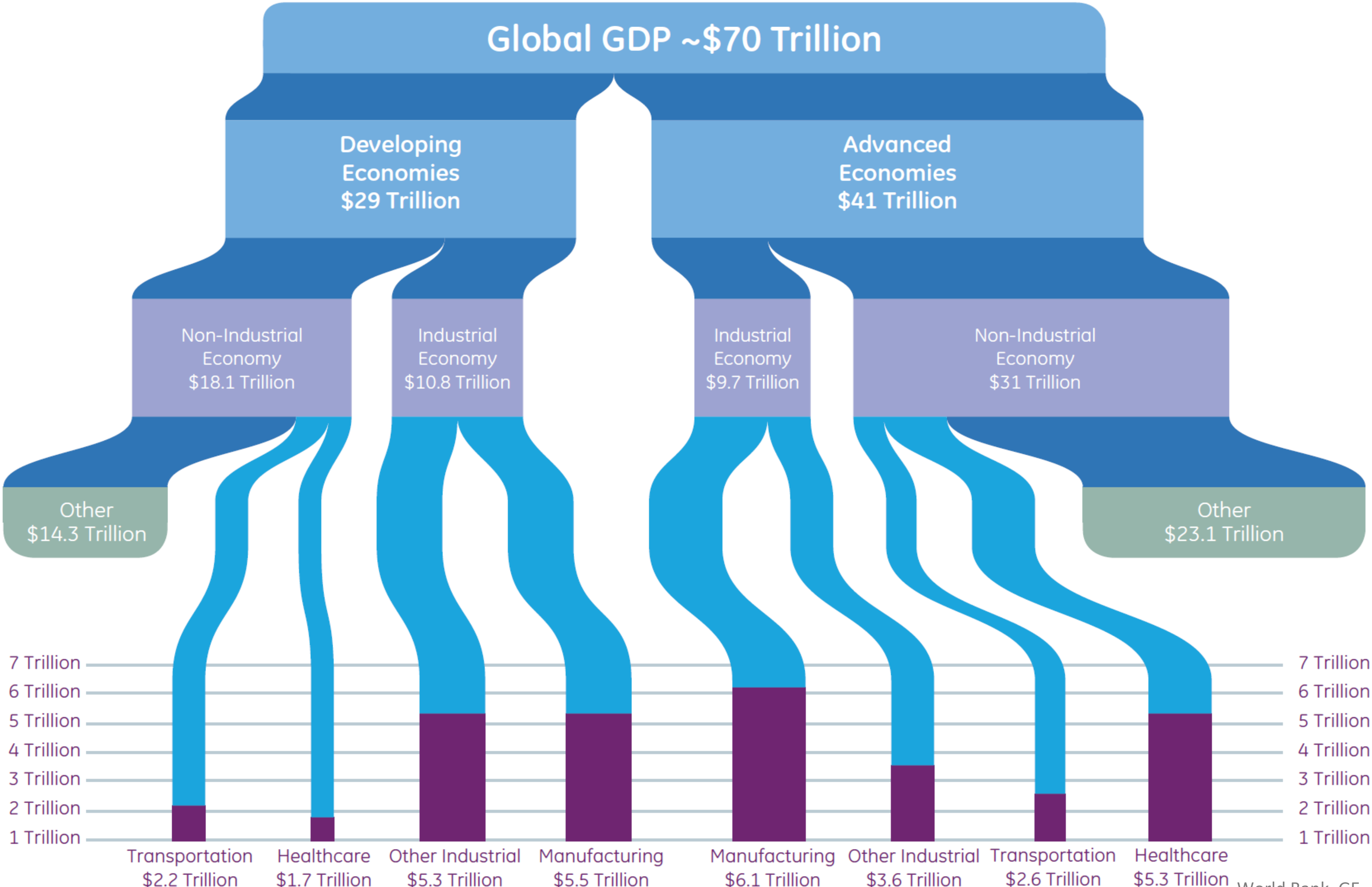
Projected Economic Impact if the Industrial Internet delivers 1% Savings

Industry	Segment	Type of Savings	Estimated Value Over 15 Years (Billion nominal US dollars)
Aviation	Commercial	1% Fuel Savings	$30B
Power	Gas-fired Generation	1% Fuel Savings	$66B
Healthcare	System-wide	1% Reduction in System Inefficiency	$63B
Rail	Freight	1% Reduction in System Inefficiency	$27B
Oil & Gas	Exploration & Development	1% Reduction in Capital Expenditures	$90B

Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

Potential ROI for GE from micro-savings approach . Estimated savings approaching $300 billion over 15 years.

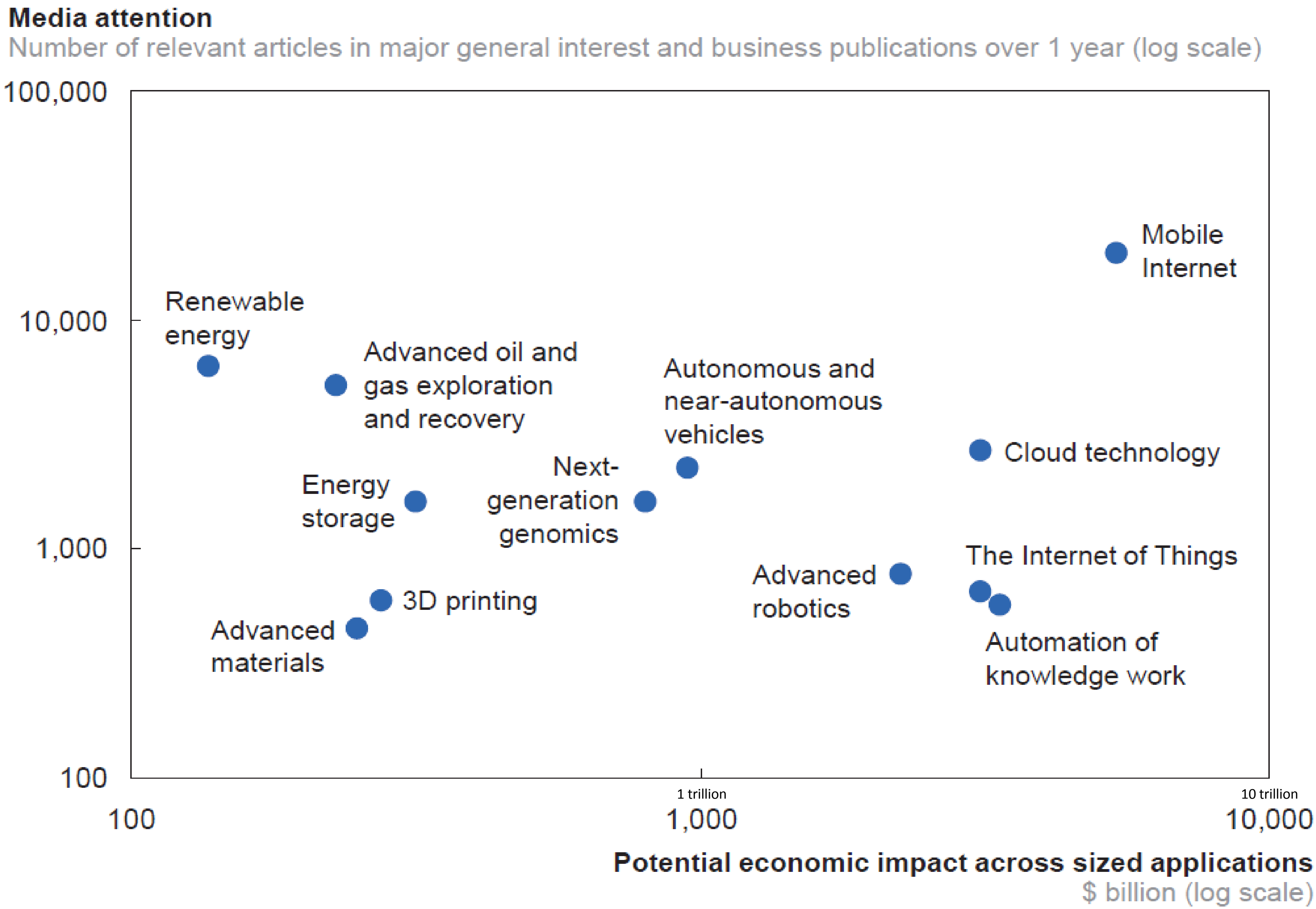
Projected Economic Impact of The Industrial Internet



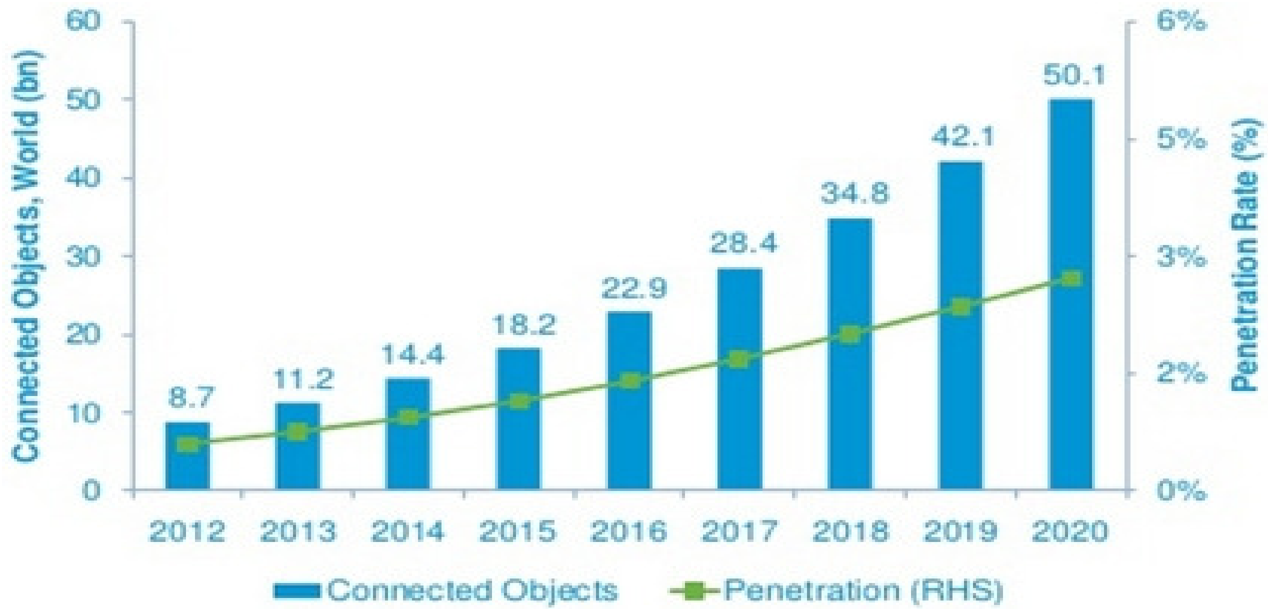
World Bank, GE

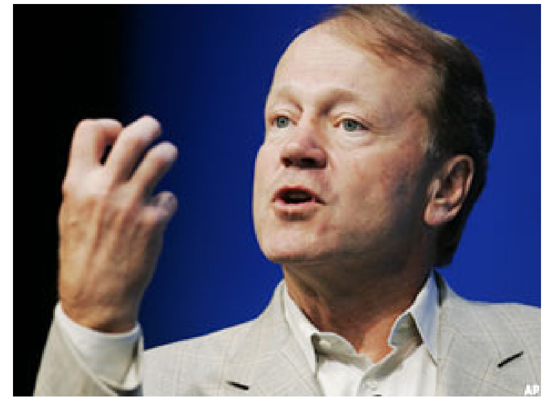
Industrial Internet opportunity ($32.3 Trillion) 46% share of global economy today

The Hella-esque Economic Impact of The Industrial Internet – Hype vs Reality



The Hella-esque Economic Impact of The Industrial Internet – Hype vs Reality





"$19 trillion opportunity"

"This is not about technology at all," Chambers said. "It's about how it changes peoples' lives forever."

LAS VEGAS (7 JANUARY 2014 @ CES) — Cisco Systems Chief Executive Officer John Chambers says that the Internet of Everything -- connected products from cars to household goods -- could be a **$19 trillion opportunity.** Chambers drew a picture of a world in which objects in homes, at airports, hotels and elsewhere are connected to the Internet and know peoples' preferences. That could lead to consumers buying more goods, he said. Connectivity will have other ripple effects, including linked garbage cans which can reduce management of waste by 30 percent.

GE PREDICTIVITY SOLUTIONS

Software solutions for asset optimization through lower inventory costs, lower maintenance costs, lower asset capex costs and minimize unplanned downtime.

Drilling iBox System (Oil & Gas) – Updates for event sequence, cycle counts and both condition-based and predictive maintenance. Connects to datalogger and provides diagnostic and prognostic condition monitoring.

ReliabilityMax (Oil & Gas) – Minimize unplanned downtime for heavy-duty and aero-derivative gas turbines. The system combines sensor data with predictive analytics on real-time and historical data plus expertise from diagnostics engineers.

Field360 (Oil & Gas) – Sensor data from electrical submersible pumps optimizes production by anticipating failure to increase mean time between failures & preventative asset maintenance.

System 1 Evolution (Oil & Gas) – Monitors machinery, plants, enterprise fleets from a secure access point.

LifeMax* Advantage (Power & Water) – Optimize to increase energy output 10%, save $600 million in fuel and boost revenue by $1 billion pa across a global B/E class power plant fleet.

PowerUp (Power & Water) – Optimize wind turbine energy output by 5% (up to 20% more profit).

RailConnect 360 Monitoring and Diagnostics (M&D) (Transportation) – Locomotive health, maintenance and repairs. Collects and analyzes performance data during locomotive operations, automating diagnostics and root cause analysis to enable optimal and proactive repairs. Enables advanced planning of resources, building, running and routing trains.

Non-destructive Testing (NDT) Remote Collaboration (Oil & Gas) – Connects field inspectors with experts (real-time video online). When critical assets (risers, turbines, BOPs) are being inspected on a platform experts can view in real time.

HoF SimSuite (Healthcare) – Improved decision support. Test future-state alternatives to understand cost, quality and patient experience trade-offs for a range of operational scenarios to understand impact on patients, staff, capacity and cost.

GE's Cloud Imaging* (Healthcare) – Platform for intelligent imaging (exchange, analytics and results).

Grid IQ™ Insight (Energy Management) – SaaS analytics to optimize and make sense of data from intelligent machines to predict, manage, model and forecast potential problems. Monitors usage, performance, weather to connect "ecosystems"

Proficy MaxxMine (Energy Management) – Predictive analytics to accurately detect and diagnose equipment problems before they happen.

Flight Efficiency Services (Aviation) – Acquires real-time data from aircraft and applies proprietary techniques to improve performance and increase efficiency in four areas: fuel use, flight analytics, navigation services and fleet synchronization.

ShipperConnect (Transportation) – Enables rail shippers, car owners, logistic providers and terminal operators to automate operations, manage inventory and control costs.

Flex Efficiency Advantage (Power & Water) – Monitoring power generation equipment in order to respond to real-time changes in power demand, grid conditions and fuel supply / source.

Subsea Integrity Management (Oil & Gas) – Underwater remote monitoring system that increases production reliability using data from sensors measuring vibration, temperature, leak detection for well heads, manifolds and production stations.

DoseWatch (Healthcare) – Track patient radiation dosing while maintaining image quality necessary to diagnose and treat diseases like cancer.

Hospital Operations Management (HOM) – Integrates bed assignment, department workflow, patient flow, transport and equipment management to reduce wait times and improve QoS.

Fuel Management (Aviation) – Improve efficiencies to reduce up to 2% fuel bill (Alitalia saved €34M)

Real-Time Operational Intelligence (Energy Management) – Detect & predict factors potentially harmful for quality, plant conditions,

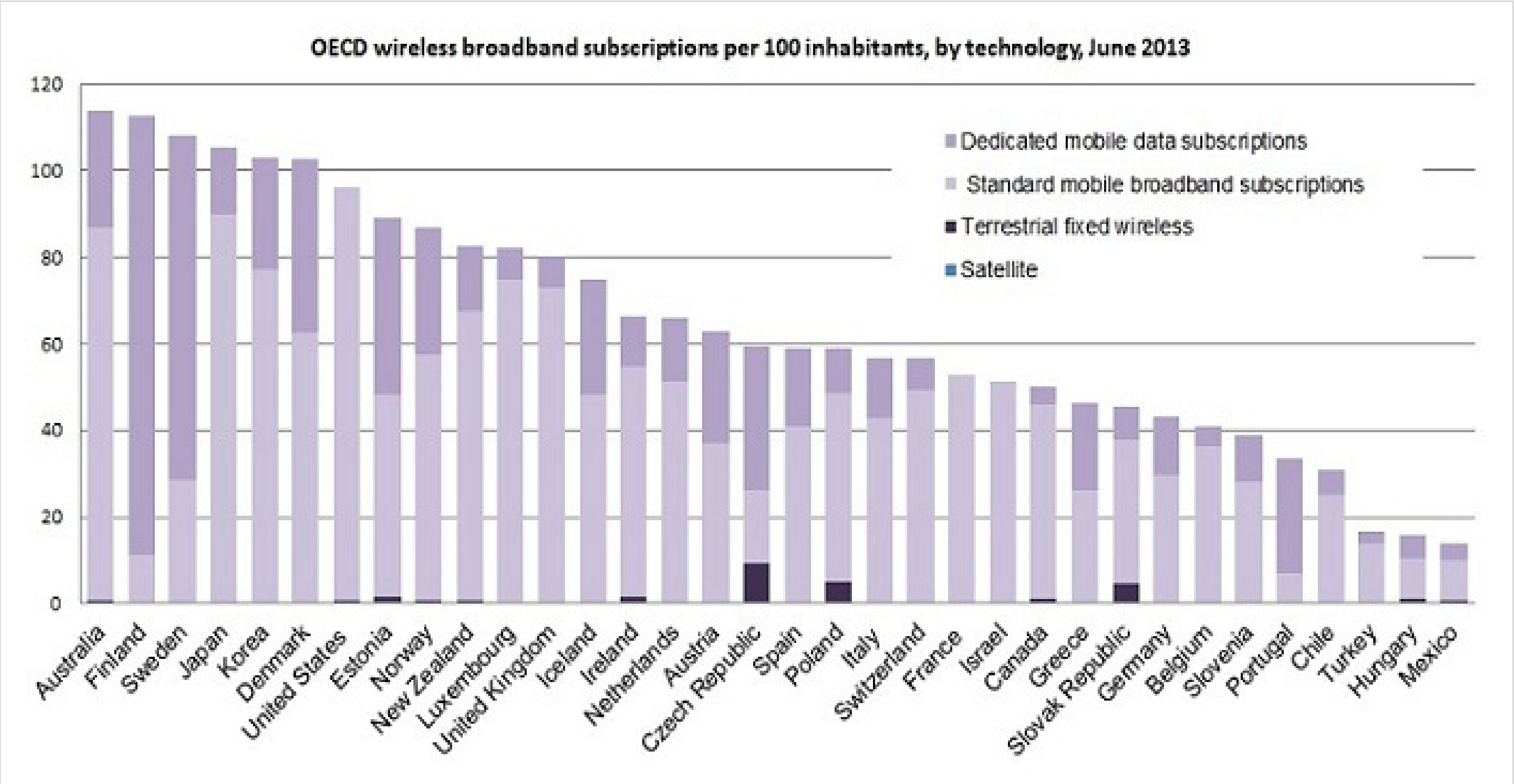
Intelligent Operations services (Aviation) – Monitor data collected from aircraft equipment and airline systems to predict, prevent and recover from operational disruptions. Avoiding 1,000 delays helps 165,000 passengers with on-time ETA.

Movement Planner System / Rail Network Optimization – Real-time analytics of in-transit information to move more freight faster (Norfolk Southern improved network velocity by 10% & 50% reduction in expired crews and on-time performance).

Barriers to reap the economic harvest?

Penetration of connectivity

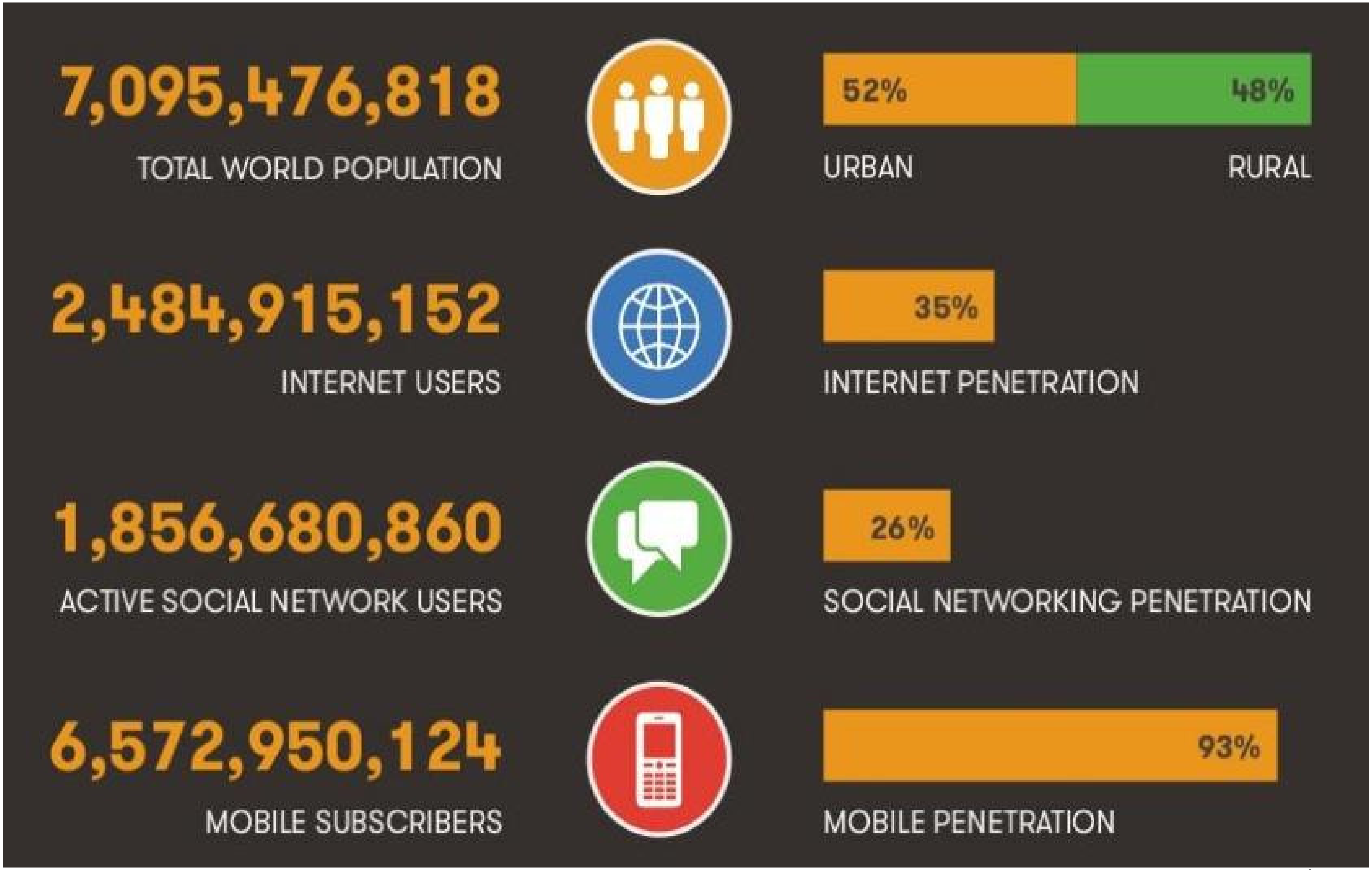
Is this the rate-limiting factor for the diffusion of the Industrial Internet ?



http://www.oecd.org/internet/broadband/oecdbroadbandportal.htm

WIRELESS BROADBAND (AND ITS ECOSYSTEM INCLUDING ALLOCATION OF SPECTRUM)

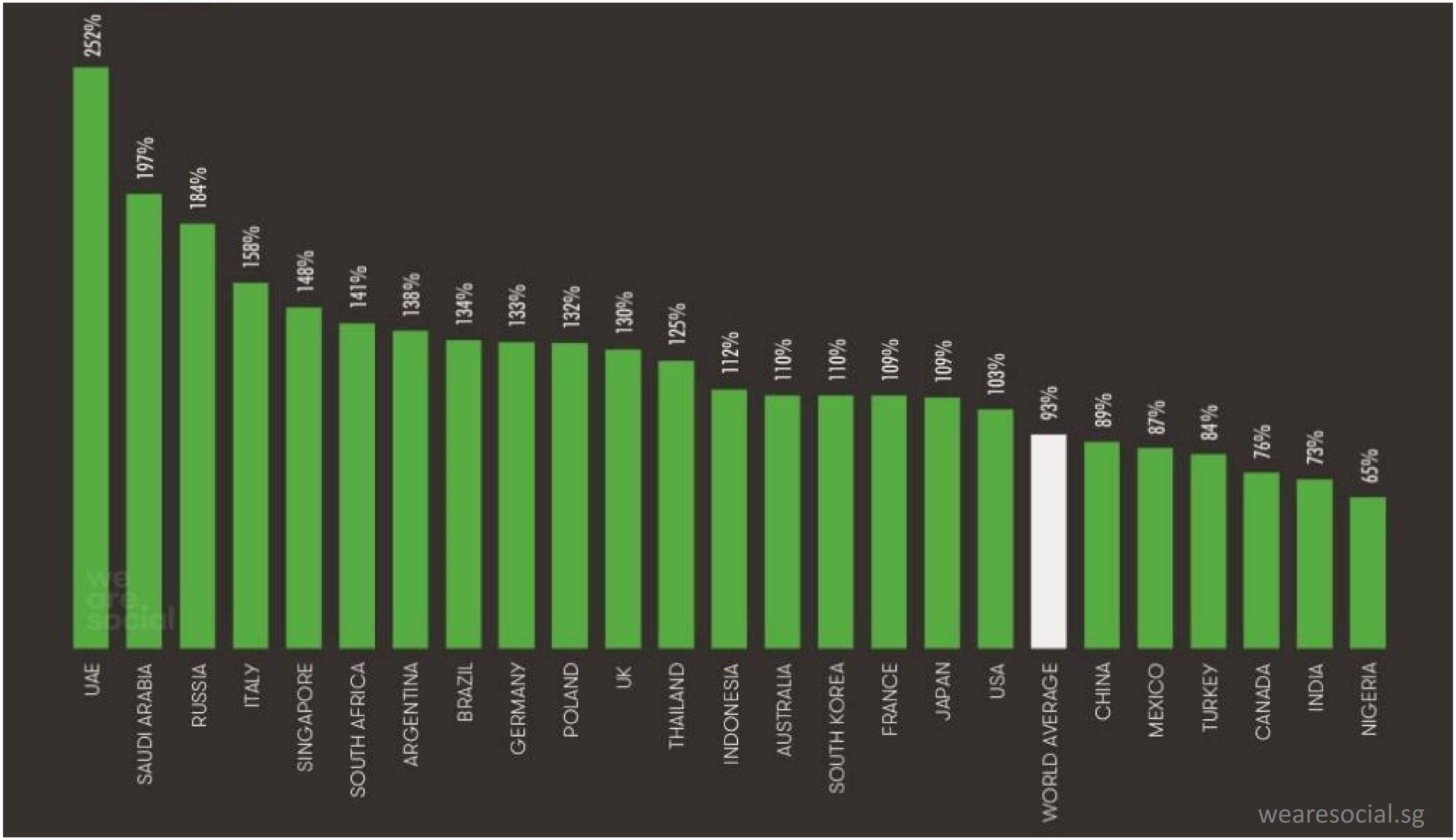
Data appears to suggest that almost everybody in the world has a mobile cell phone



wearesocial.sg

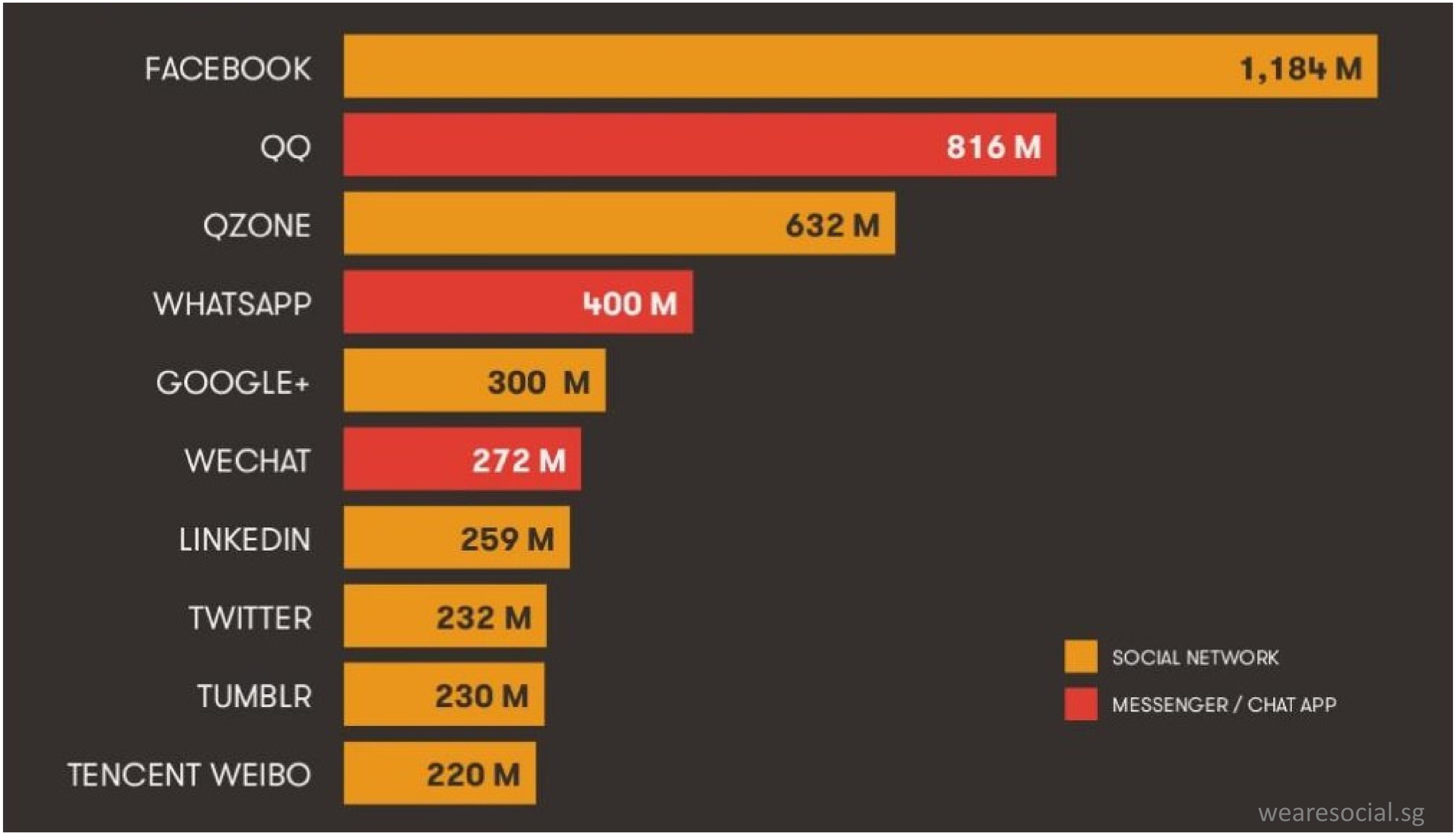
Data appears to suggest the global dominance of Android OS (percent shipped by OS)

Is Mobile Penetration by Country – Useful KPI for Connectivity ?



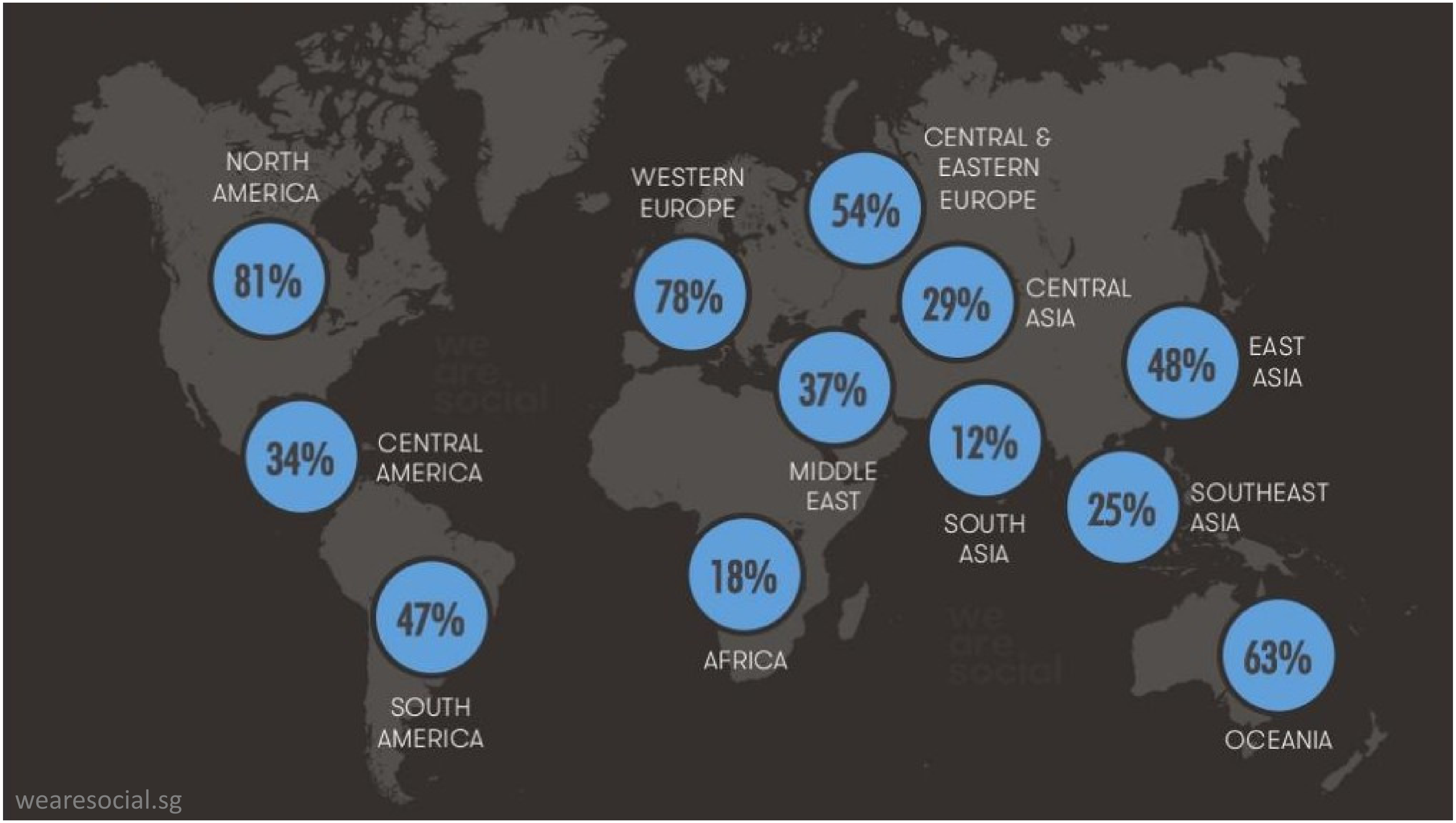
Will this form of connectivity suffice for deployment of the Industrial Internet?

Mobile Penetration by Country - Index of Social Chatter



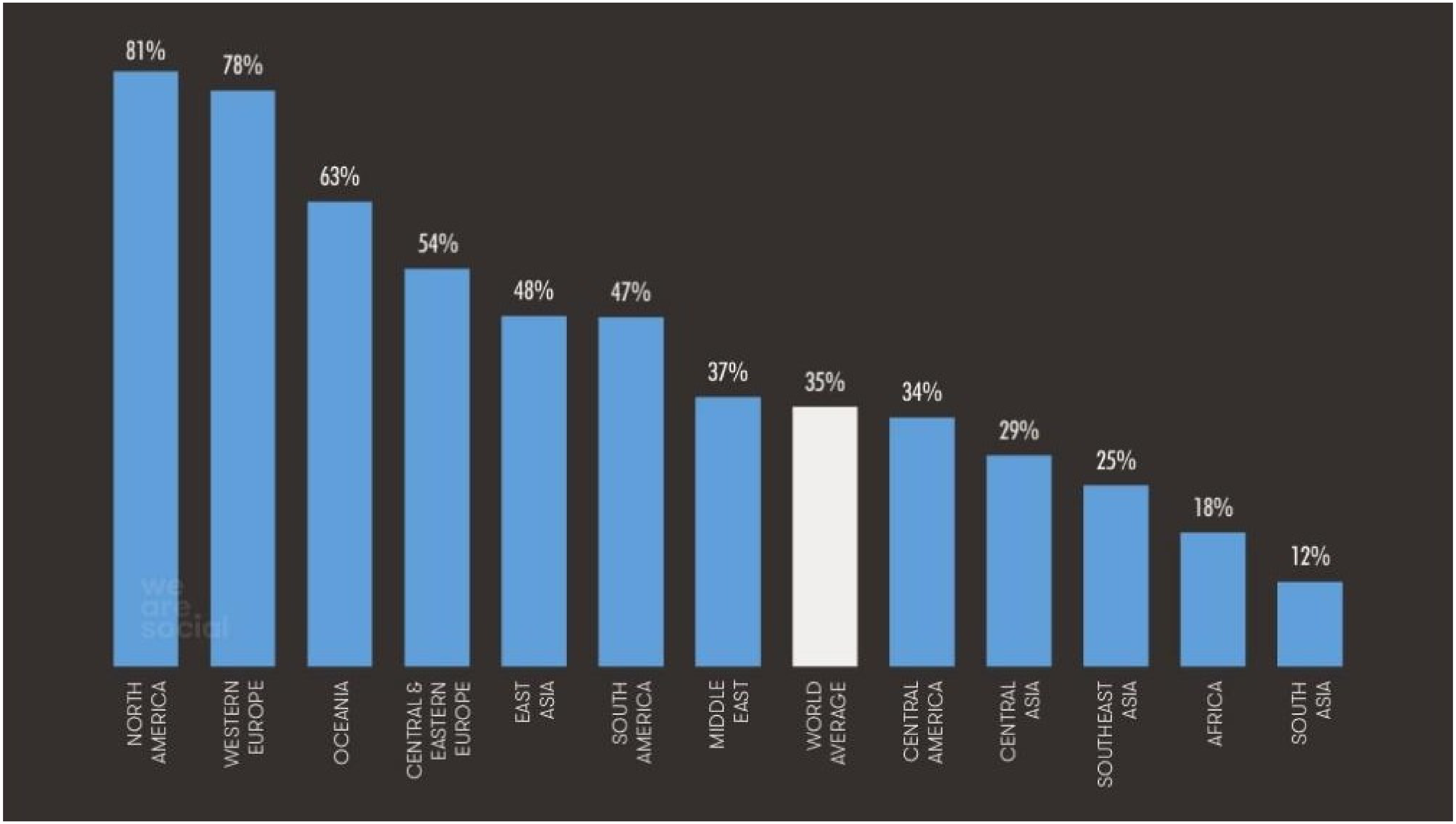
Social chatter isn’t equal to business growth. Limited impact on the Industrial Internet.

Internet Penetration



A better index for future business growth and the spread of the Industrial Internet.

Internet Penetration by Region



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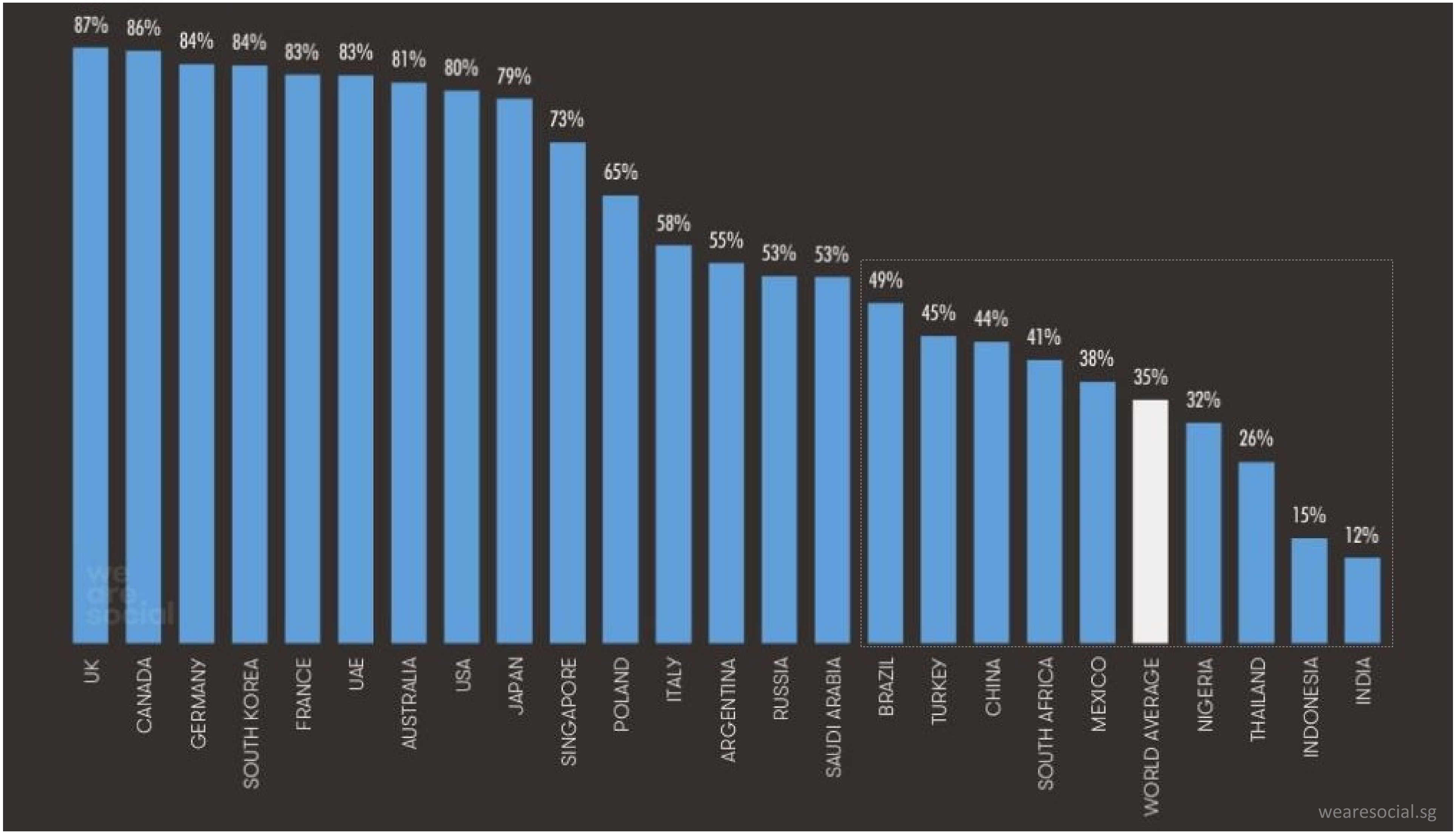
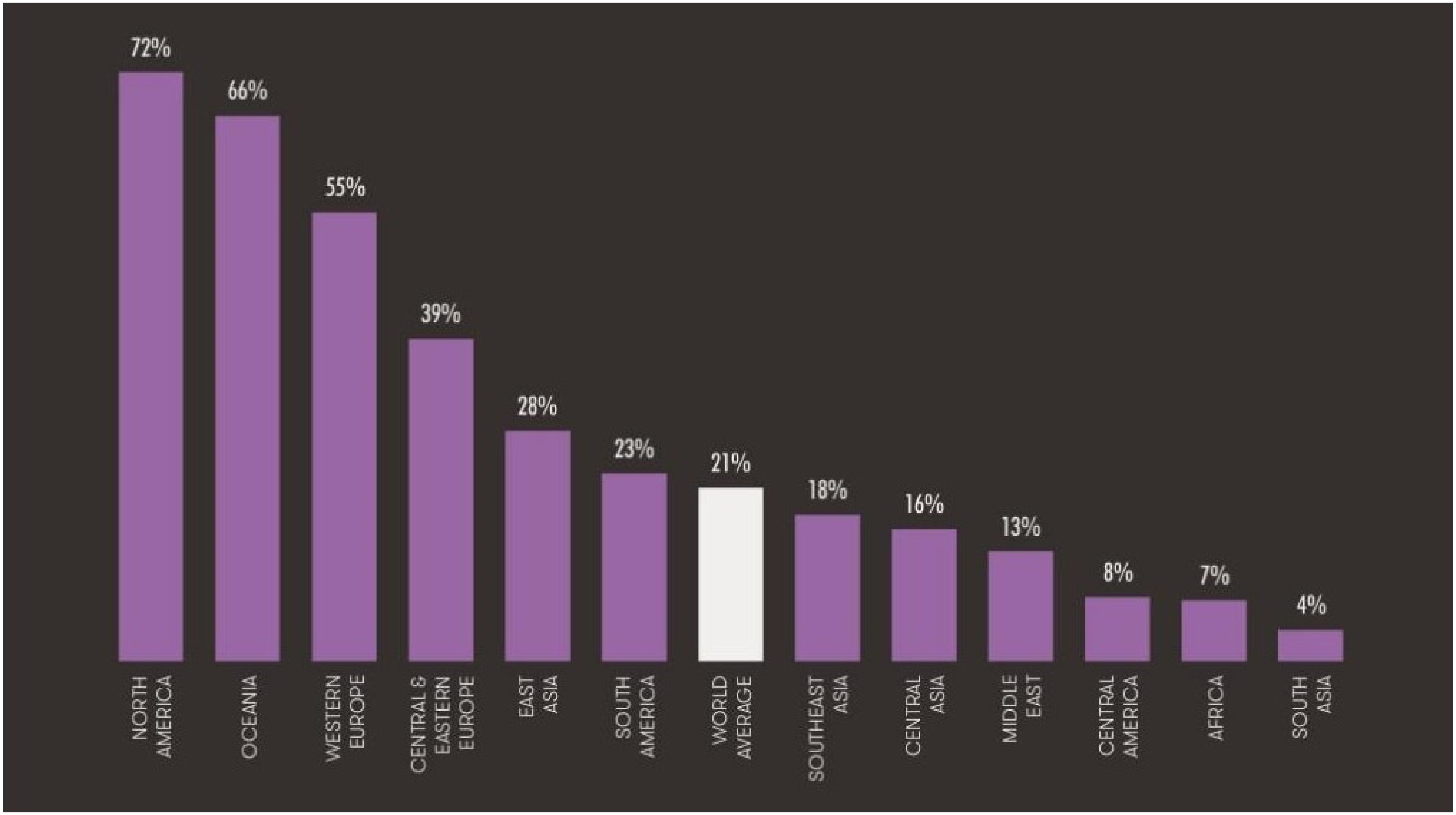
A better index for future business growth and the spread of the Industrial Internet.

Internet Penetration by Country



Potential for future business growth and the spread of the Industrial Internet.

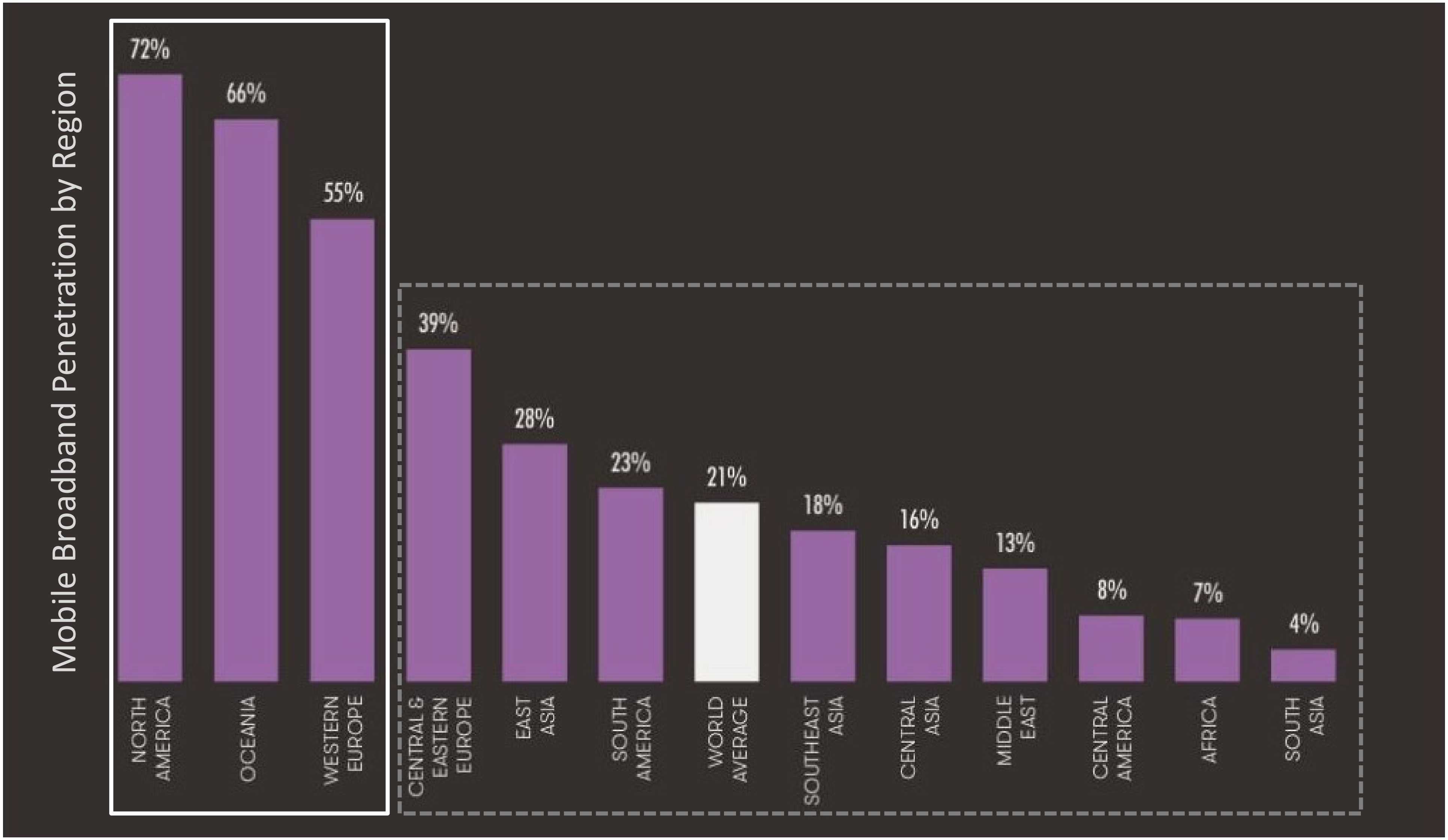
Mobile Broadband Penetration by Region



wearesocial.sg

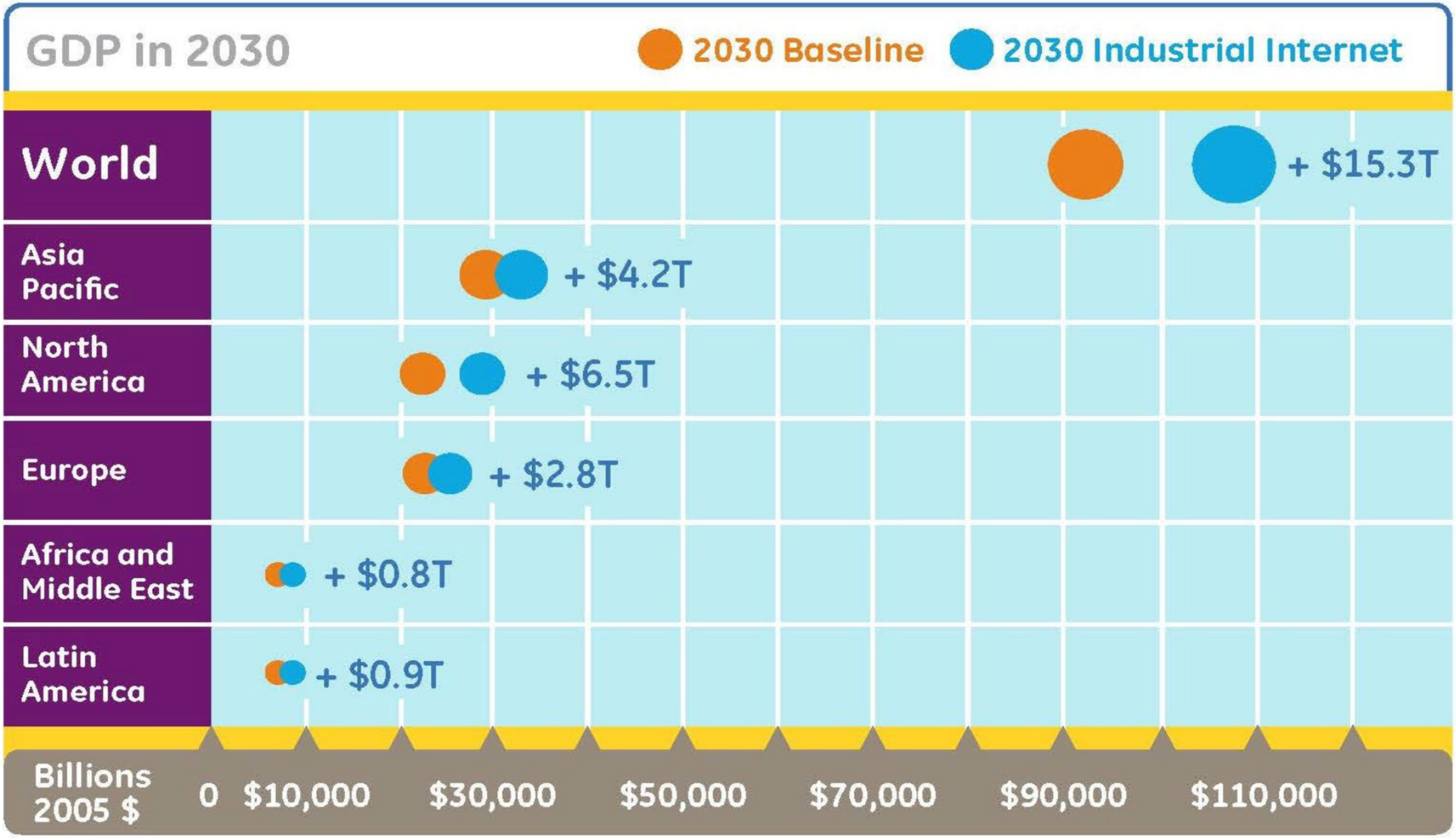
A critical index for future business growth and the spread of the Industrial Internet.

Immediate vs Future Business Growth due to the Industrial Internet ?



Is the deployment of the Industrial Internet proportional to mobile broadband access?

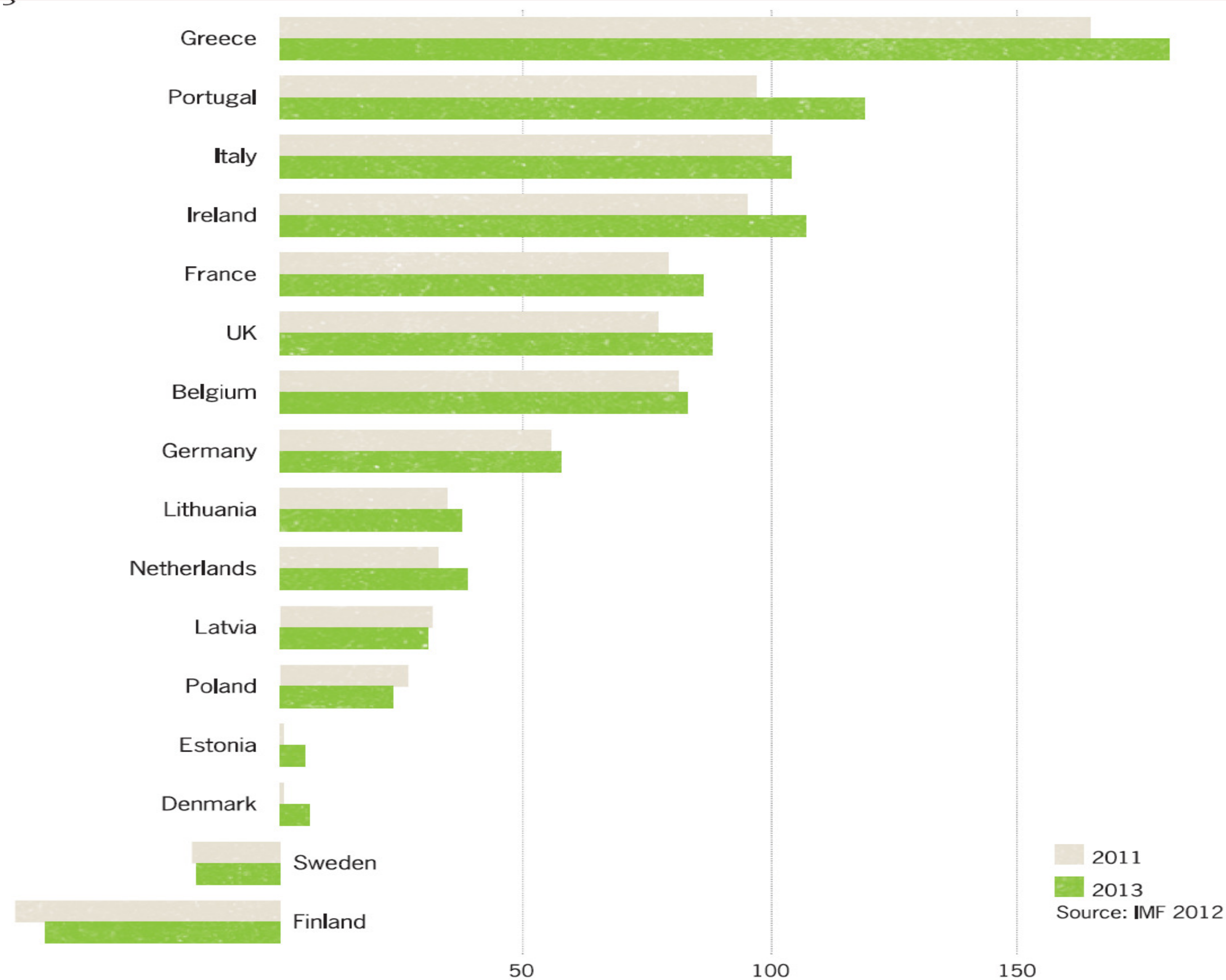
Future Business Growth due to the Industrial Internet



Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)

The Industrial Internet may add $15 Trillion to GDP 2012-2030

The Future of Business Growth → Net Government Debt as a % of GDP



Analysis of Economic Impact

Projections and estimates are not facts

Rate of Improvement

$5 million vs. $400
Price of the fastest supercomputer in 1975[1] and an iPhone 4 with equal performance

230+ million
Knowledge workers in 2012

$2.7 billion, 13 years
Cost and duration of the Human Genome Project, completed in 2003

300,000+
Miles driven by Google's autonomous cars with only one accident (human error)

3x
Increase in efficiency of North American gas wells between 2007 and 2011

85%
Drop in cost per watt of a solar photovoltaic cell since 2000

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Economic Potential 2025

2–3 billion
More people with access to the Internet in 2025

$5–7 trillion
Potential economic impact by 2025 of automation of knowledge work

$100, 1 hour
Cost and time to sequence a human genome in the next decade[2]

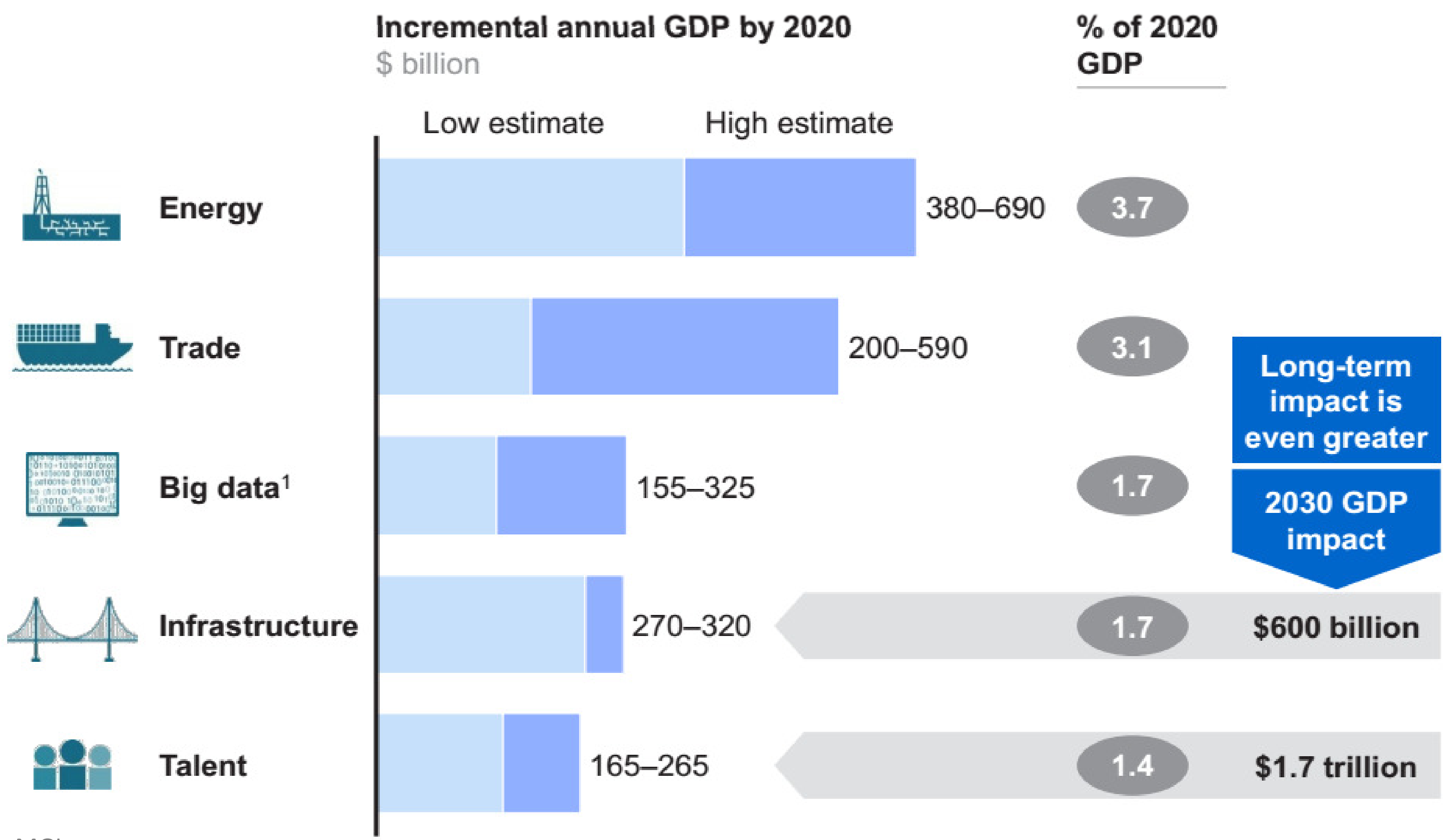
1.5 million
Driver-caused deaths from car accidents in 2025 potentially addressable by autonomous vehicles

100–200%
Potential increase in North American oil production by 2025, driven by hydraulic fracturing and horizontal drilling

16%
Potential share of solar and wind in global electricity generation by 2025

5 ECONOMIC GROWTH SECTORS + 12 DOMAINS OF RAPID ADVANCES

Sectors Predicted to Influence US GDP Growth over the next few decades



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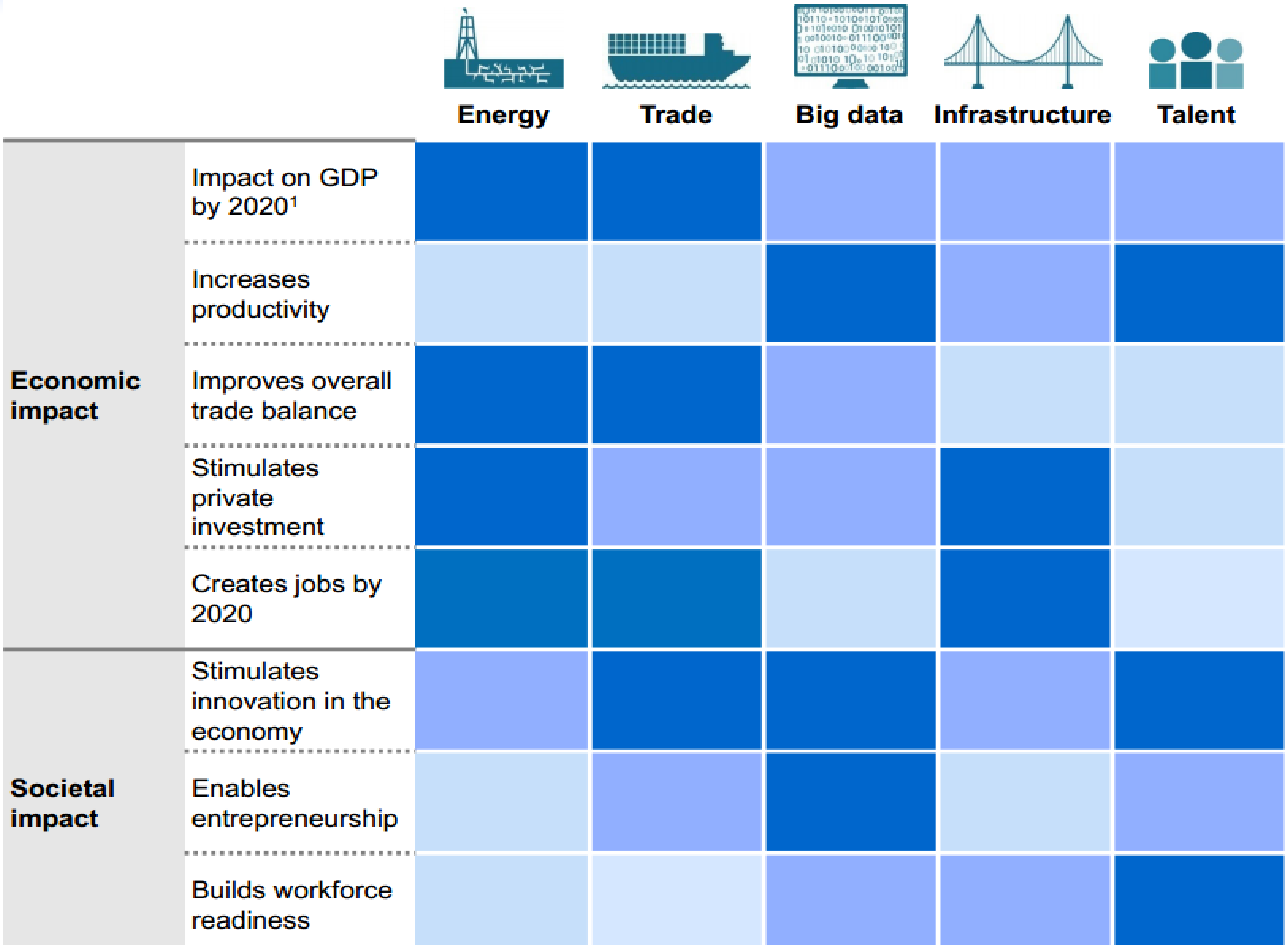
Segments of the US economy likely to be influenced over the next decades

US Bureau of Labor Statistics

Sectors of the economy	GDP, 2012 $ billion	Jobs, 2012[1] Million	Energy	Trade	Big data	Infrastructure	Talent
Resource extraction (e.g., oil and gas, mining, agriculture)	453.8	2.9	●			●	○
Knowledge-intensive manufacturing (e.g., autos, aerospace, chemicals)	894.3	4.8	○	●	●	●	●
Resource-intensive manufacturing (e.g., metals, pulp, refinery products)	427.8	3.1	●	○	○	●	○
Labor-intensive manufacturing (e.g., apparel, furniture)	544.6	4.1		○	○	●	○
Construction and utilities	863.0	6.3	●			●	
Retail	949.1	15.0		○	●	○	○
Wholesale, transport, and logistics	1,367.2	10.2	○	○	●	●	●
Information and media	690.6	2.7		○	●		●
Financial, legal, and technical services	2,730.2	15.9	○	●	●		●
Real estate	1,926.3	1.9			●	●	
Hospitality and other services[2]	1,466.1	27.5					○
Education and health care	1,344.7	20.5			●		●
Government	2,026.2	21.9			●		●

Projected Gradient of Socio-Economic Impact



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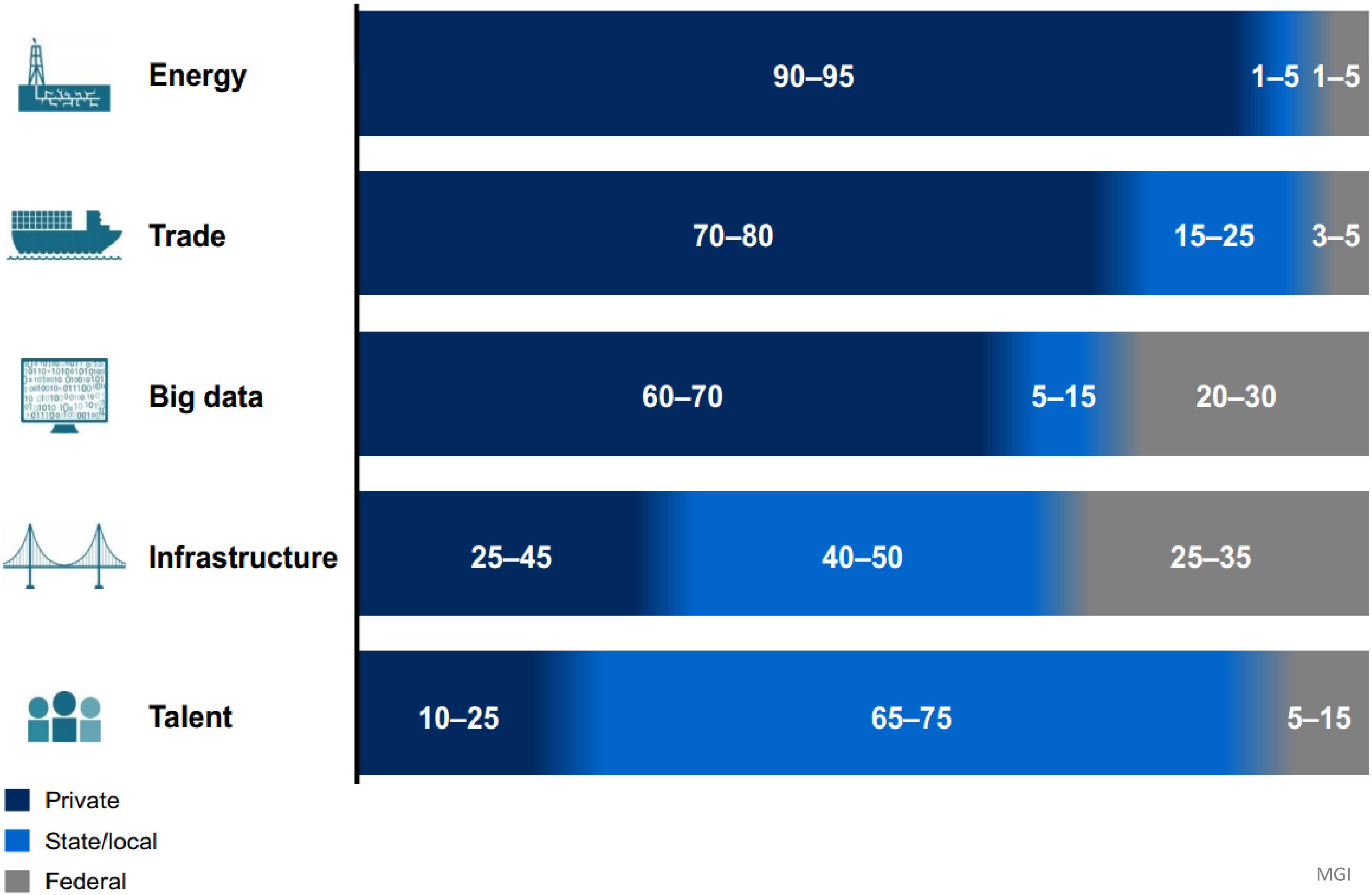
Growth fueled by investment (%) from federal, state & private sources



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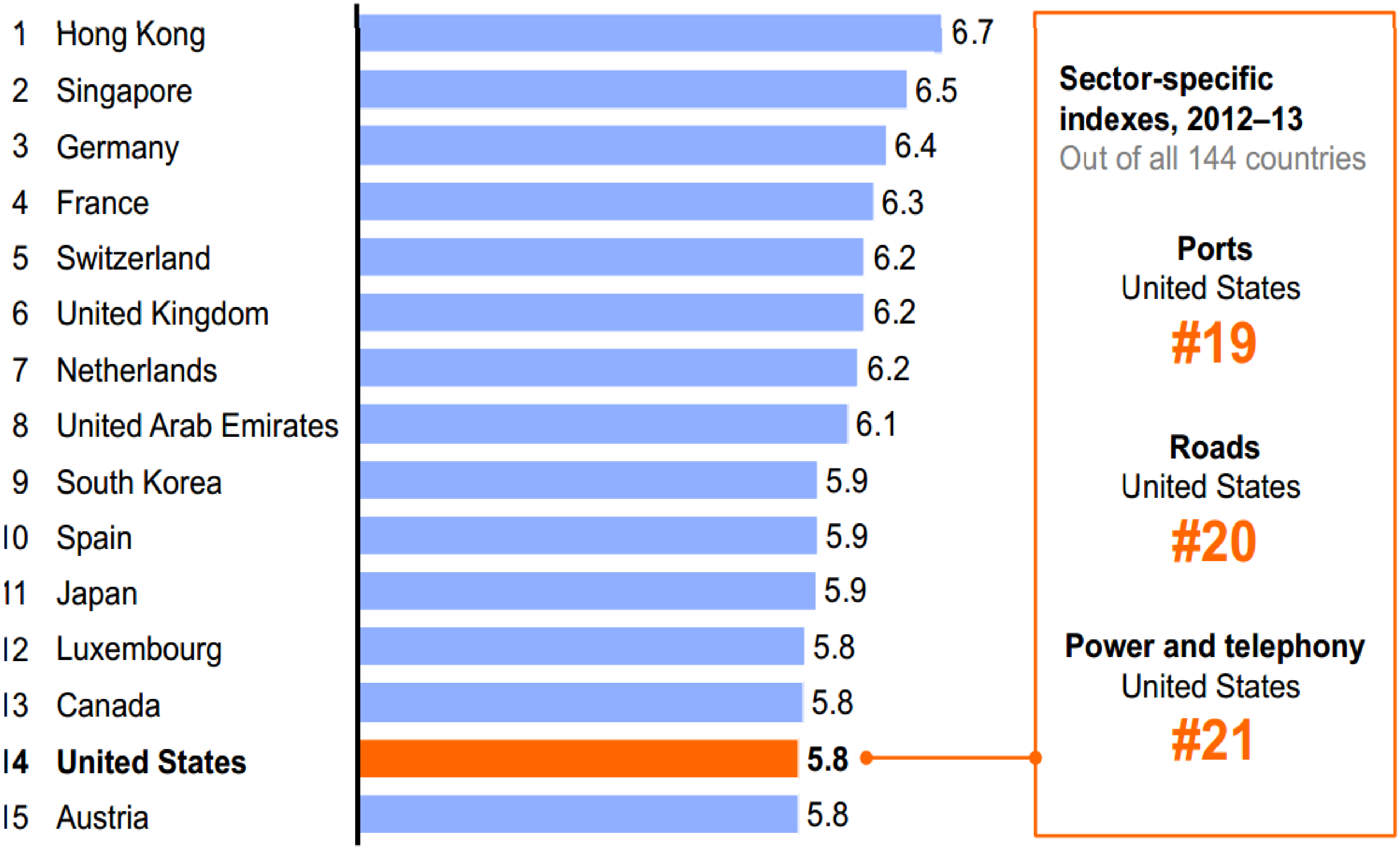
FUTURE ECONOMIC GROWTH SECTORS (PROJECTIONS ARE NOT FACTS)

- Energy
- Trade
- Big data[1]
- Infrastructure
- Talent

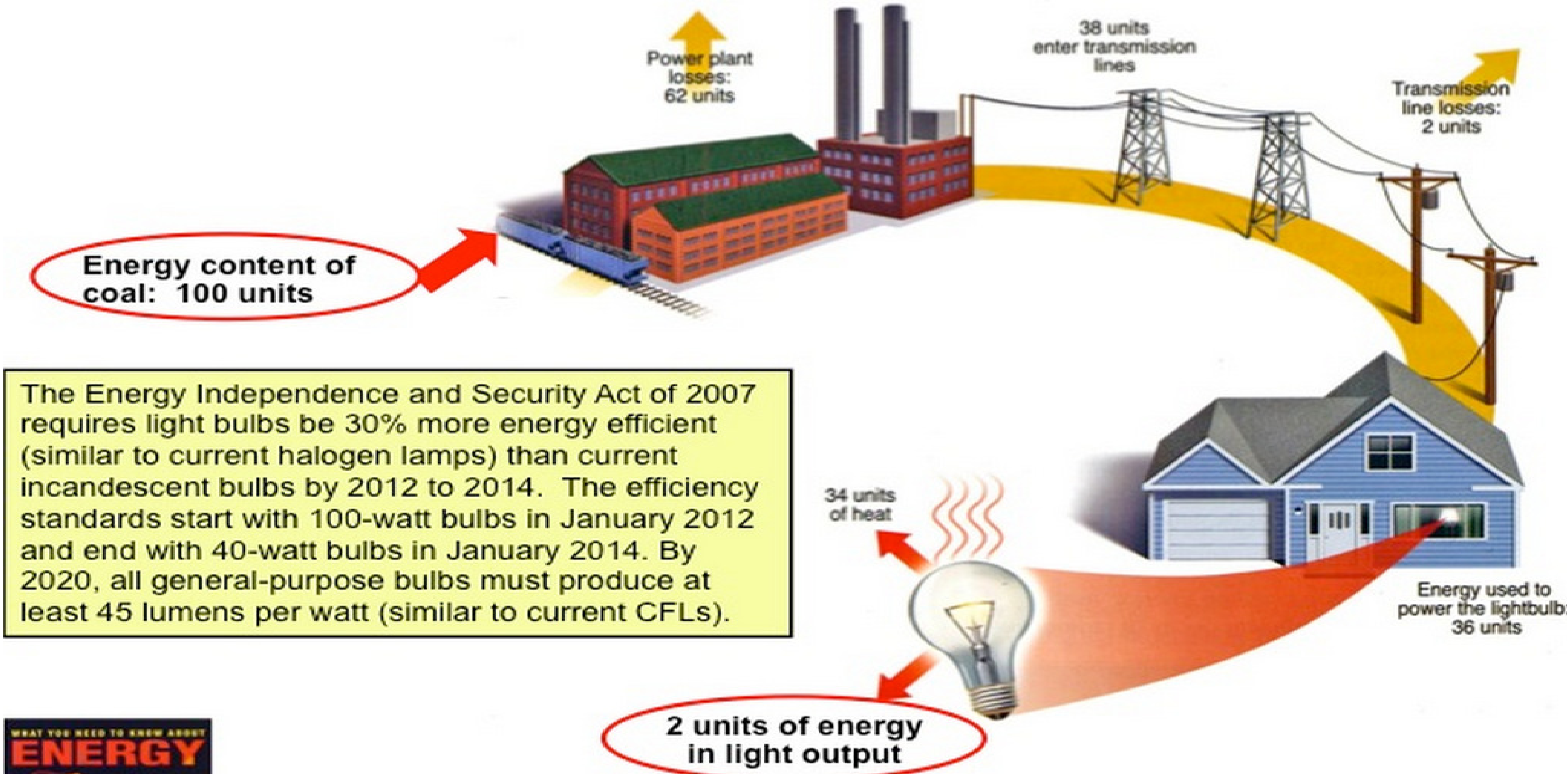
Infrastructure



FUTURE ECONOMIC GROWTH SECTORS (PROJECTIONS ARE NOT FACTS)

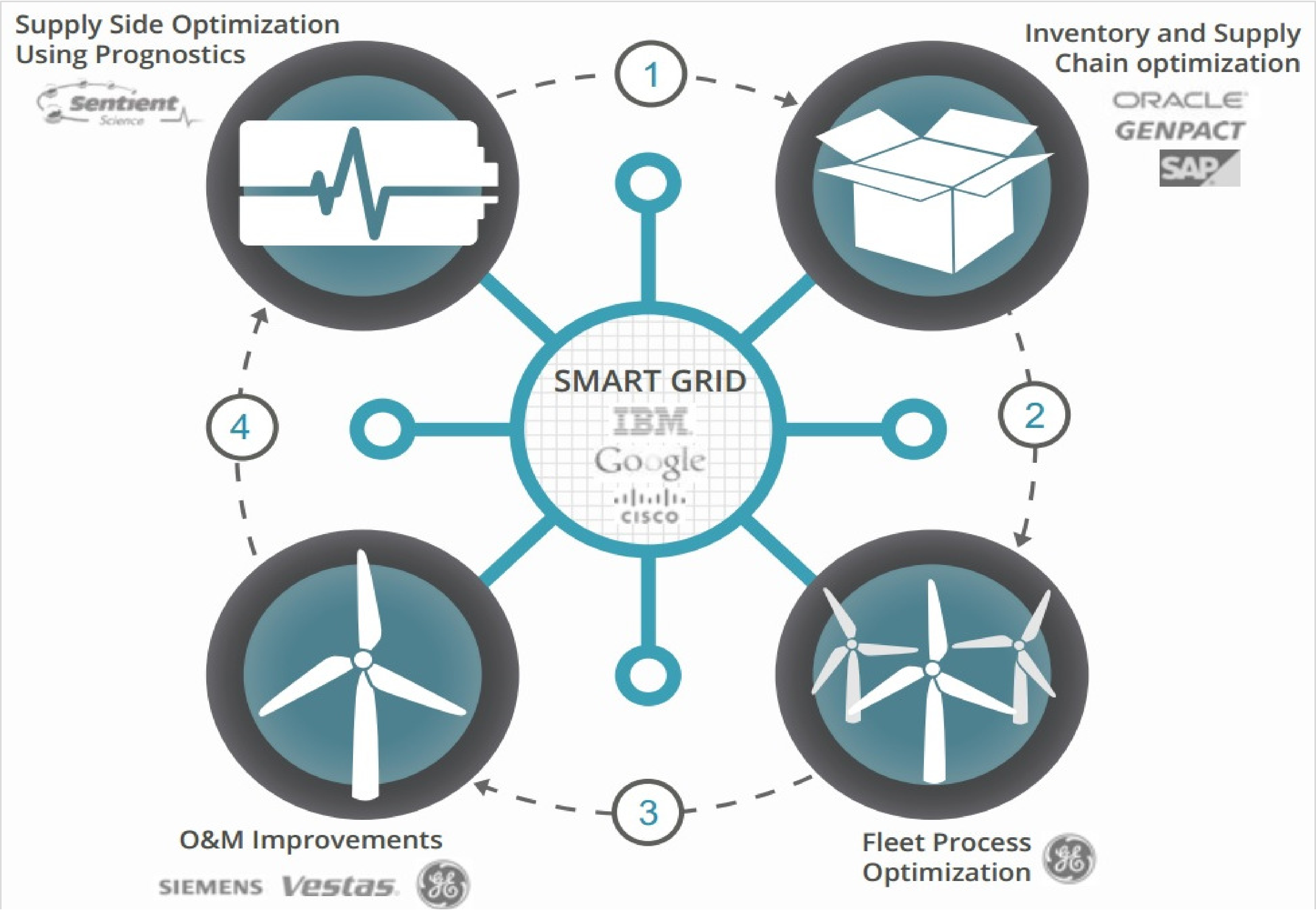
- **Energy**
- **Trade**
- **Big data**[1]
- **Infrastructure**
- **Talent**

Energy Efficiency of an incandescent light bulb ~ 2%

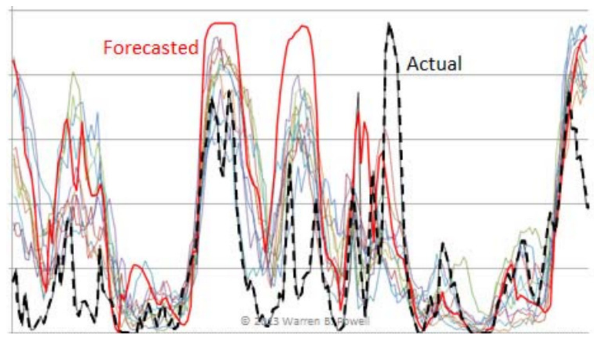


US - lighting accounts for about a quarter (~22%) of all electricity usage

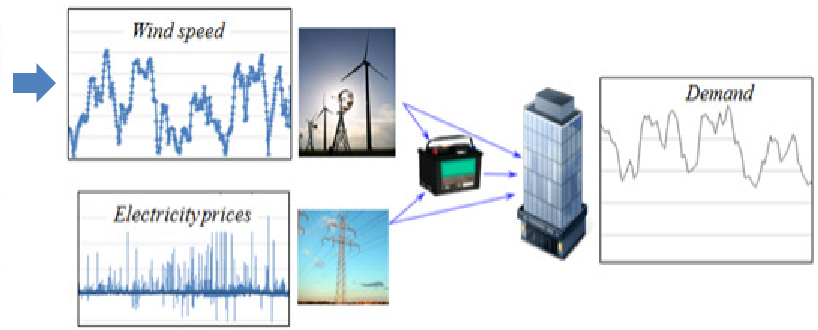
Future Energy Supply Chain – Multi-directional Flow ?



Load Balancing - energy from wind & grid to meet time-varying demand

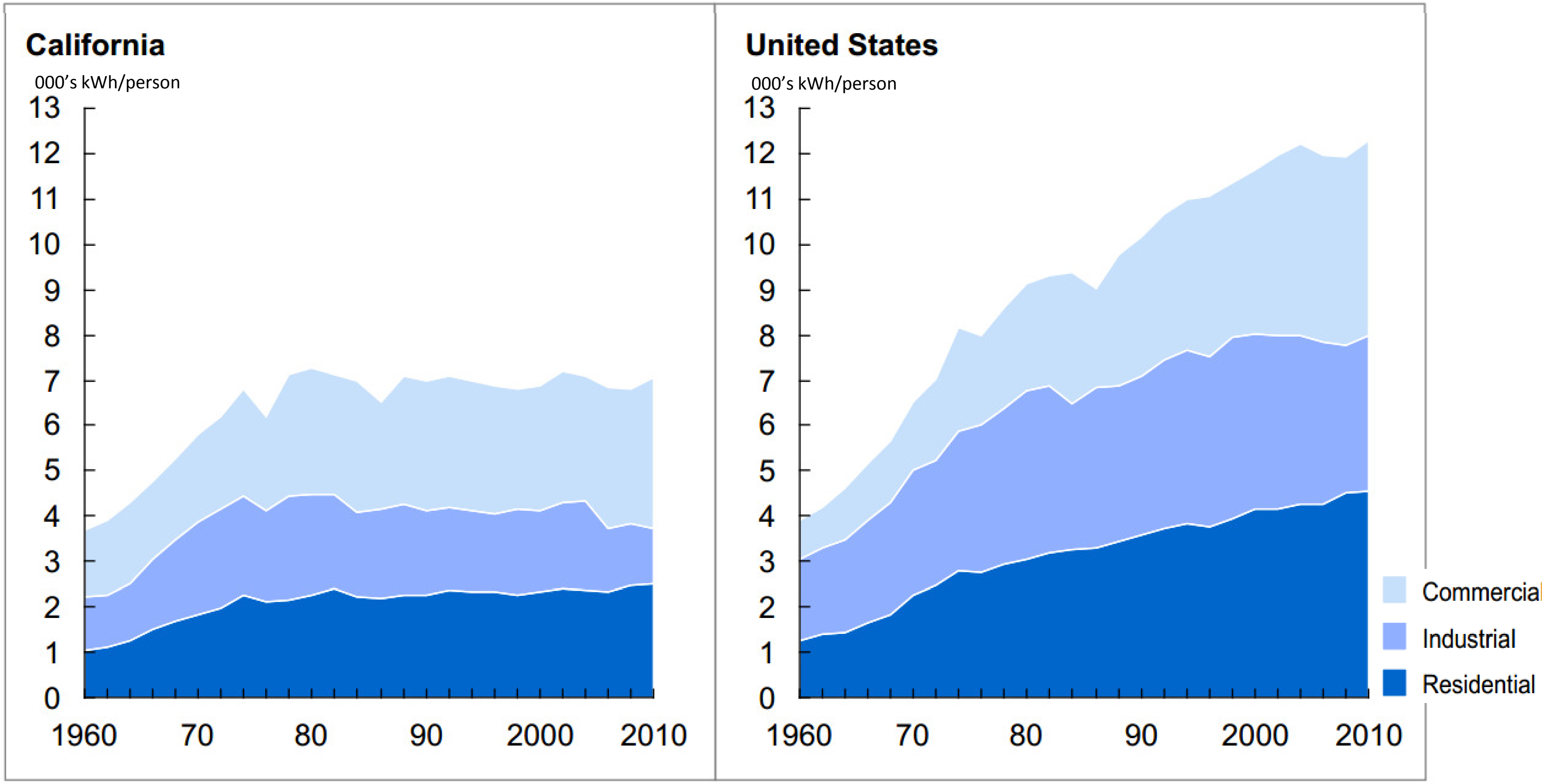


Warren Powell, Princeton University (Stochastic Optimization)



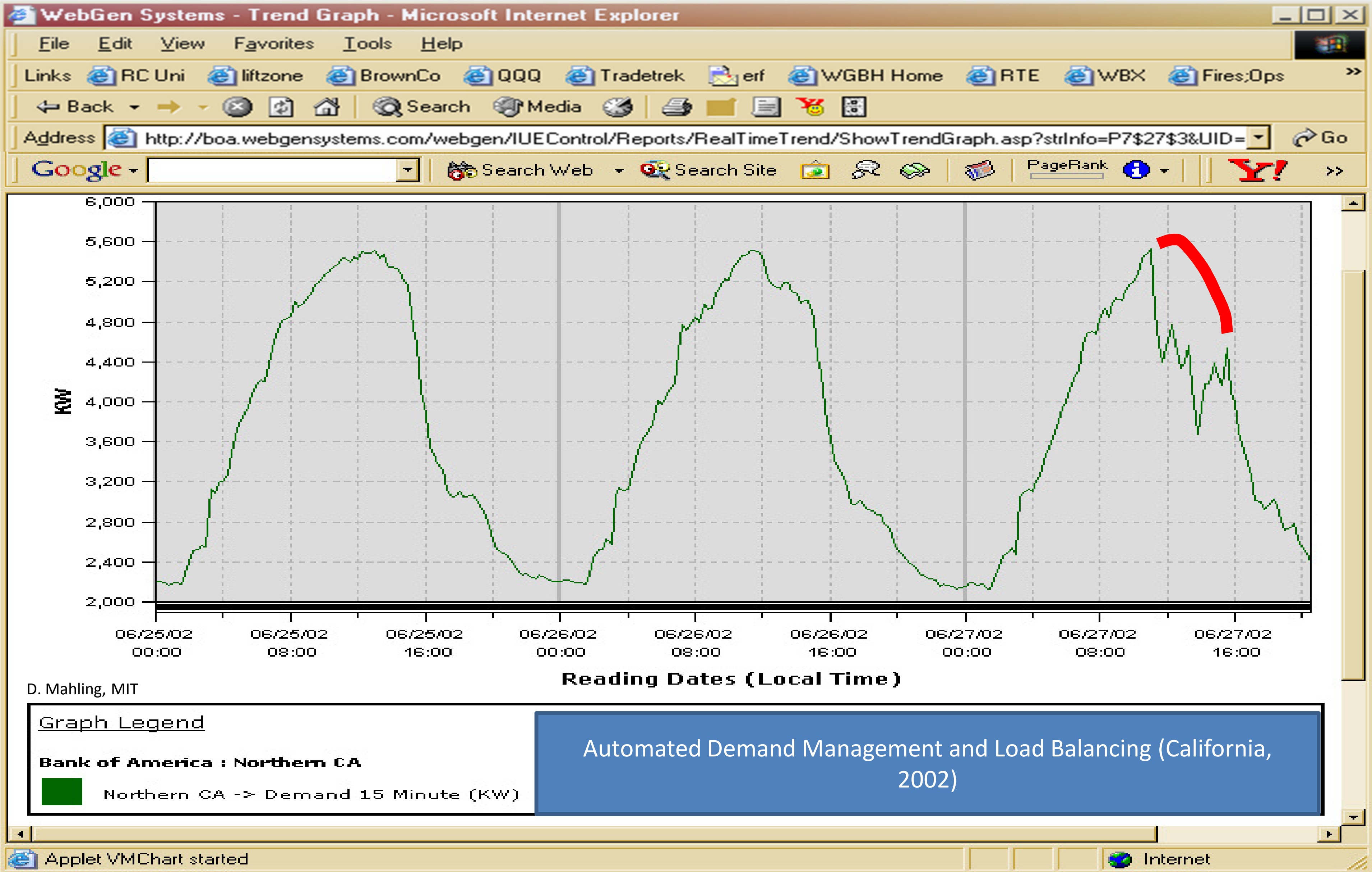
End to end connected sensor networks in the energy industrial internet

Using demand management techniques California reduced energy usage



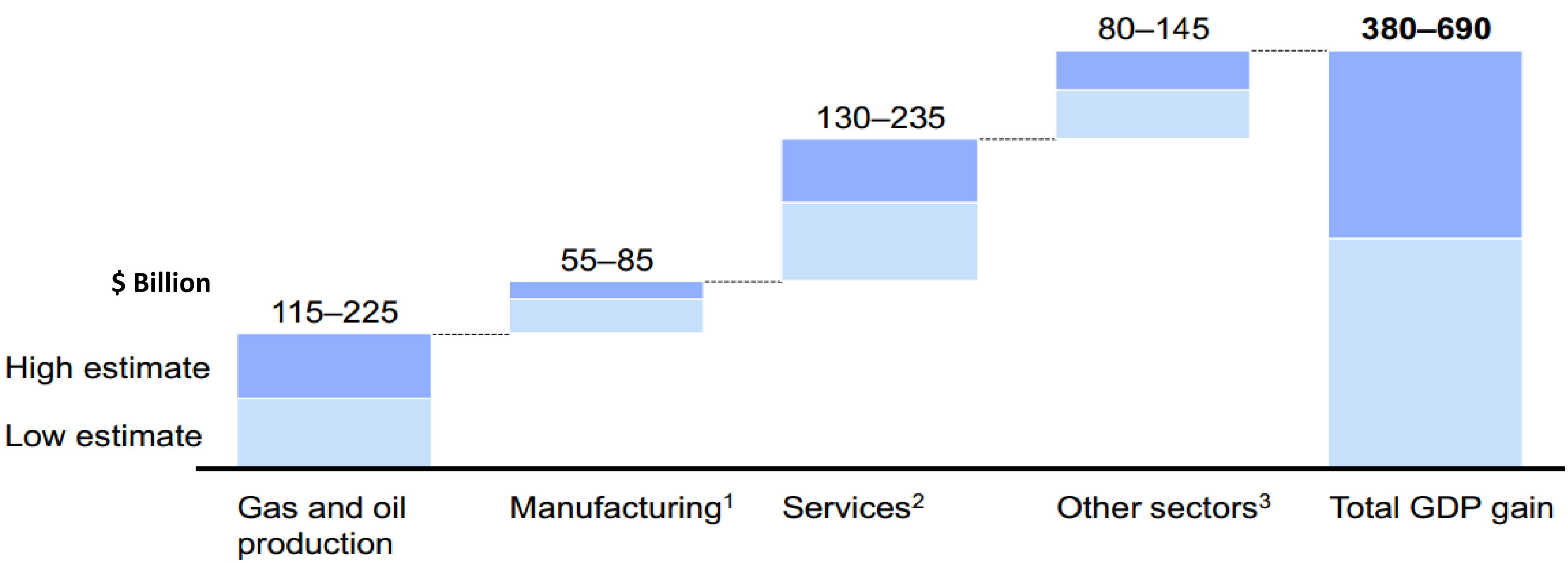
Kandel, Sheridan and McAuliffe (2008) A comparison of per capita electricity consumption: US v California [California Energy Commission]

Industrial Internet expected to improve systemic energy efficiency



US Energy Sector – Potential Impact of Shale Gas Production by 2020

By 2020, shale gas and oil could boost US GDP by $380 billion to $690 billion annually and create up to 1.7 million jobs. Cheaper natural gas may increase output in energy-intensive manufacturing by $75 billion to $105 billion. Energy imports are nearly half of the US goods trade deficit, but additional shale production could drive net US energy imports to zero. The industrial internet is expected to play a catalytic role in this transformational landscape.



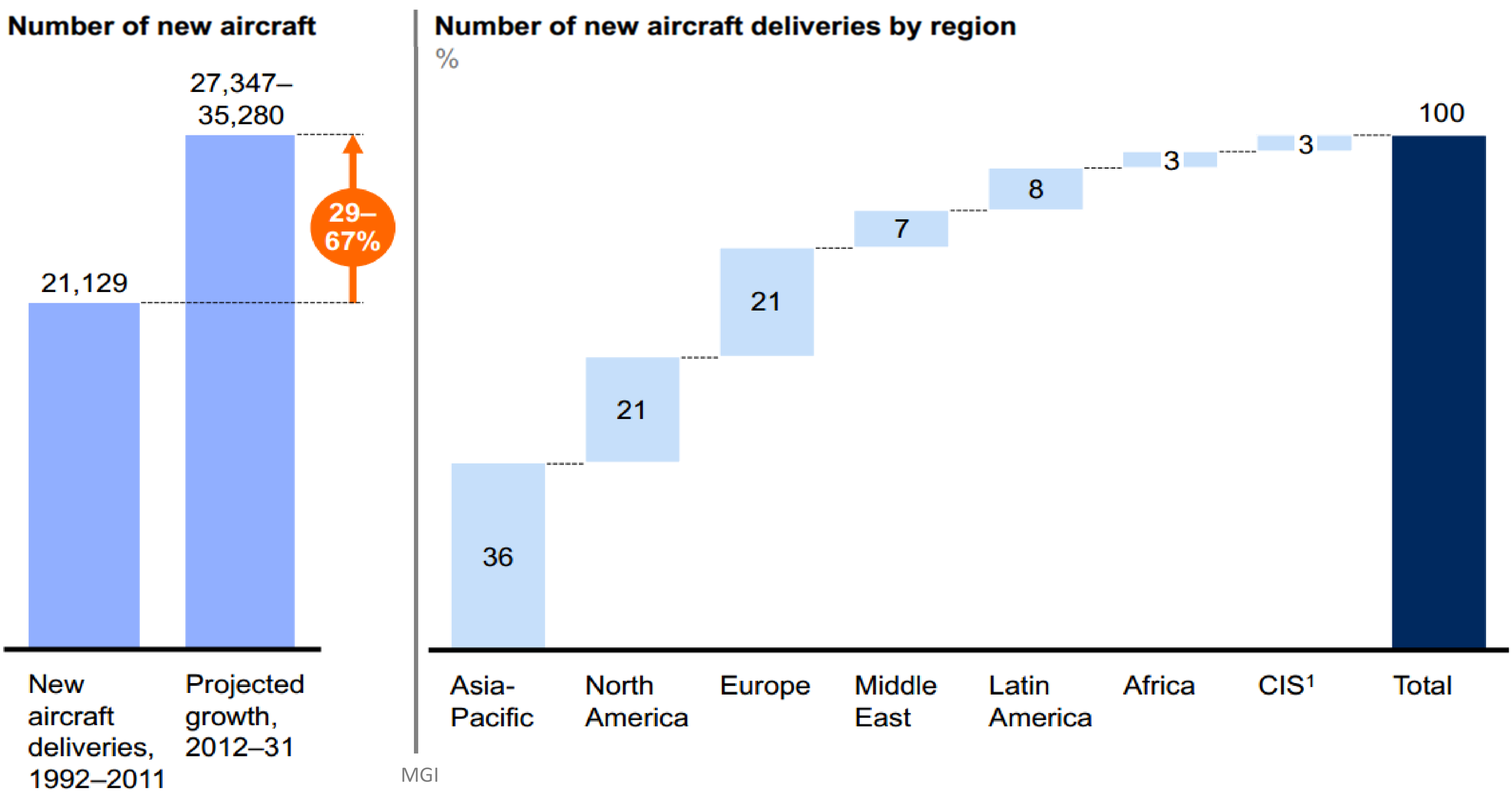
Jobs impact (direct and indirect)	110,000–215,000	165,000–270,000	250,000–450,000	385,000–725,000	1.0 million–1.7 million

www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf

FUTURE ECONOMIC GROWTH SECTORS (PROJECTIONS ARE NOT FACTS)

- **Energy**
- **Trade**
- **Big data**[1]
- **Infrastructure**
- **Talent**

Commercial aircraft forecast → 27,000 to 35,000 over the next 20 years



These aircrafts will not see three individuals guiding a plane to its door.

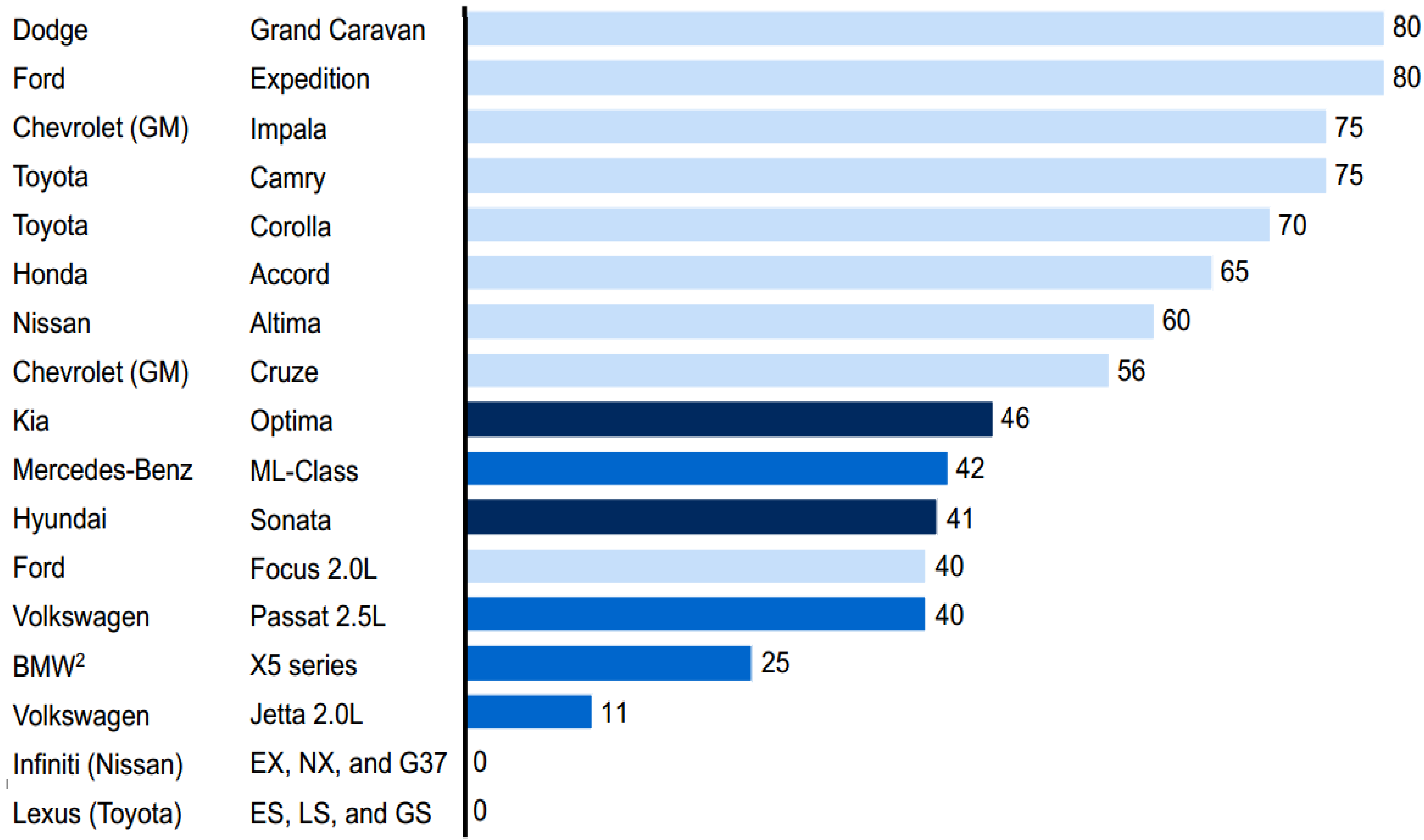
The robocrafts will sense the door, talk to the jet bridge and auto-unload

GE REPORTS

The HondaJet Just Got New Engines. Is the Flying Car Next?

May 26, 2014

% Share of US & Canadian content in production of autos sold in the US



The industrial internet is expected to transform workforce development

US$15 trillion left on the table

What skill sets and training are necessary for the workforce to unleash the economic potential of the ecosystems that include energy sector, aviation industry and automobile manufacturing?

Mining and monetizing the value of data and information from the industrial internet

There is more to the Internet of Things (IoT) than FitBits and smartphone-controlled thermostats. While consumer goods are some of the IoT's most visible applications, they're just one part of the vast and game-changing phenomenon that could soon encompass 200 billion connected devices and add trillions of dollars to the economy.

In fact, experts estimate that the IoT will resonate strongly in the "invisible" industrial sector, capturing and analyzing data generated by drilling rigs, jet engines, locomotives and other heavy-duty machines.

This network is called the Industrial Internet and it's already helping companies shave costs and boost performance. Union Pacific, America's largest railroad company, has improved productivity by wiring its locomotives with sensors that monitor parts and supply data to algorithms that try to predict whether a component might break down and when. "Industrial data is not only big, it's the most critical and complex type of big data," says Jeff Immelt, chairman and CEO of GE. "Observing, predicting and changing performance is how the Industrial Internet will help airlines, railroads and power plants operate at peak efficiency."

GE is betting big on the Industrial Internet. The company believes the network could add $10 and $15 trillion – the size of today's U.S. economy - to global GDP over the next 20 years. Its software arm has developed a software platform called Predix that allows Union Pacific, as well as oil drilling companies, wind farms, hospitals and other customers to perform prognostics, reduce downtime and increase efficiency.

Capturing Big Data and transmitting it to dedicated servers presents its own set of technological and logistical challenges. That's why GE, AT&T, Cisco and IBM teamed up this spring to launch the Industrial Internet Consortium. The goal of this open, not-for-profit group is to break down technology silos, improve machine-to-machine communications and bring the physical and digital worlds closer together.

To do that, member companies will pool their R&D capabilities to develop common server architectures and advanced test beds to standardize key components of the Industrial Internet.

www.iiconsortium.org

GE Report ▪ July 7, 2014

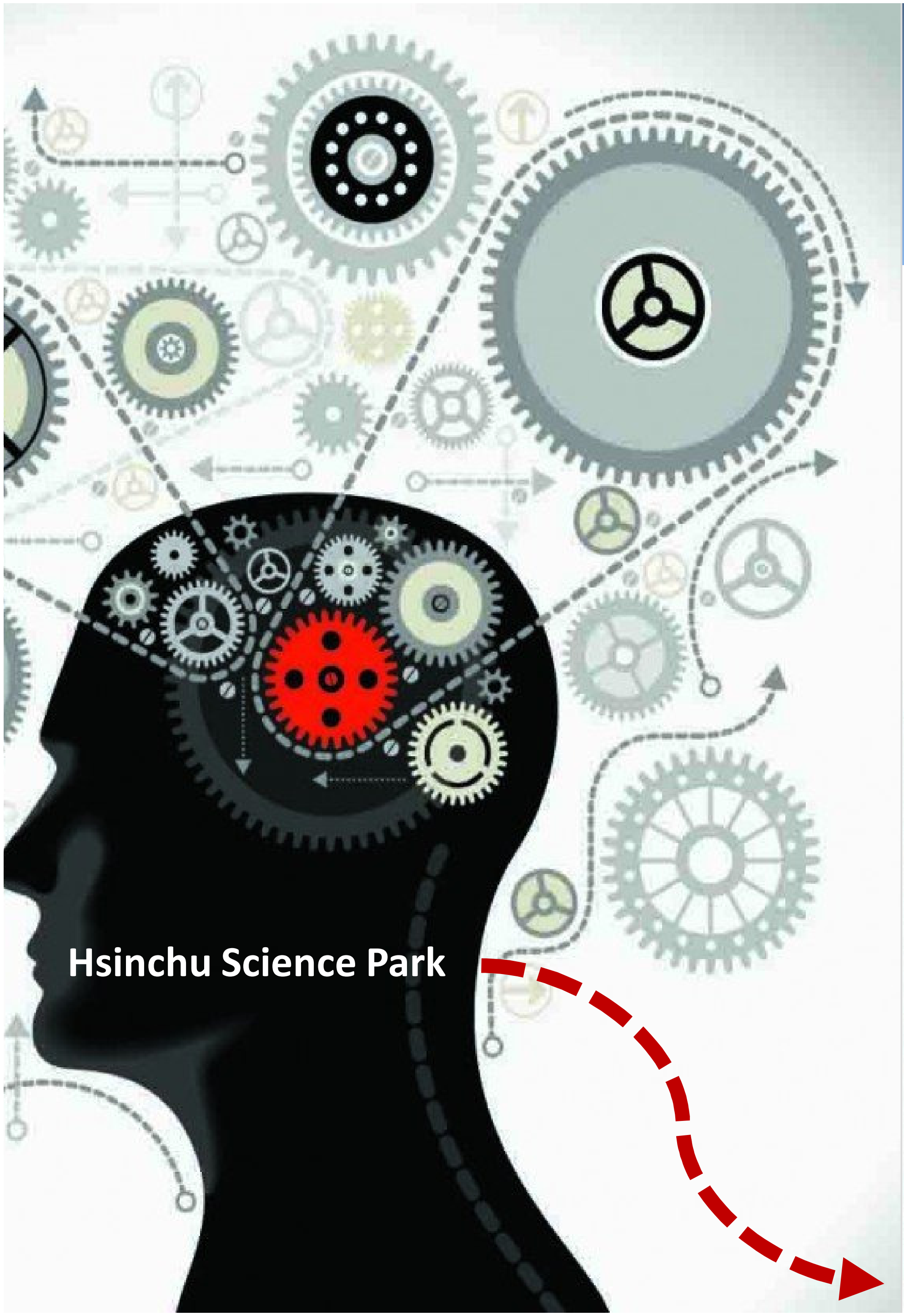
Massive gas turbines are also getting connected to the Industrial Internet.

While the possibilities of the Industrial Internet are just beginning to be harnessed, companies aren't waiting around. In a speech to power company executives, Wall Street analysts and investors at the Electrical Products Group Conference this spring, GE's Immelt said that by the end of the year, he expected GE to launch over 40 "Predictivity" industrial analytical applications, which could generate more than $1 billion in revenue for the company.

The Internet is no longer just about email, e-commerce and Twitter, says Joe Salvo, manager of the Complex Systems Engineering Laboratory at GE Global Research. "We are at an inflection point," he says. "The next wave of productivity will connect brilliant machines and people with actionable insight."

Where is my slice of the pie?

How much of the $10 - $15 trillion may be diverted to my bank?



Goldman-Sachs Quick Get Rich Insider Information

COMPANY	TICKER	GS RATING	POSITIONING
ARM Holdings	UK:ARM	Buy	Low-power chip designs
Atmel Corp.	ATML	Neutral	Exposure to microcontroller growth
Broadcom Corp.	BRCM	Neutral	Well-positioned in connectivity/broadband
Cisco Systems Inc.	CSCO	Buy	IoT thought leader (Wi-Fi, "fog" computing)
Freescale Semiconductor	FSL	Buy	Exposure to microcontroller growth
Garmin Ltd.	GRMN	Neutral	Expanding wearables, connected car portfolio
Gemalto NV	NL:GTO	Buy	Digital security expertise to monetize IoT
InvenSense Inc.	INVN	Buy	Early design wins on wearables
Maxim Integrated Products	MXIM	Buy	Exposure to microcontroller growth
Microchip Technology Inc.	MCHP	Neutral	Exposure to microcontroller growth
Murata Manufacturing Co.	JP:6981	Buy	Benefits from Japan upstream supply chain
Qualcomm Inc.	QCOM	Buy	Cellular/connectivity leadership
Ruckus Wireless Inc.	RKUS	Buy	Pure-play Wi-Fi vendor
Samsung Electronics	KR:005930	Buy	Widest hardware reach in IoT
Silver Spring Networks Inc.	SSNI	Buy	Connected city pure play (smart meters, etc)
TE Connectivity Ltd.	TEL	Buy	Increasing focus on sensors
Wistron NeWeb Corp.	TW:6285	Neutral	Expert in wireless solutions

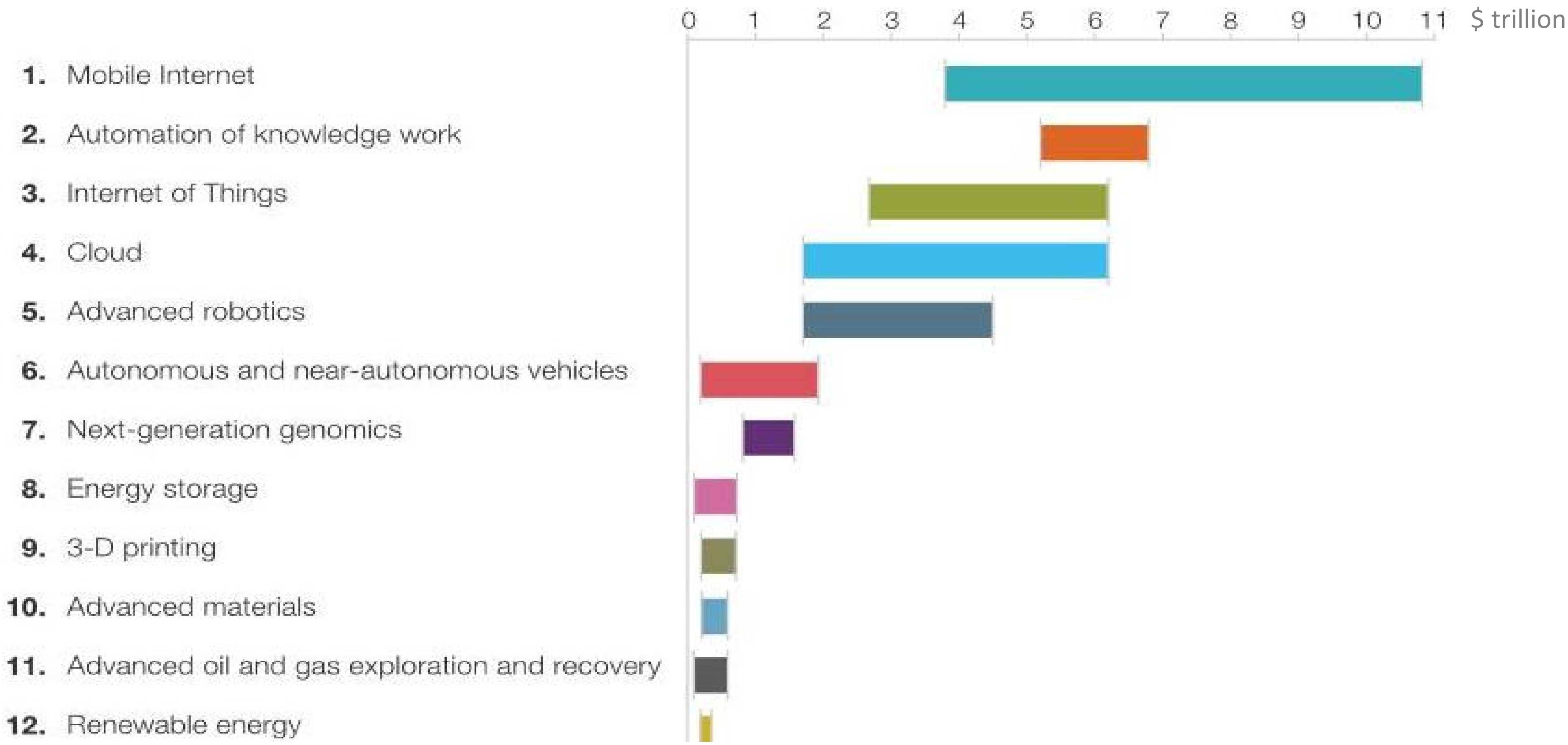
Industrial Internet

CONVERGENCE CATALYZED ECONOMIC POTENTIAL ~$15 to $50 TRILLION pa ca 2025

Technology	Application	Description
Mobile Internet	Cloud of Things	Increasingly inexpensive and capable mobile computing devices and Internet connectivity
Automation of knowledge	Predictive Analytics	Intelligent software systems that can perform knowledge work tasks involving unstructured commands and subtle judgments
The Internet of Things	Privacy, Cyber-Security	Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization
Cloud technology	Data, Decisions, SCM	Use of computer hardware and software resources delivered over a network or the Internet, often as a service
Advanced robotics	Cyber-Physical Systems	Increasingly capable robots with enhanced senses, dexterity, and intelligence used to automate tasks or augment humans
Autonomous and near-autonomous vehicles	Transportation + Disaster and Emergency First Response Systems	Vehicles that can navigate and operate with reduced or no human intervention
Next-generation genomics	Healthcare	Fast, low-cost gene sequencing, advanced big data analytics, and synthetic biology ("writing" DNA)
Energy storage	EV as storage	Devices or systems that store energy for later use, including batteries
3D printing	Manufacturing	Additive manufacturing techniques to create objects by printing layers of material based on digital models
Advanced materials	Manufacturing	Materials designed to have superior characteristics (e.g., strength, weight, conductivity) or functionality
Advanced oil and gas exploration and recovery	Energy Supply Chain	Exploration and recovery techniques that make extraction of unconventional oil and gas economical
Renewable energy	Smart Grid	Generation of electricity from renewable sources with reduced harmful climate impact
Aerospace Locomotives		Maintenance and fault prevention using in-flight monitoring; reduce down-time by auto-tracking metrics; fuel consumption; supply chain

Modified and adapted from MGI

MGI Estimated Potential Annual Economic Impact circa 2025



In highly successful firms such as McKinsey and Company hundreds of new MBAs join the firm every year and almost as many leave. But the company is able to crank out high-quality work year after year because its core capabilities are rooted in its processes and values rather than in its resources (vision). I sense, however, that these capabilities of McKinsey also constitute its disabilities. The rigorously analytical, data-driven processes that help it create value for its clients in existing, relatively stable markets render it much less capable in technology markets. **Clayton Christensen** (Harvard Business School, 2000) also in his book *The Innovators Dilemma*

#1 Mobile Internet

Increasingly inexpensive and capable mobile computing devices and Internet connectivity

Potential economic impact in 2025 across sized applications of
$3.7 trillion–$10.8 trillion

10–20% potential cost reduction in treatment of chronic diseases through remote health monitoring

Component technologies

- Wireless technologies
- Small, low-cost computing and storage devices
- Advanced display technology, natural user interfaces
- Advanced, low-cost batteries

Key applications

- Service delivery
- Worker productivity
- Additional consumer surplus from use of mobile-Internet services

Sized applications of mobile Internet could have direct economic impact of $3.7 trillion to $10.8 trillion per year in 2025

Sized applications		Potential economic impact of sized applications in 2025 ($ trillion, annually)	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Service delivery	Health care	0.9–2.1	▪ $15.5 trillion cost of treating chronic diseases	▪ 70–80% mobile penetration among patients accounting for 95% of health-care spending	▪ 10–20% cost reduction in chronic disease treatment through remote health monitoring
	Education	0.3–1.0	▪ $11 trillion global spending on education	▪ K–12 adoption of online/hybrid learning – Developed world: 80–90%[1] – Developing: 65–80% ▪ 90–100% adoption in post-secondary, corporate, and government education	▪ 5–15% rise in secondary graduation rates ▪ 10–30% productivity gain in post-secondary, corporate, and government education
	Public sector	0.2–0.5	▪ $0.9–1.2 trillion government spending on customer-facing services	▪ Adoption by 90–100% of governments for online or mobile services	▪ 60–75% cost savings on administrative tasks driven by labor efficiency
	Retail	0.1–0.4	▪ $7.2 trillion cost of retail	▪ 30–50% of retail consumption ▪ Mobile devices used in 50% of purchases	▪ 6–15% productivity gain of online hybrid retail versus traditional
	Payments	0.2–0.3	▪ $3 trillion in global transaction revenue	▪ Implementation of advanced electronic payments systems in – 80–100% of advanced economies – 65–80% of developing economies[1]	▪ 50% productivity gain in managing transactions across all stakeholders
Other worker productivity[2]	Interaction workers	0.9–1.3	▪ $19 trillion in interaction worker salaries	▪ 80–90% of workers in advanced economies ▪ 65–80% of workers in developing economies	▪ 4–5% increase in efficiency through social technology via mobile
	Transaction workers	0.1–0.4	▪ $15 trillion in transaction worker salaries	▪ 80–90% of workers in advanced economies ▪ 65–80% of workers in developing economies ▪ Mobile devices needed for 10% of work tasks	▪ 10–30% productivity gain from time saved accessing information
	Additional consumer surplus	1.0–4.8	▪ 3.6–4.9 billion mobile users	▪ 100% of users	▪ $500–1,500 per user in developed world ▪ $300–1,000 per user in developing world
	Other potential applications (not sized)				
	Sum of sized potential economic impacts	3.7–10.8			

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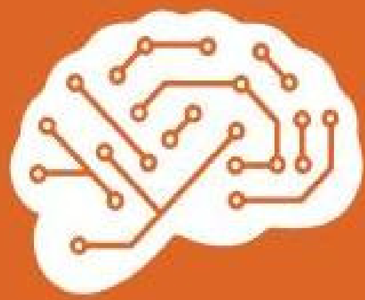

#2 Automation of knowledge work

Intelligent software systems that can perform knowledge-work tasks

Potential economic impact in 2025 across sized applications of **$5.2 trillion–$6.7 trillion**

Additional labor productivity could equal the output of **110 million–140 million** full-time workers

Component technologies

- Artificial intelligence, machine learning
- Natural user interfaces
- Big-data technologies

Key applications

- Smart learning in education
- Diagnostics and drug discovery in health care
- Discovery, contracts/patents in legal sector
- Investments and accounting in finance sector

Sized applications of automation of knowledge work could have direct economic impact of $5.2 trillion to $6.7 trillion per year in 2025

Sized knowledge worker occupations		Potential economic impact of sized occupations in 2025 ($ trillion, annually)	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Common business functions	Clerical	1.1–1.3	▪ $4.4 trillion in knowledge worker costs ▪ 125 million knowledge workers	▪ 50–65 million full-time equivalents (FTEs) of work potentially automatable	▪ $35,000 value per FTE of additional productivity
	Customer service and sales	0.6–0.9			
Social sector services	Education	0.8–1.0	▪ $2.8 trillion in knowledge worker costs ▪ 55 million knowledge workers	▪ 20–30 million FTEs of work potentially automatable	▪ $50,000 value per FTE of additional productivity
	Health care	0.3–0.4			
Technical professions	Science and engineering	0.6–0.7	▪ $2.2 trillion in knowledge worker costs ▪ 35 million knowledge workers	▪ 15 million FTEs of work potentially automatable	▪ $60,000 value per FTE of additional productivity
	IT	0.4–0.5			
	Managers	0.8–1.1	▪ $2.9 trillion in knowledge worker costs ▪ 50 million knowledge workers	▪ 15–20 million FTEs of work potentially automatable	▪ $60,000 value per FTE of additional productivity
Professional services	Finance	0.4–0.5	▪ $1.5 trillion in knowledge worker costs ▪ 25 million knowledge workers	▪ 10 million FTEs of work potentially automatable	▪ $65,000 value per FTE of additional productivity
	Legal	0.2–0.3			
Other potential applications (not sized)					
Sum of sized potential economic impacts		**5.2–6.7**			

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#3 Internet of Things

Networks of low-cost sensors and actuators for data collection, monitoring, decision making, and process optimization

Potential economic impact in 2025 across sized applications of **$2.7 trillion–$6.2 trillion**

Offers potential to drive **productivity across $36 trillion** in operating costs of key affected industries: manufacturing, health care, and mining

Component technologies

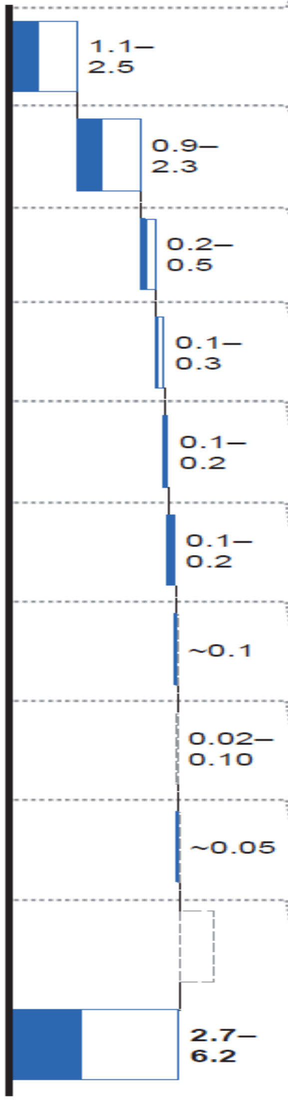
- Advanced, low-cost sensors
- Wireless and near-field communication devices—eg, RFID (radio frequency identification tags)

Key applications

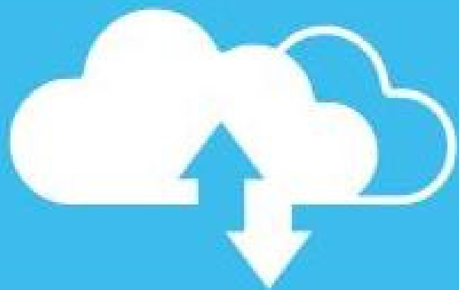
- Process optimization, especially in manufacturing and logistics
- Efficient use of natural resources—eg, smart-meter and smart-grid control of water and electricity
- Remote health-care delivery, sensor-enhanced business models

Sized applications of the Internet of Things could have direct economic impact of $2.7 trillion to $6.2 trillion per year in 2025

MGI



Sized applications	Potential economic impact of sized applications in 2025 ($ trillion, annually)	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Health care	1.1–2.5	▪ $15.5 trillion cost of treating chronic diseases ▪ $400 billion cost of counterfeit drugs, 40% addressable with sensors ▪ 50 million nurses for inpatient monitoring — Developed world: $30 per hour — Developing: $15 per hour	▪ 70–80% mobile penetration in patients who account for bulk of health-care spending ▪ Counterfeit drug tracking — Developed world: 50–80% — Developing world: 20–50% ▪ Inpatient monitoring — Developed world: 75–100% — Developing: 0–50%	▪ 10–20% cost reduction in chronic disease treatment through remote health monitoring ▪ 80–100% reduction in drug counterfeiting ▪ 0.5–1.0 hour time saved per day by nurses
Manufacturing	0.9–2.3	▪ $47 trillion in global manufacturing operating costs	▪ 80–100% of all manufacturing	▪ 2.5–5.0% saving in operating costs, including maintenance and input efficiencies
Electricity	0.2–0.5	▪ 27,000–31,000 TWh global electricity consumption ▪ $200 billion spending on transmission lines ▪ 300 billion consumer minutes outage	▪ 25–50% of consumers could adopt energy management ▪ 25–50% of grid monitored through sensors ▪ 50–100% of consumer meters automated	▪ 2–4% reduction in demand peaks in the grid ▪ Reduction of total load on grid ▪ Operating/maintenance savings; shorter outage time through automated meters
Urban infrastructure	0.1–0.3	▪ 200–300 hours commuting time per urban worker per year ▪ $200 billion spent on urban water ▪ $375 billion cost of waste handling	▪ 40–70% of working urban population living in cities with smart infrastructure ▪ 50–70% of large urban regions adopting smart water infrastructure and waste handling	▪ 10–20% reduction in average travel time through traffic and congestion control ▪ 10–20% reduction in water consumption and leaks with smart meters and demand control ▪ 10–20% reduction in cost of waste handling
Security	0.1–0.2	▪ $6 trillion cost of crime	▪ Adoption of advanced surveillance by countries accounting for 50–70% of global GDP	▪ 4–5% crime reduction through improved surveillance
Resource extraction	0.1–0.2	▪ $3.7 trillion in global mining operating costs	▪ 80–100% of all resource extraction	▪ 5–10% saving in operating costs from productivity gains
Agriculture	~0.1	▪ $1.2–1.3 trillion in agricultural production (wheat, maize, rice, soybeans, barley)	▪ 20–40% adoption of advanced irrigation systems and precision farming	▪ 10–20% increase in yields from precision application of fertilizer and irrigation
Retail	0.02–0.10	▪ $200 billion lost due to stockouts	▪ 30–80% of retail adopting smart logistics	▪ 1.5–2.0% increased sales
Vehicles	~0.05	▪ $630 billion in automotive insurance premiums[1]	▪ 10–30% of all insured cars equipped with sensors	▪ 25% reduction in cost of vehicle damage from collision avoidance and increased security[1]
Other potential applications (not sized)				
Sum of sized potential economic impacts	**2.7–6.2**			



#4 **Cloud**

Use of computer hardware and software resources to deliver services over the Internet or a network

Potential economic impact in 2025 across sized applications of
$1.7 trillion–$6.2 trillion

15–20% potential productivity gains across IT infrastructure, application development, and packaged software

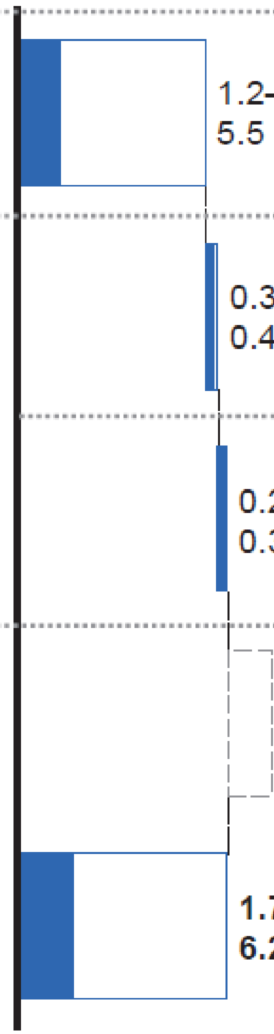
Component technologies

- Cloud-management software—eg, virtualization, metering
- Data-center hardware
- High-speed networks
- Software/platform as a service (SaaS/PaaS)

Key applications

- Cloud-based delivery of Internet services and applications
- Enterprise IT productivity

Sized applications of cloud technology could have economic impact of $1.7 trillion to $6.2 trillion per year in 2025



Sized applications	Potential economic impact of sized applications in 2025 $ trillion, annually	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Surplus from cloud-based Internet	1.2–5.5	2–3 billion more Internet users, most in developing economies	Nearly all Internet applications use cloud as a core enabler	$25–85 surplus per user per month
Enterprise productivity[1]: Infrastructure and operating expenses	0.3–0.4	$1.26 trillion or 40% of global IT spending in base scenario[2]	Varying levels of cloud adoption across enterprises ▪ All enterprises could have potential to use cloud ▪ Most enterprises may use a hybrid cloud ▪ The share of public cloud usage may increase as cybersecurity improves	20–30% productivity gains ▪ Reduced infrastructure and facilities footprint ▪ Higher task standardization and automation
Enterprise productivity[1]: Application development and packaged software	0.2–0.3	$1.68 trillion or 60% of global IT spending in base scenario[2]		10–15% productivity gains ▪ Standardization of application environment and packages ▪ Faster experimentation and testing
Other potential applications (not sized)				
Sum of sized potential economic impacts	**1.7–6.2**			

#5 Advanced robotics

Increasingly capable robots with enhanced sensors, dexterity, and intelligence; used to automate many tasks

Potential economic impact in 2025 across sized applications of
$1.7 trillion–$4.5 trillion

Offers potential to **improve the lives** of 50 million amputees and those with impaired mobility

Component technologies

- Artificial intelligence/computer vision
- Advanced robotic dexterity, sensors
- Distributed robotics
- Robotic exoskeletons

Key applications

- Industrial/manufacturing robotics
- Service robots—eg, food preparation, cleaning, and maintenance
- Robotic surgery
- Human augmentation
- Personal and home robots—eg, for cleaning, lawn care

Sized applications of advanced robotics could have direct economic impact of $1.7 trillion to $4.5 trillion per year in 2025

Sized applications	Potential economic impact of sized applications in 2025 ($ trillion, annually)	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Robotic human augmentation	0.6–2.0	▪ 50 million amputees and people with impaired mobility in advanced economies	▪ 5–10% of amputees and people with impaired mobility in advanced economies	▪ $240,000–390,000 per person for extended/ improved quality of life[1]
Industrial robots	0.6–1.2	▪ 355 million applicable industrial workers	▪ 30–60 million FTEs of work potentially automatable across key job types	▪ 75% potential improvement in productivity per unit of work automated
Surgical robots	0.2–0.6	▪ 200 million major surgeries in countries with developed health care	▪ 5–15% of major surgeries in countries with developed health-care systems	▪ 60,000–180,000 lives saved per year ▪ 50% reduction in sick and inpatient days
Personal and home robots	0.2–0.5	▪ 90–115 billion hours spent on tasks such as cleaning and lawn care per year in advanced economies	▪ 25–50% of households in advanced economies	▪ 20–50 billion hours saved per year ▪ $10 value per hour of time saved
Commercial service robots	0.1–0.2	▪ 130 million applicable service workers	▪ 10–15 million FTEs of work potentially automatable across key job types	▪ 35–55% potential improvement in productivity per unit of work automated
Other potential applications (not sized)				
Sum of sized potential economic impacts	**1.7–4.5**			

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#6 Autonomous or near-autonomous vehicles

Vehicles that can navigate and operate autonomously or semiautonomously in many situations

Potential economic impact in 2025 across sized applications of
$0.2 trillion–$1.9 trillion

Could save **30,000–150,000 lives** from potentially fatal traffic accidents

Component technologies

- Artificial intelligence, computer vision
- Advanced sensors—eg, radar, Lidar,[1] GPS
- Machine-to-machine communication

Key applications

- Self-driving cars and trucks

Sized applications of autonomous and near-autonomous vehicles could have direct economic impact of $200 billion to $1.9 trillion per year in 2025

Sized applications	Potential economic impact of sized applications in 2025 $ trillion, annually	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Autonomous cars	0.1–1.4	▪ 900 million new cars produced in or after 2018 ▪ 500 hours per year spent in car by average owner	▪ 5–20% of all driving autonomous – 20–30% of cars sold from 2017–20 with potential to be autonomous – 50–100% driving time spent under full computer control	▪ $2–8 per hour in value of time saved ▪ 70–90% fewer accidents ▪ 15–20% gain in fuel efficiency
Autonomous trucks	0.1–0.5	▪ 24 million trucks produced in 2018 or later	▪ 10–30% of new trucks with autonomous driving capabilities ▪ 50% driven by human drivers	▪ 70–90% fewer accidents ▪ 10–40% greater fuel efficiency ▪ 1–2 drivers per 10 trucks (for monitoring)
Other potential applications (not sized)		▪ Potential applications not sized include commercial drones, military drones, and/or autonomous and near-autonomous submersible vehicles for applications such as fossil fuels exploration		
Sum of sized potential economic impacts	0.2–1.9			

#7 Next-generation genomics

Fast, low-cost gene sequencing, advanced analytics, and synthetic biology (ie, “writing” DNA)

Potential economic impact in 2025 across sized applications of
$0.7 trillion–$1.6 trillion

Extending and enhancing lives accounts for 75% of potential impact—eg, through faster disease detection, new drugs

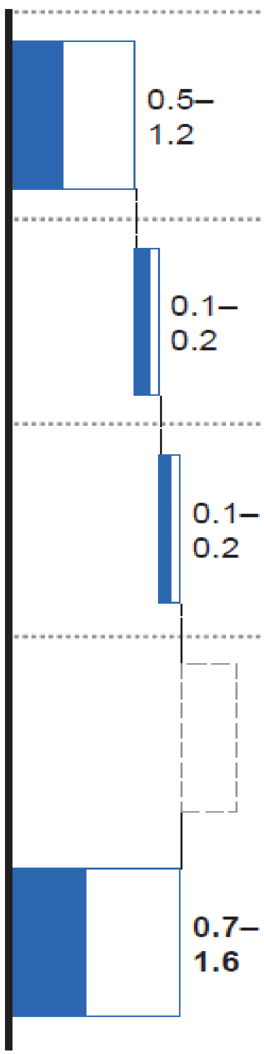
Component technologies

- Advanced DNA-sequencing technologies
- DNA-synthesis technologies
- Big data and advanced analytics

Key applications

- Disease treatment
- Agriculture
- Production of high-value substances

Sized applications of next-generation genomics could have direct economic impact of $700 billion to $1.6 trillion per year in 2025



Sized applications	Potential economic impact of sized applications in 2025 $ trillion, annually	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Disease treatment	0.5–1.2	▪ Estimated deaths from relevant diseases – Cancer: 12 million – Cardiovascular: 23 million – Type 2 diabetes: 4 million ▪ 160 million newborns	▪ Patients with access to relevant treatment – Cancer: 20–40% – Cardiovascular: 15–40% – Type 2 diabetes: 20–40% ▪ Access to prenatal genetic screening: – Developed world: 100% – Less-developed: 30–50%[1]	▪ Extended life expectancy – Cancer: 0.5–2 years[2] – Cardiovascular: 1 year – Type 2 diabetes: 1 year[3] ▪ Value of prenatal screening[4] – Developed world: $1,000 – Less-developed: $200
Substance production	0.1–0.2	▪ 60 billion gallons per year of ethanol ▪ 350–500 billion gallons per year of diesel	▪ Ethanol: 20–40% of world production ▪ Diesel: 2–3% of world production	▪ 15–20% cost saving in ethanol production ▪ 150–200% price premium for diesel ▪ 30–70% CO_2 reduction from fuels over life cycle
Agriculture	0.1–0.2	▪ $1.2–1.3 trillion worth of major crops (wheat, maize, rice, soybeans, barley, tomatoes)	▪ 60–80% of agricultural production improved using genomics data ▪ 20–80% of current genetically engineered crops to be further enhanced	▪ 5–10% increase in yields due to process optimization ▪ 5–10% increase in yields from use of advanced genetically engineered crops
Other potential applications (not sized)				
Sum of sized potential economic impacts	**0.7–1.6**			

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#8 Energy storage

Devices or physical systems that store energy for later use

Potential economic impact in 2025 across sized applications of
~$0.1 trillion–$0.6 trillion

40–100% of new vehicles sold in 2025 could be electric or hybrid

Component technologies

- Battery technologies—eg, lithium-ion and fuel cells
- Mechanical technologies—eg, pumped hydro and pressurized gas
- Advanced materials, nanomaterials

Key applications

- Electric and hybrid vehicles
- Distributed energy (including off-grid)
- Utility-scale grid storage

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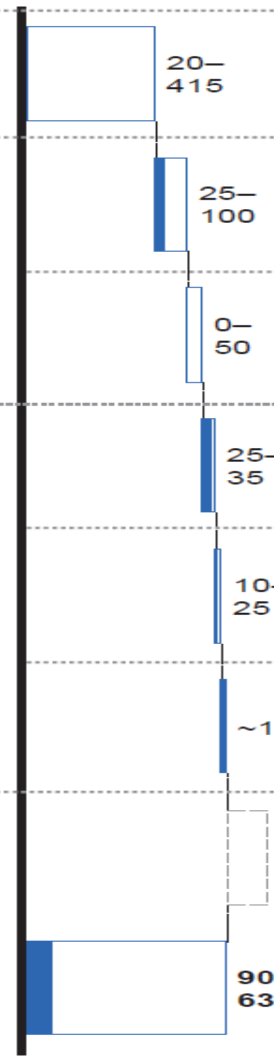
Sized applications of energy storage could have economic impact of $90 billion to $635 billion per year in 2025, including consumer surplus



Sized applications		Potential economic impact of sized applications in 2025 ($ billion, annually)	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
	Electric and hybrid vehicles	20–415	▪ 115 million passenger vehicles sold ▪ Over 1 billion vehicles in the market	▪ 40–100% of vehicles sold in 2025 could be electric or hybrid	▪ Fuel price: $2.80–7.60 per gallon ▪ 0.22 KWh per mile fuel efficiency for EVs
Distributed energy	Stabilizing electricity access	25–100	▪ 13,000 TWh electricity consumption in emerging markets ▪ 2–70 hours per month without electricity	▪ 35–55% adoption with solar and battery combination ▪ 35–55% of companies in Africa, Middle East, and South Asia own diesel generators	▪ $0.75–2.10 per KWh value of uninterrupted power supply to an enterprise ▪ $0.20–0.60 per KWh value per household
Distributed energy	Electrifying new areas	0–50	▪ 60–65% rural electrification rate ▪ 1.2 billion people without electricity access ▪ 60 KWh monthly electricity requirement of average household	▪ 50–55% adoption based on number of people projected to earn above $2 per day	▪ $0.20–0.60 per KWh value per household for direct lighting, TV, and radio benefits
Utility grid	Frequency regulation	25–35	▪ 27,000–31,000 TWh global electricity consumption ▪ 1.5% electricity production reserved for frequency regulation ▪ 2.5% additional reserved for renewable integration	▪ 100% technology adoption, more efficient, and cost competitive with incumbent solutions	▪ $30 per MWh weighted average frequency-regulation price
Utility grid	Peak load shifting	10–25	▪ 12% of total electricity production possible to shift ▪ 850 million tons additional CO_2 release	▪ 10–20% adoption of energy storage, given costs compared with combined cycle gas turbines	▪ $65–80 per MWh between non-renewable peak and base load ▪ $45–65 per MWh between peak and average wind price ▪ $30–45 per MWh between peak and average solar price
Utility grid	Infrastructure deferral	~10	▪ $295 billion per year investment in infrastructure T&D deferral ▪ 10% spent to reduce congestion	▪ 15% adoption based on share of transmission lines economical for energy storage	▪ Possible deferral of infrastructure investment by 2.5 years
	Other potential applications (not sized)				
	Sum of sized potential economic impacts	90–635			

#9 3-D printing

Additive-manufacturing techniques that create objects by printing successive layers of material using digital models

Potential economic impact in 2025 across sized applications of
$0.2 trillion–$0.6 trillion

Consumers' use of 3-D printing could save them **35–60% in costs** per printed product, while enabling a high level of customization

Component technologies

- Selective laser sintering (SLS)
- Fused deposition modeling (FDM)
- Stereolithography (SLA)
- Direct metal laser sintering (DMLS)

Key applications

- Consumer use of 3-D printers
- Direct product manufacturing
- Tool and mold manufacturing
- Bioprinting of tissue and organs

Sized applications of 3D printing could have direct economic impact of $230 billion to $550 billion per year in 2025

Sized applications	Potential economic impact of sized applications in 2025 $ billion, annually	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Consumer use of 3D printing	100–300	▪ $4 trillion in sales of consumer products that might be 3D printed	▪ 5–10% of relevant products (e.g., toys) could be 3D printable, assuming easy consumer access	▪ 60–80% value increase per 3D-printed product – 35–60% cost savings to consumers – 10% added value from customization
Direct product manufacturing[1]	100–200	▪ $300 billion spending on complex, low-volume items such as implants and tools ▪ $470 billion spending on complex, low-volume parts in transportation	▪ 30–50% of products in relevant categories replaceable with 3D printing	▪ 40–55% cost savings to buyers of 3D-printed products
Tool and mold manufacturing	30–50	▪ $360 billion global market for injection-molded plastics	▪ 30–50% of injection-molded plastics produced with 3D-printed molds	▪ 30% production cost reduction using superior 3D-printed molds
Other potential applications (not sized)				
Sum of sized potential economic impacts	**230–550**			

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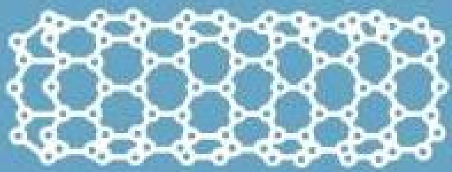

#10 Advanced materials

Materials that have superior characteristics such as better strength and conductivity or enhanced functionality such as memory or self-healing capabilities

Potential economic impact in 2025 across sized applications of
$0.2 trillion–$0.5 trillion

Nanomedicine could be used to **deliver targeted drugs** to 20 million new cancer cases worldwide in 2025

Component technologies

- Graphene
- Carbon nanotubes
- Nanoparticles—eg, nanoscale gold and silver
- Other advanced and smart materials—eg, piezoelectric materials, memory metals, self-healing materials

Key applications

- Nanoelectronics, displays
- Nanomedicine, sensors, catalysts, advanced composites
- Energy storage, solar cells
- Enhanced chemicals and catalysts

Sized applications of advanced materials could have direct economic impact of $150 billion to $500 billion per year in 2025

Sized applications	Potential economic impact of sized applications in 2025 $ billion, annually	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Drug delivery	150–500	20 million new cancer cases worldwide in 2025	5–10% of cancer patients could benefit from nano-based drug delivery treatments	$130,000–230,000 QALY value created per patient[1] ▪ $100,000–200,000 for 1–2 years increased life expectancy ▪ $30,000 from reduced chemotherapy side effects
Other potential applications (not sized)		Example applications not sized include nanomaterials for electronics and composites and applications of other advanced and smart materials, such as self-healing concrete or memory metals		
Sum of sized potential economic impacts	150–500			

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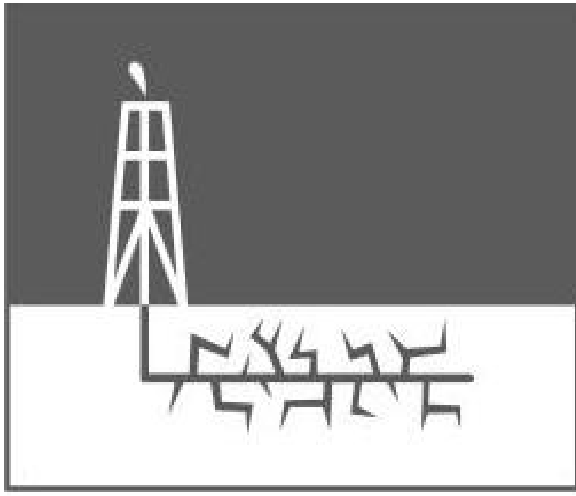


#11 Advanced oil and gas exploration and recovery

Advancements in exploration and recovery techniques that make extraction of additional oil and gas economical

Potential economic impact in 2025 across sized applications of
$0.1 trillion–$0.5 trillion

Offers potential to supply an **additional 3.6 billion–6.2 billion oil-equivalent barrels** of oil and gas annually by 2025

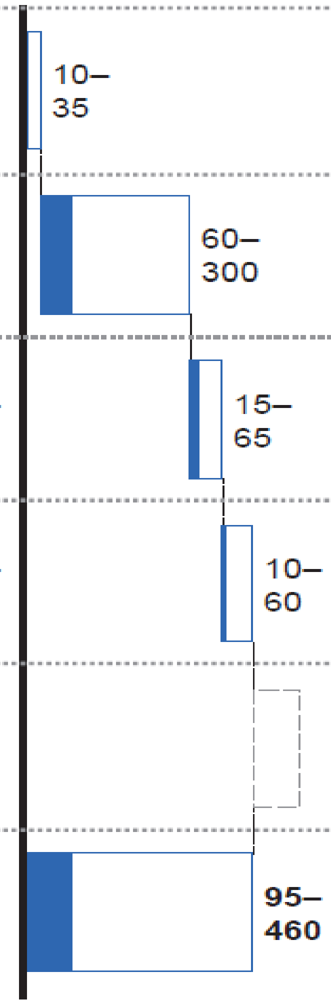
Component technologies

- Horizontal drilling
- Hydraulic fracturing ("fracking")
- Microseismic monitoring

Key applications

- Energy from fuel extraction; includes shale gas, light tight oil, and coal-based methane
- Coalbed methane and methane clathrate

Sized applications of advanced oil and gas exploration and recovery could have direct economic impact of $95 billion to $460 billion per year in 2025



Sized regions and applications	Potential economic impact of sized applications in 2025 ($ billion, annually)	Currently estimated reserves	Estimated potential incremental annual production in 2025	Assumed price in 2025
North America – shale gas[1]	10–35	▪ 71 trillion cubic meters (Tcm) of reserves – 60 Tcm in United States – 11 Tcm in Canada	▪ 145 billion cubic meters (Bcm)	▪ $2–8 per million British thermal unit (MMBtu); nearly $70–280 million per Bcm
North America – light tight oil	60–300	▪ 64 billion barrels of reserves – 57 billion barrels in United States – 7 billion barrels in Canada	▪ 5.4–9.0 million barrels per day	▪ $50–150 per barrel
Rest of the world – shale gas	15–65	▪ More than 150 Tcm of reserves – 36 Tcm in China – 22 Tcm in Argentina	▪ 70–220 Bcm	▪ Regional pricing (per MMBtu) – China, Australia: $8–10 – Argentina: $7–8 – Europe: $6–11
Rest of the world – light tight oil	10–60	▪ More than 130 billion barrels of reserves – 24 billion barrels in Russia – 13 billion barrels in Argentina	▪ 0.5–1.7 million barrels per day	▪ $50–150 per barrel
Other potential applications (not sized)		▪ Potential unsized applications include coalbed methane and methane clathrate		
Sum of sized potential economic impacts[2]	**95–460**			

#12 Renewable electricity— solar and wind

Generation of electricity from renewable sources with reduced harmful climate impact

Potential economic impact in 2025 across sized applications of **$0.2 trillion–$0.3 trillion**

Potential to avoid emissions of **1,000 million–1,200 million tons of CO_2** annually by 2025

Component technologies

- Photovoltaic cells
- Wind turbines
- Concentrated solar power
- Hydroelectric and ocean-wave power
- Geothermal energy

Key applications

- Electricity generation
- Reduction in CO_2 emissions
- Distributed generation

Sized applications of renewable energy could have economic impact of $165 billion to $275 billion per year in 2025

Sized renewable energy sources[1]		Potential economic impact of sized renewables in 2025 $ billion, annually	Estimated scope in 2025	Estimated potential reach in 2025	Potential productivity or value gains in 2025
Cost impact	Solar photovoltaics	105–110	▪ 27,000–31,000 TWh global electricity consumption ▪ 8,500–9,500 TWh renewables generation (wind, solar, hydro) ▪ $4.5–5.5 trillion annual generation cost of global electricity ▪ 2–degree Celsius maximum temperature rise target by 2050 ▪ 450 ppm global greenhouse gas concentration limit by 2050	▪ 1,330–1,570 TWh, or 5% of total electricity generation ▪ 1,100–1,300 TWh incremental generation vs. base scenario	▪ 60–65% drop in the levelized cost of electricity (LCOE) over base scenario
	Wind	40–45		▪ 2,700–3,500 TWh, 10–11% of total ▪ 500–550 TWh incremental generation vs. base scenario	▪ 25–30% drop in LCOE over base scenario – Onshore: 13–15% – Offshore: 50%
	Total cost impact	**145–155**			
Social impact (CO_2 avoided)	Solar photovoltaics	15–90		▪ 700–880 million tons	▪ $20–100 per ton of CO_2 avoided
	Wind	5–30		▪ 280–300 million tons	▪ $20–100 per ton of CO_2 avoided
	Other potential applications (not sized)		▪ Potential applications not sized include hydro, biomass, ocean thermal and wave energy, geothermal, next-generation nuclear, and concentrated solar power.		
	Sum of sized potential economic impacts[2]	**165–275**			

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IoE enabled examples

How the medium of the internet is generating value in the public sector

Examples of IoE enabled value in the public sector

1. **Employee productivity ($1.8 trillion):** IoE improves labor effectiveness for new and existing services.
2. **Connected militarized defense ($1.5 trillion):** IoE generates a fourfold force-multiplier effect through improved situational awareness and connected command centers, vehicles, and supplies.
3. **Cost reductions ($740 billion):** IoE improves labor efficiency and capital-expense utilization, leading to reduced operational costs.
4. **Citizen experience ($412 billion):** IoE shortens "search" times, improves the environment, and produces better health outcomes.
5. **Increased revenue ($125 billion):** IoE improves the ability to match supply with demand, while also enhancing monitoring and compliance.

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Examples of IoE enabled value in the public sector – Smart Parking $41 billion

- **New *things* created:** Connected parking spaces, parking meters
- **New *data* flows:** Space availability
- ***Process* innovation:** Pricing/payment; enforcement; finding spaces
- ***People* impact:** Traffic wardens; citizens/drivers; city planners
- **Value impact:** Increases compliance by 30 percent; enables city data sales; reduces traffic congestion/time required to park/fuel usage; dynamic pricing increases revenues

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Examples of IoE enabled value in the public sector – Water Management $39 billion

- **New *things* created:** Connected water meters
- **New *data* flows:** Water meters
- ***Process* innovation:** Water usage
- ***People* impact:** Citizens, city planners
- **Value impact:** Reduces labor and maintenance costs; improves accuracy of readings; decreases water consumption by citizens; lowers meter-reading costs

Cisco Systems

Examples of IoE enabled value in the public sector – Gas Monitoring $69 billion

- **New *things* created:** Connected gas meters
- **New *data* flows:** Gas meters
- ***Process* innovation:** Gas usage
- ***People* impact:** Citizens, city planners
- **Value impact:** Reduces labor and maintenance costs; improves accuracy of readings; decreases gas consumption by citizens; lowers meter-reading costs

Cisco Systems

Examples of IoE enabled value in the public sector – Chronic Disease Management $146 billion

- **New *things* created:** Patient-monitoring systems
- **New *data* flows:** Patient statistics
- ***Process* innovation:** Treatment protocol, admissions, discharge
- ***People* impact:** Patients, clinicians
- **Value impact:** Reduces admissions; enables shorter hospital stays due to home-monitoring systems; promotes usage of standardized treatments that conform to best practices

Examples of IoE enabled value in the public sector – Road Pricing $18 billion

- **New *things* created:** Vehicle payment system
- **New *data* flows:** Vehicle records, payment prices
- ***Process* innovation:** Pricing, payment
- ***People* impact:** Citizens/drivers; city planners; traffic wardens
- **Value impact:** Increases revenue; reduces traffic congestion, leading to savings in road expansion; reduces CO_2 emissions

Examples of IoE enabled value in the public sector – Telecommuting $125 billion

- **New *things (capabilities)* created:** Traveling employees
- **New *data* flows:** Information and communication
- ***Process* innovation:** Connectivity, collaboration
- ***People* impact:** Employees, employers
- **Value impact:** Reduces the real-estate requirement for employers; lowers janitorial and printing costs; improves employee retention and productivity; provides additional employment opportunities

Examples of IoE enabled value in the public sector – MOOC driven Digital Learning $258 billion

- **New *things (capabilities)* created:** Connected students, teachers, campuses
- **New *data* flows:** Study modules, lectures
- ***Process* innovation:** Instruction, learning techniques
- ***People* impact:** Students, teachers
- **Value impact:** 40 percent improvement in teacher utilization through recorded lessons; 50 percent reduction in instructional supplies

Note: MOOCs are valuable due to their ability to deliver factual learning outside of face time in the classroom. Hence, classrooms can serve as project learning or test-bed for activities which transforms theory to practice. Digital learning helps to flip the classroom from a lecture theater to a project based learning (PBL) environment. MOOCs will help promote the principles first practiced by Maria Montessori and her education philosophy.

CISCO SYSTEMS

Examples of IoE enabled value in the public sector – Connected Militarized Defense $1.5 trillion

- **New *things* created:** Connected command centers, vehicles, supplies
- **New *data* flows:** Location of allied and other forces
- ***Process* innovation:** Situational awareness
- ***People* impact:** Combat personnel
- **Value impact:** Multiplier effect – fourfold increase in combat-mission effectiveness

Cisco Systems

POLICY – The ultimate driver and catalyst to unleash the value from IoE, IoT & industrial internet

Policy and regulation: Governments will continue to have a policymaking and regulatory role in relation to IoE. They will need to devise policies for the allocation of resources, such as radio spectrum, as well as support the openness and efficient operation of markets. The pervasive nature of IoE – and the potential for it to be used extensively for management of critical infrastructure – means that governments will need to help ensure the safety and security of the systems themselves, while also protecting users' personal information and privacy. As an increasing number of the societal systems become "smart" through IoE technologies, government will be responsible for ensuring social cohesion and inclusion as part of the process. The development of new technologies across all sectors – driverless cars, food testing, or health monitoring, for example – will also call for new regulations in the interests of protecting public safety. Other IoE applications may lead to policy and/or regulatory actions to support environmental sustainability (such as a requirement to use smart meters) or access (for example, ensuring all schools can use IoE-related technologies for collecting and analyzing data about students' learning behaviors).

Cisco Systems

IoT enabled examples

How the medium of the internet is generating value in other verticals

Examples of IT enabled value

Boehringer Ingelheim sponsored a competition on Kaggle (platform for data-analysis) to predict if a new drug molecule may cause genetic mutations. The winning team, from among nearly 9,000 competitors, combined experience in insurance, physics and neuroscience. Its analysis beat existing predictive methods by >25%.

FedEx's SenseAware: Customers place a small device the size of a mobile phone inside packages. Device includes GPS, sensors to monitor temperature, light, humidity, barometric pressure and special criteria which may be critical to biomedical products and/or sensitive electronics. Real-time info about product location and if ambient conditions have changed. The data-rich variation of RFID tags helps companies manage complex and perishable supply chains.

Acxiom offers clients, from banks to auto companies, profiles of 500 million customers. Each profile enriched by more than 1,500 data points gleaned from the analysis of up to 50 trillion transactions.

Data from real-time monitoring of blogs, news and Tweets may detect subtle shifts in sentiment that can affect product and pricing strategy. Advanced analytic software allows machines to identify hidden patterns in massive data flow or documents. This machine "intelligence" means that a wider range of knowledge tasks may be automated at lower cost. As companies collect more data from operations, they may gain new revenue streams by selling sanitized information on spending patterns or physical activities to third parties ranging from economic forecasters to health-care companies.

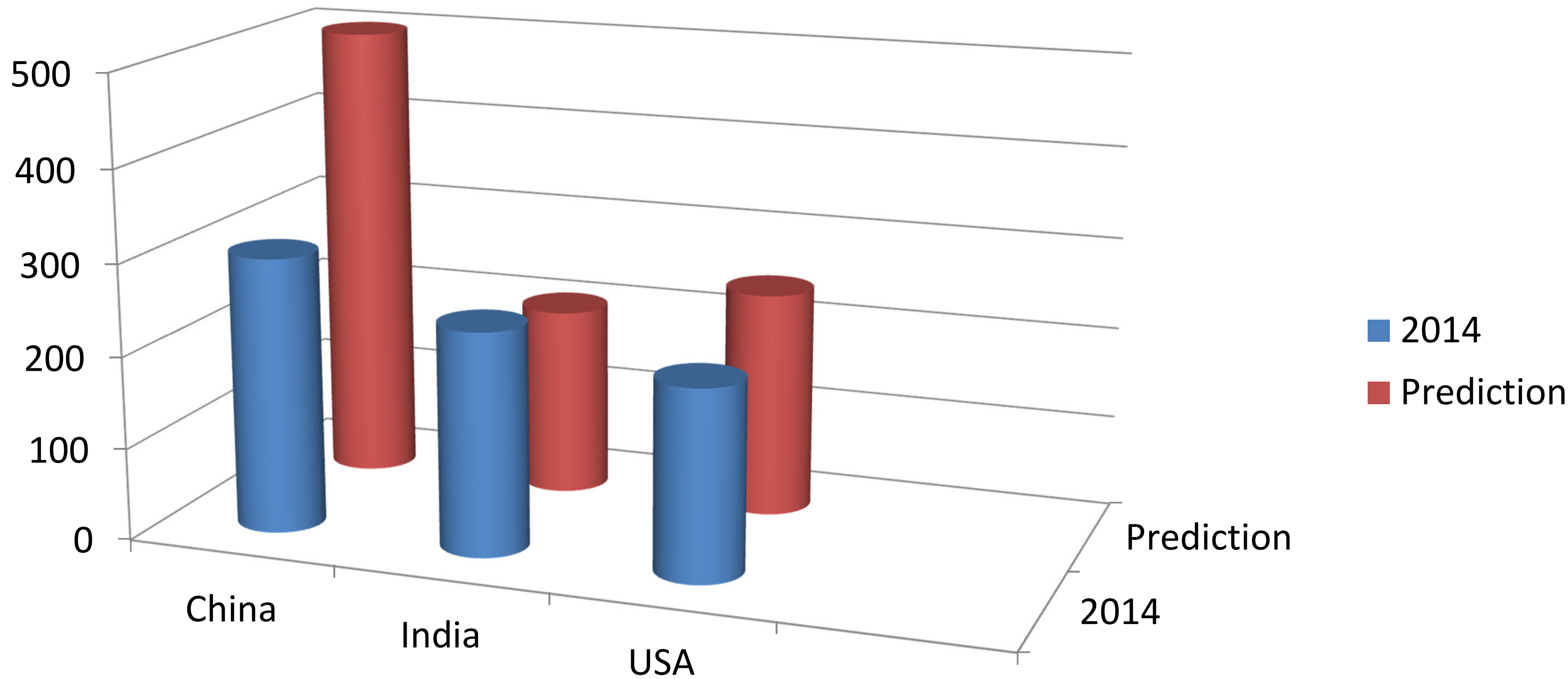
Examples of IT enabled value

Clearwell Systems (Silicon Valley) analyzes legal documents for pretrial discovery. Machines scanned >0.5 million documents and pinpointed the 0.5% which were relevant. What would have taken a legal team several weeks took 3 days. Machines are becoming adept at structuring basic content for reports, auto-generating marketing and financial materials by scanning documents and data.

Signaling a new quest for AI based decision support system (DSS), IBM's Watson is tackling cancer research by reading >600,000 medical-evidence reports, 1.5 million patient records and 2 million pages of clinical-trial reports and medical-journal articles. Aids decision-support for oncologists at Memorial Sloan-Kettering Cancer Center, NY.

Food retailers Tesco and Delhaize deployed life-size store displays at S. Korean & Belgian subway stations. It allows commuters waiting for trains to use smartphones to order groceries, which are shipped to their homes or available for pickup at a physical store location. Other retailers are using similar displays in physical stores so consumers can also order out-of-stock (OOS) products.

Connectivity may exponentially enhance IT enabled value in emerging economies



November 14, 2013 (TNN)
With 243 million users by 2014, India exceeds US in internet reach. But, India's digital penetration is only 10% and China 40%. Rising levels of connectivity presents potentially enormous opportunities for business.

Connectivity and IT enabled value will influence government, healthcare, education

India has enrolled 380 million citizens in the largest biometric-identity program (Aadhaar). It plans to use the system to make >$50billion in cash transfers to the poor (saves $6billion fraud)

Smartphones and tablets are entering classrooms to deliver personalized MOOC. India is running trials of the sub-$50 Aakash tablet to link more than 25,000 colleges in an e-learning program.

In rural Bangladesh, 90% of births occur outside hospitals. A mobile-notification system alerts clinics to dispatch nurse–midwife teams.

In China, a public–private partnership created a cardiovascular-monitoring system that allows patients to self-administer electrocardiograms and transmit data to specialists in Beijing, who may suggest treatments by phone.

In 2011, US government introduced a Cloud First policy, which laid out a vision to shift a quarter of the $80 billion in annual federal spending to the cloud from in-house data centers. It may save 20-30% on the cost of the shifted work.

Mt Sinai Hospital (NYC) collaborates with GE to use smart tags to track the flow of hundreds of patients, treatments and medical assets in real time. The hospital estimates may treat 10,000 more patients / year and generate $120 million in savings and revenues over several years.

Connectivity and IT catalyzed value – What does this mean?

Transparent and innovative business models are in dynamic state with real-time information, instant price discovery and quick problem resolution. The latter is now a basic expectation of consumers, citizens and business customers. Taken together, these changes will force many companies to rethink elements of their business models which are not in pace with these progressive practices. Leaders will need to make their companies more transparent and elevate rapid responsiveness as a core competency. Business models built on transparency and responsiveness will satisfy customers and help companies become more agile and credible with their stakeholders as long as privacy and security concerns are adequately addressed.

- http://www.ibm.com/analytics/us/en/
- http://hbr.org/2012/10/big-data-the-management-revolution/ar/1
- http://googleblog.blogspot.com/2010/10/what-were-driving-at.html
- http://hbr.org/2012/10/data-scientist-the-sexiest-job-of-the-21st-century
- http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03575usen/GBE03575USEN.PDF
- http://spectrum.ieee.org/automaton/robotics/artificial-intelligence/how-google-self-driving-car-works

Connectivity and IT catalyzed value – Who will deliver the value?

The rising economic and business impact of information technology means that competition will heat up for graduates in science, technology, engineering and mathematics (STEM) where job growth is likely to be several times faster than in other areas. As the automation of knowledge work gains momentum and computers start handling a growing number of tasks now performed by knowledge workers, some mid-level jobs will disappear. People with higher-level skills will become more important. Providing new forms of training to upgrade knowledge workers' capabilities and rethinking the nature of public education, especially in mathematics, will be critical priorities for businesses to invest in and for government leaders to decrease bureaucracy.

The need for education, talent and skilled workforce development.

Skilled Workforce

Where are they now?

What is the underlying discipline key to these skills?

Math-based role: Actuaries

Roll over any industry group (below) to chart its talent by roles.

Roll over a role (to the right) to see its total population in all industry groups.

Roles

Actuaries
Epidemiologists
Mathematicians
Mathematical technicians
Statisticians
Economists
Industrial engineers
Mathematical scientists and all others
Operations research analysts

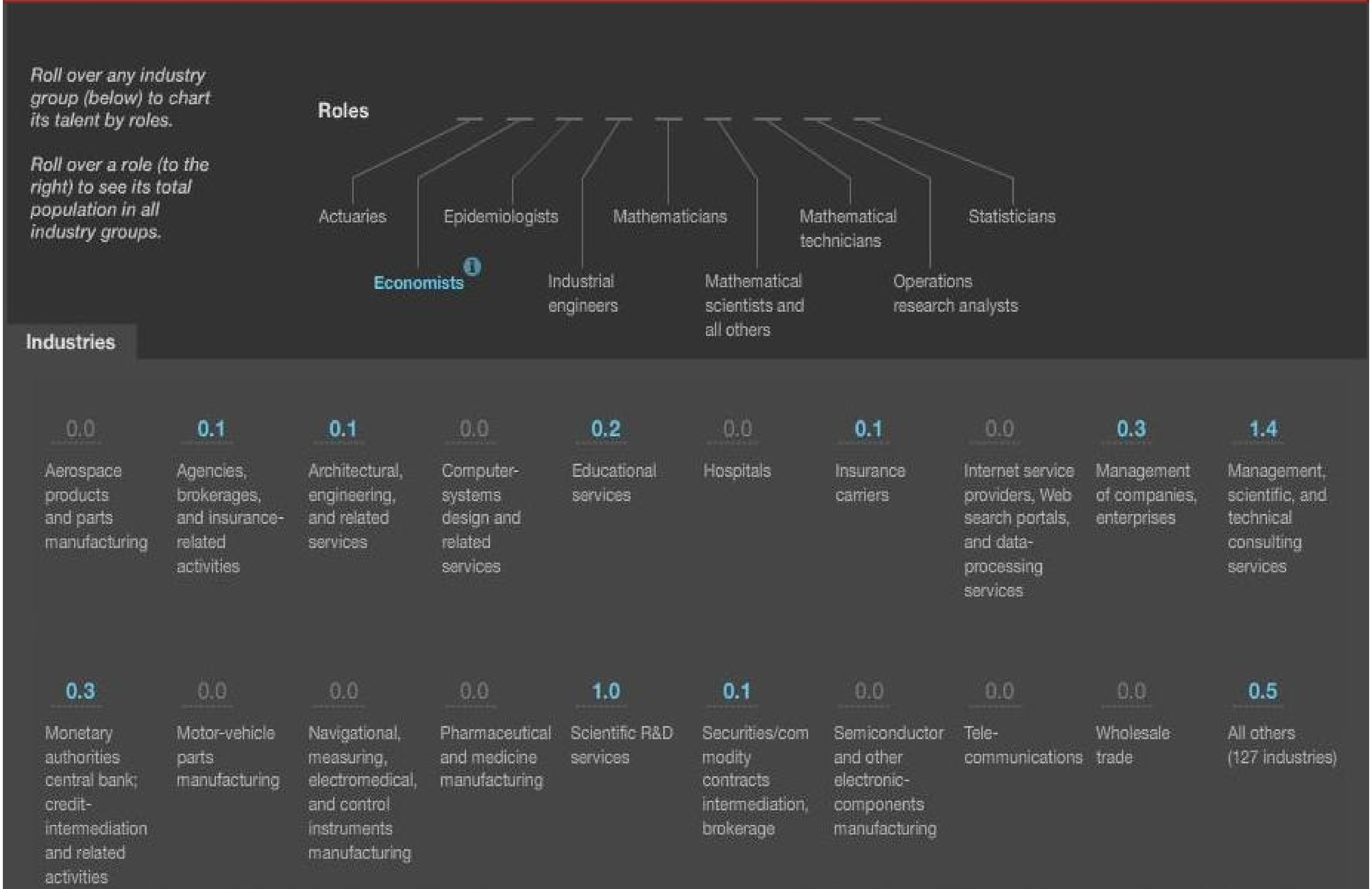
Industries

0.0	Aerospace products and parts manufacturing
2.4	Agencies, brokerages, and insurance-related activities
0.0	Architectural, engineering, and related services
0.0	Computer-systems design and related services
0.0	Educational services
0.1	Hospitals
10.3	Insurance carriers
0.0	Internet service providers, Web search portals, and data-processing services
1.7	Management of companies, enterprises
2.9	Management, scientific, and technical consulting services
0.0	Monetary authorities central bank; credit-intermediation and related activities
0.0	Motor-vehicle parts manufacturing
0.0	Navigational, measuring, electromedical, and control instruments manufacturing
0.0	Pharmaceutical and medicine manufacturing
0.1	Scientific R&D services
0.0	Securities/commodity contracts intermediation, brokerage
0.0	Semiconductor and other electronic-components manufacturing
0.0	Tele-communications
0.0	Wholesale trade
0.5	All others (127 industries)

[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in '000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis

Math-based role: Economists



[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in '000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis

Math-based role: Epidemiologists

Roll over any industry group (below) to chart its talent by roles.

Roll over a role (to the right) to see its total population in all industry groups.

Roles

Actuaries

Economists

Epidemiologists

Industrial engineers

Mathematicians

Mathematical scientists and all others

Mathematical technicians

Operations research analysts

Statisticians

Industries

Aerospace products and parts manufacturing	0.0
Agencies, brokerages, and insurance-related activities	0.0
Architectural, engineering, and related services	0.0
Computer-systems design and related services	0.0
Educational services	0.5
Hospitals	0.9
Insurance carriers	0.0
Internet service providers, Web search portals, and data-processing services	0.0
Management of companies, enterprises	0.0
Management, scientific, and technical consulting services	0.3
Monetary authorities central bank; credit-intermediation and related activities	0.0
Motor-vehicle parts manufacturing	0.0
Navigational, measuring, electromedical, and control instruments manufacturing	0.0
Pharmaceutical and medicine manufacturing	0.1
Scientific R&D services	0.4
Securities/commodity contracts intermediation, brokerage	0.0
Semiconductor and other electronic-components manufacturing	0.0
Tele-communications	0.0
Wholesale trade	0.0
All others (127 industries)	0.1

[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in '000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis

Math-based role: Industrial Engineers

Roll over any industry group (below) to chart its talent by roles.

Roll over a role (to the right) to see its total population in all industry groups.

Roles

- Actuaries
- Economists
- Epidemiologists
- Industrial engineers
- Mathematicians
- Mathematical scientists and all others
- Mathematical technicians
- Operations research analysts
- Statisticians

Industries

3.5	Aerospace products and parts manufacturing
0.1	Agencies, brokerages, and insurance-related activities
2.8	Architectural, engineering, and related services
1.0	Computer-systems design and related services
0.1	Educational services
0.1	Hospitals
0.1	Insurance carriers
0.1	Internet service providers, Web search portals, and data-processing services
0.0	Management of companies, enterprises
0.9	Management, scientific, and technical consulting services
0.0	Monetary authorities central bank; credit-intermediation and related activities
2.5	Motor-vehicle parts manufacturing
2.8	Navigational, measuring, electromedical, and control instruments manufacturing
0.8	Pharmaceutical and medicine manufacturing
1.6	Scientific R&D services
0.0	Securities/commodity contracts intermediation, brokerage
2.5	Semiconductor and other electronic-components manufacturing
0.2	Tele-communications
1.2	Wholesale trade
22.0	All others (127 industries)

[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in '000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis

Mathematicians

Roll over any industry group (below) to chart its talent by roles.

Roll over a role (to the right) to see its total population in all industry groups.

Roles

- Actuaries
- Economists
- Epidemiologists
- Industrial engineers
- **Mathematicians**
- Mathematical scientists and all others
- Mathematical technicians
- Operations research analysts
- Statisticians

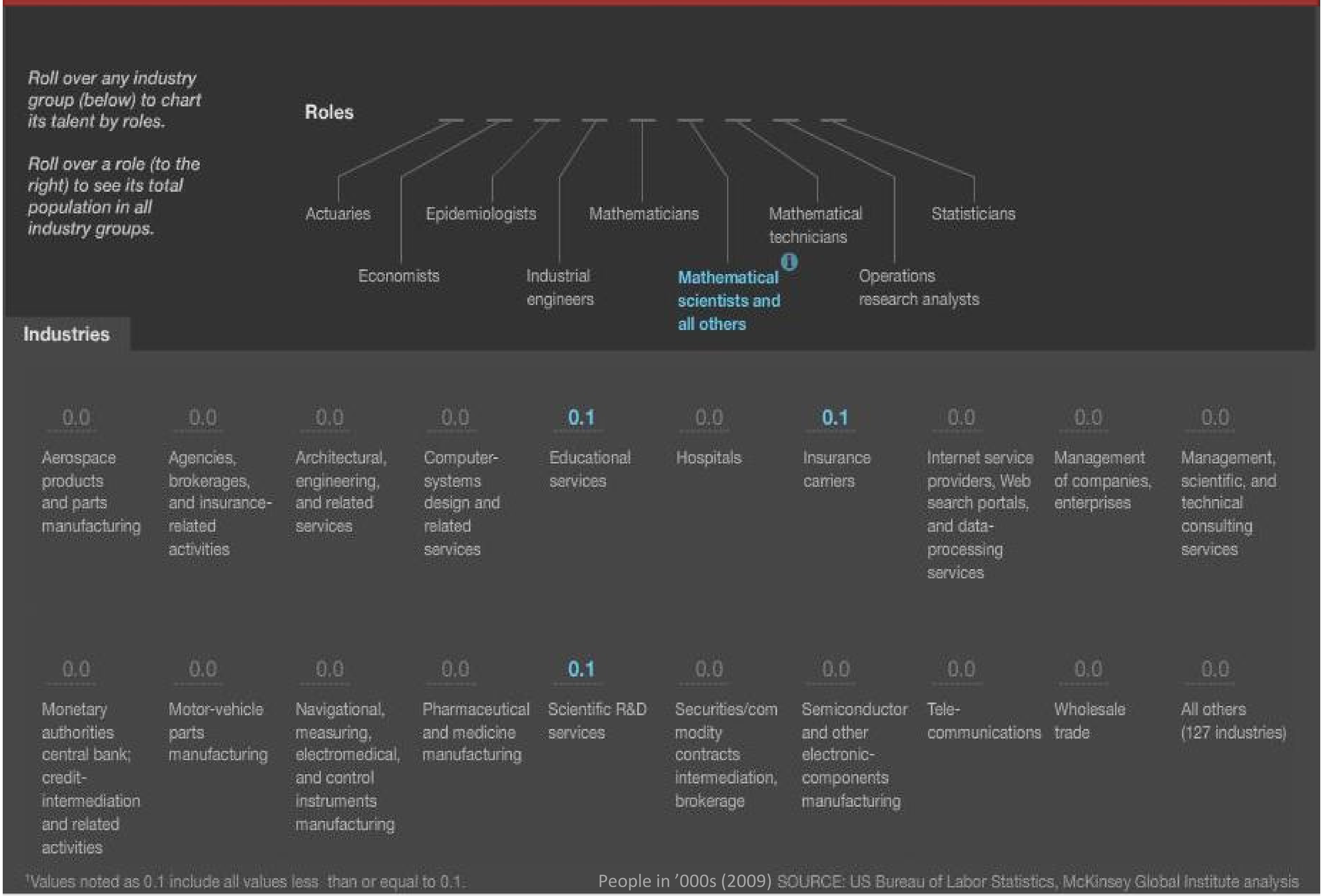
Industries

0.0	Aerospace products and parts manufacturing
0.0	Agencies, brokerages, and insurance-related activities
0.0	Architectural, engineering, and related services
0.1	Computer-systems design and related services
0.1	Educational services
0.0	Hospitals
0.0	Insurance carriers
0.0	Internet service providers, Web search portals, and data-processing services
0.1	Management of companies, enterprises
0.1	Management, scientific, and technical consulting services
0.0	Monetary authorities central bank; credit-intermediation and related activities
0.0	Motor-vehicle parts manufacturing
0.0	Navigational, measuring, electromedical, and control instruments manufacturing
0.0	Pharmaceutical and medicine manufacturing
0.1	Scientific R&D services
0.0	Securities/commodity contracts intermediation, brokerage
0.0	Semiconductor and other electronic-components manufacturing
0.0	Tele-communications
0.0	Wholesale trade
0.1	All others (127 industries)

[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in ’000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis

Math-based role: Mathematical Scientists



Math-based role: Mathematical Technicians

Roll over any industry group (below) to chart its talent by roles.

Roll over a role (to the right) to see its total population in all industry groups.

Roles

- Actuaries
- Economists
- Epidemiologists
- Industrial engineers
- Mathematicians
- Mathematical scientists and all others
- Mathematical technicians
- Operations research analysts
- Statisticians

Industries

Aerospace products and parts manufacturing	0.0
Agencies, brokerages, and insurance-related activities	0.0
Architectural, engineering, and related services	0.1
Computer-systems design and related services	0.1
Educational services	1.0
Hospitals	0.0
Insurance carriers	0.1
Internet service providers, Web search portals, and data-processing services	0.0
Management of companies, enterprises	0.0
Management, scientific, and technical consulting services	0.1
Monetary authorities central bank; credit-intermediation and related activities	0.0
Motor-vehicle parts manufacturing	0.0
Navigational, measuring, electromedical, and control instruments manufacturing	0.0
Pharmaceutical and medicine manufacturing	0.0
Scientific R&D services	0.1
Securities/commodity contracts intermediation, brokerage	0.0
Semiconductor and other electronic-components manufacturing	0.0
Tele-communications	0.0
Wholesale trade	0.0
All others (127 industries)	0.0

[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in '000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis

Math-based role: Operations Research

Roll over any industry group (below) to chart its talent by roles.

Roll over a role (to the right) to see its total population in all industry groups.

Roles

- Actuaries
- Economists
- Epidemiologists
- Industrial engineers
- Mathematicians
- Mathematical scientists and all others
- Mathematical technicians
- **Operations research analysts**
- Statisticians

Industries

0.8	Aerospace products and parts manufacturing
0.7	Agencies, brokerages, and insurance-related activities
1.0	Architectural, engineering, and related services
6.4	Computer-systems design and related services
3.5	Educational services
1.9	Hospitals
5.1	Insurance carriers
2.9	Internet service providers, Web search portals, and data-processing services
5.7	Management of companies, enterprises
6.5	Management, scientific, and technical consulting services
6.3	Monetary authorities central bank; credit-intermediation and related activities
0.4	Motor-vehicle parts manufacturing
0.6	Navigational, measuring, electromedical, and control instruments manufacturing
0.9	Pharmaceutical and medicine manufacturing
2.7	Scientific R&D services
1.6	Securities/commodity contracts intermediation, brokerage
0.6	Semiconductor and other electronic-components manufacturing
3.6	Tele-communications
1.3	Wholesale trade
8.5	All others (127 industries)

[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in '000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis

Math-based role: Statisticians

Roll over any industry group (below) to chart its talent by roles.

Roll over a role (to the right) to see its total population in all industry groups.

Roles

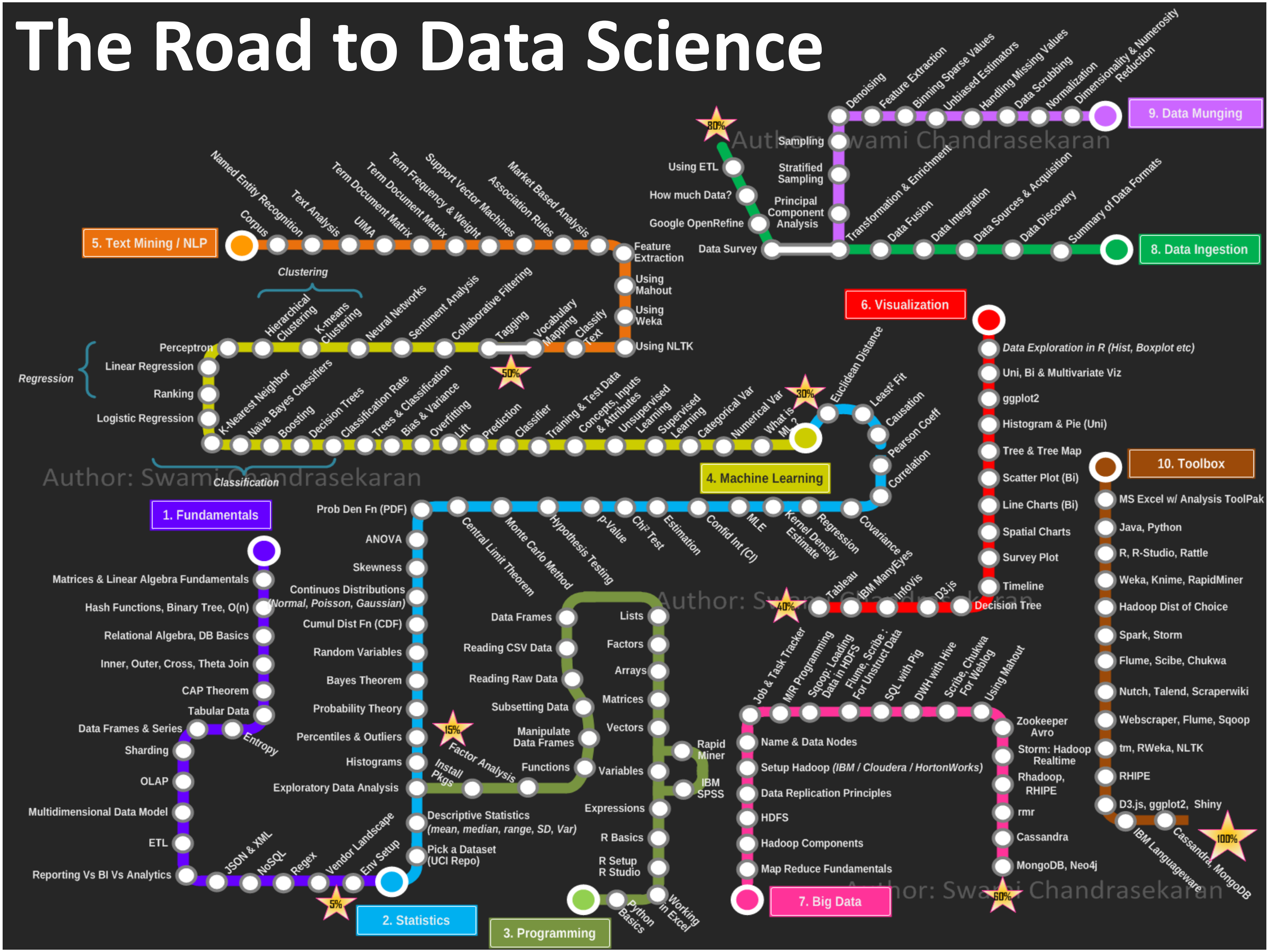
Actuaries, Economists, Epidemiologists, Industrial engineers, Mathematicians, Mathematical scientists and all others, Mathematical technicians, Operations research analysts, **Statisticians**

Industries

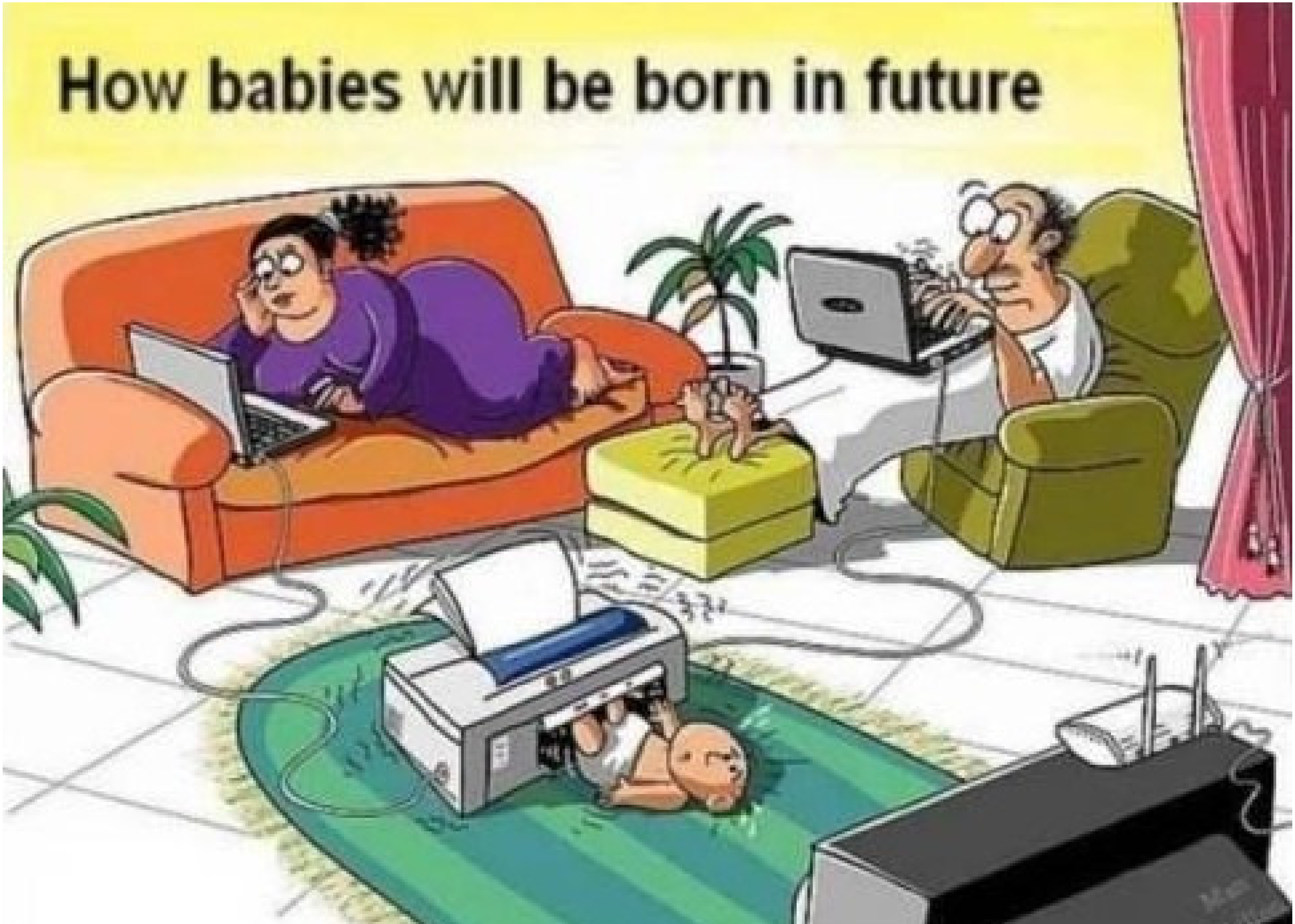
0.0	Aerospace products and parts manufacturing
0.6	Agencies, brokerages, and insurance-related activities
0.2	Architectural, engineering, and related services
0.5	Computer-systems design and related services
3.2	Educational services
1.9	Hospitals
2.6	Insurance carriers
0.4	Internet service providers, Web search portals, and data-processing services
1.5	Management of companies, enterprises
0.9	Management, scientific, and technical consulting services
0.5	Monetary authorities central bank; credit-intermediation and related activities
0.0	Motor-vehicle parts manufacturing
0.0	Navigational, measuring, electromedical, and control instruments manufacturing
1.8	Pharmaceutical and medicine manufacturing
4.8	Scientific R&D services
0.1	Securities/commodity contracts intermediation, brokerage
0.0	Semiconductor and other electronic-components manufacturing
0.0	Tele-communications
0.0	Wholesale trade
2.6	All others (127 industries)

[1]Values noted as 0.1 include all values less than or equal to 0.1.

People in '000s (2009) SOURCE: US Bureau of Labor Statistics, McKinsey Global Institute analysis


The Road to Data Science
Author: Swami Chandrasekaran
1. Fundamentals
Matrices & Linear Algebra Fundamentals
Hash Functions, Binary Tree, O(n)
Relational Algebra, DB Basics
Inner, Outer, Cross, Theta Join
CAP Theorem
Tabular Data
Entropy
Data Frames & Series
Sharding
OLAP
Multidimensional Data Model
ETL
Reporting Vs BI Vs Analytics
JSON & XML
NoSQL
Regex
Vendor Landscape
Env Setup
5%
2. Statistics
Pick a Dataset (UCI Repo)
Descriptive Statistics (mean, median, range, SD, Var)
Exploratory Data Analysis
Histograms
Percentiles & Outliers
Probability Theory
Bayes Theorem
Random Variables
Cumul Dist Fn (CDF)
Continuos Distributions (Normal, Poisson, Gaussian)
Skewness
ANOVA
Prob Den Fn (PDF)
Central Limit Theorem
Monte Carlo Method
Hypothesis Testing
P-Value
Chi² Test
Estimation
Confid Int (CI)
MLE
Kernel Density Estimate
Regression
Covariance
Correlation
Pearson Coeff
Causation
Least² Fit
Euclidean Distance
3. Programming
Python Basics
Working in Excel
R Setup R Studio
R Basics
Expressions
Variables
IBM SPSS
Rapid Miner
Vectors
Matrices
Arrays
Factors
Lists
Data Frames
Reading CSV Data
Reading Raw Data
Subsetting Data
Manipulate Data Frames
Functions
Factor Analysis
Install Pkgs
15%
4. Machine Learning
What is ML ?
Numerical Var
Categorical Var
Supervised Learning
Unsupervised Learning
Concepts, Inputs & Attributes
Training & Test Data
Classifier
Prediction
Lift
Overfitting
Bias & Variance
Trees & Classification
Classification Rate
Decision Trees
Boosting
Naïve Bayes Classifiers
K-Nearest Neighbor
Classification
Logistic Regression
Ranking
Linear Regression
Regression
Perceptron
Hierarchical Clustering
K-means Clustering
Clustering
Neural Networks
Sentiment Analysis
Collaborative Filtering
Tagging
30%
50%
5. Text Mining / NLP
Corpus
Named Entity Recognition
Text Analysis
UIMA
Term Document Matrix
Term Frequency & Weight
Support Vector Machines
Association Rules
Market Based Analysis
Feature Extraction
Using Mahout
Using Weka
Using NLTK
Classify Text
Vocabulary Mapping
6. Visualization
Data Exploration in R (Hist, Boxplot etc)
Uni, Bi & Multivariate Viz
ggplot2
Histogram & Pie (Uni)
Tree & Tree Map
Scatter Plot (Bi)
Line Charts (Bi)
Spatial Charts
Survey Plot
Timeline
Decision Tree
D3.js
InfoVis
IBM ManyEyes
Tableau
40%
7. Big Data
Map Reduce Fundamentals
Hadoop Components
HDFS
Data Replication Principles
Setup Hadoop (IBM / Cloudera / HortonWorks)
Name & Data Nodes
Job & Task Tracker
M/R Programming
Sqoop: Loading Data in HDFS
Flume, Scribe: For Unstruct Data
SQL with Pig
DWH with Hive
Scribe, Chukwa For Weblog
Using Mahout
Zookeeper Avro
Storm: Hadoop Realtime
Rhadoop, RHIPE
rmr
Cassandra
MongoDB, Neo4j
60%
8. Data Ingestion
Summary of Data Formats
Data Discovery
Data Sources & Acquisition
Data Integration
Data Fusion
Transformation & Enrichment
Data Survey
Google OpenRefine
How much Data?
Using ETL
80%
9. Data Munging
Dimensionality & Numerosity Reduction
Normalization
Data Scrubbing
Handling Missing Values
Unbiased Estimators
Binning Sparse Values
Feature Extraction
Denoising
Sampling
Stratified Sampling
Principal Component Analysis
10. Toolbox
MS Excel w/ Analysis ToolPak
Java, Python
R, R-Studio, Rattle
Weka, Knime, RapidMiner
Hadoop Dist of Choice
Spark, Storm
Flume, Scibe, Chukwa
Nutch, Talend, Scraperwiki
Webscraper, Flume, Sqoop
tm, RWeka, NLTK
RHIPE
D3.js, ggplot2, Shiny
IBM Languageware
Cassandra, MongoDB
100%

Data driven decisions with target the message and marketing will morph

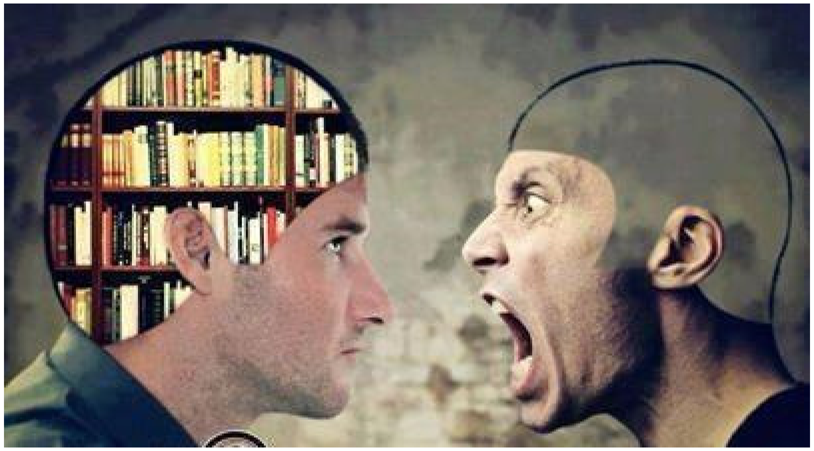


Is this a likely solution to ameliorate our lives or alleviate the endemic anathema for mathematics fueling the increasing skills gap (chasm) in US ?

How baby-sitting will be automated in the future …

The Third Industrial Revolution cannot progress under any ‘boss’ → it needs leaders

Optimizing the signal to noise ratio is key to determining the measurable impact of the industrial internet



Empty vessels make the most noise

WORK IN PROGRESS

CYBER-PHYSICAL SYSTEMS

∑(nCPS)

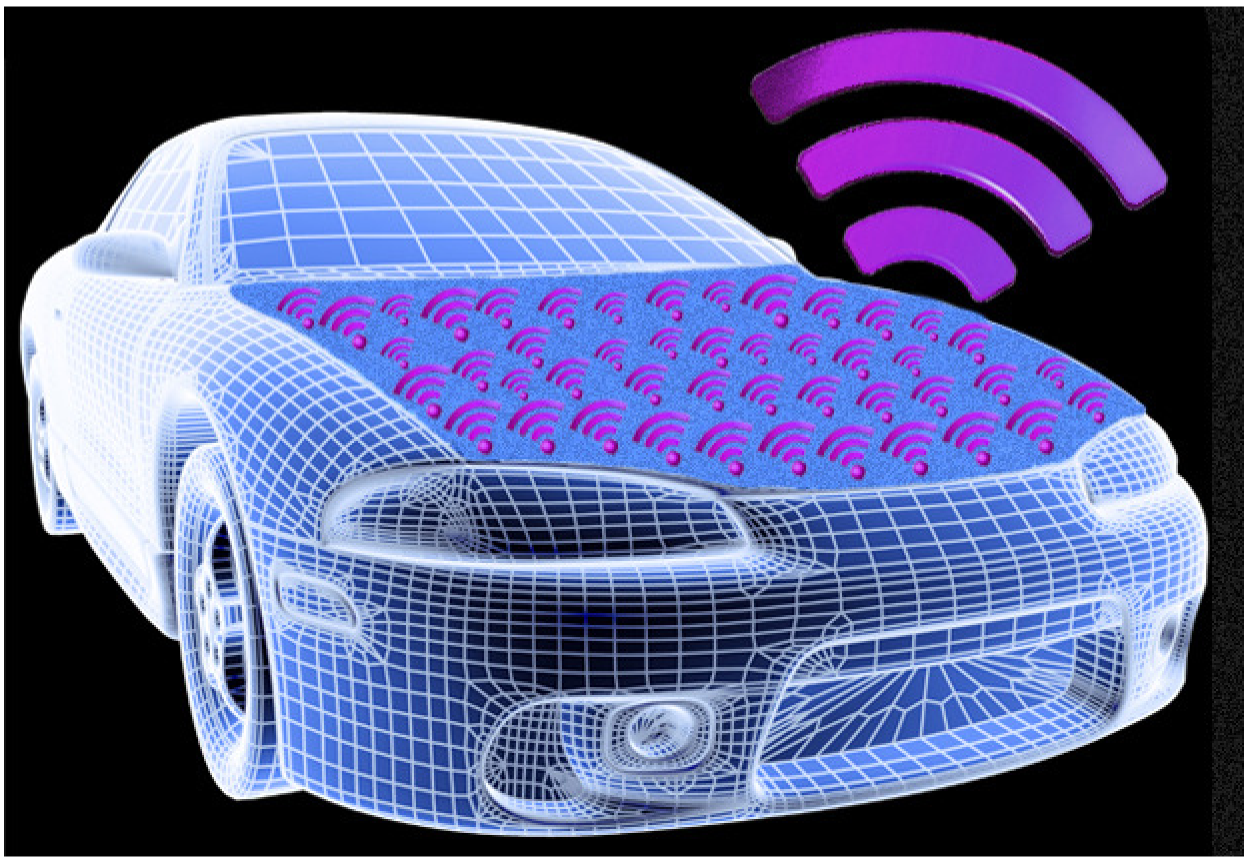
Economic Value from the Management of Information Entropy and Application of the Cybernetics Approach

Introducing

CYBER-PHYSICAL SYSTEMS

Grossly OVER-SIMPLIFIED VERSION SUITABLE MERELY AS A FIRST LOOK for the UNINITIATED

$\sum$(nCPS)



∑(nCPS)

THIS DOCUMENT IS PURELY FOR AN ELEMENTARY LEVEL INTRODUCTION to differentiate between the popular concept of “time” in so-called “real-time” events that we associate with internet of things [IoT] versus critical time centricity necessary for time guarantees in true cyber-physical systems. In some instances, CPS may overlap with industrial internet events where time assurances are vital (eg: healthcare or jet engine monitoring in-flight). This document, in subsequent versions, will address “time” issues with greater clarity with respect to some of the topics mentioned in the document. References to CPS related activities in EU and elsewhere is provided to indicate that CPS and the industrial internet are global advances where trust, transparency, security and standards are quintessential for progress. This is a tutorial for people to get acquainted with CPS. This is not a marketing tool. This is a collection of ideas from various sources and does not include any original research by the author. You may share this document without any restrictions. Email comments to shoumendatta@gmail.com

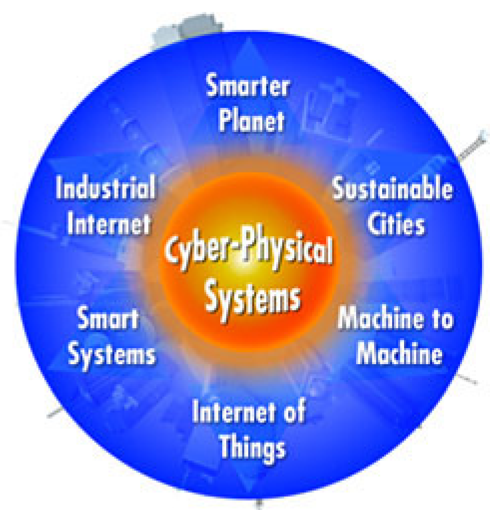
The Industrial Internet of Things for a Smarter Planet ?

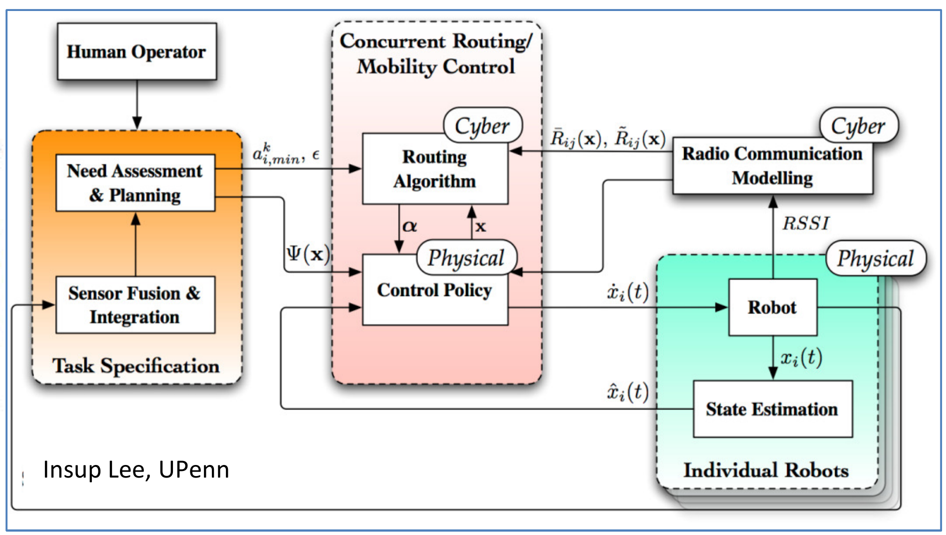
industrial
Internet of Things

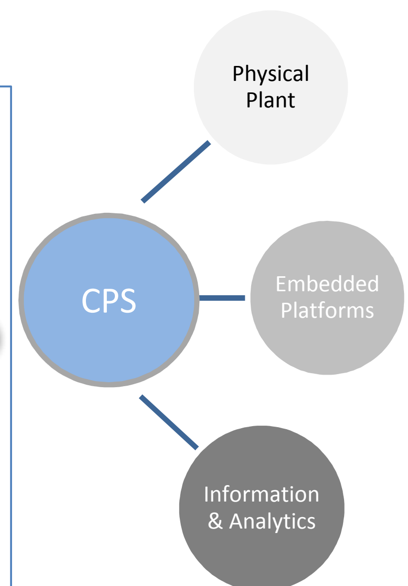
Autonomy of physical objects to communicate and respond to feedback from internal and external data via the internet presents potential for developing classes of networked cyberphysical systems (nCPS). It may offer new economic value for various industries. The connected confluence of objects, data and decisions may catalyze the emergence of the internet of humanity (IoH) to improve the quality of our lives.

The Industrial Internet   Cyber-Physical Systems

- Cyber-Physical Systems – term was coined by Dr Helen Gill (2006, NSF)
- Orchestration of networked computational resources with physical systems (EAL)
- Integration of information processing in and with physical environment or systems
- CPS builds on Embedded Systems and ICT (conjunction of physical and computational dynamics with software and network of sensors/actuators)

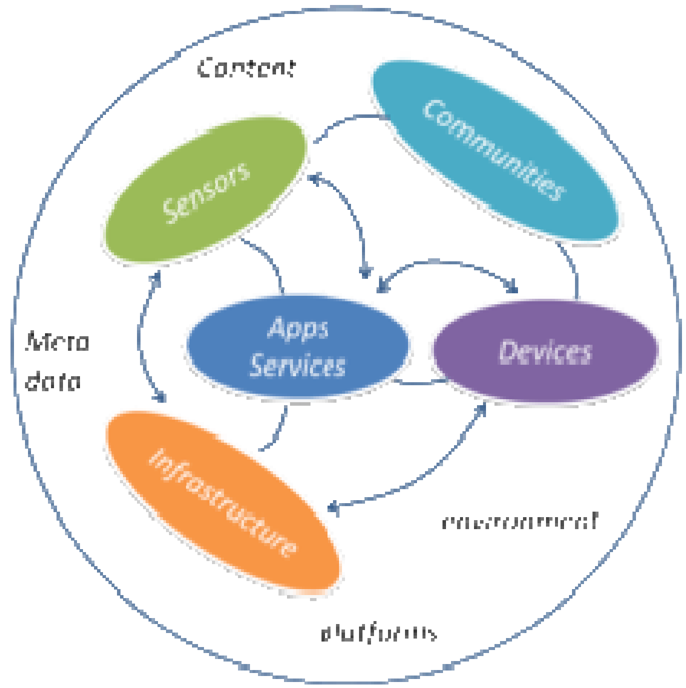


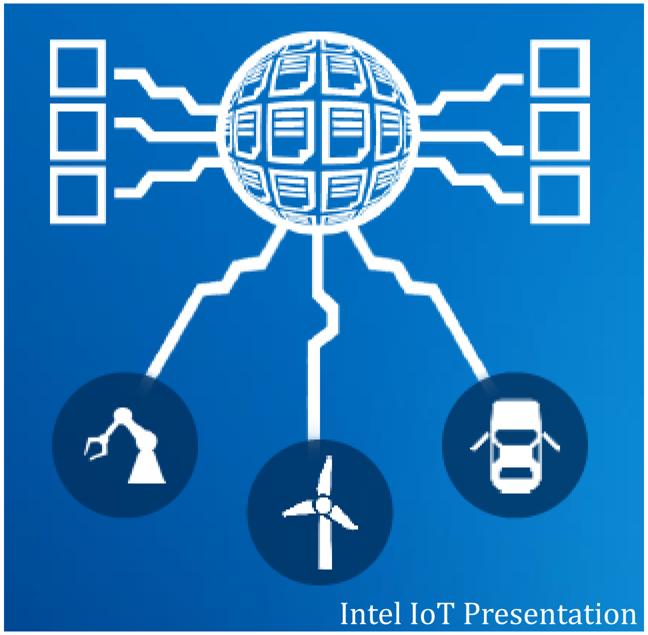




The Industrial Internet

- Modus Operandi
- Key Components
- Strategic Elements
  - Demonstrate
  - Duplicate
  - Disseminate
  - Productize / Integration
  - Standardize / Standardization
  - Commoditize / Implementation
- US Progress
- EU Advances
- Other Groups



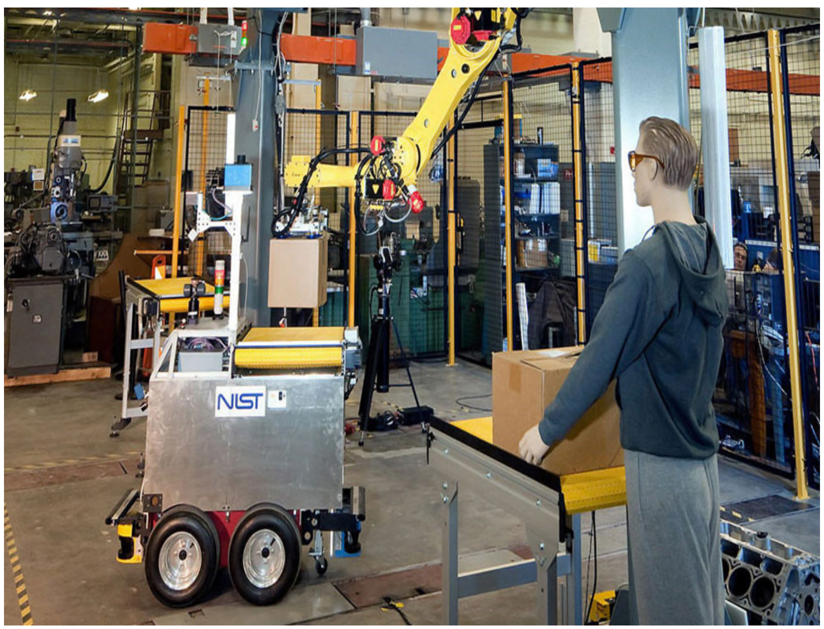


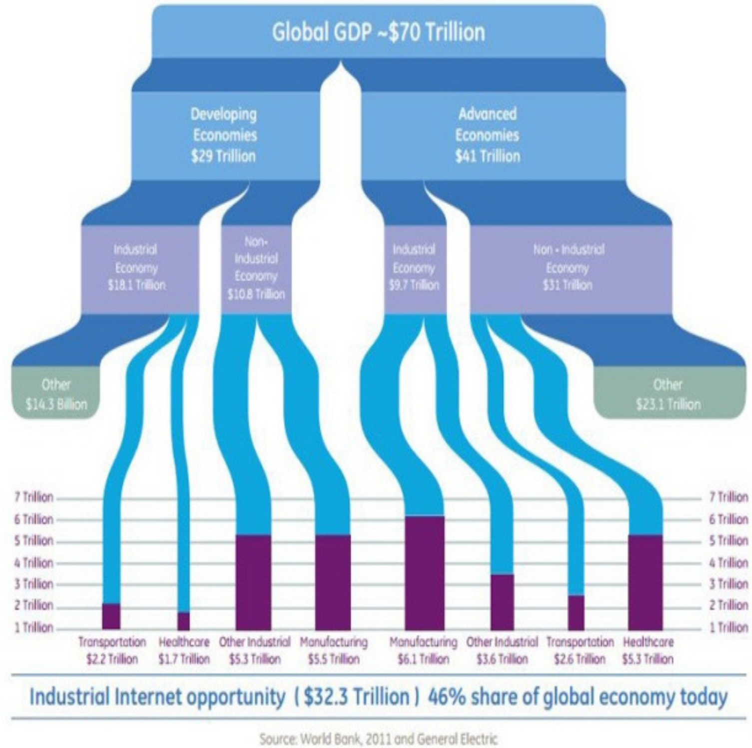
Intel IoT Presentation

The Industrial Internet

Create Economic Value

- **Demonstrate**
- **Duplicate**
- **Disseminate**





- **Productize / Integration**
- **Standardize / Standardization**
- **Commoditize / Implementation**

The Industrial Internet

- Network
- [n] Cyber Physical Systems (*nmc/mc*)
- Co-Engineering Systems of Ecosystems
- Standardization / Virtualization
- Cybersecurity
- Privacy

[nCPS] Components

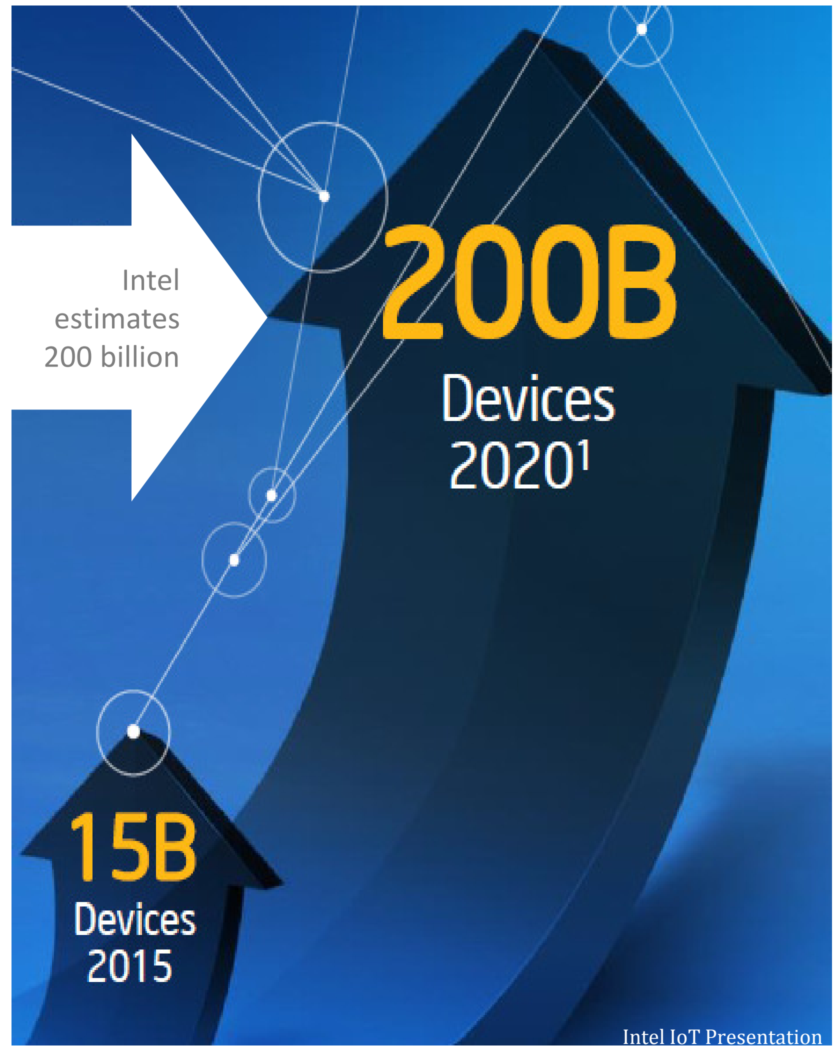
- Sensors / mesh networks, self-organizing
- Embedded Systems / Transducer, Actuator
- Query, Data, Information, Analytics,
- Integrating Semantics of Time (RTOS)
- Autonomous Feedback Regulation
- Model Driven Engineering / Architecture
- Systems Interoperability Standards / Tools
- Application and Economic Analyses / EVA

The Industrial Internet

- **Demonstrate**

Demonstrate : *Back drop*

- Heard on the Hill …
- Internet of Everything is the next evolution of the Internet, connecting people, processes, data and things.
- Cisco predicts by 2015 there will be 25 billion devices connected to the internet and 50 billion by 2050. An estimated $14.4 trillion at stake for global businesses over the next decade.
- GE estimates the Industrial Internet will save $150 billion pa from efficiency gains.
- Internet of Everything will lead to new lines of business and job creation.



Demonstrate : *Policy Issues*

- **Spectrum** More required. War over spectrum (gov versus public and private sectors).

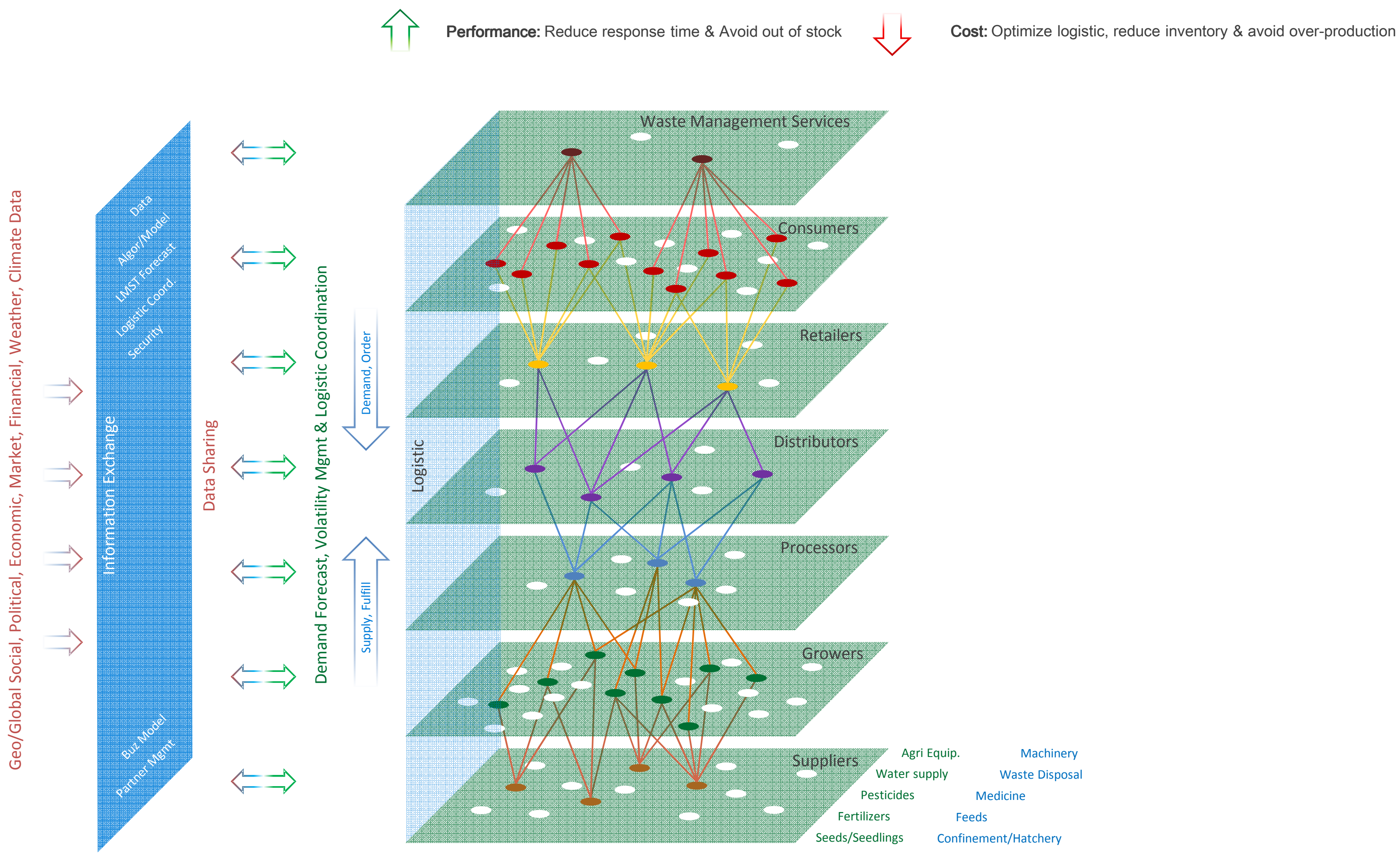
- **Privacy & Security** Requires global interoperable concepts (balance/accommodate local cultures, governance structures). Avoid focusing on hypothetical or imagined distress.

- **Standardization & Interoperability** Open standards necessary for devices, machines (D2D/M2M/V2V/O2O) and communications (data) technologies. To be driven by industry utilizing current global standards-setting organizations in collaboration with global industries, agencies, organizations, governments in trusted collaborations.

Demonstrate : *Test Bed*

- Design select domains to demonstrate
- End-2-End Test Bed Scenarios
  - Manufacturing (auto, fab, military)
  - Aerospace Maintenance
  - Healthcare Monitoring
  - Energy Efficiency
  - Oil and Gas
  - Logistics
  - Finance
  - Retail
- Map Domains
  - Map domains to industry / partner
  - Map scenario to partner WIP
  - Integration Gap Analysis
  - Resources / BOM
  - Work packages
  - Funding
  - Build
  - Test

Demonstrate : *Test Bed Example*



Dr Shi-Wan Lin, Intel

Demonstrate : *Test Bed Transition to Deployment*

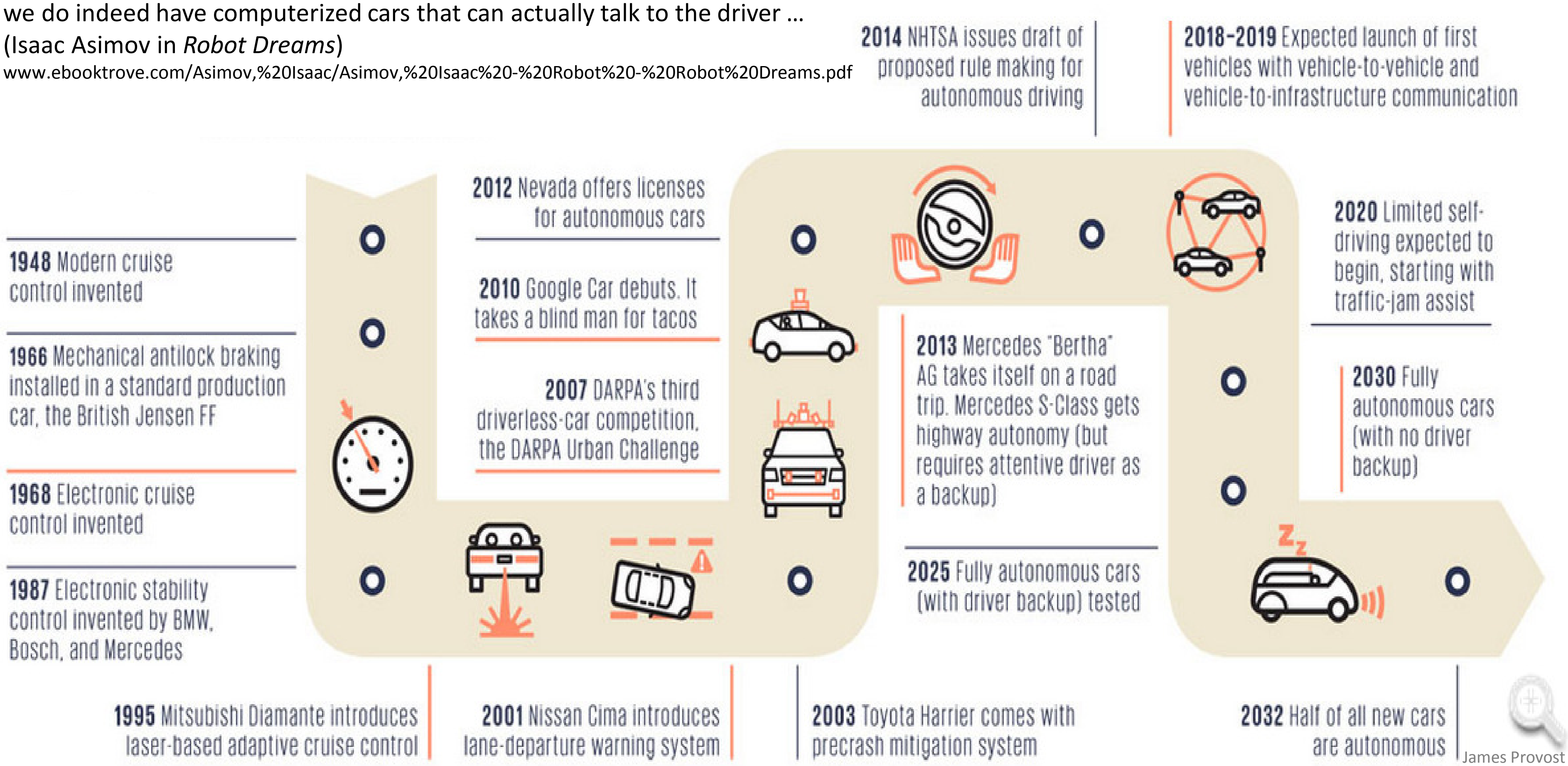
- Public Space Deployment Scenario

  Refrigerated truck transporting cargo containers with perishable grocery arrives at an intermodal operation (for transportation by sea or air or rail or cross-dock)

  - *Driver disembarks prior to entering security perimeter*
  - *Truck shifts to autonomous mode and enters secure zone*
  - *Unloads / uploads cargo (informs supply chain partners)*
  - *Exits secure zone and arrives at a Hilton to pick-up driver*
  - *Truck driver continues to warehouse / distribution center*

Can we deploy semi-autonomous freight transportation ?

… in my story "Sally," published in 1953, I described computerized cars that had almost reached the stage of having lives of their own. And, in the last few years, we do indeed have computerized cars that can actually talk to the driver …
(Isaac Asimov in *Robot Dreams*)
www.ebooktrove.com/Asimov,%20Isaac/Asimov,%20Isaac%20-%20Robot%20-%20Robot%20Dreams.pdf



In 2002, transportation-related goods & services accounted for more than ten percent (over $1 trillion) of US GDP [www.rita.dot.gov/bts/programs/freight_transportation/html/transportation.html]

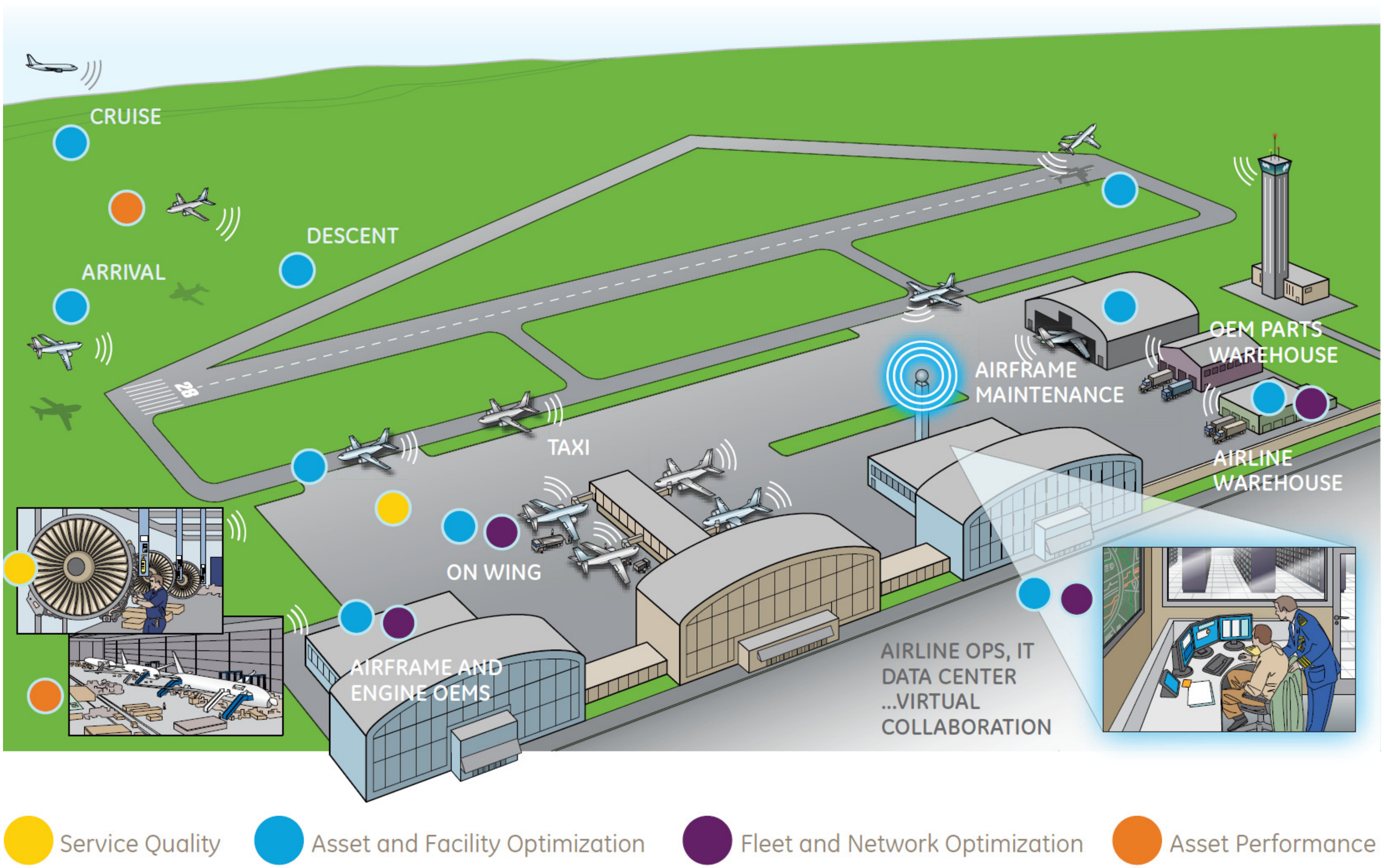
Semi-Autonomous Transportation – connecting atoms (cargo and goods via land, sea and air) with bits (data)

- Highly granular micro-localization of goods movement between various nodes and modes
- Intra-container visibility and tamper-proofing / tamper-evidence (data via 5G network devices)
- Sequential check of bill of lading and tracking (compliant with SOX-409 / DHS CBP e-manifests)

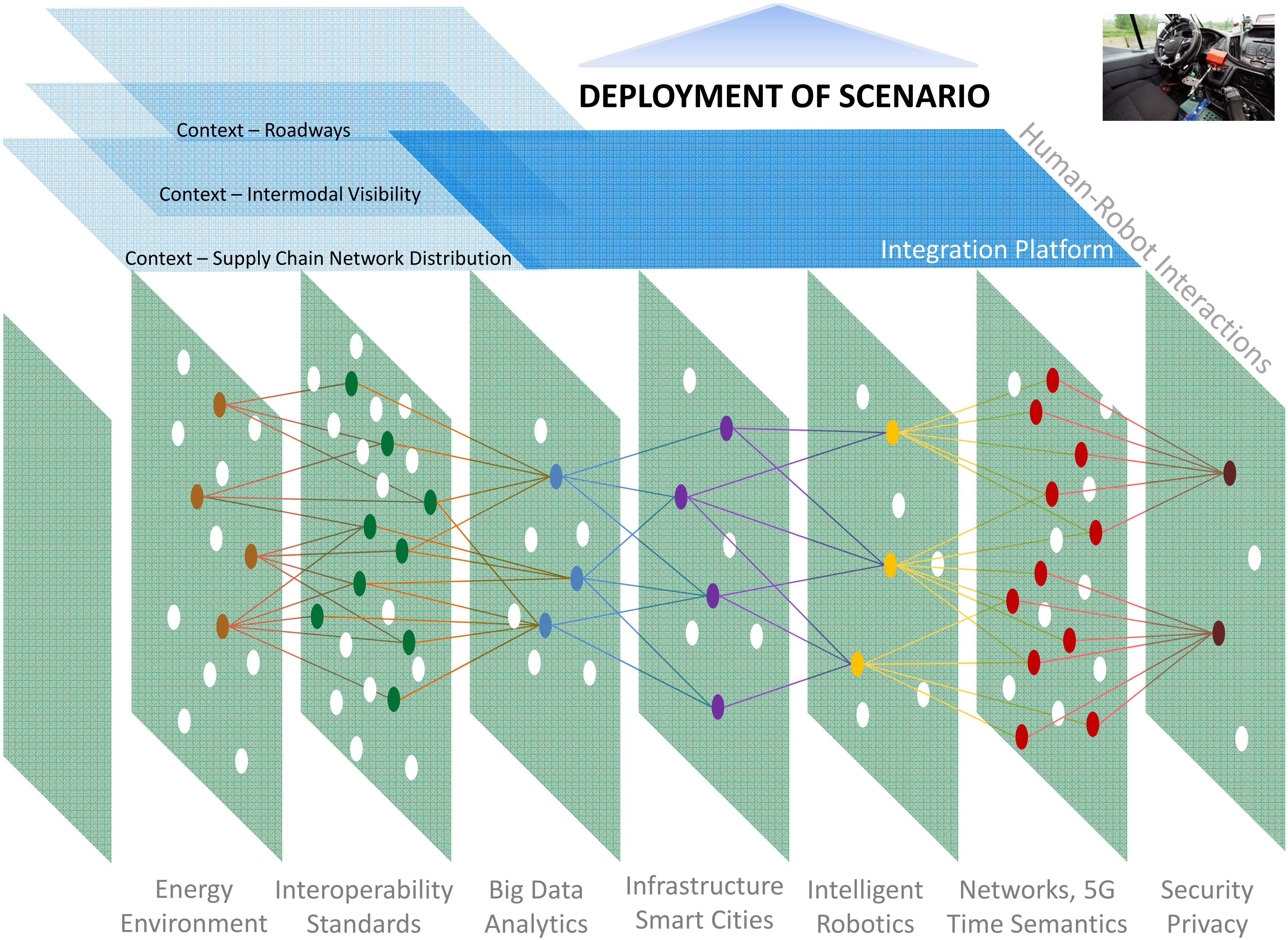
Autonomous Transportation – connect to freight and global container track and trace (goods transparency)

Autonomous Transportation – Air Freight Forwarding

Asset optimization, security enhancement and supply chain visibility



Dr Peter Closson Evans (GE Global Strategy and Analytics, 2013)



DEPLOYMENT OF SCENARIO
Context – Roadways
Context – Intermodal Visibility
Context – Supply Chain Network Distribution
Integration Platform
Human-Robot Interactions
Energy Environment
Interoperability Standards
Big Data Analytics
Infrastructure Smart Cities
Intelligent Robotics
Networks, 5G Time Semantics
Security Privacy

Semi-Autonomous Freight Transportation

- Pragmatic Perspectives
  - Standards based transportation solutions catalytic to global economic growth
  - Pragmatic solution to really “grand” problems with socio-economic impact
  - Real world test bed must transition to real world implementation which can be replicated across various contexts (context of warehouse, highways, airports)
  - Solutions leading to new lines of business growth, new products and services which will create new jobs which will exceed job loss due to automation
  - Solution created by industry-academia-government cooperative supporting interoperability and standardization across multiple global stakeholders
  - Solutions exhibiting optimization of multi-disciplinary convergence (security, performance, feasibility) with future smart city infrastructure
  - Solution must be evaluated for industry impact and cost effectiveness using key performance indicators to develop benchmarking tools and guiding metrics

Semi-Autonomous Freight Transportation

- R&D (basic principles with applications relevant to transport)
  - Language and representation of model based development
  - Interoperability with legacy code and model driven architecture (models written in code vs models developed by simulation)
  - Immersive prototyping of the environment and the interaction of the object with the environment (creating deterministic models using simulation)
  - Time synchronization of multiple objects (robots, drones, vehicles, cargo containers)
  - Autonomous objects and human interactions in collaborative environments
  - Convergence of robotics (autonomous objects) with networking (spectrum, bandwidth, latency, standards and protocols) and what happens to the data in the system
  - Real-time vs run-time cybersecurity (threat matrix evaluation, intruder detection and repulsion) using time + context integrated algorithms (HTM)
  - Human learning captured to aid and improve machine learning precision used in conjunction with ANN algorithms such as hierarchical temporal memory (HTM) cortical learning algorithms (CLA)

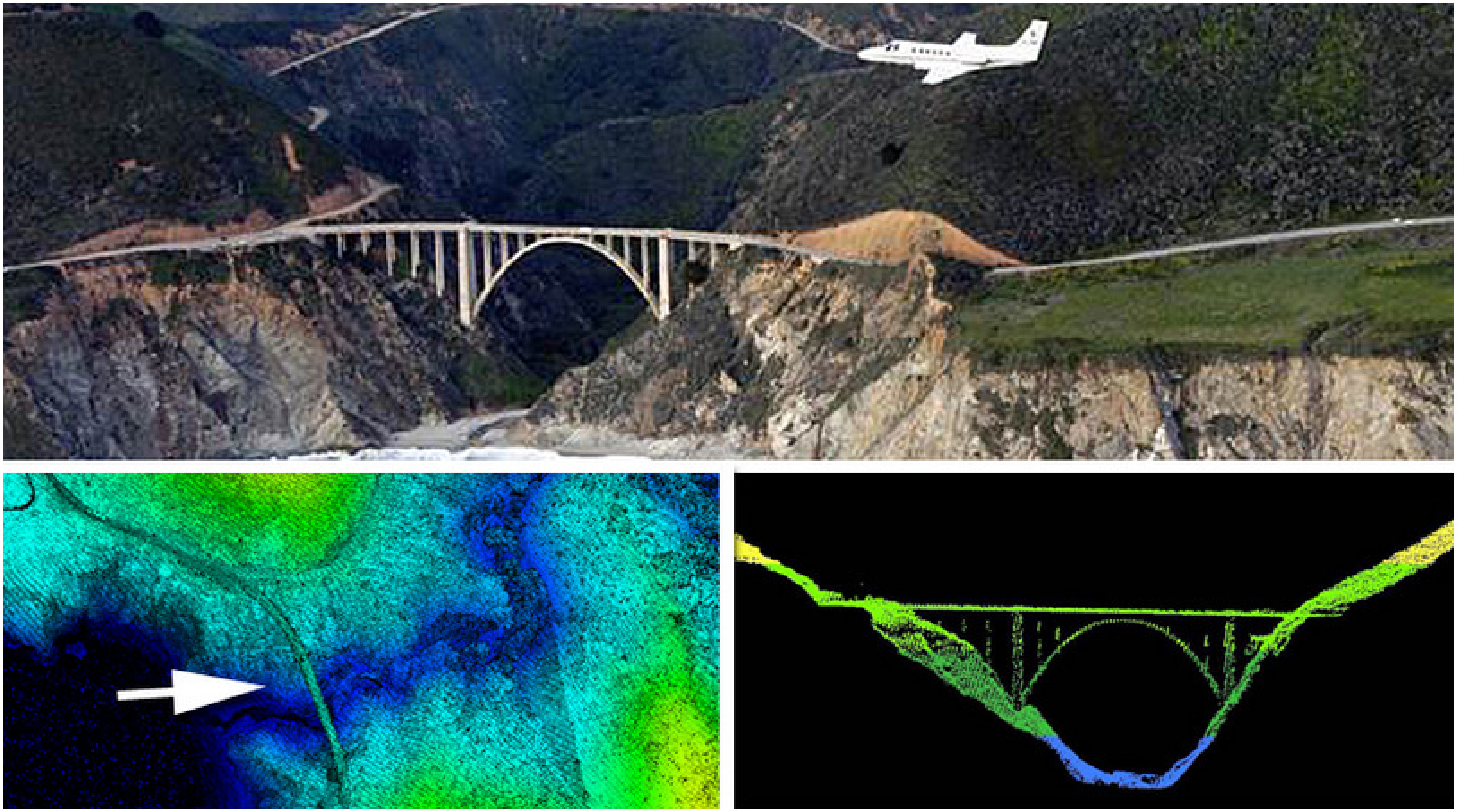
Semi-Autonomous Freight Transportation

- Industry seeks solutions for business development
  - Abstraction of the operating system “brain” to the level of PnP
  - PnP to convert manual vehicles to semi-autonomous objects
  - High definition 3D point cloud and LIDAR maps which can be downloaded as street maps for human view (eg Google maps) and enables autonomous vehicles to “see” the “streetlet” view (in the future - Google map for any autonomous vehicle or object)
  - Monetization of data and analytics
  - Savings from economies of efficiencies

Complex Urban Mission Testbed

HD 3D Point Cloud for Immersive Mapping of road segmentation, obstacle detection, situation awareness, uncertainty estimation

LIDAR is one part of the HD 3D Point Cloud for Immersive Mapping



LIDAR data is often collected by air, such as with this NOAA survey aircraft (top) over Bixby Bridge in Big Sur, Calif. Here, LIDAR data reveals a top-down (bottom left) and profile view of Bixby Bridge. NOAA scientists use LIDAR-generated products to examine both natural and manmade environments. LIDAR data supports activities such as inundation and storm surge modeling, hydrodynamic modeling, shoreline mapping, emergency response, hydrographic surveying, and coastal vulnerability analysis.

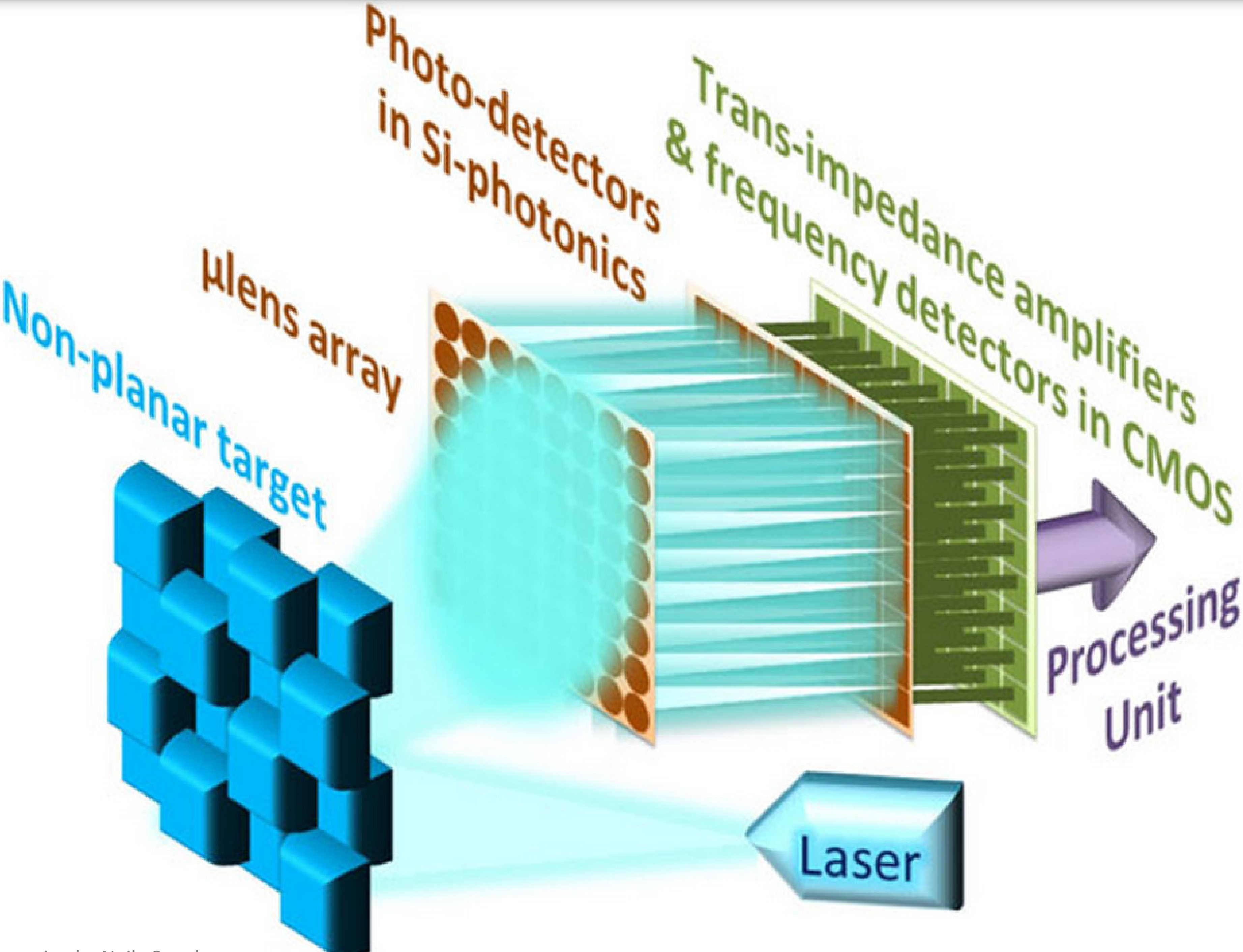
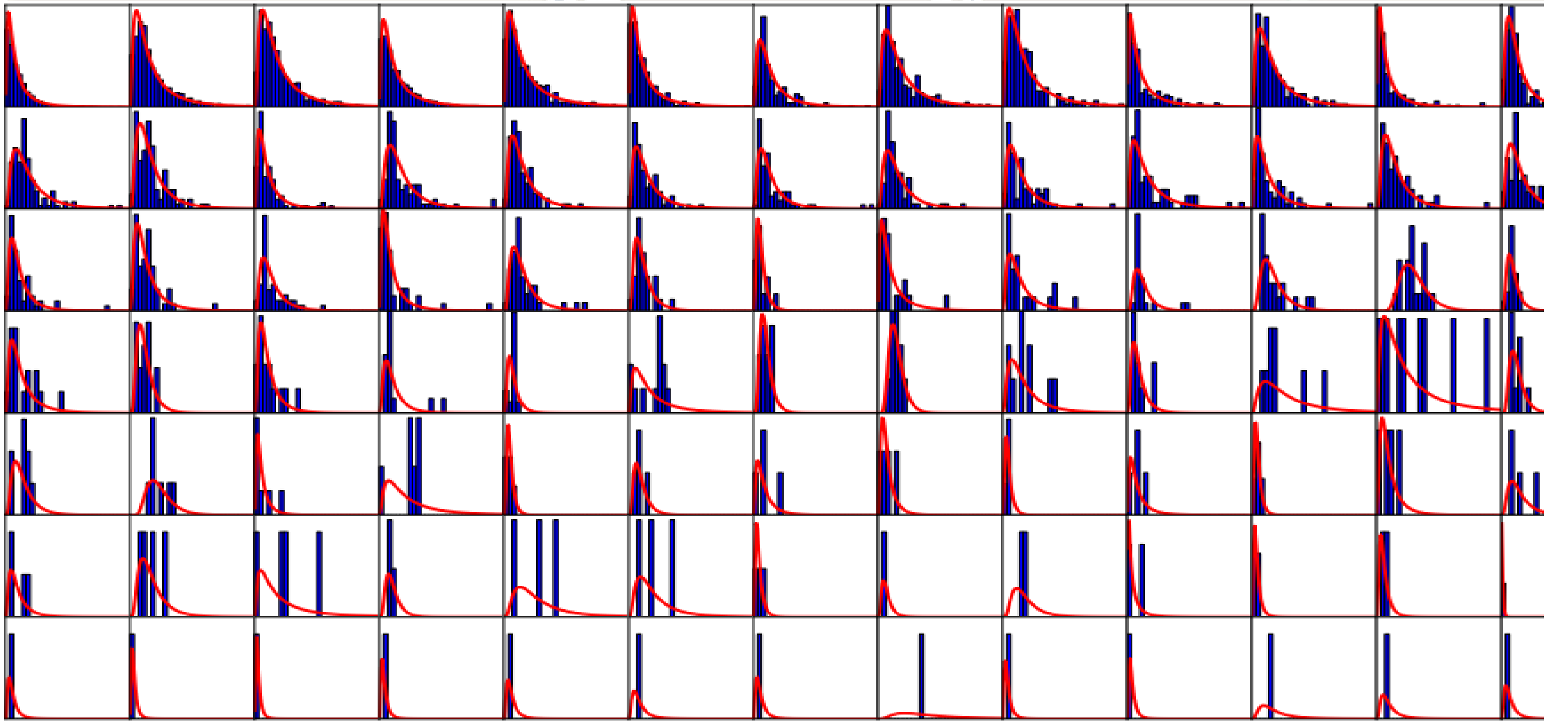


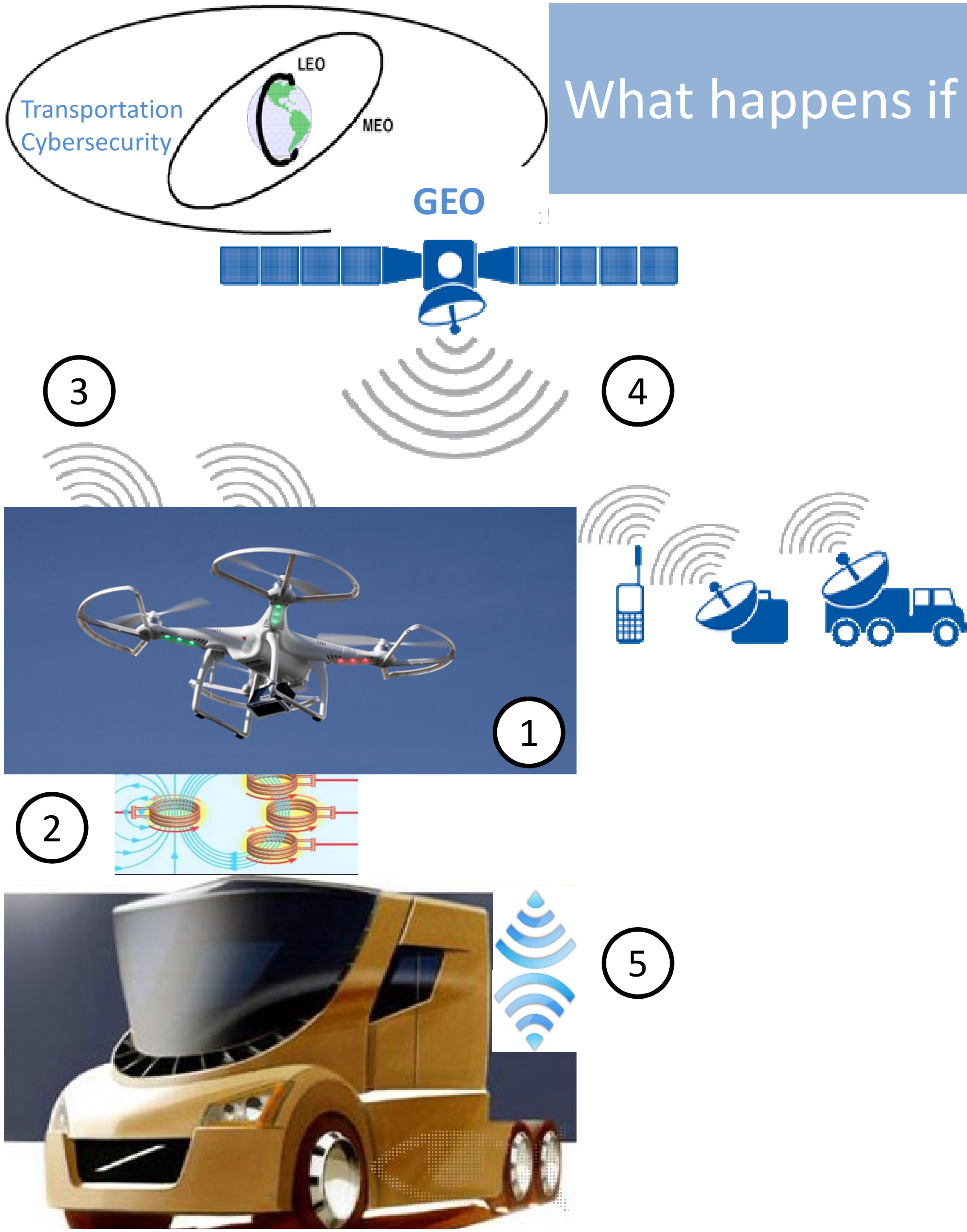
Illustration by Neils Quack

Streets

Streetlets



What happens if the network is disrupted ?



Truck equipped with **Droneport**

- [1] Drones on board using HACMS and fitted with UWB transceivers to create *ad hoc* radio network

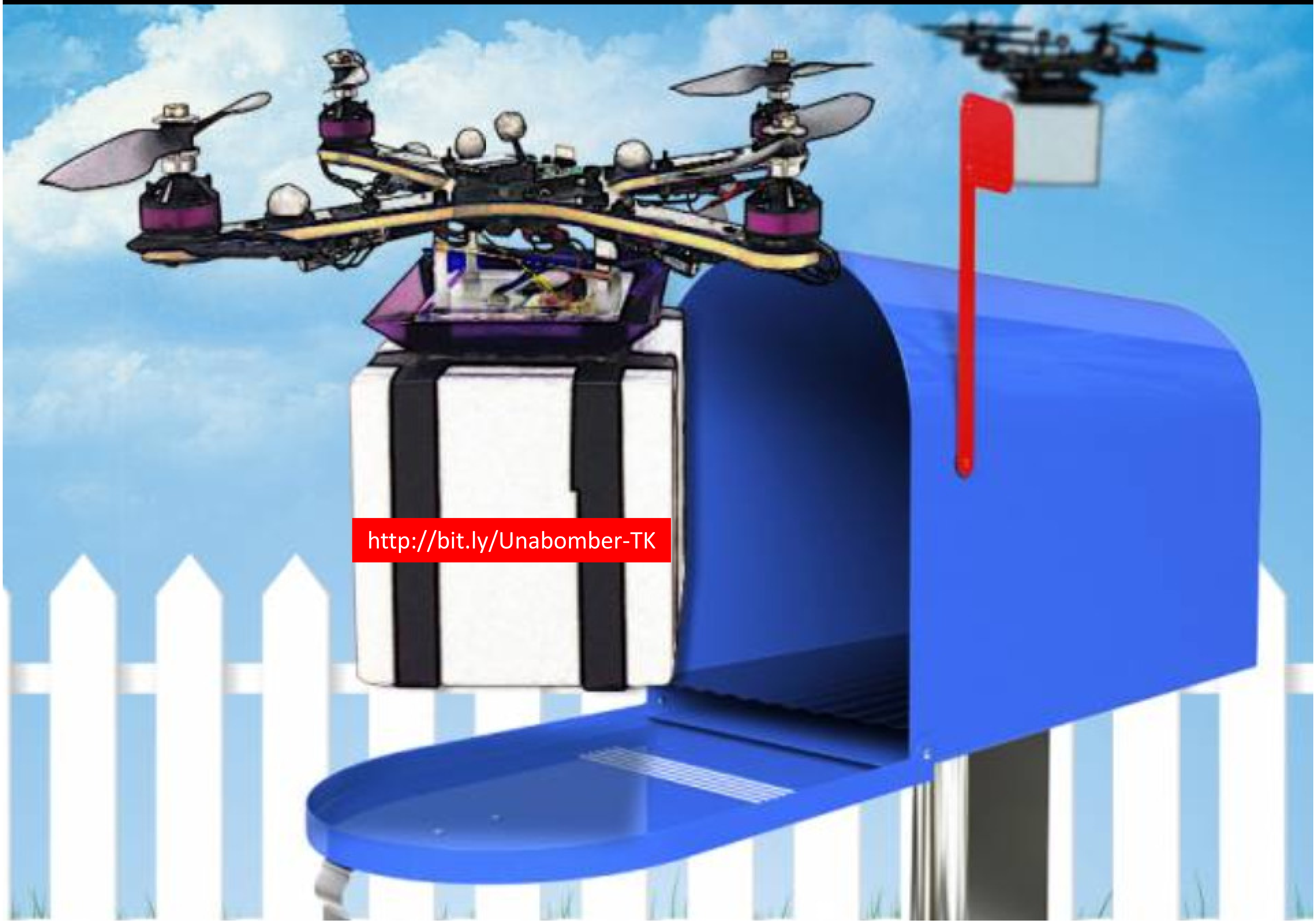
- [2] Roof-top wireless electricity charging pad for droneport provided by WiTriCity

- [3] Drones transmit signal to LEO, MEO, HEO or GEO satellites in range

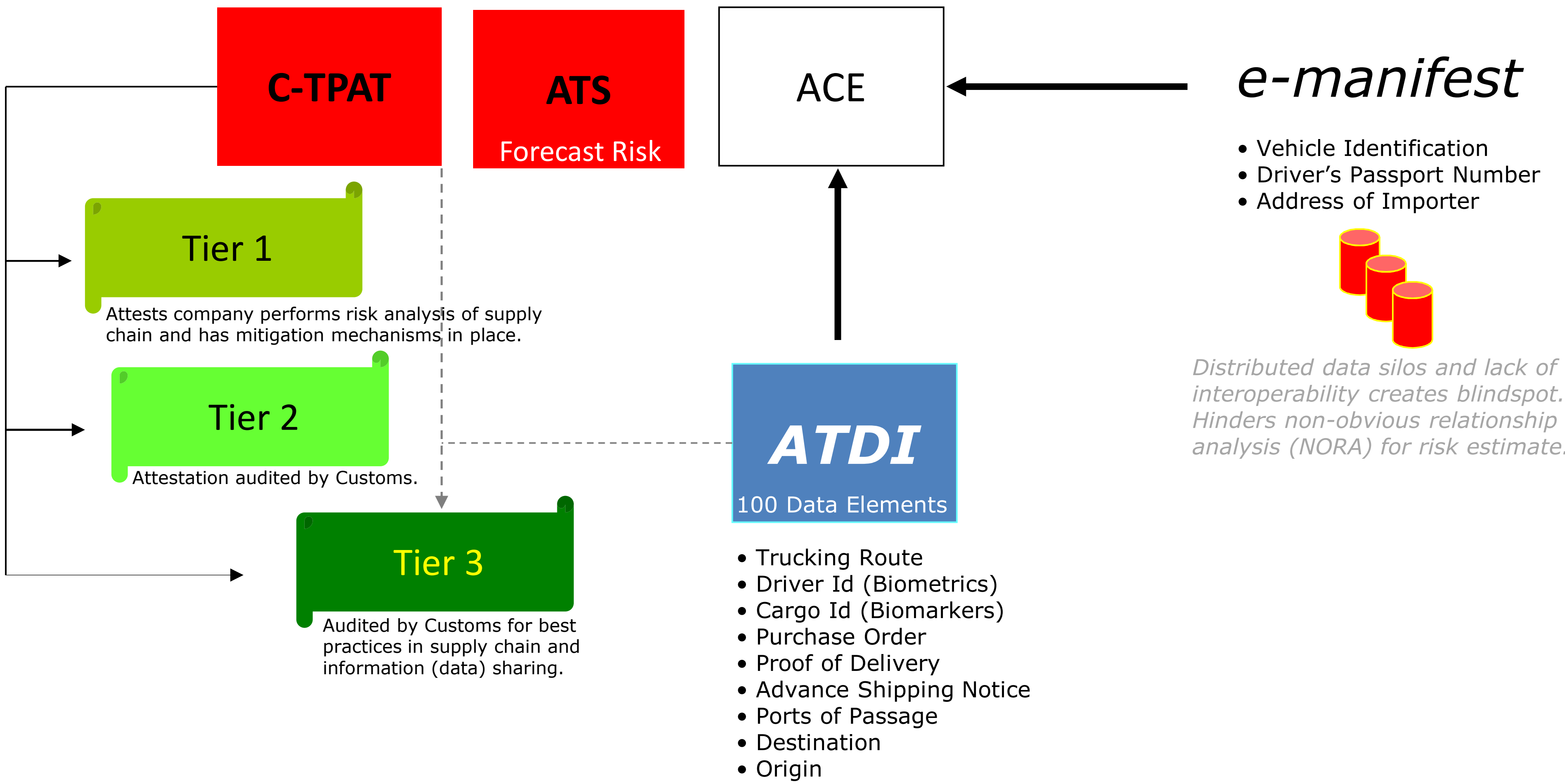
- [4] Satellite re-transmits to safe zones for communication / update

- [5] Responds with message and/or guidance to autonomous vehicle

THEODORE KACZYNSKI’S ‘DRONACHARYA’ DELIVERS TO YOUR DOOR-STEP er MAIL BOX



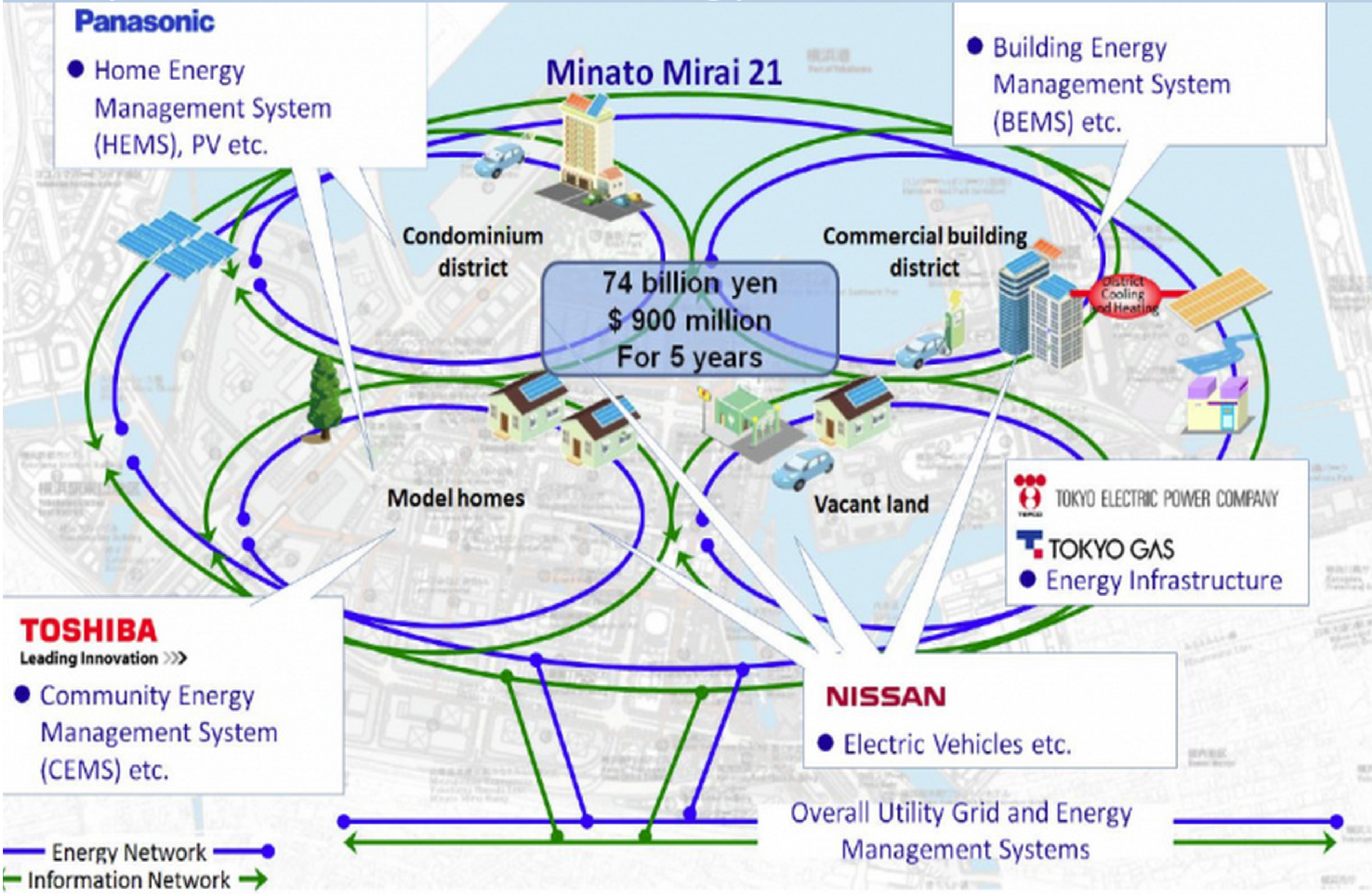
Autonomous Transportation • Operation Safe Commerce



C-TPAT	>	Customs-Trade Partnership Against Terrorism
ACE	>	Automated Commercial Environment (the enterprise system equivalent)
ATDI	>	Advanced Trade Data Initiative (necessary for C-TPAT Tier 3)
ATS	>	Automated Targeting System (in operation since 1990's)

Transportation in Smart Cities

Autonomous Transportation Must Connect to Smart City Infrastructure for Energy and Clean Environment

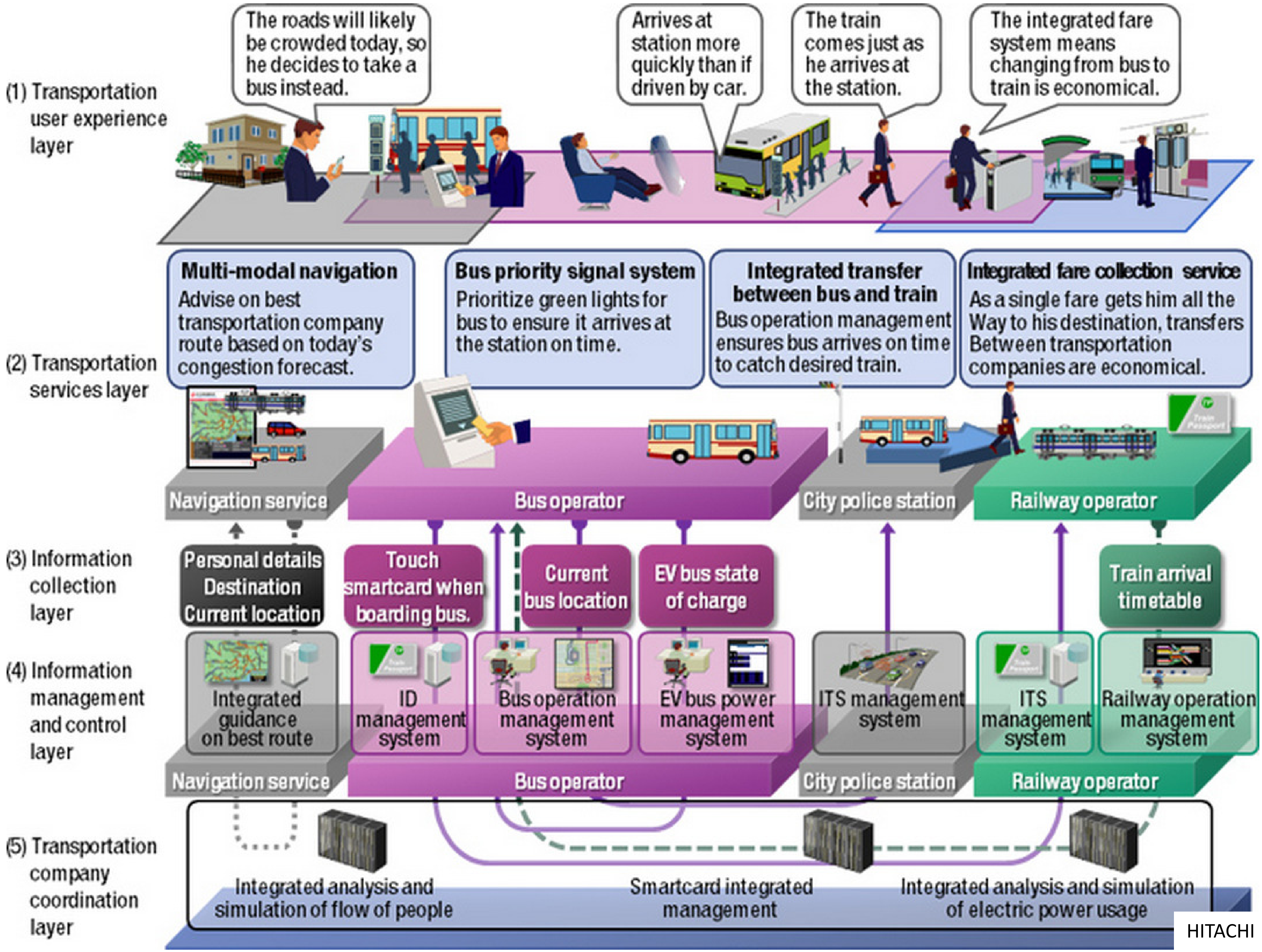


India invests $20 million for smart cities linked to transport

NATIONAL INDUSTRIAL CORRIDOR AUTHORITY TO BE SET-UP

SMART CITIES ALONG INDUSTRIAL CORRIDORS PROPOSED

The Union Finance Minister Shri Arun Jaitley while presenting his first Budget in Parliament today, announced that a National Industrial Corridor Authority, with its headquarter in Pune, is being set-up with an amount of Rs. 100 crore, to coordinate the development of industrial corridors with smart cities linked to transport connectivity. The Finance Minister has also announced that the Amritsar Kolkata Industrial Master Planning will be completed expeditiously for the establishment of Industrial Smart cities in seven States in this corridor.



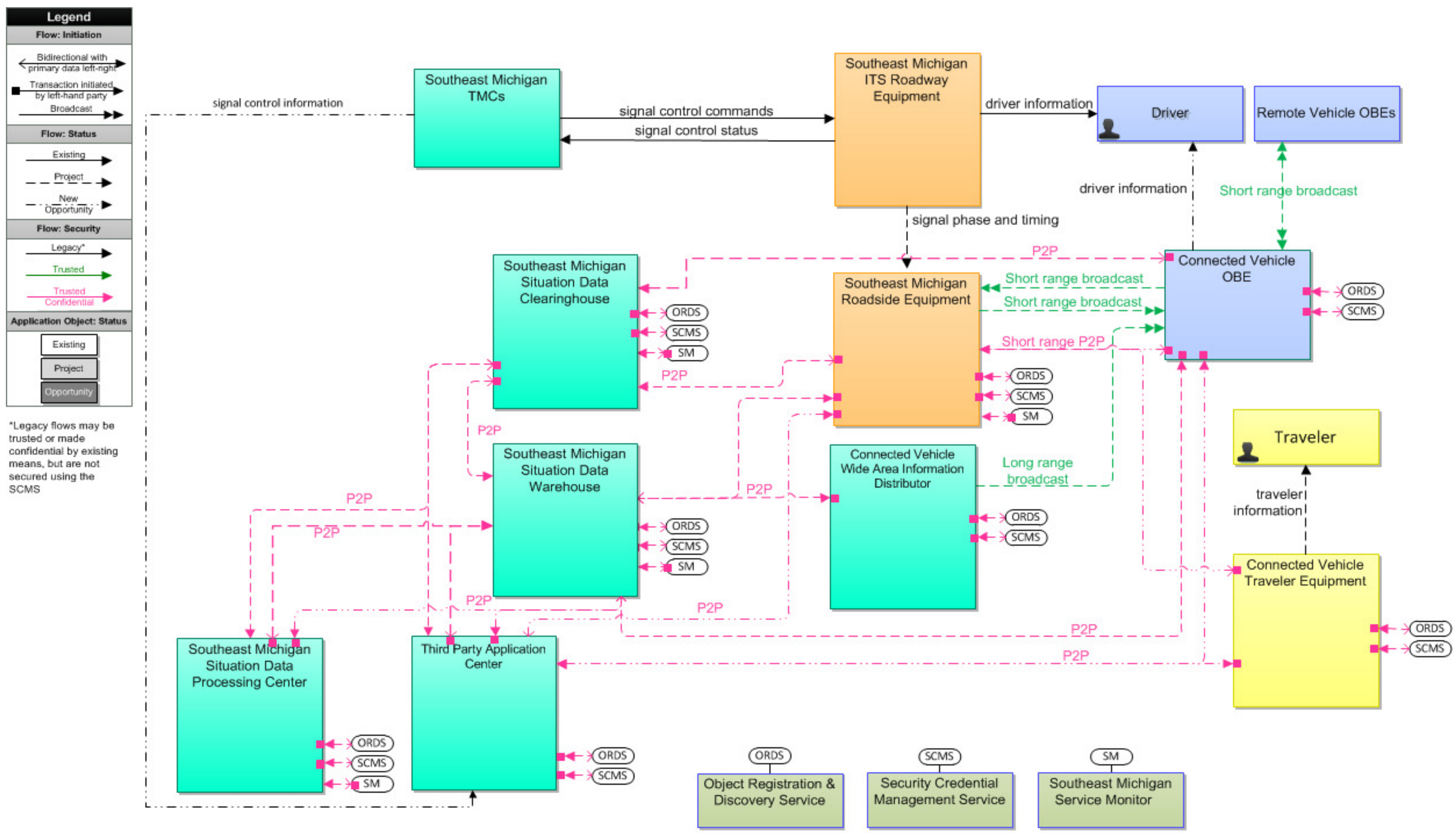
(1) Transportation user experience layer
The roads will likely be crowded today, so he decides to take a bus instead.
Arrives at station more quickly than if driven by car.
The train comes just as he arrives at the station.
The integrated fare system means changing from bus to train is economical.
(2) Transportation services layer
Multi-modal navigation
Advise on best transportation company route based on today's congestion forecast.
Bus priority signal system
Prioritize green lights for bus to ensure it arrives at the station on time.
Integrated transfer between bus and train
Bus operation management ensures bus arrives on time to catch desired train.
Integrated fare collection service
As a single fare gets him all the Way to his destination, transfers Between transportation companies are economical.
Navigation service
Bus operator
City police station
Railway operator
(3) Information collection layer
Personal details Destination Current location
Touch smartcard when boarding bus.
Current bus location
EV bus state of charge
Train arrival timetable
(4) Information management and control layer
Integrated guidance on best route
ID management system
Bus operation management system
EV bus power management system
ITS management system
ITS management system
Railway operation management system
Navigation service
Bus operator
City police station
Railway operator
(5) Transportation company coordination layer
Integrated analysis and simulation of flow of people
Smartcard integrated management
Integrated analysis and simulation of electric power usage

HITACHI

US DoT – SEMI Architecture

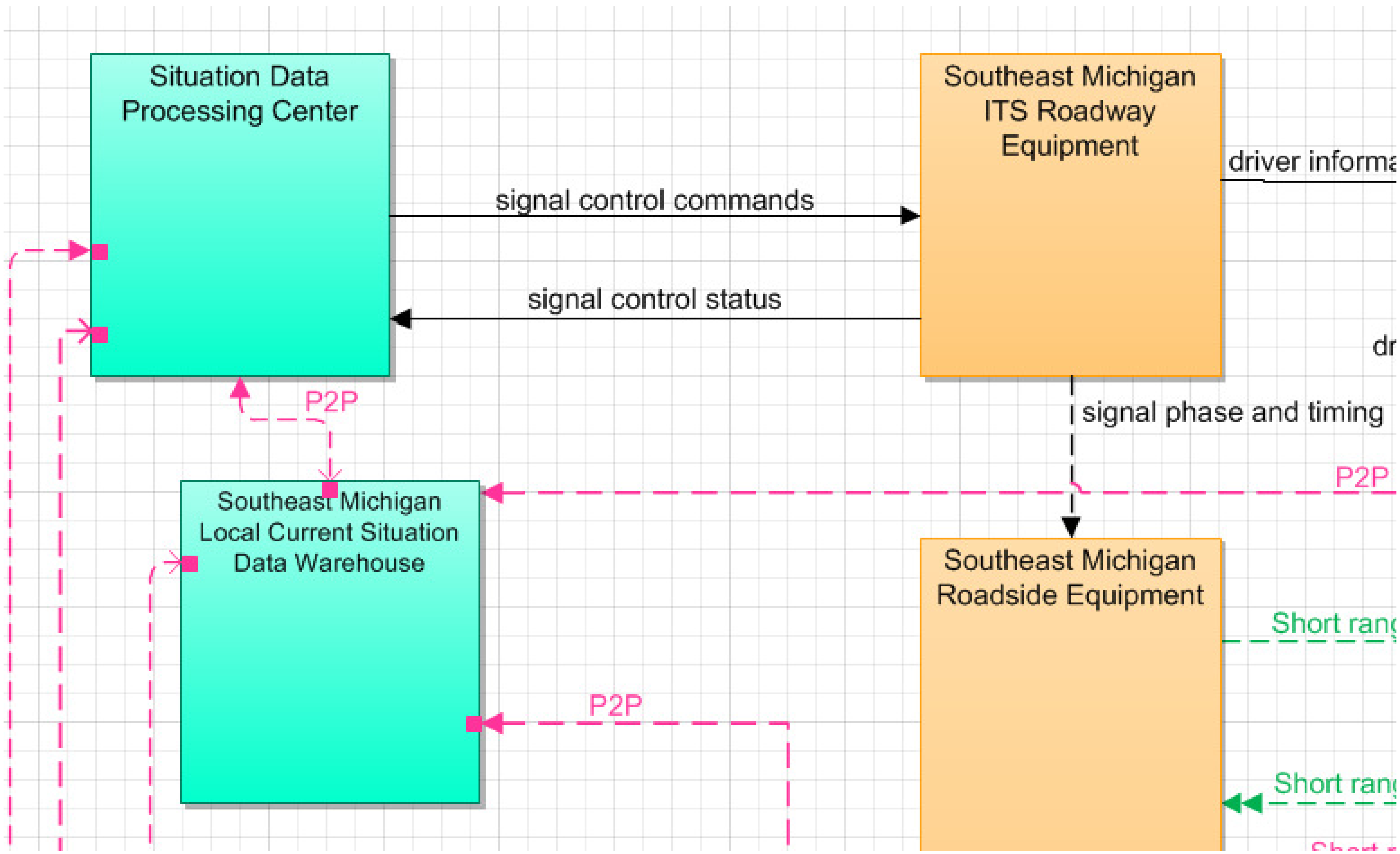
- **Physical View**
  - Layer 0: The physical objects that participate, the interconnects between them
  - Layer 1: The project-specific functions performed by each physical object, and the data exchanged between them
  - Layer 2: Application-specific; shows only those objects that are part of the application, with more detail on the flow of data
- **Enterprise View**
  - Layer 0: The people and agencies that own and operate physical objects
  - Layer 1: The people and agencies that own and operate physical objects and application objects
- **Communications View**
  - For each information flow in the Physical View, the layered communications protocols necessary to implement the information flow

US DoT – SEMI Architecture Physical View Layer 0

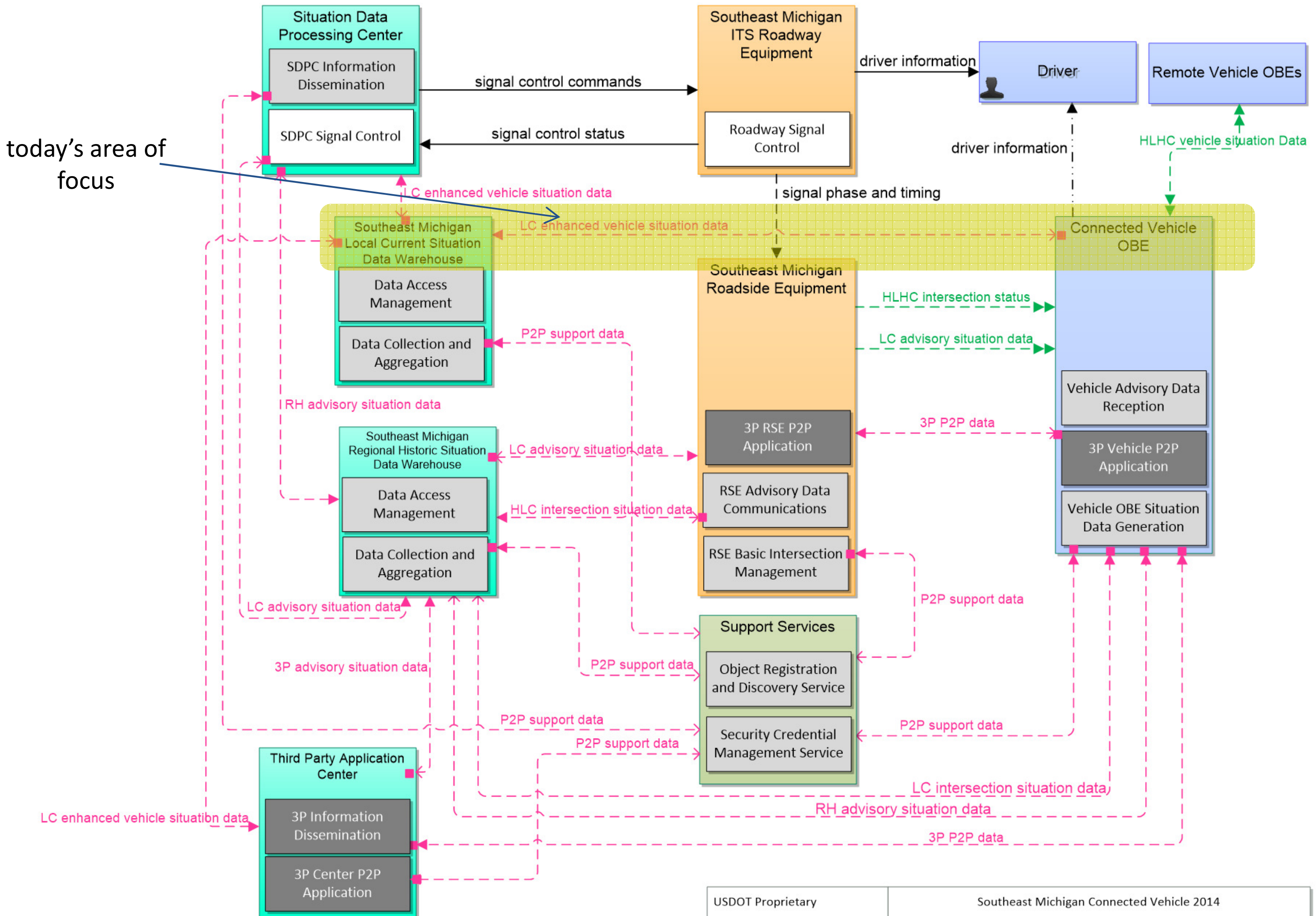


USDOT Proprietary	Southeast Michigan Connected Vehicle 2014		
26	Physical Layer 0	June 7, 2014	JLM

US DoT – SEMI Architecture Physical View Layer 0 Example



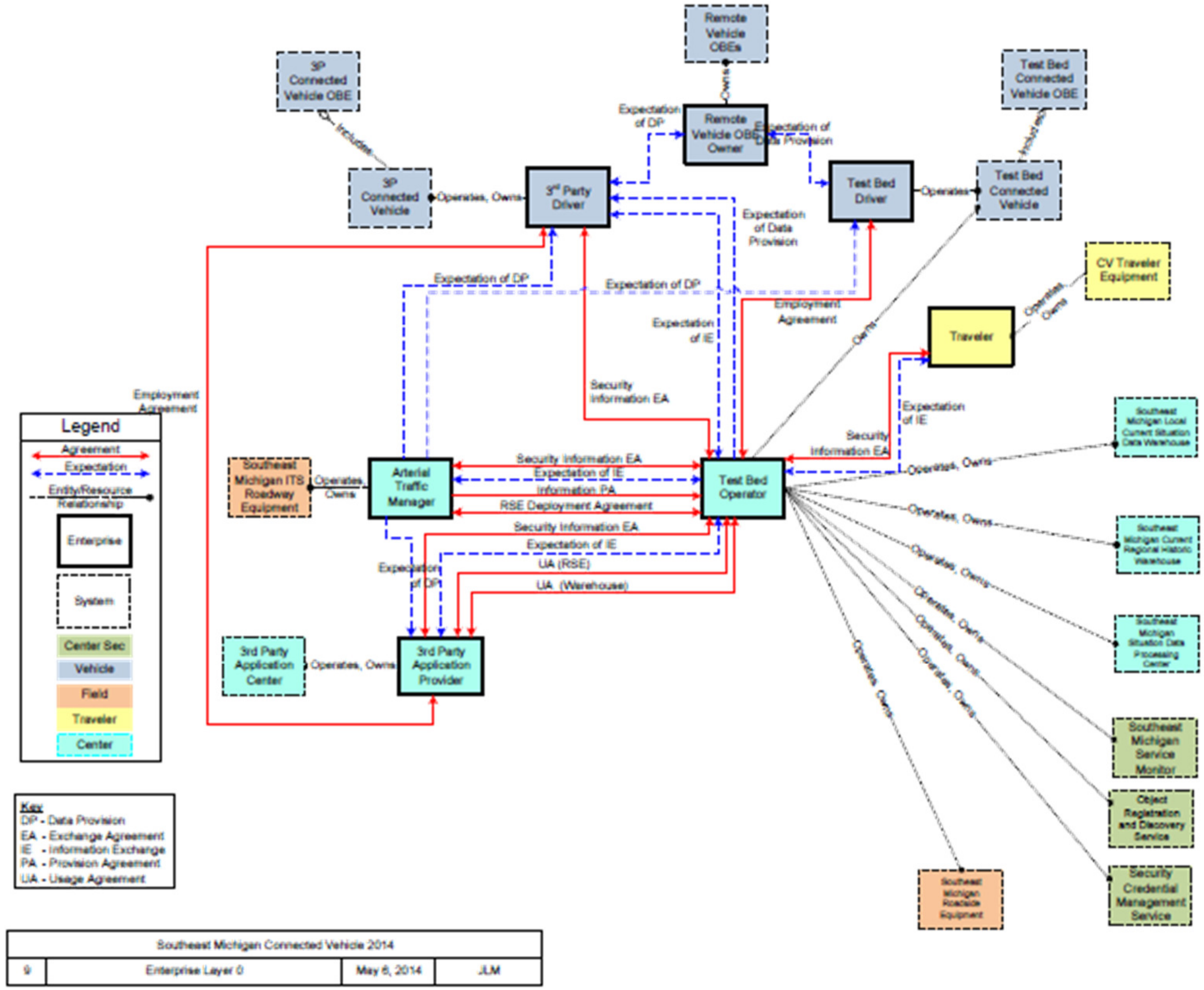
US DoT – SEMI Architecture Physical View Layer 1



USDOT Proprietary	Southeast Michigan Connected Vehicle 2014		
19	Physical Layer 1 - Comprehensive	Jan 28, 2014	WLF

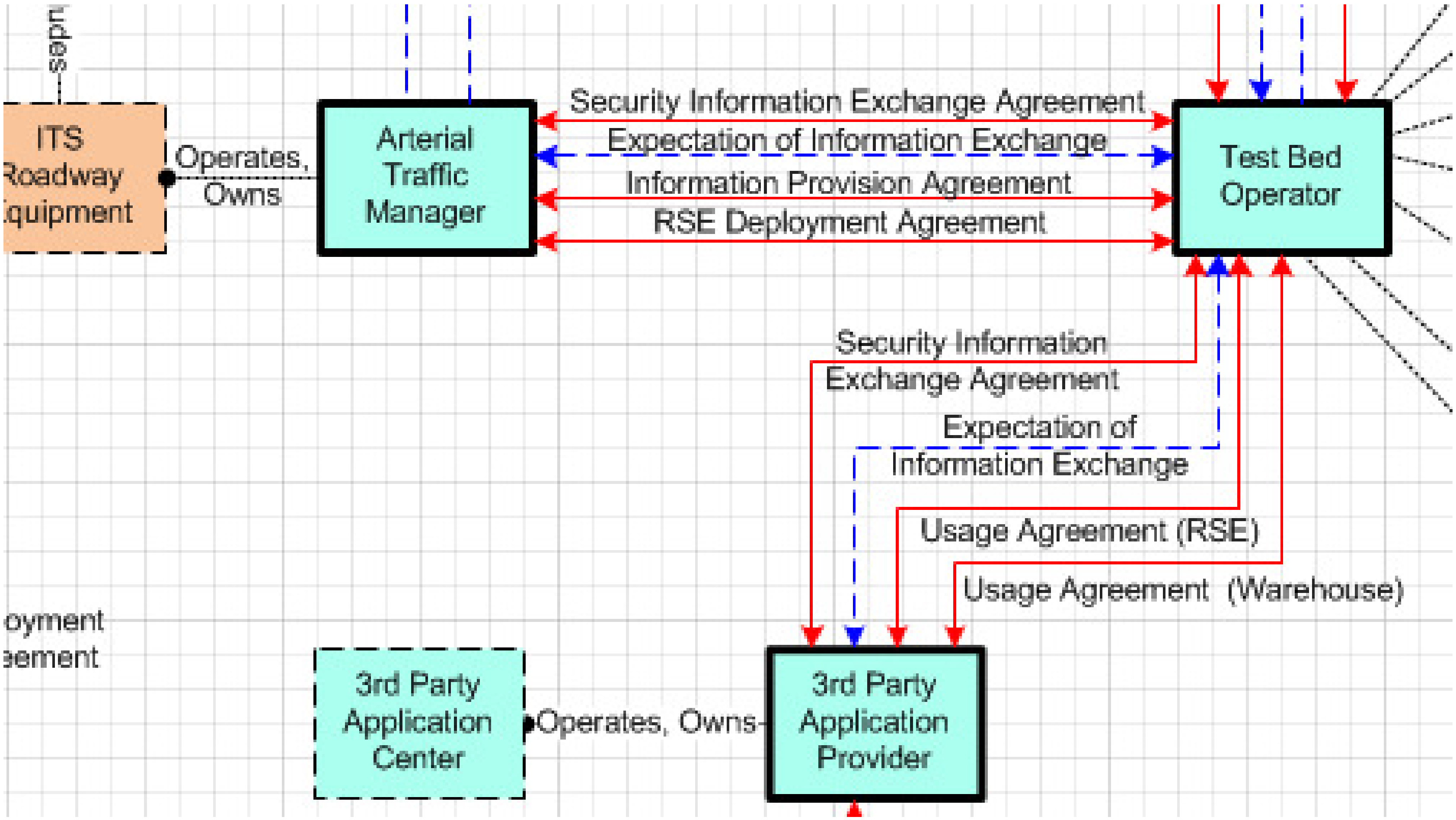
Walton Fehr, Intelligent Transport Systems, FWHA, US DoT

US DoT – SEMI Architecture Enterprise View



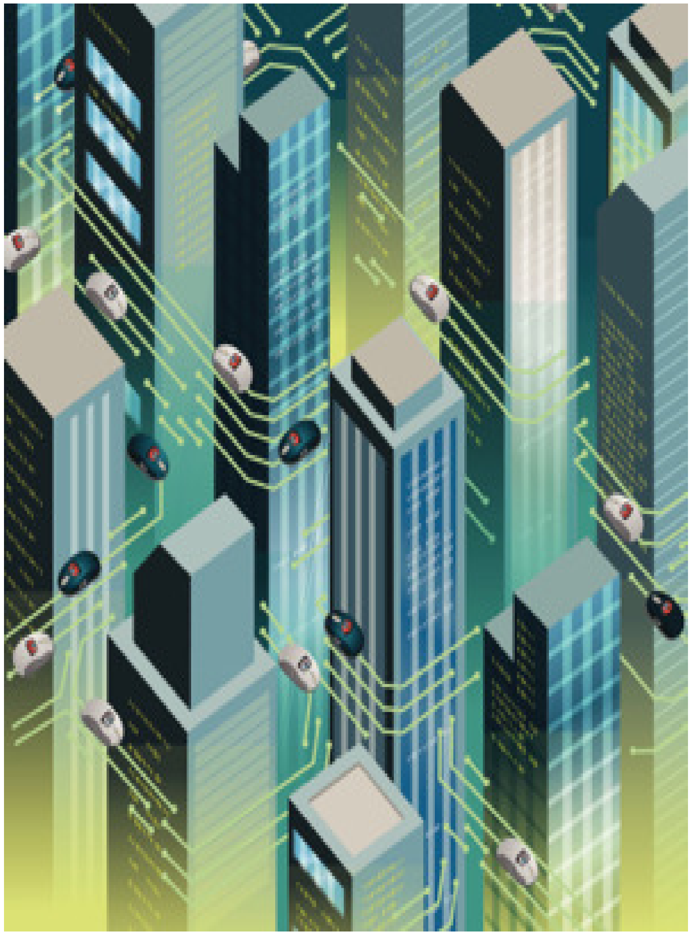
Walton Fehr, Intelligent Transport Systems, FWHA, US DoT

US DoT – SEMI Architecture Enterprise View Layer 0 Example



The Industrial Internet

- **Replicate transportation - EU, Asia**



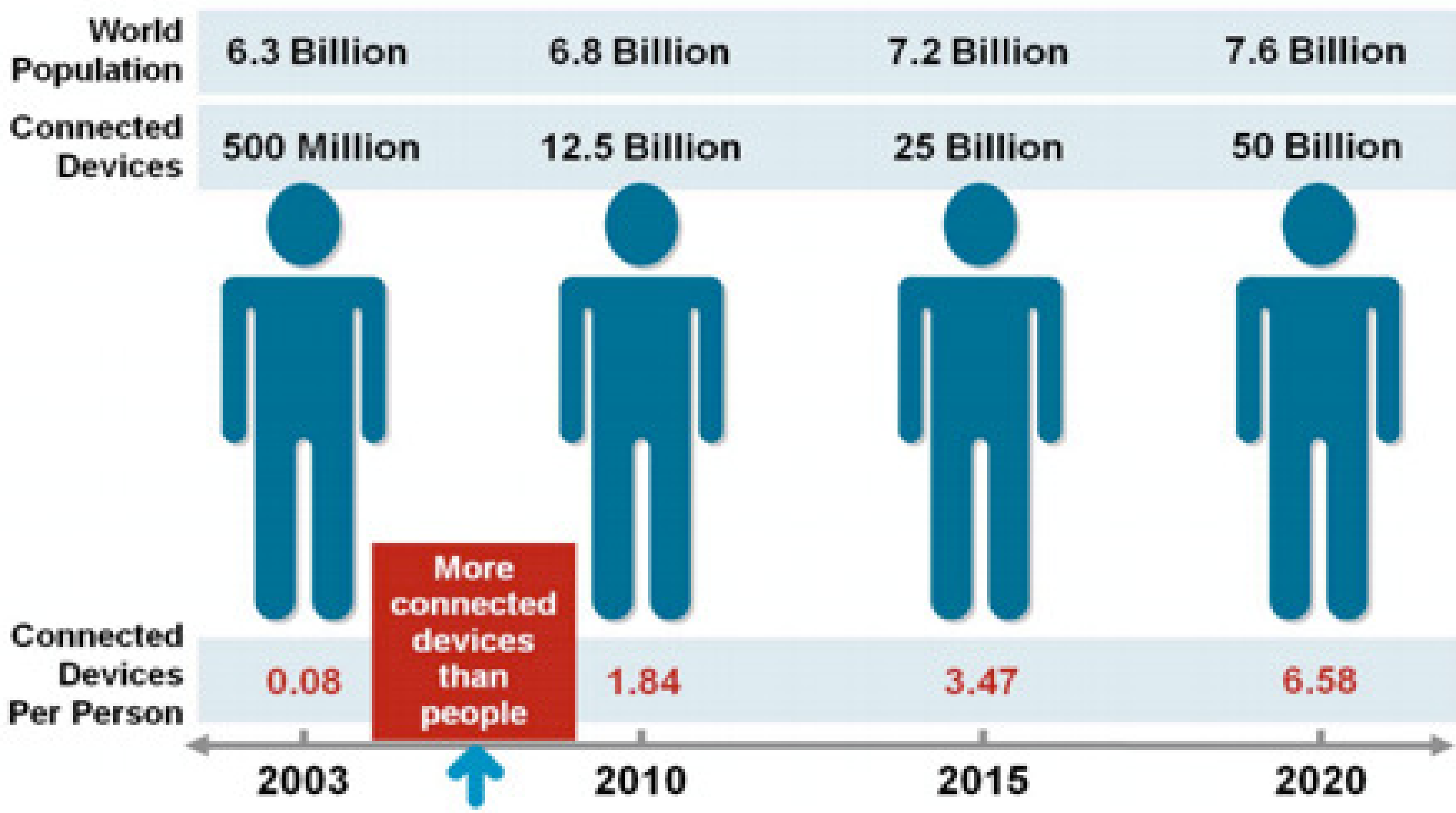
Duplicate

- Demonstration Case Study / Analyses
- Test Bed Evaluation / Modification
- Identify new partners / Design
- Create working group
- Global engagement

- New Test Bed
  - Map domains to new partners
  - Map scenario to partner WIP
  - Integration Gap Analysis
  - Resources / BOM
  - Work packages
  - Funding
  - Build
  - Test

The Industrial Internet

- **Disseminate**



Source: Cisco IBSG, April 2011

Disseminate

- Case studies and external evaluation
- Tutorials / workshops / conferences
- Government and agency liaison
- Catalyze large-scale projects
- Induce cognitive bias / PR

- yVNR
  - Diabetes (Steel Magnolias)
  - www.ge.com/mindsandmachines
  - www.youtube.com/watch?v=etAYyCitLD0
  - www.youtube.com/watch?v=loinY8MmVq8
  - www.youtube.com/watch?v=sb8mk2HSJUc
  - www.youtube.com/watch?v=2QMO1SZ0-is&feature=youtu.be

How to initiate …

- Catalogue various test beds / in progress
- Connected scenarios WIP / ready
- Collaborate / collective design
- Starting point for demo
- Resources and funding
- Organizational links ?
- EU, METI, BRIC ?
- High value PR ?
- Research ?

- Liaison
  - US CTO OSTP
  - METI, EU (Neeli Kroes)
  - 113th Congress NCCIP Act 2013 • HR 3696 / Dec 11, 2013
  - NIST REPORTS (www.nist.gov/el/isd/cps-020613.cfm)
  - Presidential Innovation Fellows (Cyber-Physical Systems)

Corporate Expectations

- ROI
- Economic growth
- New lines of business
- New sources of revenue
- Capture emerging markets

TECHNOLOGICAL INNOVATION

CATALYST FOR CIVILIZATION

Government Expectations

- ROI
- Economic growth
- New lines of business
- New sources of revenue
- Capture emerging markets
- New jobs creation
- Workforce development
- Quality of life improvements
- Public accountability and security

TECHNOLOGICAL INNOVATION

CATALYST FOR CIVILIZATION

The Industrial Internet Create Economic Value

- Demonstrate
- Duplicate
- Disseminate

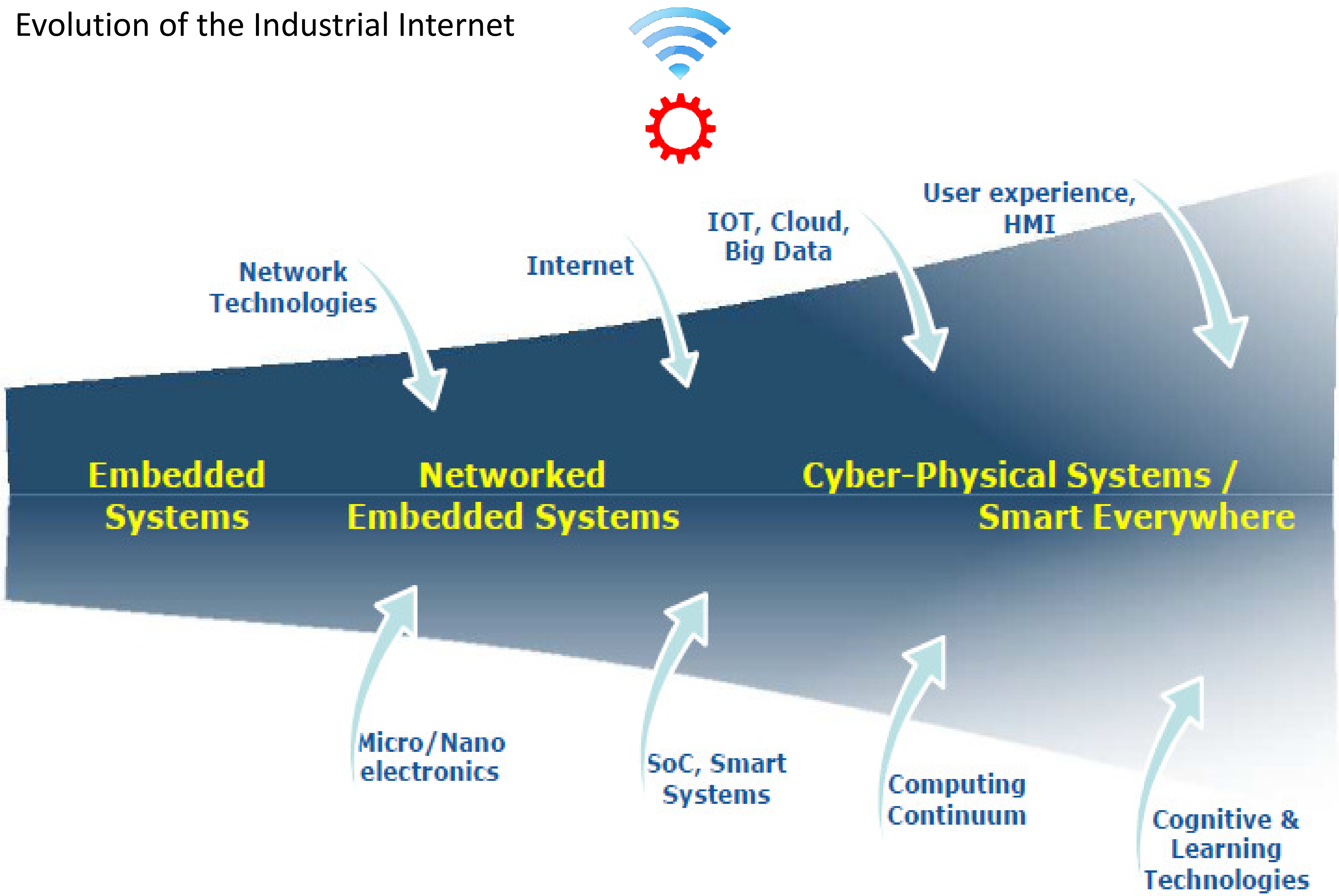
- **Productize / Integration**

Clarity ?

The scope of the Industrial Internet needs definition, at least internally. Clarity is necessary to differentiate between functions which are not mission critical with respect to time granularity (supply chain) versus mission critical (mc) functions where real time dependency is vital to prevent catastrophe (heart pacemakers).

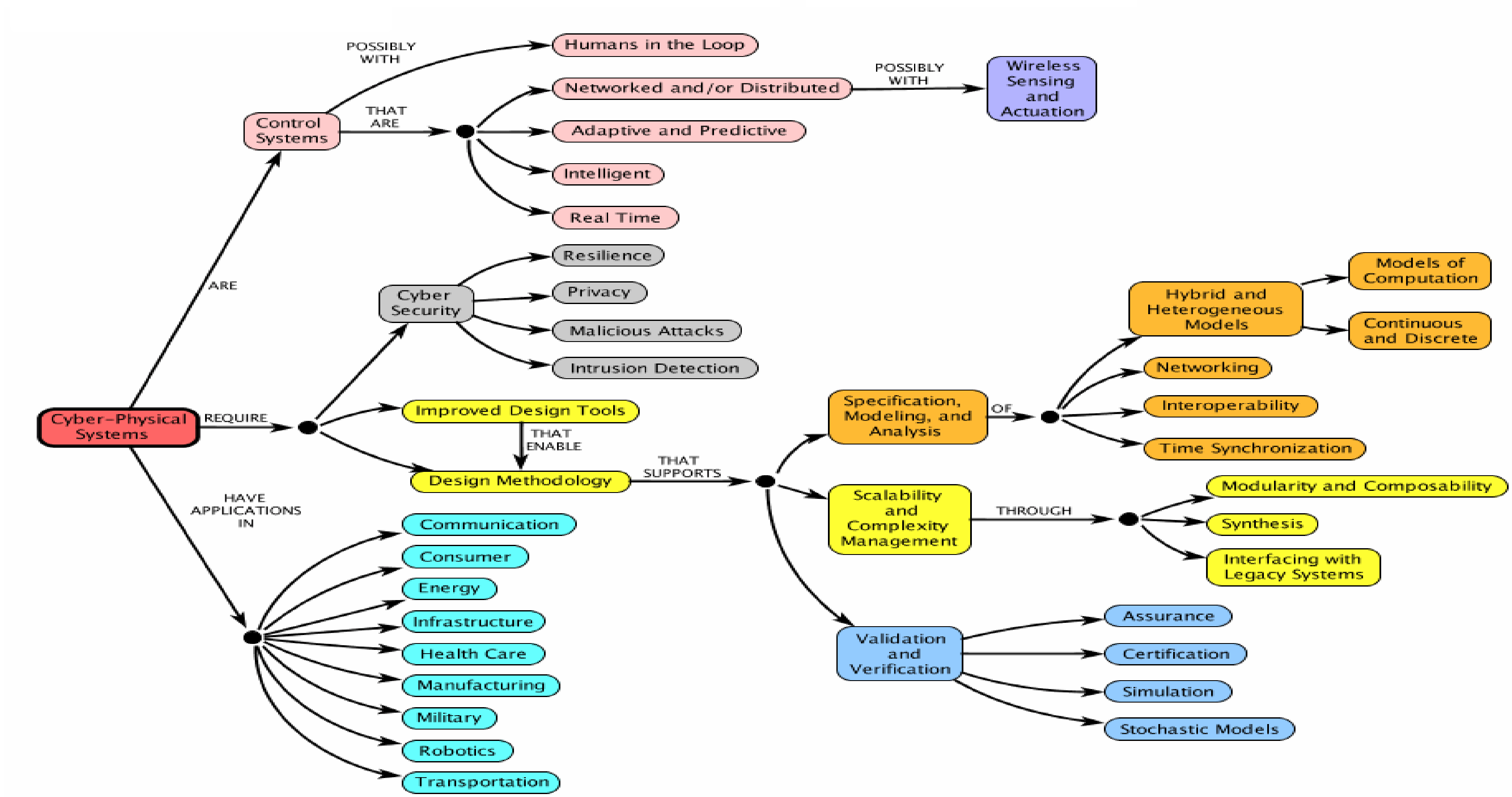
Networked cyber-physical systems may be the shared common foundation for $\sum[nCPS]_{nmc}$ as well as $\sum[nCPS]_{mc}$ with emphasis on clarity about proposed project goals, expectations of outcome, correctness of hardware and software systems synchronization following physical realization of functional integration.

Evolution of the Industrial Internet



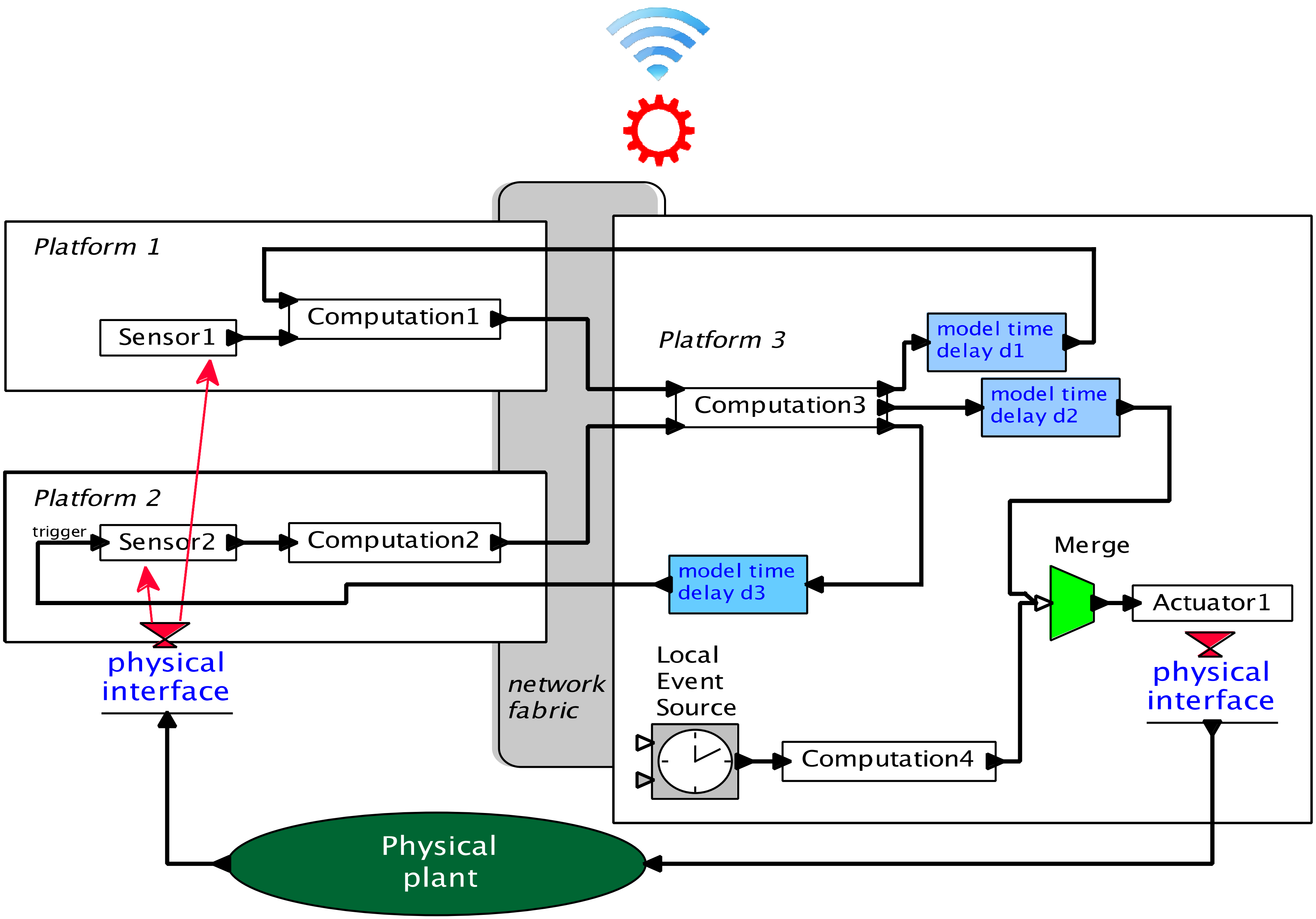
Foundation of the Industrial Internet

Concept Map: Cyber-Physical Systems



Professor Edward Lee, University of California at Berkeley • NSF Contract CNS 1035672

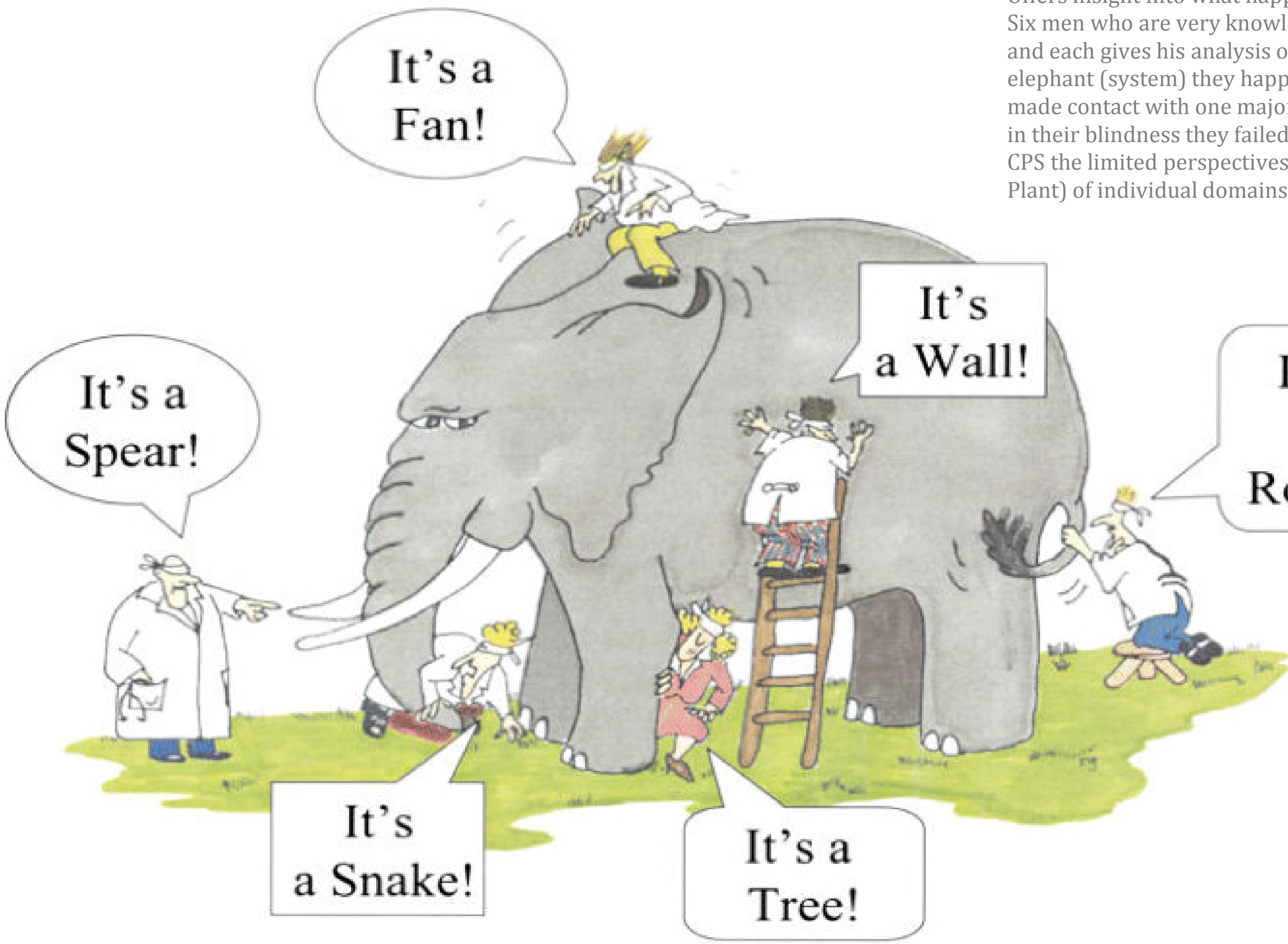
Even a small sub-system

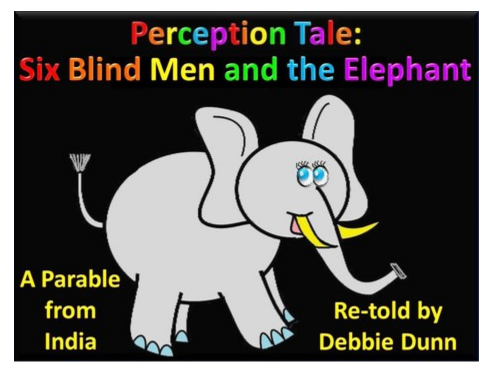


http://chess.eecs.berkeley.edu

Even a small sub-system may be an Elephant

Children's story based on an Indian folk tale dating back at least 2000 years. Offers insight into what happens if the systems view of a problem is ignored. Six men who are very knowledgeable are blind. They encounter an elephant and each gives his analysis of the 'system' based on the particular part of the elephant (system) they happen to touch. Each is partly right since they have made contact with one major subsystem. However, they are wrong because in their blindness they failed to comprehend the system as a whole. Often in CPS the limited perspectives (embedded systems, communication, physical Plant) of individual domains may lead to failure for as a whole (integration).



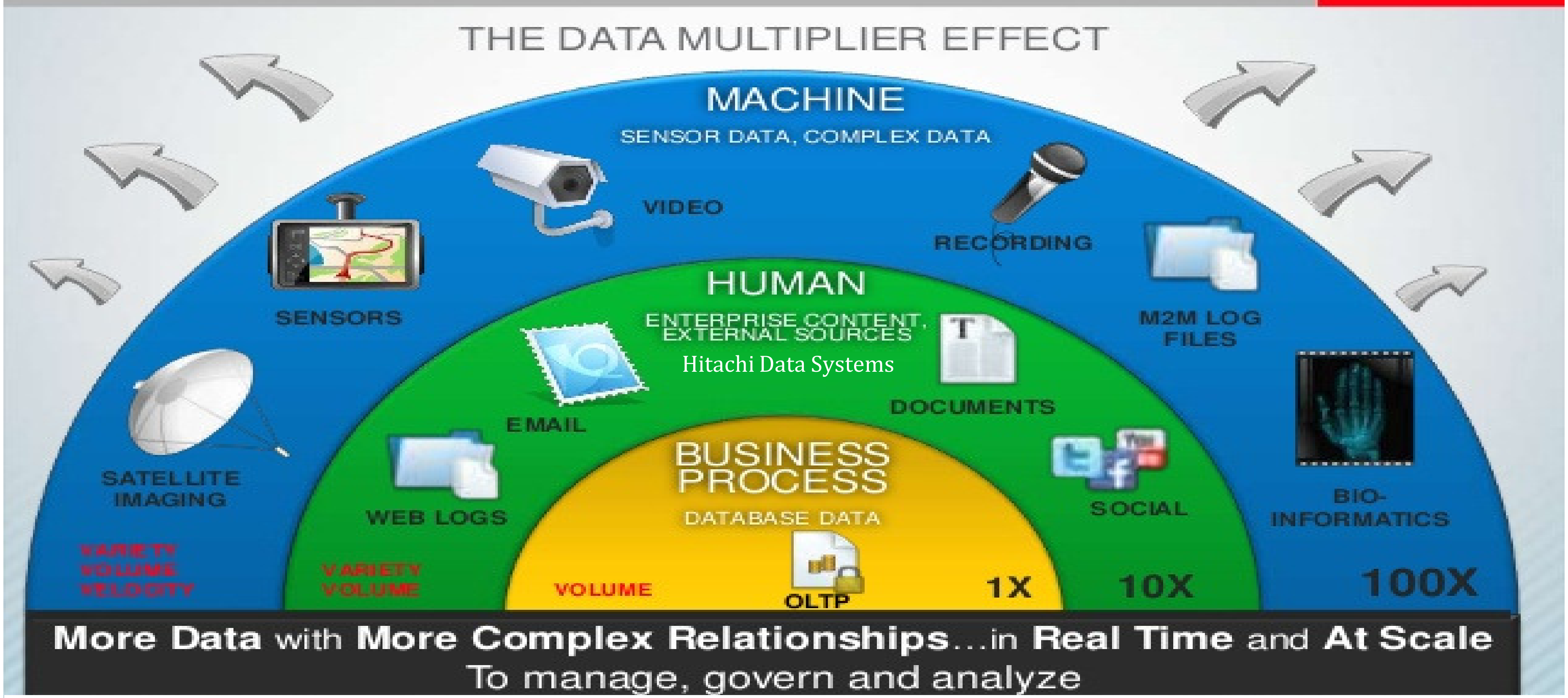


Slapstick Internet vs Industrial Internet

Manage Entropy & Improve S2N Ratio

Unstructured, Non-Relational, Asynchronous, Broad, Complex, Distributed → Big Data

Information ENTROPY



TBD (to be discussed)

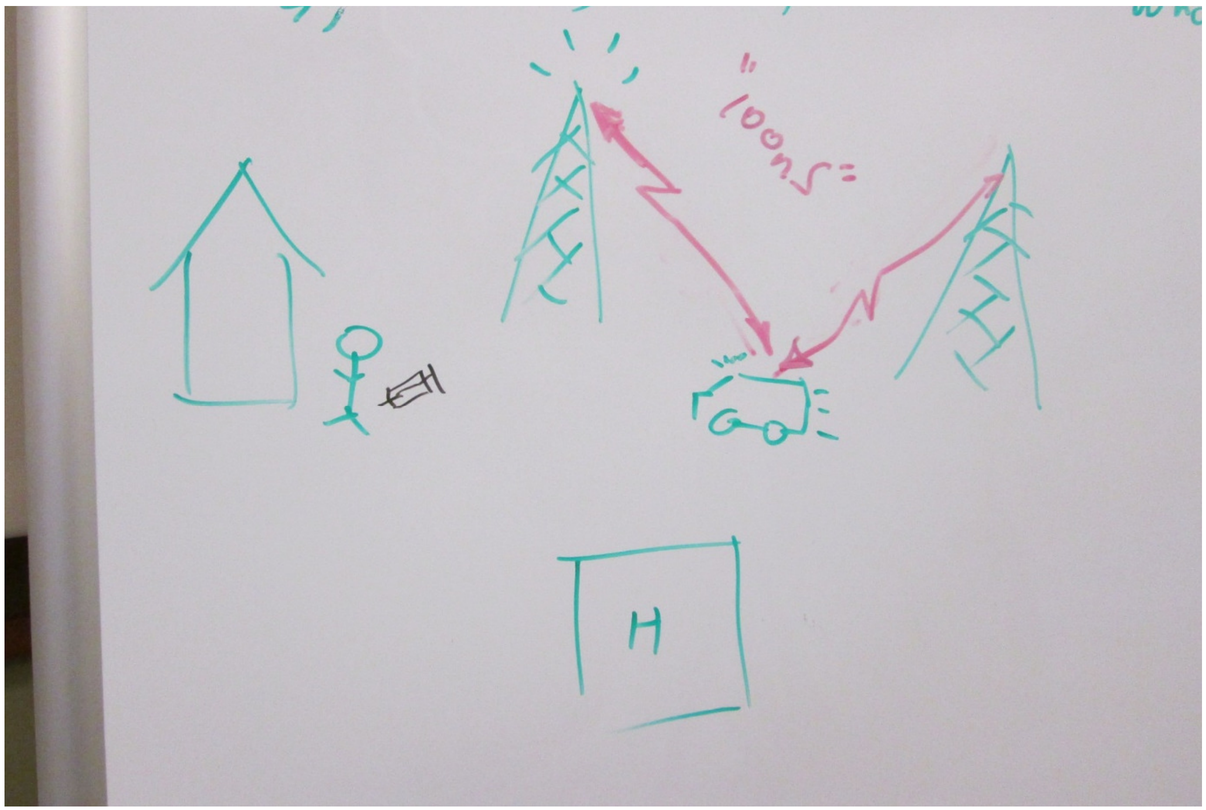
Future CPS / Physical Systems

- Deterministic Models (Edward Lee, Insup Lee)
- Model Engineering Embedded Systems
- Temporal Semantics of Time (ISA, Concurrency)
- CyberSecurity (HR 3696)

Communication / Systems Software

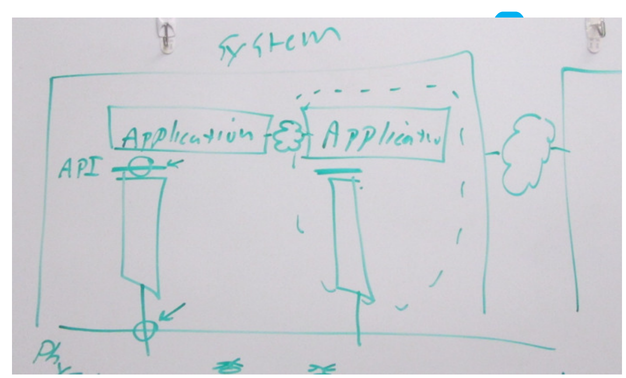
- Languages / Tools / Interfaces (PTIDES, FMI)
- Model Driven Architecture (Richard Soley) / RT CORBA
- HDFS + Cassandra (Lakshman & Malik); Tessellation OS
- unABCD → Big / Small Data

It is about TIME - Room 110

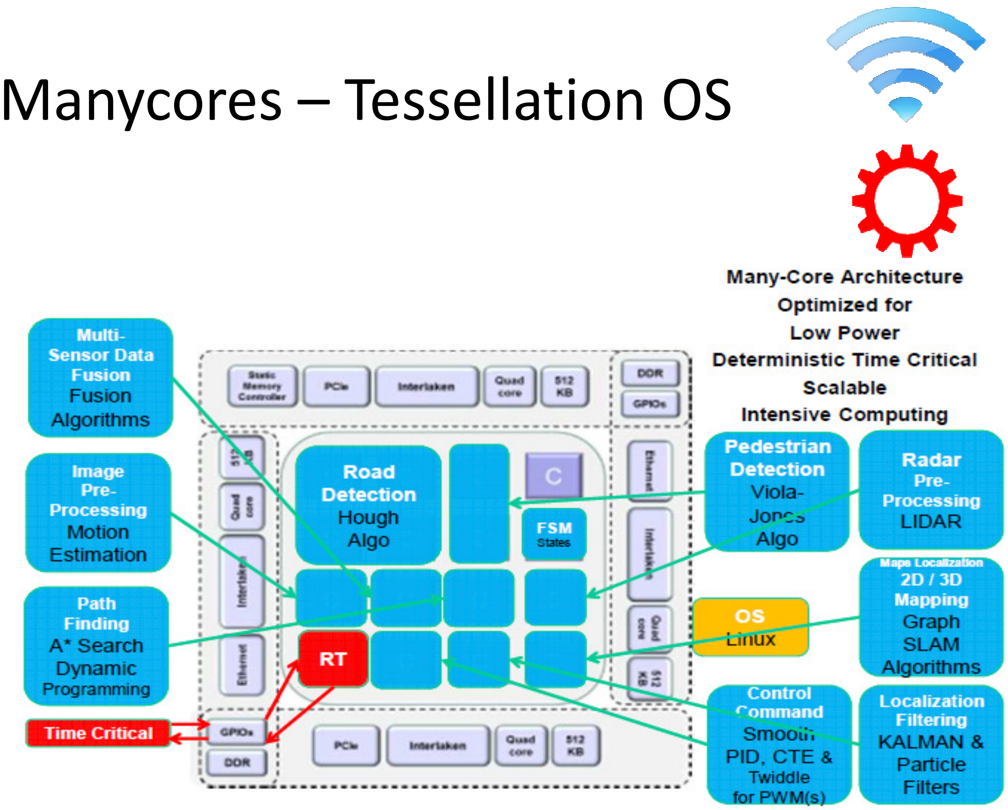


Problem Areas/Challenges

- Need for a unified Abstract Model for frequency/ phase/time - > protocols - > physical implementation-platform for the applications with different requirements; API semantics; precision, traceability; when did an event really happened; Interworking between time aware something (NTP/PTP/System Time, etc.); common view of the time/legal time/standard/epoch time – standard precision-granularity; From abstract model to realization
- Value for timing in a trillions of network elements - IoT; does it help? Scaling aspects; distribution in a wide network. Hierarchy is a problem or a solution;
- Time in a virtual (but physical!) network/network elements-how to monitoring a virtual network;
- Guaranteed /Traceability timing with appropriate accuracy/precision; Both in the physical network and in the model (e.g. for prediction)

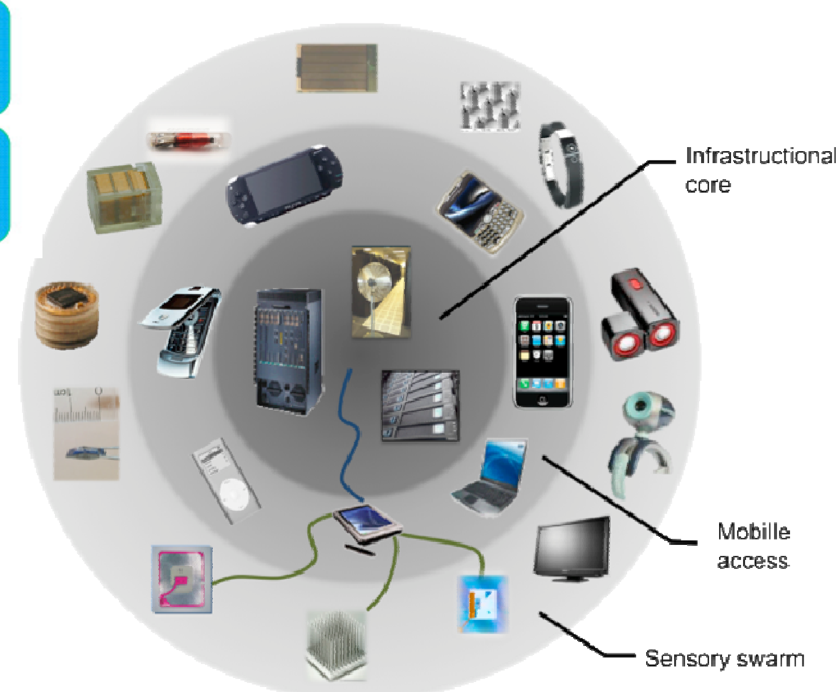


Manycores – Tessellation OS



Integration

Swarm App Store
Middleware and services
Swarm-OS
Distributed Sense-Control-Actuate Platforms
Innovative Devices and Materials



Professor John Kubiatowicz, Swarm Lab, University of California at Berkeley

TBD

- Modus Operandi
- Key Components
- Strategic Elements
  - Demonstrate
  - Duplicate
  - Disseminate
  - Productize / Integration
  - Standardize / Standardization
  - Commoditize / Implementation
- US Progress
- EU Advances
- Other Groups

The Industrial Internet

- Modus Operandi
- Key Components
- Strategic Elements
  - Demonstrate
  - Duplicate
  - Disseminate
  - Productize / Integration
  - Standardize / Standardization
  - Commoditize / Implementation
- US Progress
- EU Advances
- Other Groups

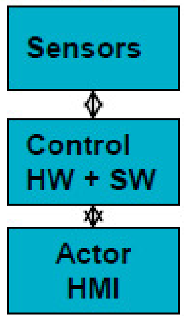
- Industrial Internet - IoT - IoE - SMART
  - ATT, Cisco, GE, IBM, Intel, Rockwell, Boeing, GM, UTC
  - CSRA - RSA, Intel, AMD, EMC, Lockheed, Honeywell
- Academic / Industry Leadership - CPS
  - UCB, MIT, CMU, UPenn, CalTech, UCLA, UIUC
  - Vanderbilt, UMich, UMD, Notre Dame, TAMU
  - CHESS, TerraSwarm, FORCES, Ptolemy, PRET
  - Correct-by-Design, iCyPhy (IBM/UTC) , Millennial Net
- US Government Support
  - NASA, NSF, NIST, NREL
  - DOE (ARPA-E), DOD (DARPA)
  - DHS, DOJ, DOT, NIST (www.cybersecurityresearch.org)

The Industrial Internet

- EU Advances

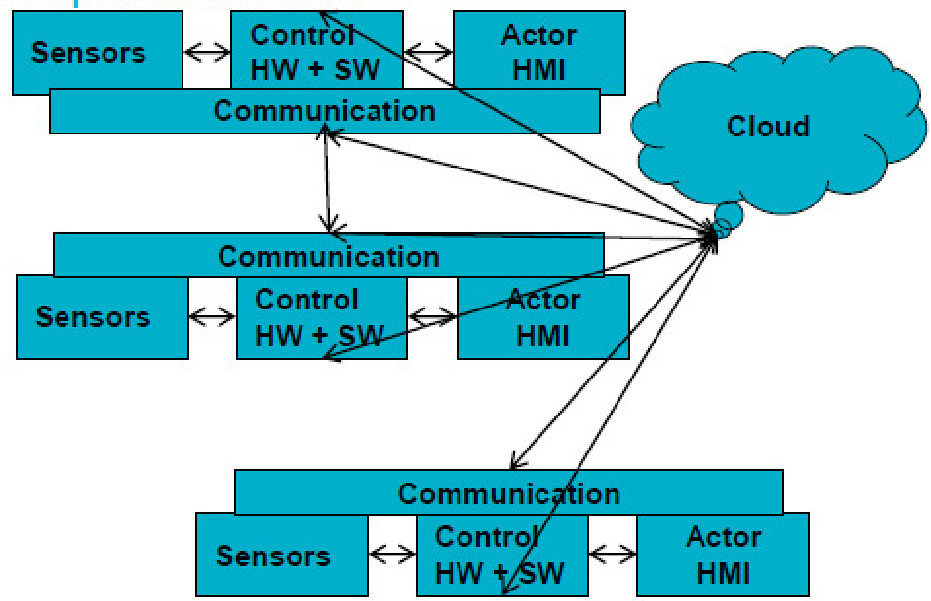
EU Perception

USA vision about CPS



- Focus on connection to physical world
- Describing the control laws and its SW

Europe vision about CPS



- CPS subsytems interconnected
- More than control
- Including services and including value-add from communication between intelligent subsystem
- May include "The Cloud"

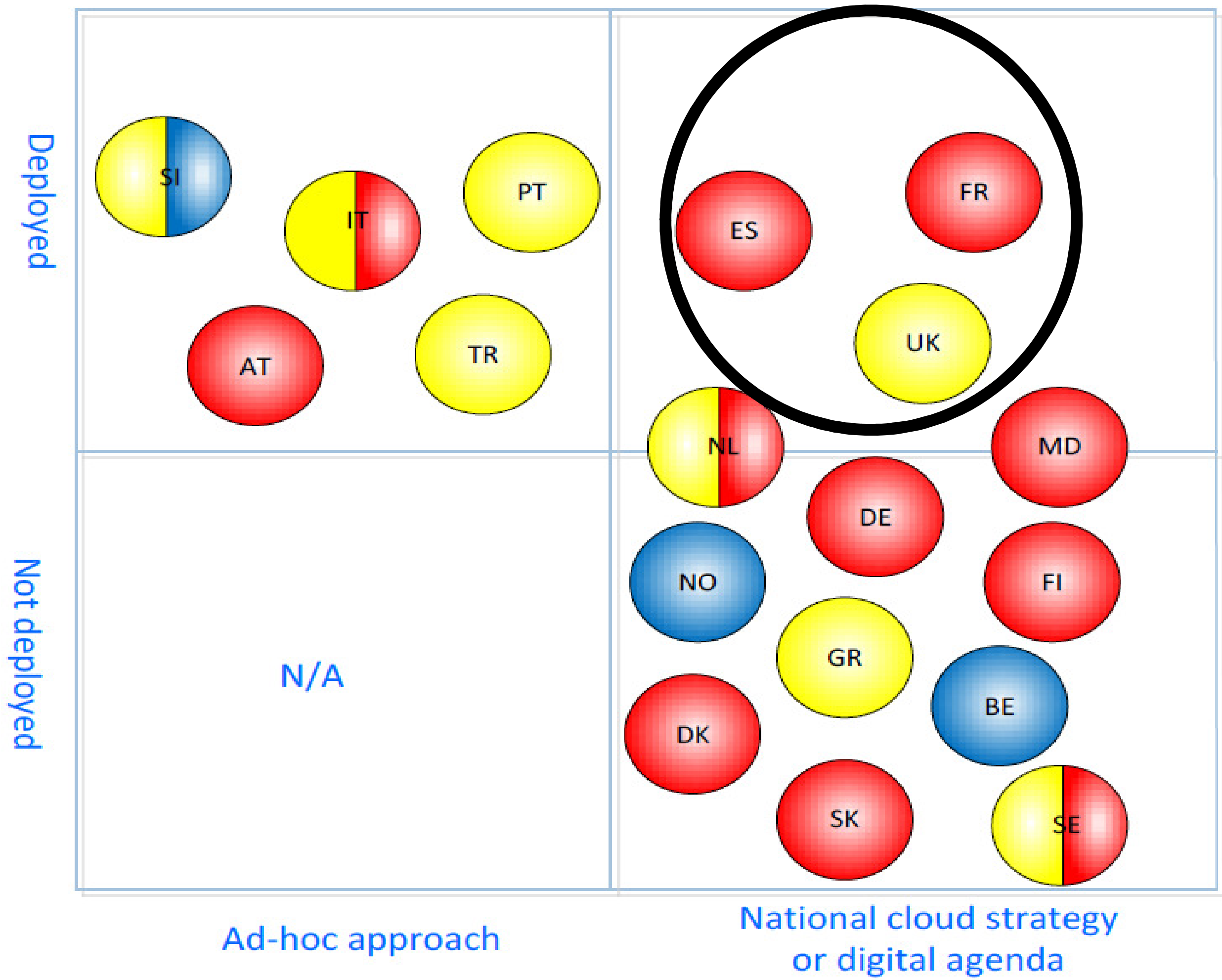
Indra

Industrial Visions for CPS

Cyber-Physical Systems:
Uplifting Europe's innovation capacity

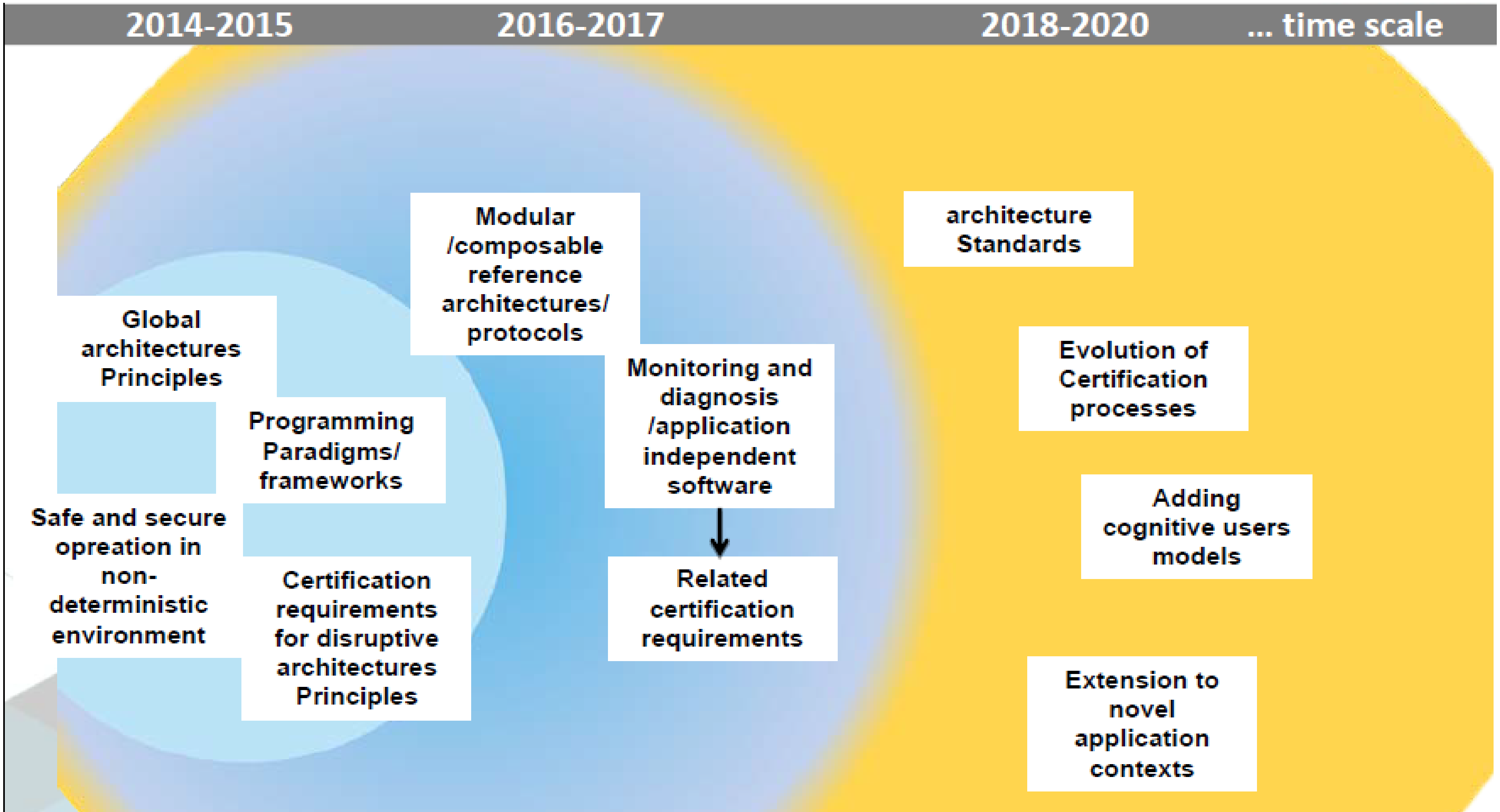
Jose Luis Angoso (jlangoso@indra.es)
Head of Innovation & Alliances
Brussels – 29th-30th October 2013

EU – Cloudy Forecast CPS Infrastructure ?



EU ARTEMIS [7th Framework]

Embedded Digital Intelligence



EU ARTEMIS [7th Framework]

CPS Vision [5 December 2013]

Published 05 December 2013

<u>ARTEMIS</u>

Advanced Research and Technology
for
Embedded Intelligence and Systems

Dr Heinrich Daembkes, President of ARTEMIS

EU Horizon 2020 [7th Framework]

SCPS Vision [30 Oct 2013]

H2020 – LEIT – ICT: Smart Cyberphysical Systems

European Commission

Societal Challenges

CPS in Horizon 2020:

WP 2014-15: ~250 M€ (draft)
Estimate for 2014-20, around 1 B€ all encompassing
Comparison FP7: 700 M€

LEIT - ICT

Components & Systems: **Smart CPS** ... **ESCEL JTI**	**Advanced Computing**	Future Internet PPP	Content Techs	Robotics & Smart Spaces Robotics PPP	ICT KETs – Micro/Nano Electronics Photonics **ECSEL JTI** Photonics 21 PPP	ICT for Manuf.: **Process (Chain) Opt.** Factories of the Future PPP

Cross cutting actions: Open Disruptive Innovation, **Internet of Things/Smart connected Objects**, Digital SSH, Cyber-Security, Horizontal Support to Innovation

EFFRA SRA

Platforms for Connected Smart Objects (ICT30)

Manufacturing: Process (Chain) Optimisation (FoF1, FoF9)

http://ec.europa.eu/dgs/connect/

Smart Cyber-Physical Systems (ICT1)

Customised low power Computing (ICT4)

K. Rouhana, Director Components and Systems

http://ec.europa.eu/research/horizon2020/index_en.cfm

EU CORDIS CPS PROJECTS

1. **CONTROL-CPS** - Reactive control protocols for cyber-physical systems
Start Date: 2013-09-01 **End Date**: 2017-08-31

2. **CYPHERS** - Cyber-Physical EU Roadmap and Strategy
Start Date: 2013-07-01 **End Date**: 2014-12-31
Integration of software-intensive embedded systems and global communication networks in CPS is the next revolution in ICT

3. **VICYPHYSYS** - Virtual CPS
Start Date: 2012-03-01 **End Date**: 2014-02-28
In CPS physical processes are controlled by a pervasive network of embedded computers. Computation, communication and the physical environment very tightly integrated.

4. **ADVANCE** - Advanced Design and Verification Environment for CPS
Start Date: 2011-10-01 **End Date**: 2014-03-31
Develop unified tool-based framework for automated formal verification and simulation-based validation of CPS.

EU CORDIS CPS PROJECTS

5. **MODESEC** - Model-based Design of Secure Cyber Physical Systems
Start Date: 2013-06-24 **End Date**: 2016-06-23
Develop a design methodology that integrates security in the model-based design (MBD) process of CPS.

6. **SPHINX** Co-Evolution Framework for Model Refactoring & Proof Adaptation in CPS.

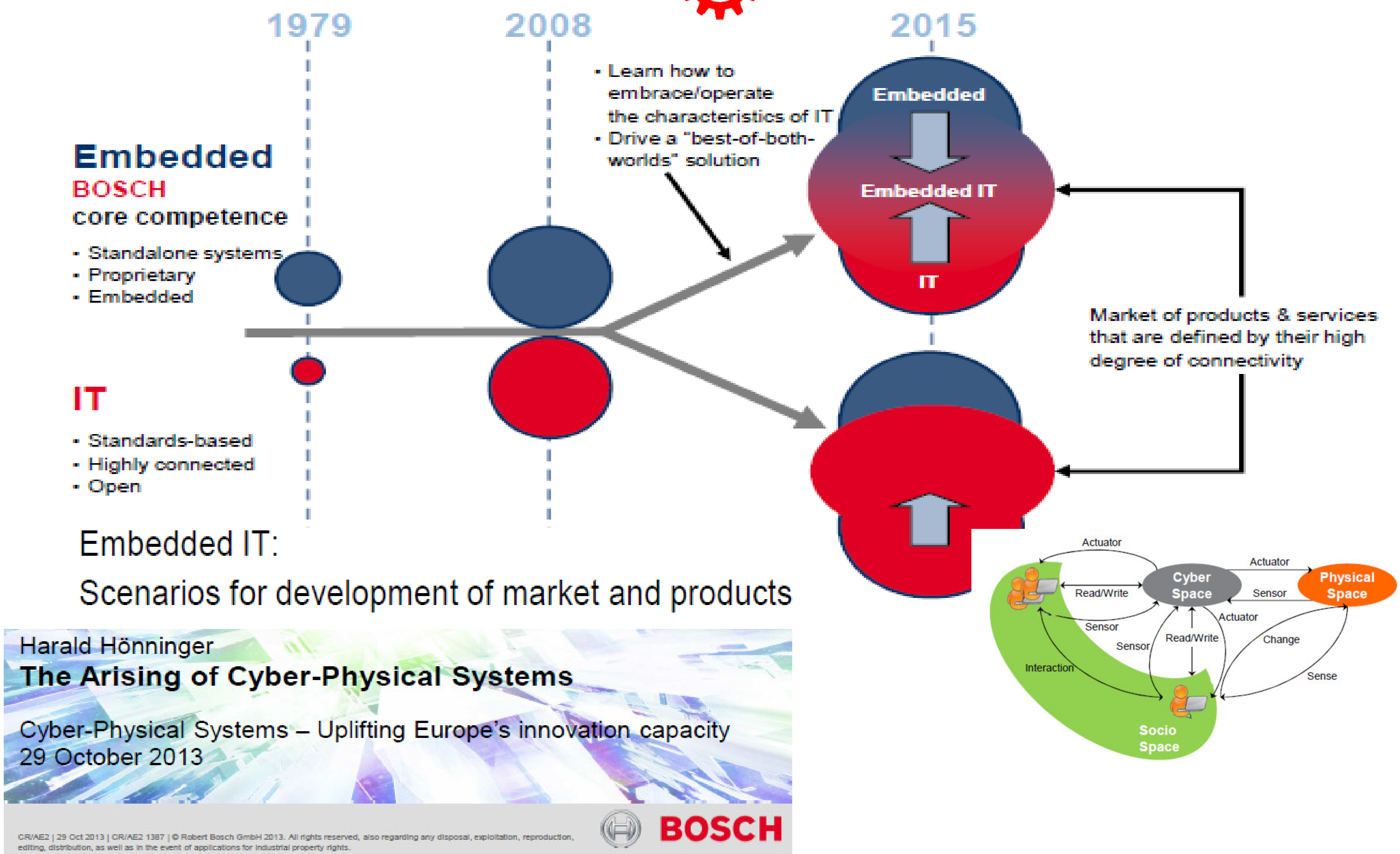
- ARTEMIS: www.artemis-ju.eu
  http://cordis.europa.eu/fp7/ict/embedded-systems-engineering/documents/artemis-sra-2011.pdf
- ERC: http://erc.europa.eu
- EIT: http://eit.europa.eu, www.eitictlabs.eu
- EC, SoS reports, 2009 and 2012

ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/esd/workshop-report-v1-0_en.pdf
http://cordis.europa.eu/fp7/ict/embedded-systems- engineering/home_en.html

7. **CPSOS** – Roadmap on R&D and Innovation in Engineering and Management of CPS of Systems.
Start Date: 2013-10-01 **End Date**: 2016-03-31
Exchange platform for SoS related projects and communities.

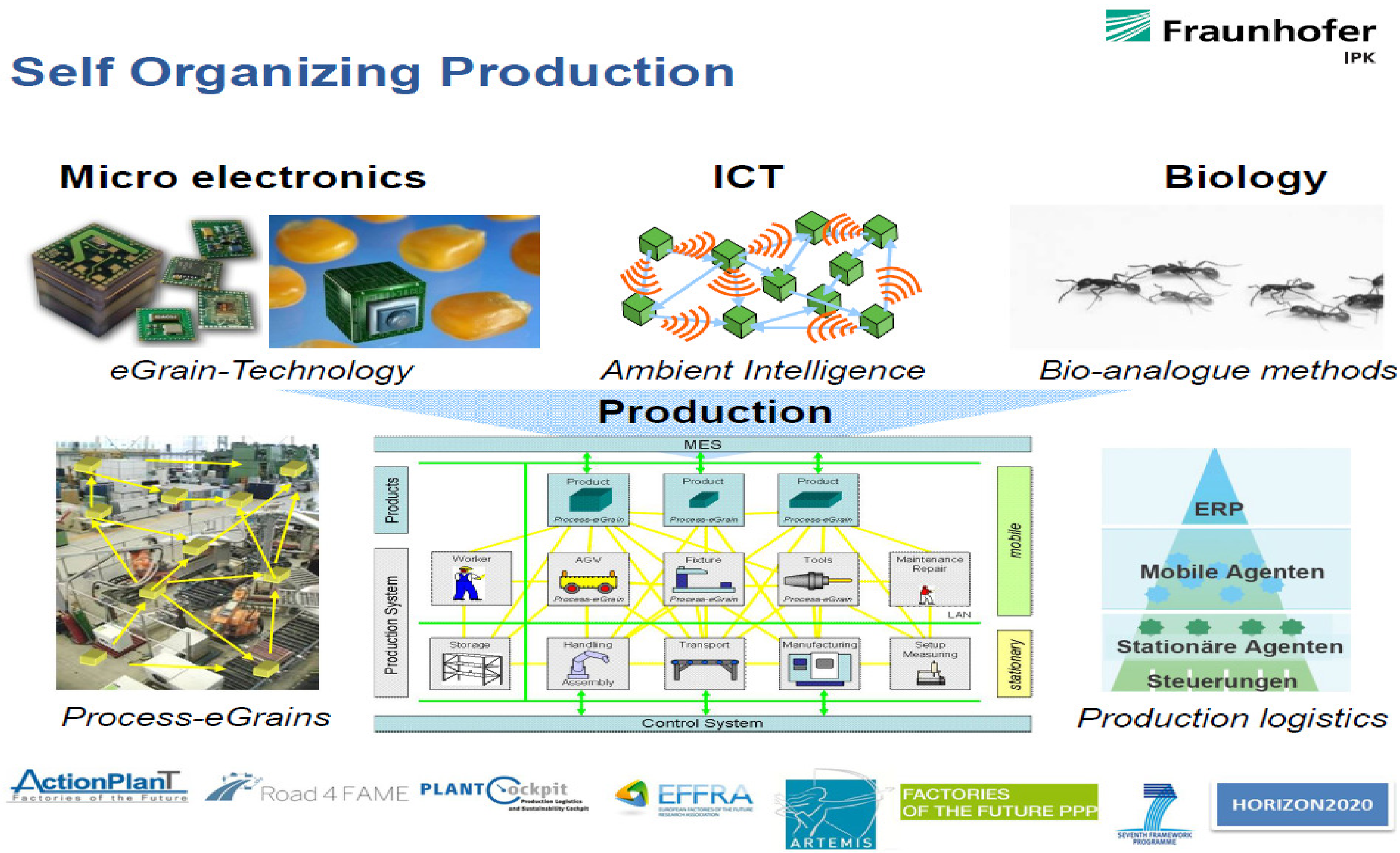
8. **EURO-MILS -** Virtualisation for Trustworthy Applications and Security in Critical Domains
Start Date: 2012-10-01 **End Date**: 2015-09-30
Cyber-physical networks based on embedded systems will connect next generations of aircrafts and vehicles.

EU BOSCH CPS


1979
2008
2015
Embedded
BOSCH
core competence
• Standalone systems
• Proprietary
• Embedded
IT
• Standards-based
• Highly connected
• Open
• Learn how to embrace/operate the characteristics of IT
• Drive a "best-of-both-worlds" solution
Embedded
Embedded IT
IT
Market of products & services that are defined by their high degree of connectivity
Embedded IT:
Scenarios for development of market and products
Harald Hönninger
The Arising of Cyber-Physical Systems
Cyber-Physical Systems – Uplifting Europe's innovation capacity
29 October 2013
CR/AE2 | 29 Oct 2013 | CR/AE2 1387 | © Robert Bosch GmbH 2013. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.
BOSCH
Actuator
Read/Write
Sensor
Interaction
Cyber Space
Physical Space
Socio Space
Actuator
Sensor
Actuator
Read/Write
Sensor
Change
Sense

Fraunhofer EU Projects

Fraunhofer Institut for Production systems and Design (IPK)
Pascalstraße 8-9
10587 Berlin



EU SIEMENS

Thomas Runkler, Siemens Corporate Technology

Session: The role of Cyber-Physical Systems (CPS) for manufacturing

Cyber-Physical Systems in manufacturing and production workshop Brussels 30th October

SIEMENS

Cyber-physical systems (CPS) enable the future of manufacturing

Communication everywhere and every time

- Future infrastructure will support the access to information everywhere and every time without any specific installation / parameterization needs

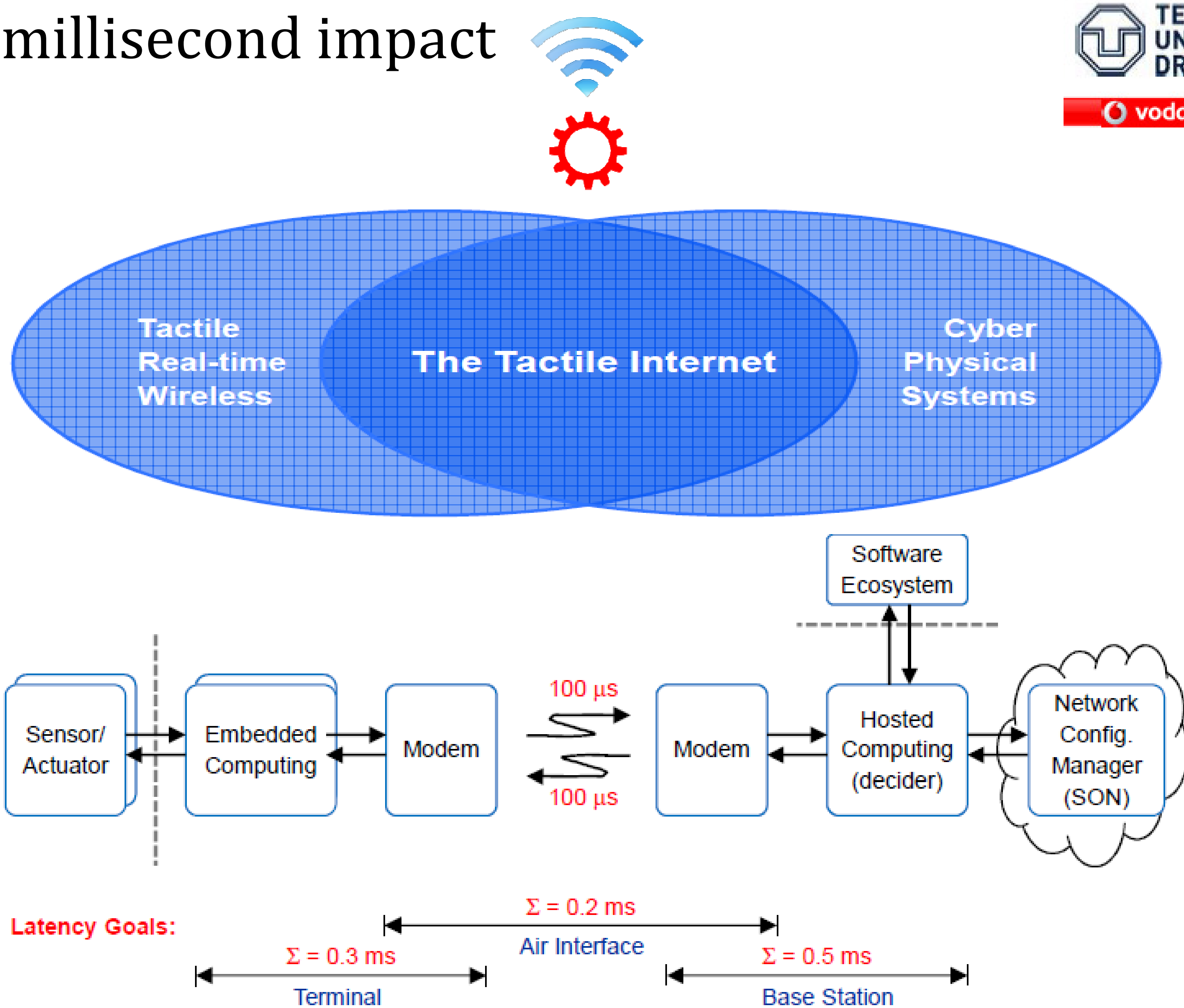
Production and products will be intelligent

- Production resources will be autonomic and will connect to each other (M2M)
- Products know their own production systems

Digital and real world will merge

- Each real object will have a digital shadow, which reflects the characteristics of the real object

The 1 millisecond impact



EU EIT ICT LAB

VTT

Budapest University of Technology and Economics

DFKI

Ericsson

FBK

Fortiss

Royal Institute of Technology KTH

SICS

Siemens

Technical University of Berlin

Technical University of Munich

TNO

University of Bologna

University of Trento

CPS-specific extension of sensor-net test-beds for the development, testing and evaluation of cyber-physical applications

Demonstrator for water-cycle management

Methods & tools addressing the engineering of complex CPS

Reference architecture for medical applications

http://www.eitictlabs.eu/innovation-areas/cyber-physical-systems/

German Industry Initiative

A german initiative preparing the fourth industrial revolution

Funding Bodies: BMBF, BMWi

Budget: 200 MEUR

Source: http://www.bmbf.de/de/19955.php

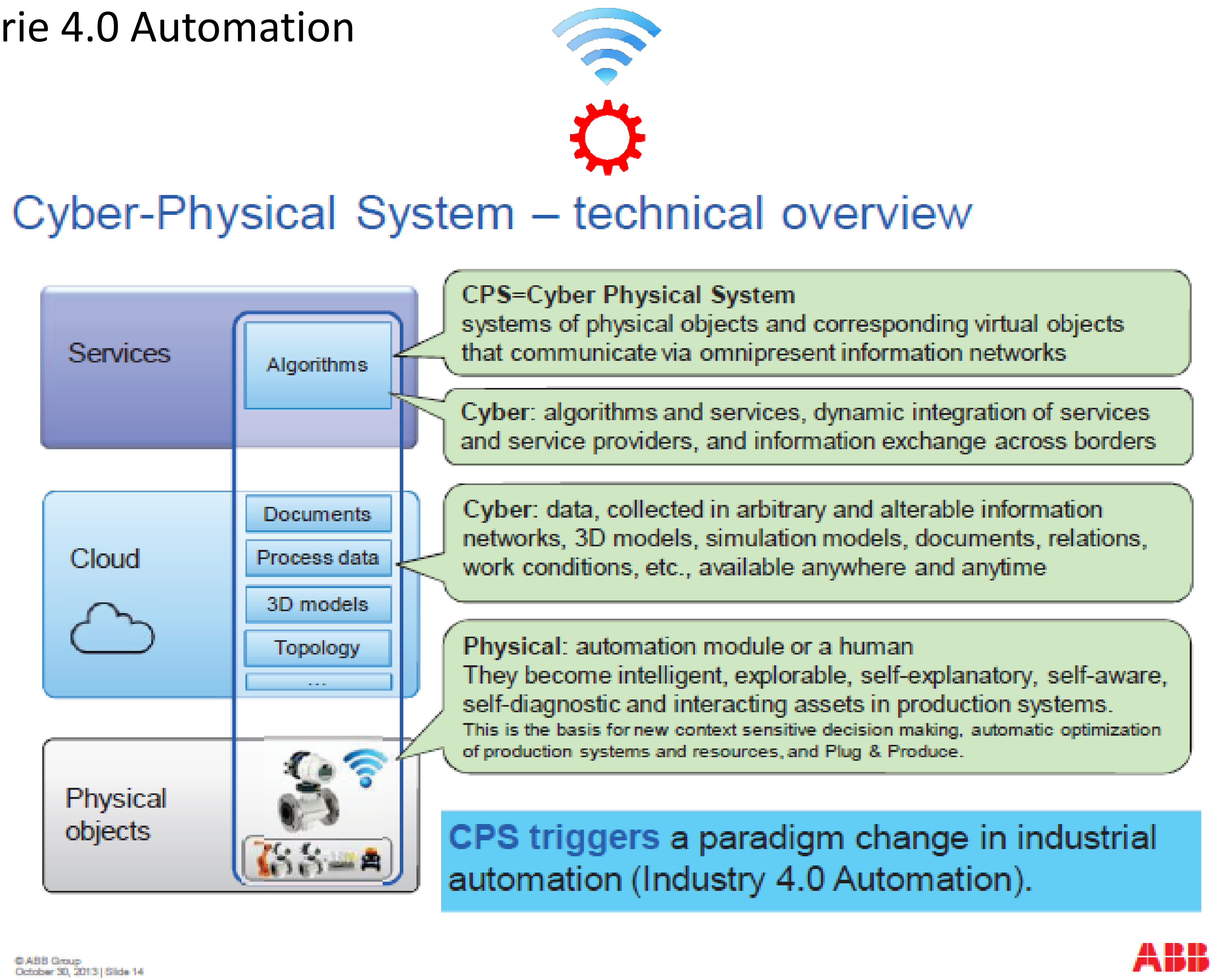
Alf Isaksson, ABB, Västerås, Sweden, Rainer Drath, ABB, Ladenburg, Germany

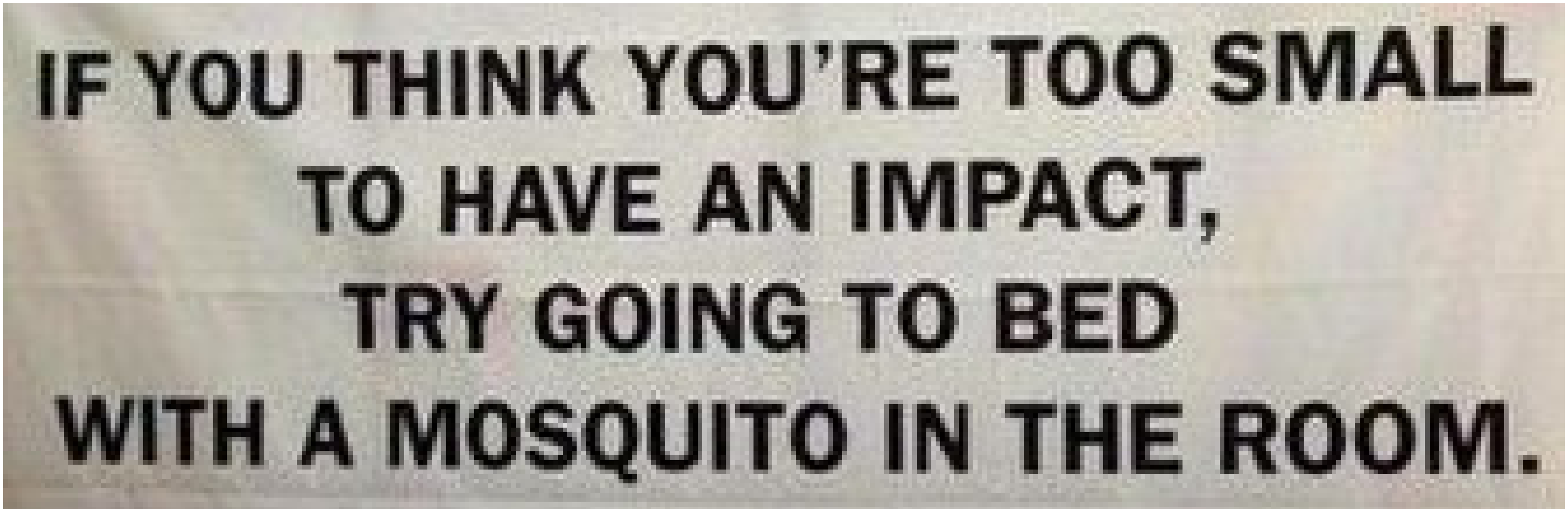
Cyber Physical Production Systems
The next industrial revolution?

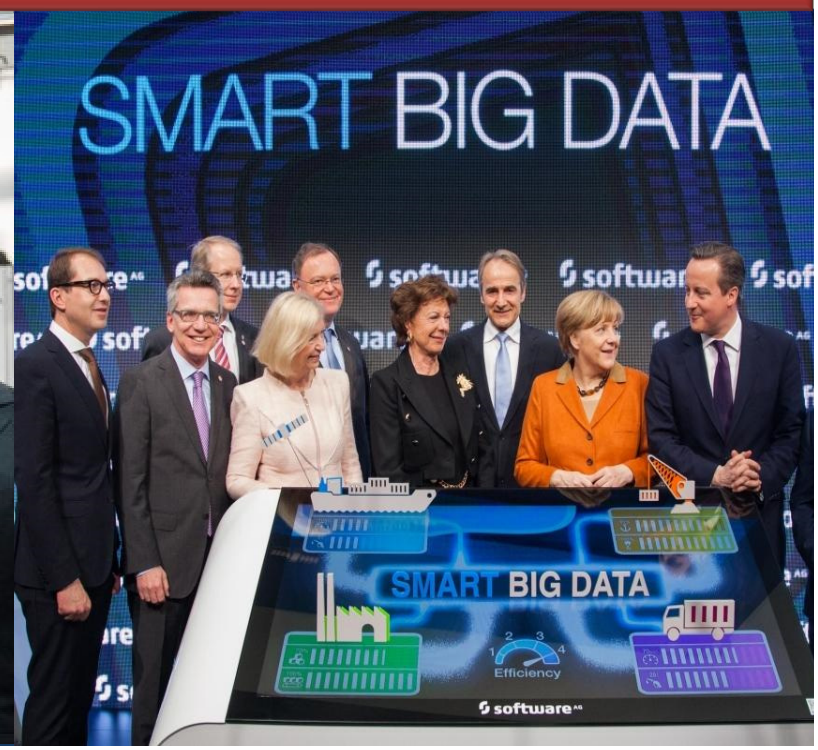
- ZVEI companies
  - ABB
  - Bosch
  - Infineon
  - Phoenix Contact
  - Siemens
- VDMA companies
  - Festo
  - Trumpf
  - Thyssen Krupp
  - Wittenstein
- BITKOM companies
  - Hewlett Packard
  - IBM
  - SAP
  - Telekom
- One representative from scientific board
- One representative from union IG Metall

Corporate Steering Committee

Industrie 4.0 Automation




IF YOU THINK YOU'RE TOO SMALL
TO HAVE AN IMPACT,
TRY GOING TO BED
WITH A MOSQUITO IN THE ROOM.


SMART BIG DATA
SMART BIG DATA
Efficiency
software AG

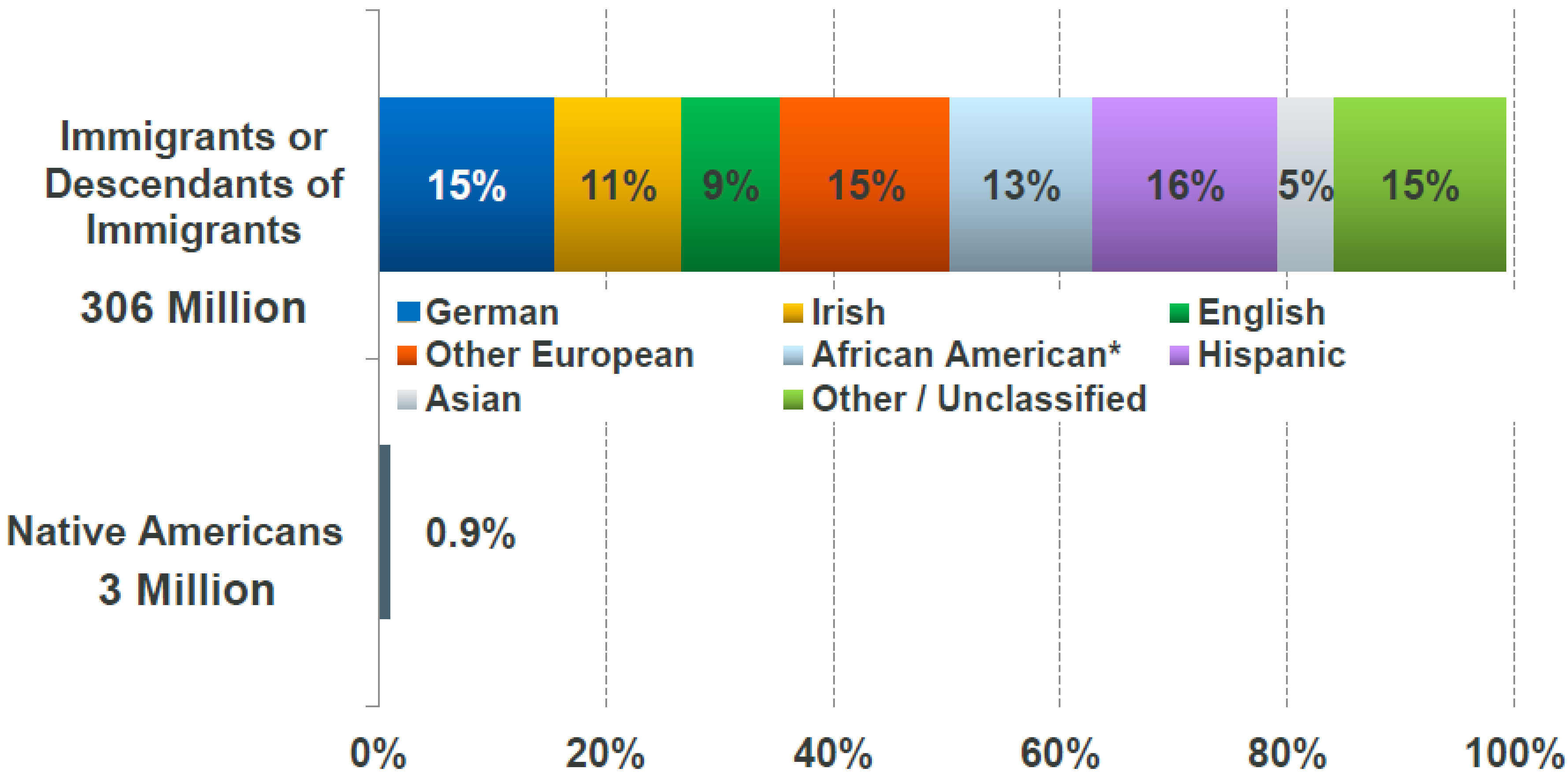
Founders / Co-Founders of Top 25 U.S. Public Tech Companies, Ranked by Market Capitalization

Rank	Company	Mkt Cap ($MM)	LTM Rev ($MM)	Employees	1st or 2nd Gen Immigrant Founder / Co-Founder	Generation
1	Apple	$416,622	$164,346	76,100	Steve Jobs	2nd-Gen, Syria
2	Google	268,445	49,958	53,861	Sergey Brin	1st-Gen, Russia
3	IBM	239,530	104,507	434,246	Herman Hollerith	2nd-Gen, Germany
4	Microsoft	234,828	72,764	94,000	--	--
5	Oracle	172,044	37,230	115,000	Larry Ellison / Bob Miner	2nd-Gen, Russia / 2nd-Gen, Iran
6	Amazon.com	119,011	61,093	88,400	Jeff Bezos	2nd-Gen, Cuba
7	Cisco	116,904	47,252	66,639	--	--
8	Intel	105,721	53,341	105,000	**Andy Grove**	**1st-Gen, Hungary**
9	Ebay	65,357	14,028	31,500	Pierre Omidyar	1st-Gen, France
10	Facebook	63,472	5,089	4,619	Eduardo Saverin	1st-Gen, Brazil
11	EMC	53,347	21,714	60,000	Roger Marino	2nd-Gen, Italy
12	Hewlett-Packard	43,118	118,397	331,800	--	--
13	Texas Instruments	38,756	12,690	34,151	Cecil Green / J. Erik Jonsson	1st-Gen, UK / 2nd-Gen, Sweden
14	VMware	35,917	4,605	13,800	Edouard Bugnion	1st-Gen, Switzerland
15	Priceline	35,583	5,261	7,000	--	--
16	Automatic Data Processing	31,274	10,945	57,000	Henry Taub	2nd-Gen, Poland
17	salesforce.com	25,840	3,050	9,800	--	--
18	Dell	25,003	56,982	111,300	--	--
19	Yahoo!	24,306	4,987	11,700	Jerry Yang	1st-Gen, Taiwan
20	Cognizant Technology	23,648	7,346	156,700	Francisco D'souza / Kumar Mahadeva	1st-Gen, India** / 1st-Gen, Sri Lanka
21	Adobe Systems	20,640	4,373	11,144	--	--
22	Broadcom	19,713	8,006	11,300	Henry Samueli	2nd-Gen, Poland
23	Intuit	19,393	4,153	8,500	--	--
24	LinkedIn	19,357	972	3,458	Konstantin Guericke / Jean-Luc Vaillant	1st-Gen, Germany / 1st-Gen, France
25	Symantec	16,916	6,839	20,500	--	--
Total Founded by 1st or 2nd Gen Immigrants		**$1,590,800**	**$507,516**	**1,151,835**		

KPCB

US Population by Ancestry

US Census Bureau, 2010



Should we analyze demographics coupled with ancestry in order to account for cultural bias and role of behavorial genetics when modeling parameters necessary to predict market potential ?

Future-Ready Fiction

Please download this book from
http://tinyurl.com/SD-86935

THANK YOU

CONSCIENCE AND COMMON SENSE

Far Reaching Changes in the Near Future

Shoumen Palit Austin Datta

Back to the Future

Observing the Changing World Around Us

Pursuit of Ideas …

- I am pursuing a convergence of ideas (partially expressed in the papers below) related to the potential arising out of the diffusion of the Internet of Things (IoT). In addition to IoT, the growth of the industrial internet may lead to positive global developments including the following -

  – better connectivity and transparency of processes linked to humans and objects which may unleash potentially game-changing outcomes that may induce new lines of business growth, economic growth and create new jobs in distinctly non-traditional areas still unknown to us

  – broad spectrum of data and interoperability standards may [a] bridge syntactic and semantic incompatibility due to proprietary data dictionaries [b] create global platforms for connectivity, eg, healthcare EHR/EMR/devices interoperability platform [c] intelligent predictive analytics to influence or improve dynamic events or transactions at the core and the edge which may or may not be human-assisted eg automating the digital supply chain network

  – analytics and diagnostics will catalyze real-time and run-time feedback loops to [a] improve efficiency, [b] strengthen cybersecurity and [c] enhance data driven decision support in human-aided environments (human-robot interactions) and autonomous systems (land, sea, air, space)

– **Datta, S.** (2008) Auto ID Paradigm Shifts from Internet of Things to Unique Identification of Individual Decisions in System of Systems. *Supply Chain Europe* **17** 38-43 (May-June 2008) http://dspace.mit.edu/handle/1721.1/41900 ▪ http://dspace.mit.edu/handle/1721.1/57508 • MIT Engineering Systems WPS http://esd.mit.edu/WPS/2008/esd-wp-2008-09.pdf

– **Datta, S.,** Granger, C. W. J., Barari, M. and Gibbs, T. (2007) Management of Supply Chain: an alternative modeling technique for forecasting. *Journal of the Operational Research Society* **58** 1459-1469 http://dspace.mit.edu/handle/1721.1/41906

– **Datta, S.,** *et al* (2003) Adaptive Value Network (Chapter 1 in *Evolution of Supply Chain Management: Symbiosis of Adaptive Value Networks and ICT* (Information Communication Technology). www.wkap.nl/prod/b/1-4020-7812-9?a=1

Predictions …

The telephone has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us”
- Western Union internal memo (1876)

Heavier than air flying machines are impossible.
- Lord Kelvin (William Thomson), President of Royal Society of London (1895)

There is no reason for any individuals to have a computer in their home.
- Ken Olsen, President, Chairman and Founder of DEC (1977)

An expert is someone who can tell you exactly how it can’t be done.

… in my story “Sally,” published in 1953, I described computerized cars that had almost reached the stage of having lives of their own. And, in the last few years, we indeed have computerized cars that can actually talk to the driver … (Asimov in *Robot Dreams*)

Hitchhiking robot thumbs its way across Canada

Aug 02, 2014 by Michel Comte

www.cnn.com/2014/08/01/tech/social-media/hitchhiking-robot-hitchbot/index.html

This photo obtained July 31, 2014 shows creators Dr. Frauke Zeller of Ryerson University and Dr. David Harris Smith of McMaster University with hitchBOT

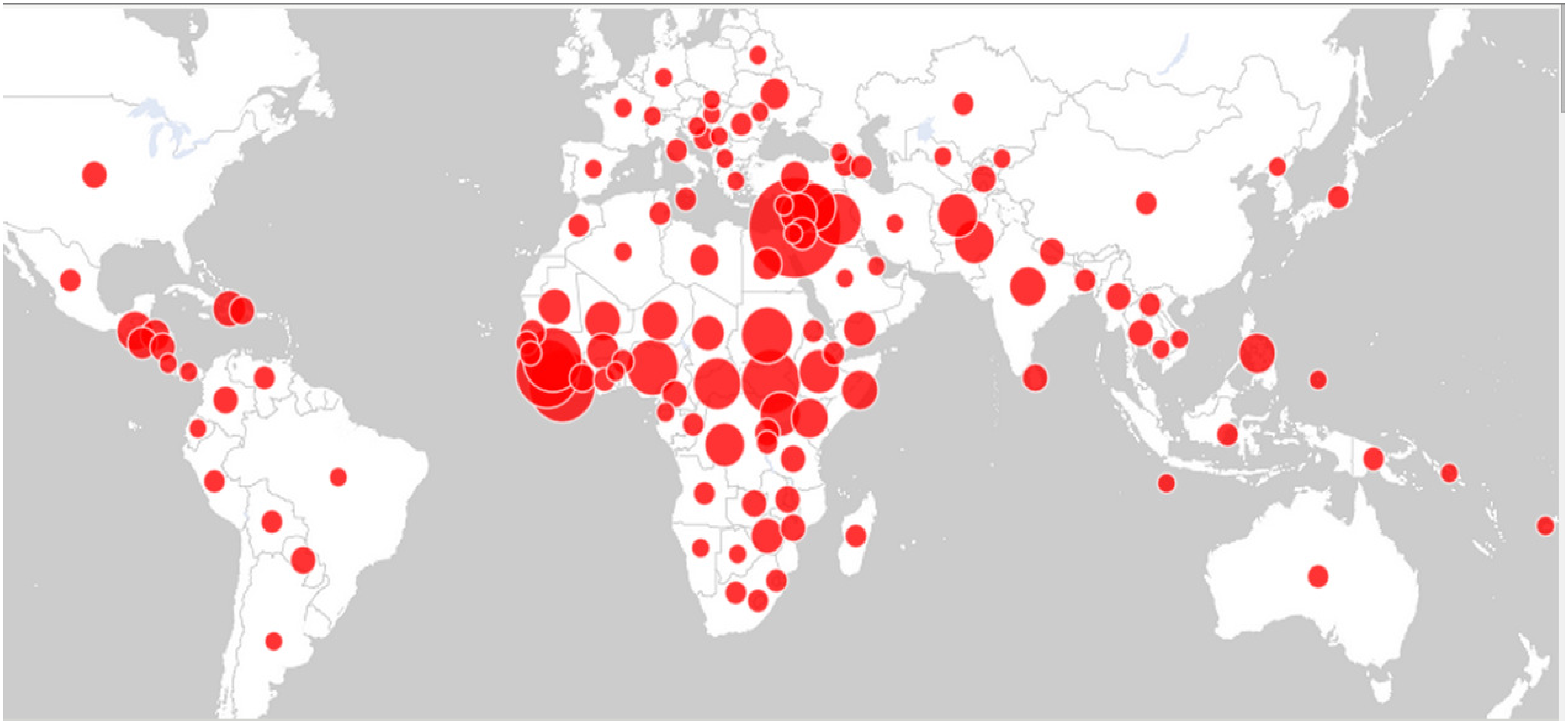
http://vimeo.com/100845249

A talking robot assembled from household odds and ends is hitchhiking thousands of kilometers across Canada this summer as part of a social experiment to see if those of its kind can trust humans.

www.hitchbot.me

Think Different – Emergency Response and Resilience

"The role of a creative leader is not to have all the ideas; it's to create a culture where everyone can have ideas and feel that they're valued." GLENN THEODORE SEABORG



William Taft visited Panama five times as Theodore Roosevelt's Secretary of War and twice as President Taft. He also hired John Stevens and later recommended Goethals. Taft became president in 1909, when the construction of the canal was only at the halfway mark and remained in office for most of the remainder of the work. Goethals later wrote that "the real builder of the Panama Canal was Theodore Roosevelt".

The following words of Theodore Roosevelt are displayed in the Rotunda of the Administration Building of The Panama Canal:

It is not the critic who counts, not the man who points out how the strong man stumbled, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena; whose face is marred by dust and sweat and blood; who strives valiantly, who errs and comes short again and again; who knows the great enthusiasms, the great devotions, and spends himself in a worthy cause; who, at the best, knows in the end the triumph of high achievement; and who, at the worst, if he fails, at least fails while daring greatly, so that his place shall never be with those cold and timid souls who know neither victory nor defeat.

Grand Challenges

In Praise of Imperfection

Gerald Santucci
Head of Unit "Knowledge Sharing" at European Commission

Dear Shoumen,

Thank you so much! This is the BEST report I ever read on the IoT, Industrial Internet, whatever it's called. I like the evidence-based analysis, the notion of "impotence" of II without data and data analytics, the description of II around the dimensions of Technology, Strategy and Organisation (with an emphasis on culture change), the detailed analysis and predictions about application fields, etc. So well done!

Dr Shoumen Palit Austin Datta ● shoumen@mit.edu ● shoumendatta@gmail.com ● http://bit.ly/S-Datta