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Dr Shoumen P Austin Datta ● Research Affiliate, School of Engineering, MIT ● SVP, Industrial Internet Consortium ● shoumen@mit.edu

Paradox to Paradigms

TEMPORARILY CATALYZED BY CYBERPHYSICAL SYSTEMS (CPS) AND INTERNET OF THINGS (IoT)

Dr Shoumen P Austin Datta ● Research Affiliate, School of Engineering, MIT ● SVP, Industrial Internet Consortium ● shoumen@mit.edu

- THE ORIGIN OF THE TITLE

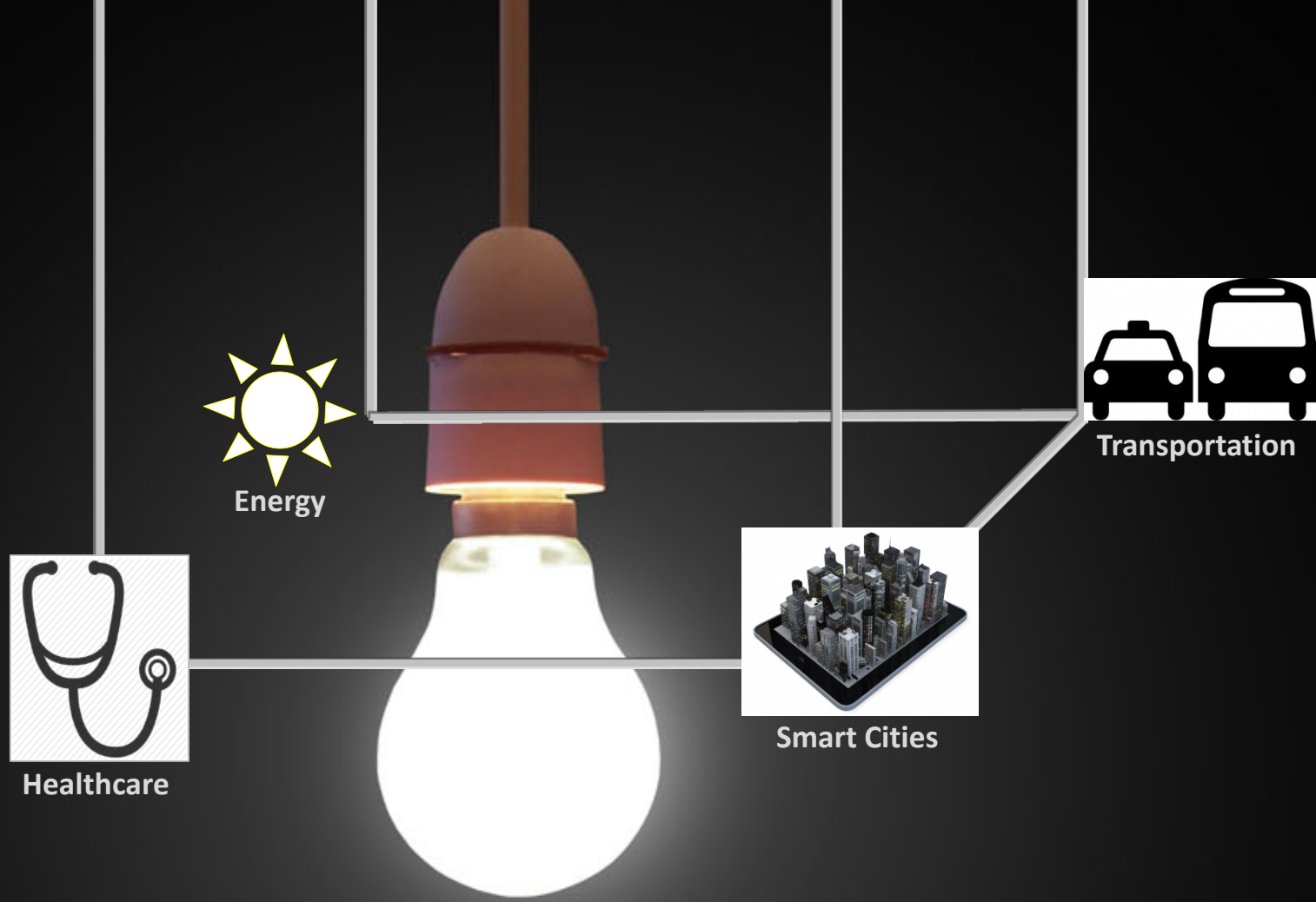
The Nobel Prize in Physics 2004

David J. Gross, H. David Politzer, Frank Wilczek

Nobel Lecture

Asymptotic Freedom: From Paradox to Paradigm

Frank Wilczek held his Nobel Lecture December 8, 2004, at Aula Magna, Stockholm University. He was presented by Professor Sune Svanberg, Chairman of the Nobel Committee for Physics.



Grand Challenges

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

- Failure is the only road to success ● http://bit.ly/VANDERBILT

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

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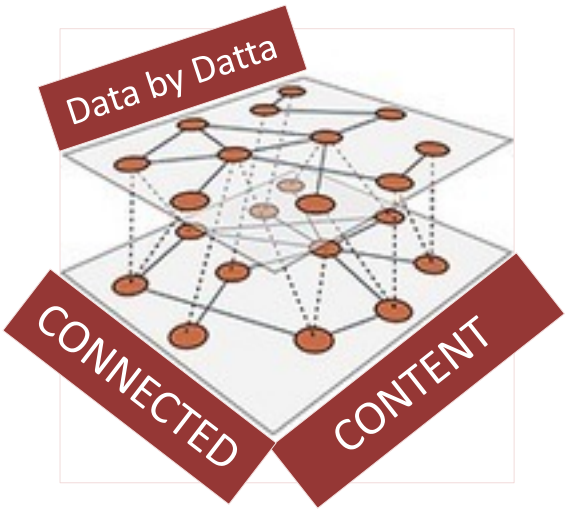
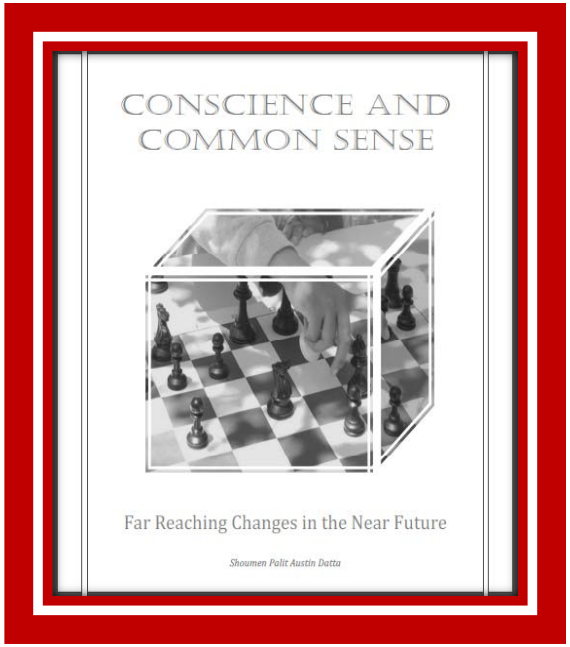


Files in this item

Name	Size	Format	Description
Dynamic Disequilibrium ...	87.66Kb	PDF	Dynamic Disequilibrium
IoT-Infographic.pdf	4.473Mb	PDF	IoT - made simple
L'humanité a besoin ...	35.68Mb	PDF	L'humanité a besoin rêveurs
MIT-Technology-Re ...	2.778Mb	PDF	IoT
The Time Lab.pdf	759.4Kb	PDF	The Time Lab
The Commencement.pdf	166.0Kb	PDF	The Commencement Address
IIC June 2014.zip	11.50Mb	Unknown	IIC June 2014
MOOC Library.zip	162.6Mb	Unknown	MOOC Library
34_Conscience and ...	10.00Mb	PDF	Conscience and Common Sense
Advisory _ Folder ...	184.0Mb	Unknown	Advisory Folder 01
Advisory _ Folder ...	139.3Mb	Unknown	Advisory Folder 02
Advisory _ MIT Task ...	5.541Mb	PDF	MIT Education
TEG_303.pdf	46.41Mb	PDF	Tools for Economic Growth
TNT_508.pdf	76.14Mb	PDF	THE NEXT TSUNAMI
FINAL Program _ ...	852.9Kb	PDF	Program for Sep 15-16
US GOV GRANTS.pdf	2.254Mb	PDF	US GOV GRANTS
EQM _ work in ...	193.2Kb	PDF	EQM
IoT _ The Networked ...	20.50Mb	PDF	IoT - The Networked Physical World
Grand Challenge _ ...	6.575Mb	PDF	Grand Challenges

• Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

- The Big Picture
  - → Birth of IoT and its life in the Smart Cities
- Challenges
  - → In progress
    - ☑ Autonomous Transportation
      - Got Drone?
      - Semantics of Time
      - Roadmap - Cloud, Fog, Rain, Snow
  - → In the wings
    - ☑ Healthcare
      - Semantics
      - HL7 codes
      - Don't use my data
      - Data de-identification
      - Medical device interoperability
    - ☑ Big Data
      - Bad name
      - Elusive Quest for Monetization (EQM)
- Disequilibrium
  - Death of a Middleman
  - Girls Who Code
  - Gini Coefficient
  - Energy
  - Water
  - Willy Wonka and The Chocolate Factory
- The Bigger Picture
  - Women in Physics
  - Teachers in Classrooms
  - State of California Prisons



• Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

- The Big Picture

  → Birth of IoT and its life in the Smart Cities

• The Art of Automaton

● **10th Century BC -** CHINA - Life-size, human-shaped figure created by mechanical engineer Yan Shi and presented to King Mu of Zhou (1023-957 BC)

● **8th Century BC -** GREECE - Athenian craftsman Daidalos created statues endowed with movement. The most famous of these was the Bull of Pasiphae.

● **8th Century BC -** PERSIA (IRAQ) – Wind powered automata - statues that turned with the wind over the domes of the four gates and palace complex of Round City of Baghdad. Banū Mūsā brothers invented programmable automatic flute (documented in *Book of Ingenious Devices*).

● **1st Century AD** - First programmable robot from Alexandria, Greece (circa 60 AD).

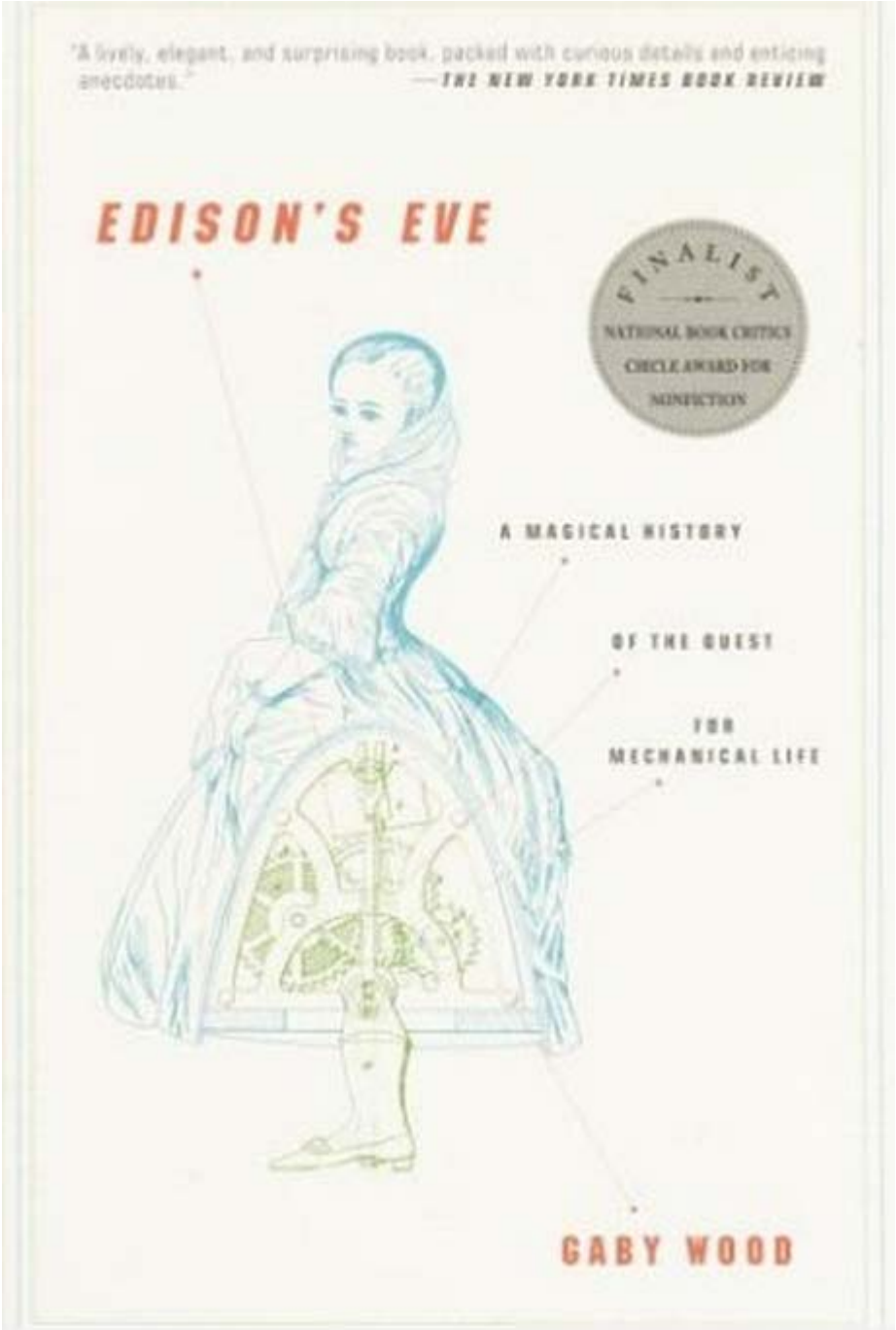
● **13th Century AD** - Al-Jazari described complex programmable humanoid automata amongst other machines he constructed. Documented in the *Book of Knowledge of Ingenious Mechanical Devices* in 1206. Created the first flushing toilet. Villard de Honnecourt (1230s sketchbook) designed animal automata and an angel that perpetually turns to face the sun.

● **15th Century AD** - Leonardo da Vinci sketched a more complex automaton around the year 1495. The design of Leonardo's robot was not rediscovered until 1950s. The robot could, if built, move its arms, twist its head and sit up.

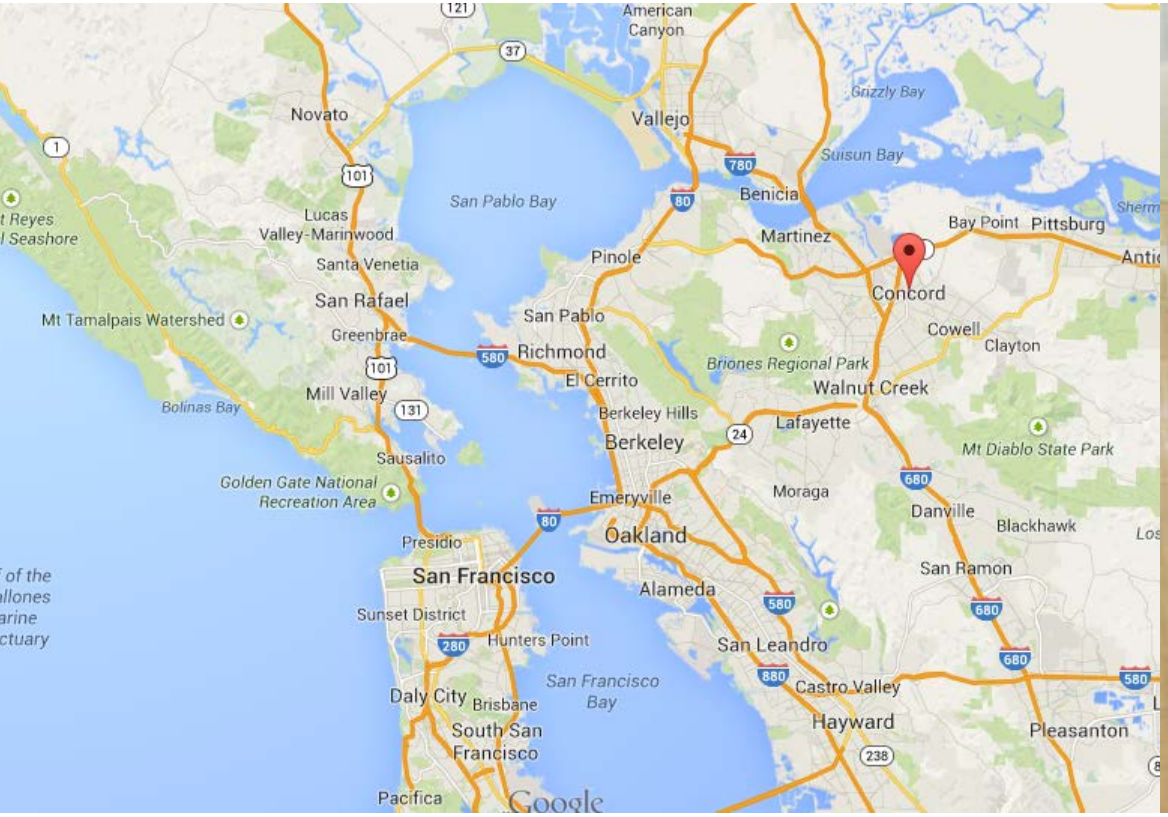
● **16th Century AD** - Smithsonian Institution has in its collection a clockwork monk, about 15 in tall, manufactured by Juanelo Turriano, mechanician to the Holy Roman Emperor Charles V (circa 1560).

● **18th Century AD** - Automaton Flute Player was constructed by Jacques de Vaucanson in 1737 (1709-1782) and first exhibited on February 11, 1738 in Paris, France. Vaucanson claims that the idea came to him in a dream. Later (1939) he created the digesting duck.

A Brief History of Automaton



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)

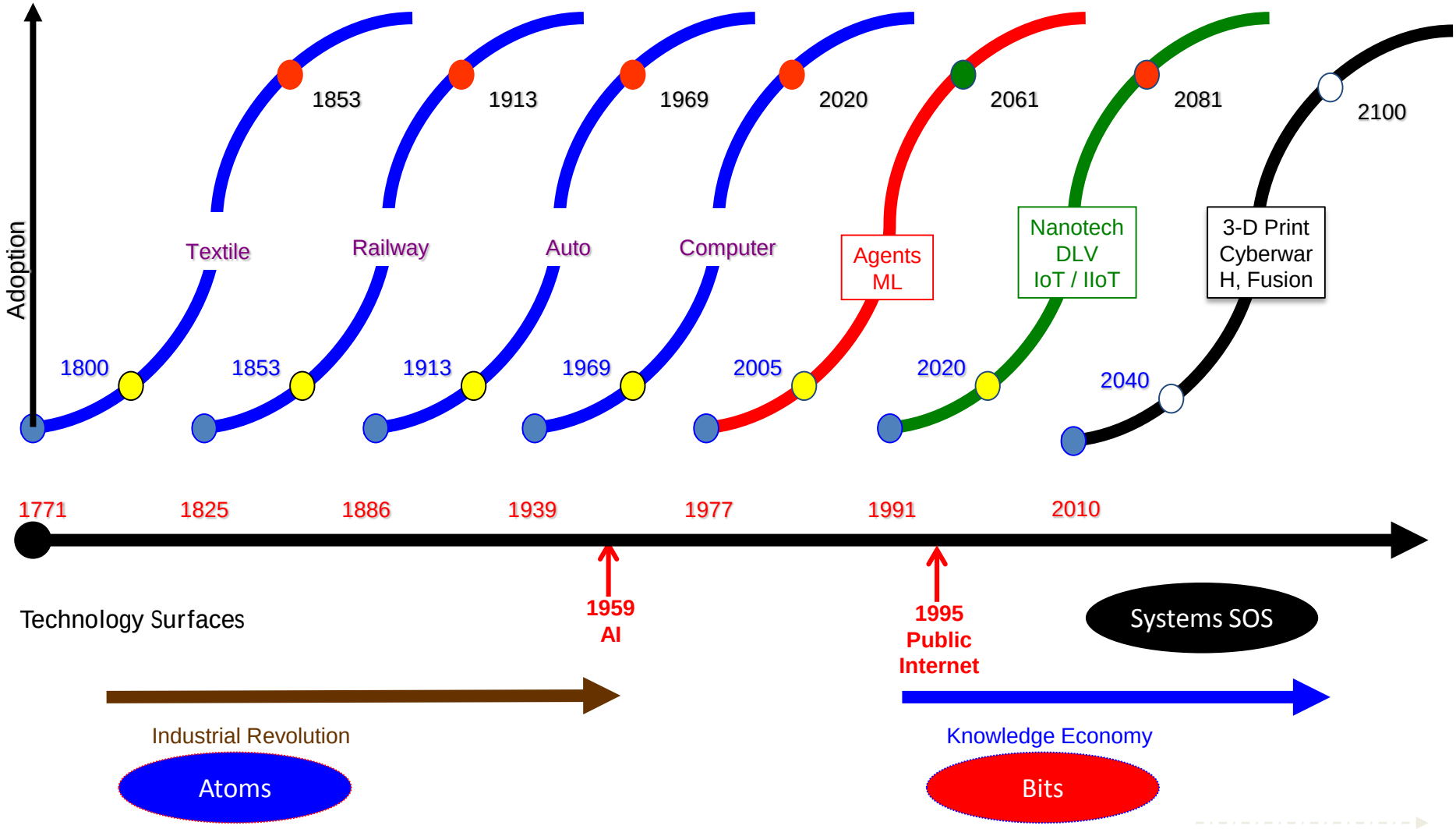
IoT – Internet of Things – let us start at the beginning

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 2000 as a member of the Technology Board at Auto ID Center.

The Wealth of Nations

Economic history and data related to Textile, Railway, Automobiles and Computers taken from work by Norman Poire



It takes about 28-30 years for an idea to be socialized before it is accepted and adopted. 1999 was the birth year for the IoT concept. Hence, it may mature for adoption in 2025.

• The Birth of the Internet of Things and the nascent Industrial Internet

1953

In my story "Sally," published in 1953, I described computerized cars that had almost reached the stage of having lives of their own. In the last few years, we do indeed have computerized cars that can actually talk to the driver. (*Robot Dreams* by Isaac Asimov aka Isaak Ozimov)

1987

Herbert Simon (June 15, 1916 – February 9, 2001) in his paper "*The Steam Engine and the Computer: What makes technology revolutionary*" framed his thoughts about the computer, "*you have to make friends with it, talk to it, let it talk to you.*"

1991

Mark Weiser (July 23, 1952 – April 27, 1999) of Xerox Palo Alto Research Center coined the term "ubiquitous computing" and suggested in 1988 that computers may *"weave themselves into the fabric of everyday life"* and influence the future of business (*Scientific American, 1991*).

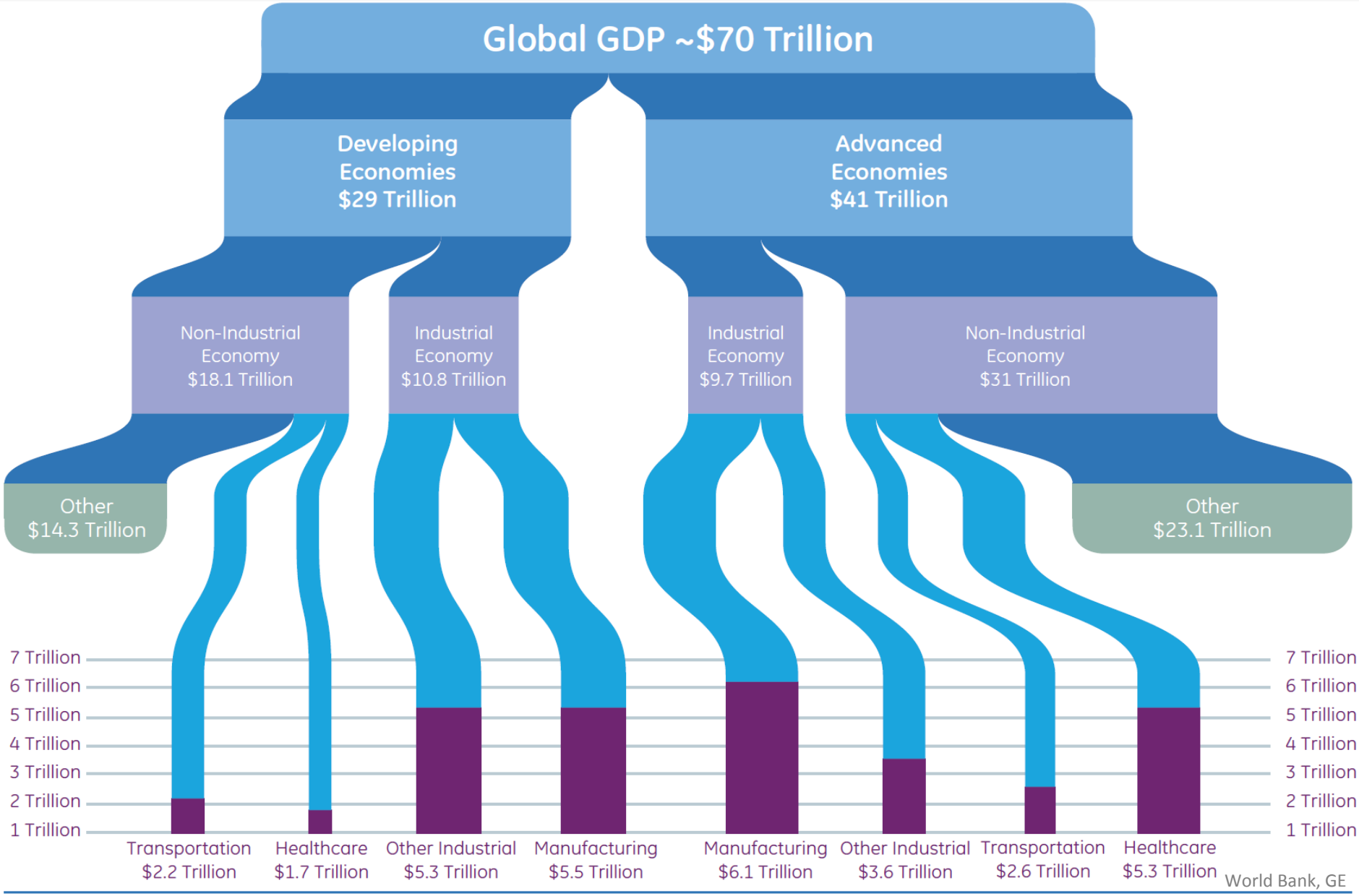
2000

The seminal paper *The Networked Physical World* by Sanjay Sarma *et al* spread the concept of the Internet of Things (IoT) through the creation of the Auto ID Center at MIT.

2013

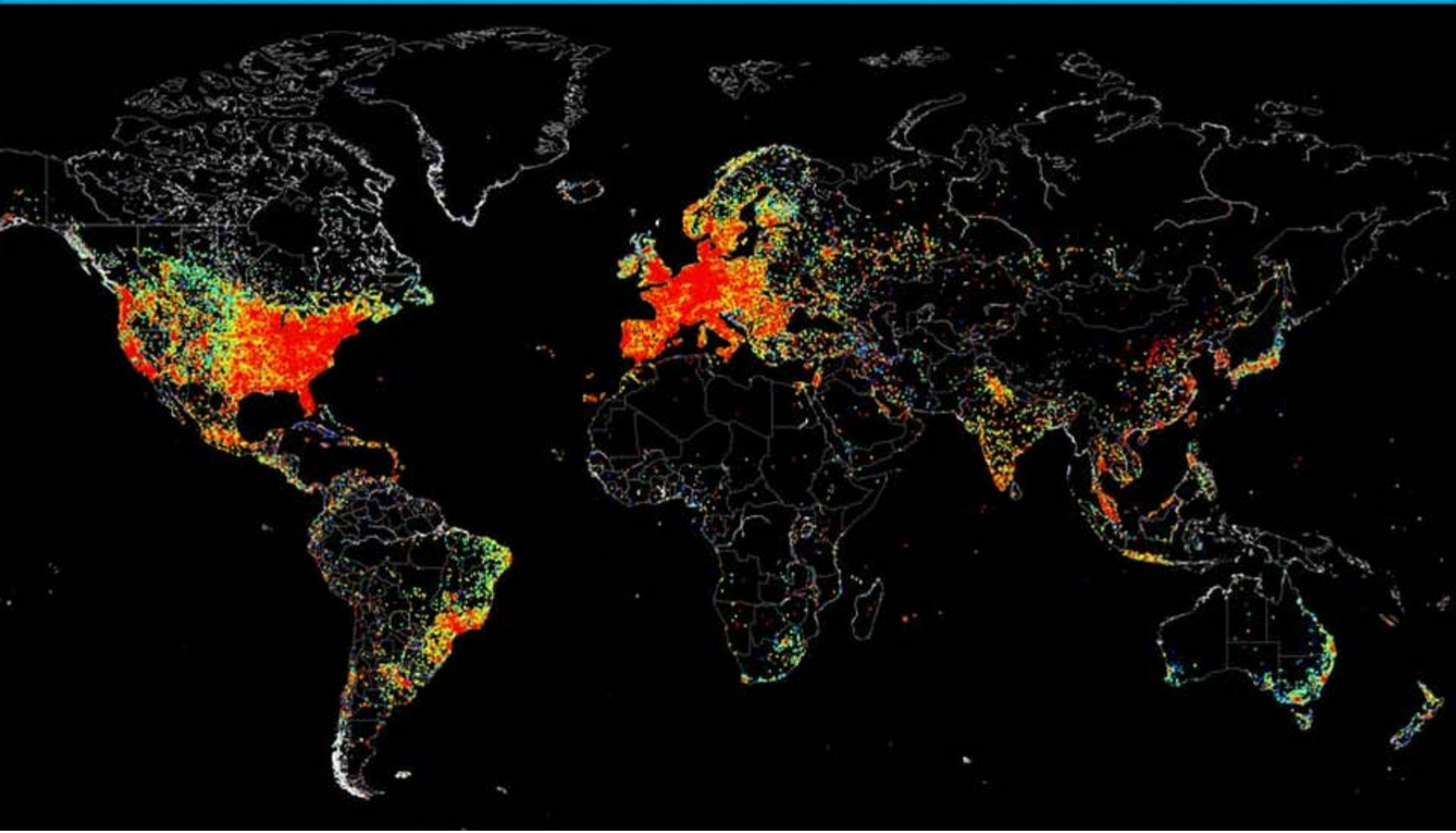
After sixty years of *Robot Dreams*, the evolution of the internet and the industrial revolution merged to conceive and create the Industrial Internet Consortium (03/27/2014) to catalyze global economic growth (www.iiconsortium.org). Sponsored by 5 founders with $1T market cap.

Projected Economic Impact of The Industrial Internet



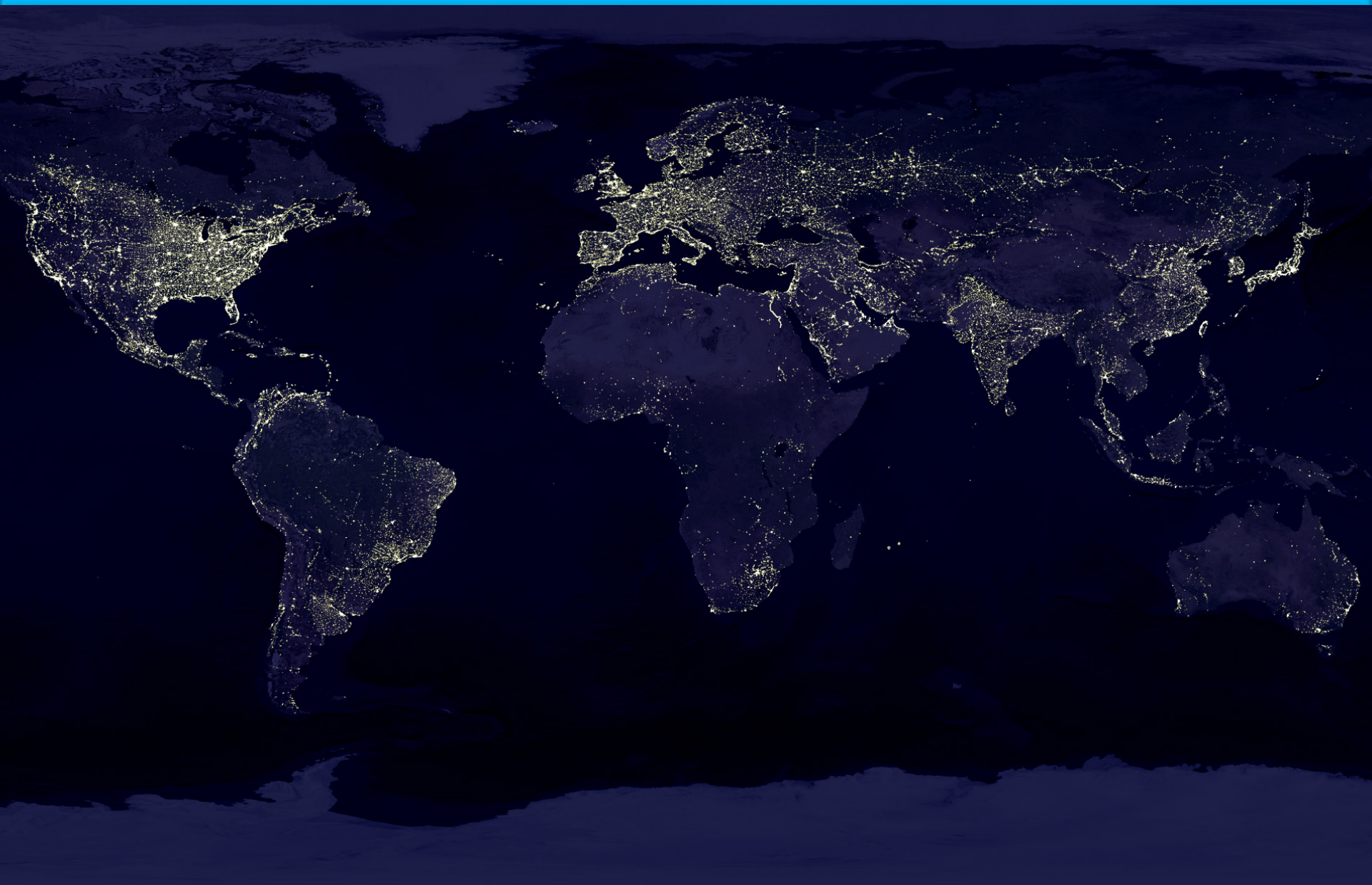
Industrial Internet opportunity ($32.3 Trillion) 46% share of global economy today

THE NETWORKED PHYSICAL WORLD

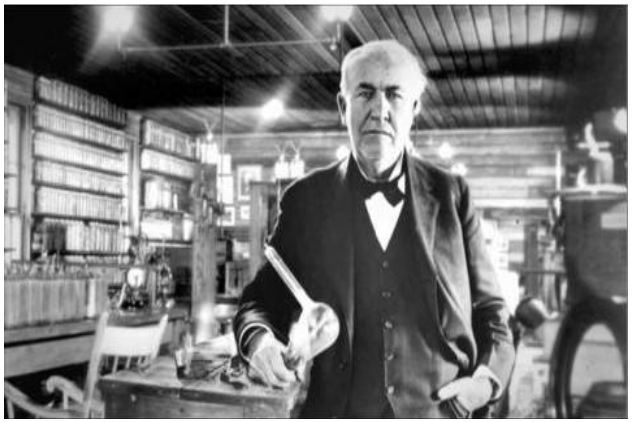


Map of every device connected to the internet on the evening of 2 August 2014 (Shodan). John Matherly pinged all IP addresses of devices online on 2 August (11pm UK). It took about 5 hours. Map represents all the devices (red = many) that pinged back in 12 hours using matplotlib.

IoT development proportional to infrastructure & dependent on energy resources?



The Economic Impact of the Internet of Things – Energy Under The Curve

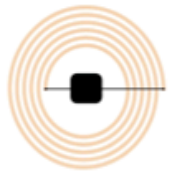


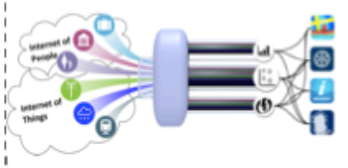
The concept of energy under the curve is directly analogous to an economy's money supply at a given time. Both the energy and the money supply are known amounts. The money is going to be spent by someone (device is going to output its energy). The key is for the money to be spent where it has the most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

A Short History of the Development of the Internet of Things starts with the re-invention of RFID





1994~1999

RFID based solutions

early 2000

WSAN oriented, Distributed WSANs, Communication technologies, Smart meter …

mid 2000

Smart Devices/ Web-enabled Apps/Services, initial products, vertical applications, concepts and demos, …

~2010

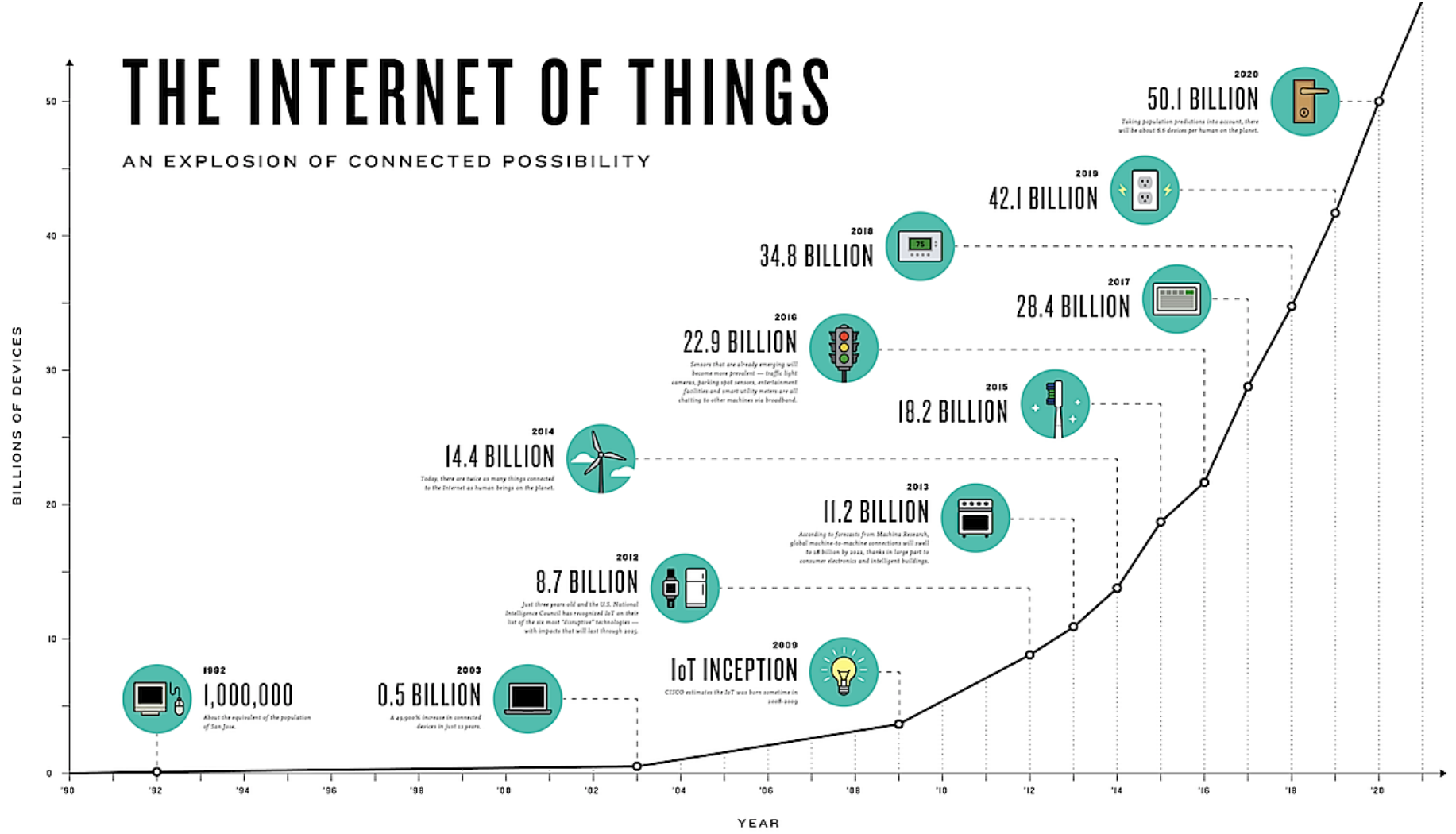
Physical-Cyber-Social Systems, Linked-data, semantics, More products and services (e.g. Smart Buildings), more heterogeneity, control and monitoring applications, …

~2020

Cloud platforms, Big (IoT) Data analytics, Mature IoT applications with actionable information, Multimodal fusion and intelligent data processing, Enhanced cellular/ wireless com. for IoT, Operational use-cases and commercial services/ applications, more Standards…

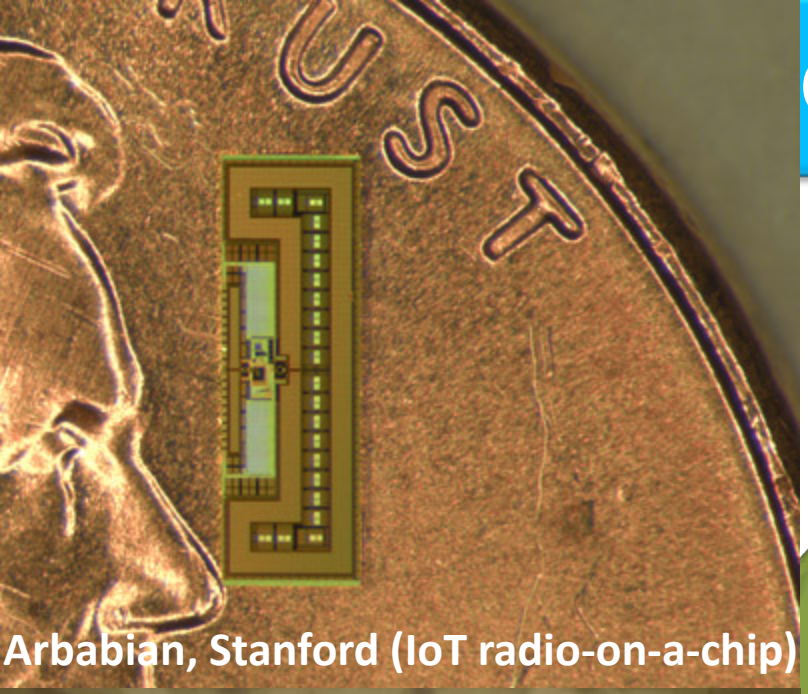
http://iot.ieee.org/images/files/newsletter/201409-barnaghi-figure1.png

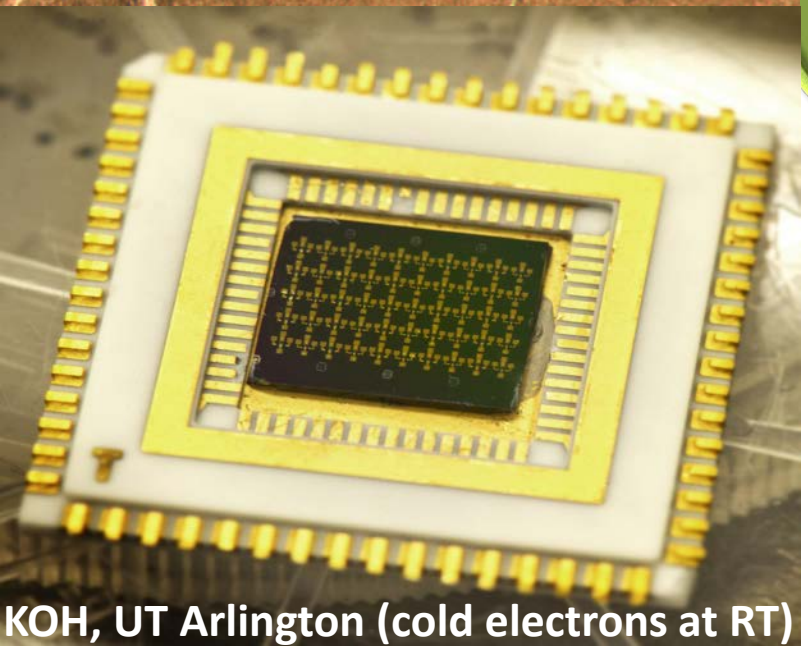
THE NETWORKED PHYSICAL WORLD

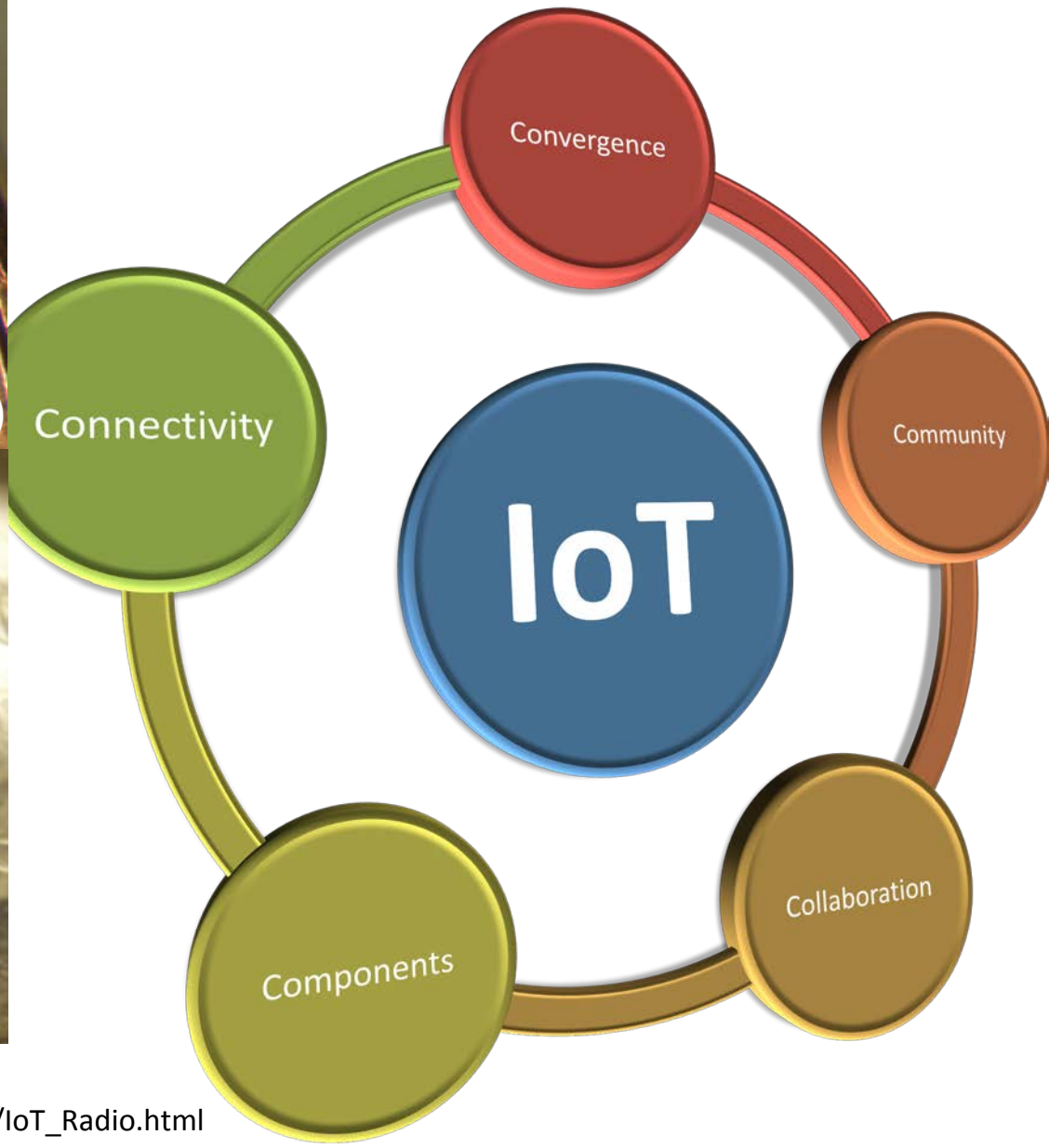


ECONOMIC GROWTH ENGINES

COMBINE THE TWO 2 CONNECT



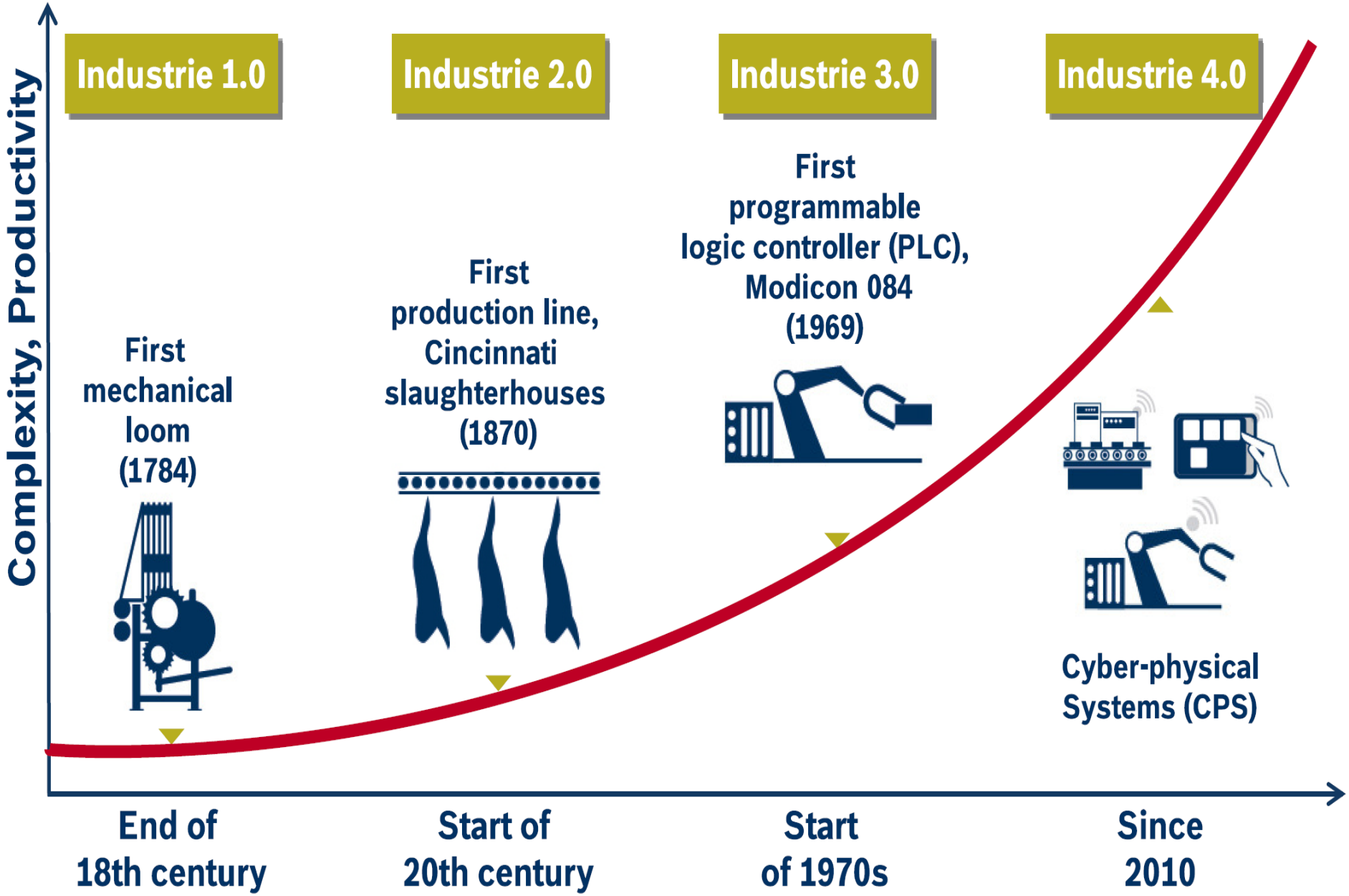




KOH●DOI: 10.1038/ncomms5745

ARBABIAN●http://web.stanford.edu/~arbabian/Home/IoT_Radio.html

THEN PREPARE FOR THE NEXT REVOLUTION

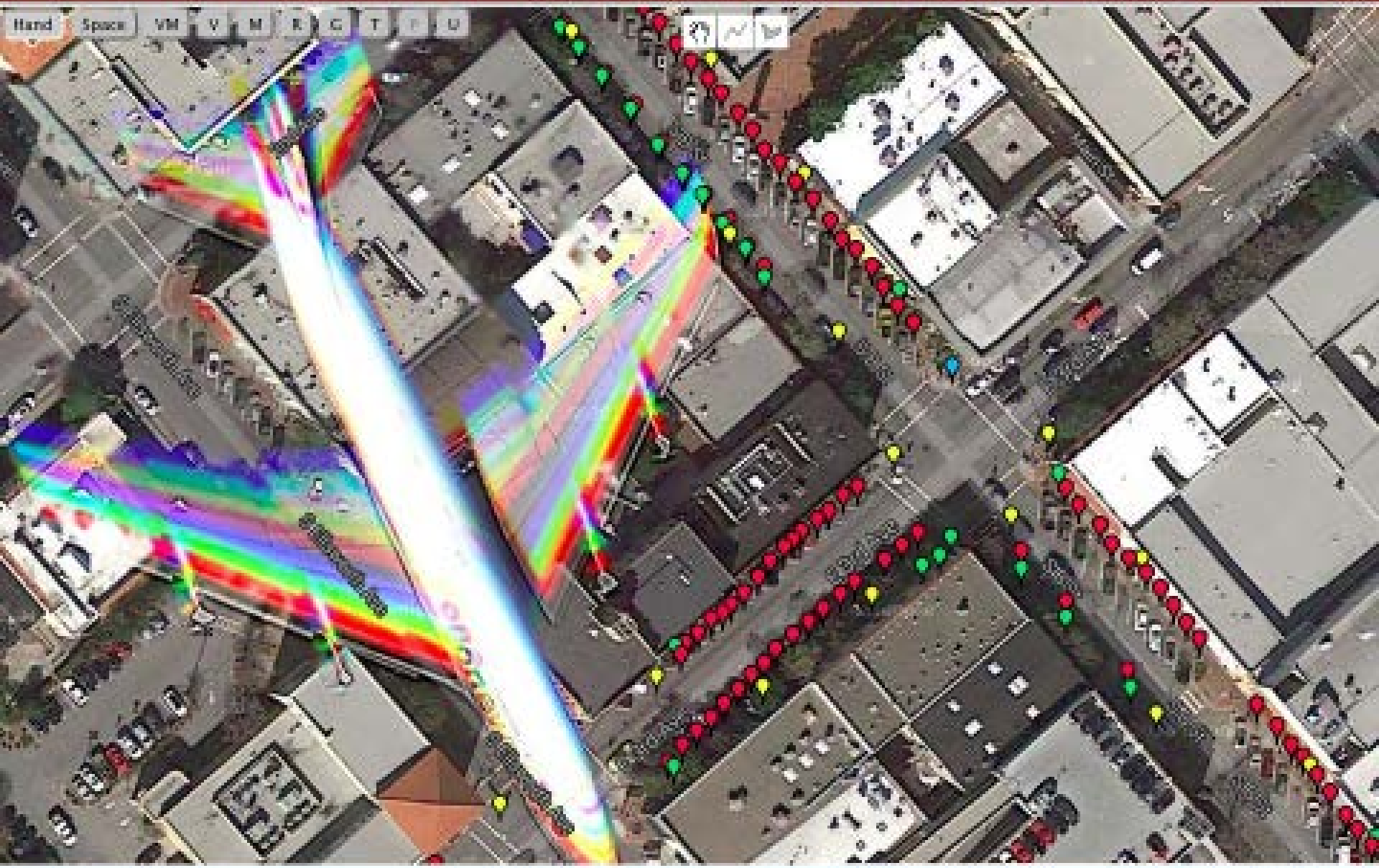


Design to Delivery

D2D

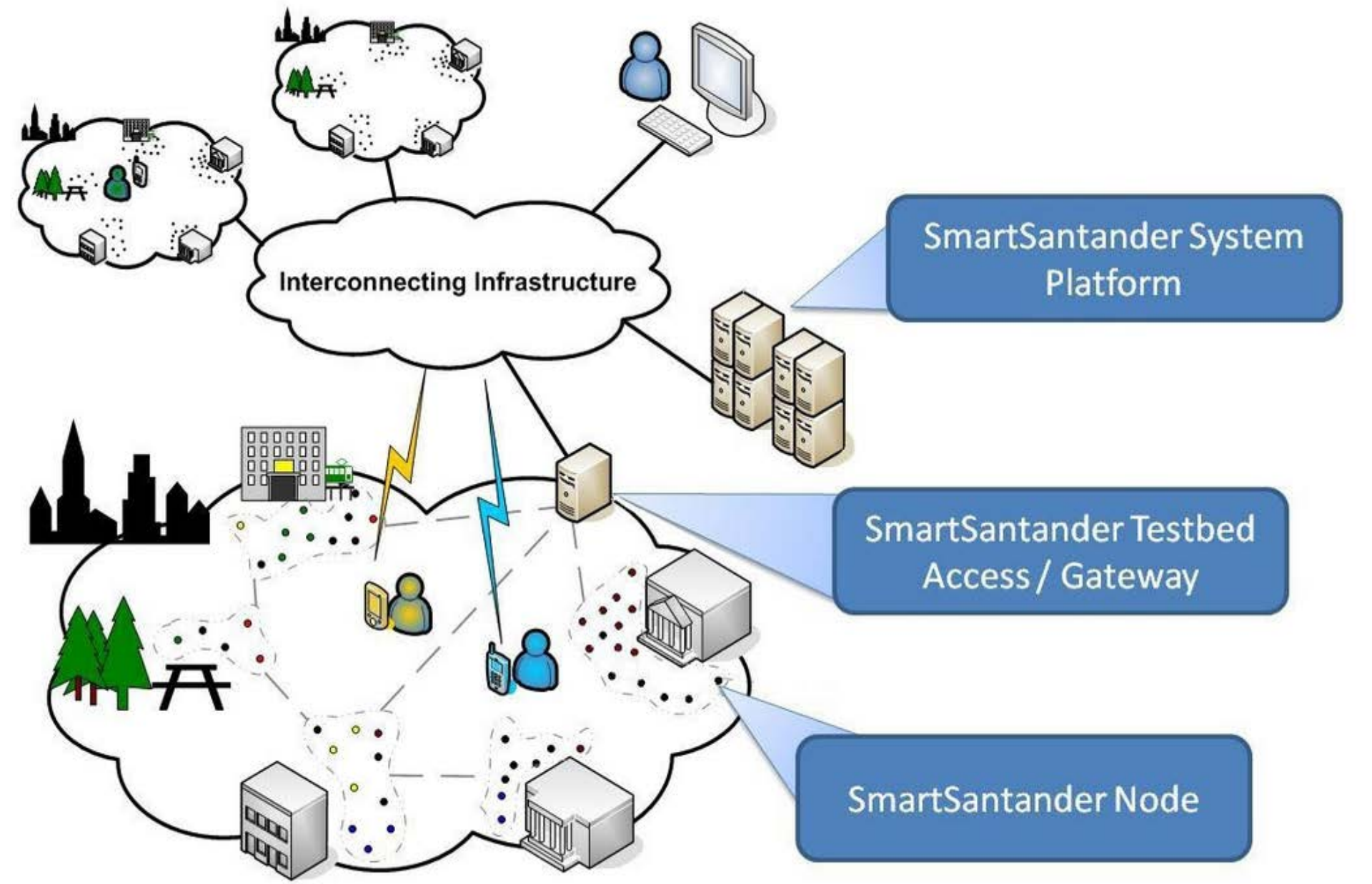
Industrial Internet – IoT – Services Ecosystem → Convergence

Industrial Internet ← IoT Services → Parking Spaces Talks to Cars

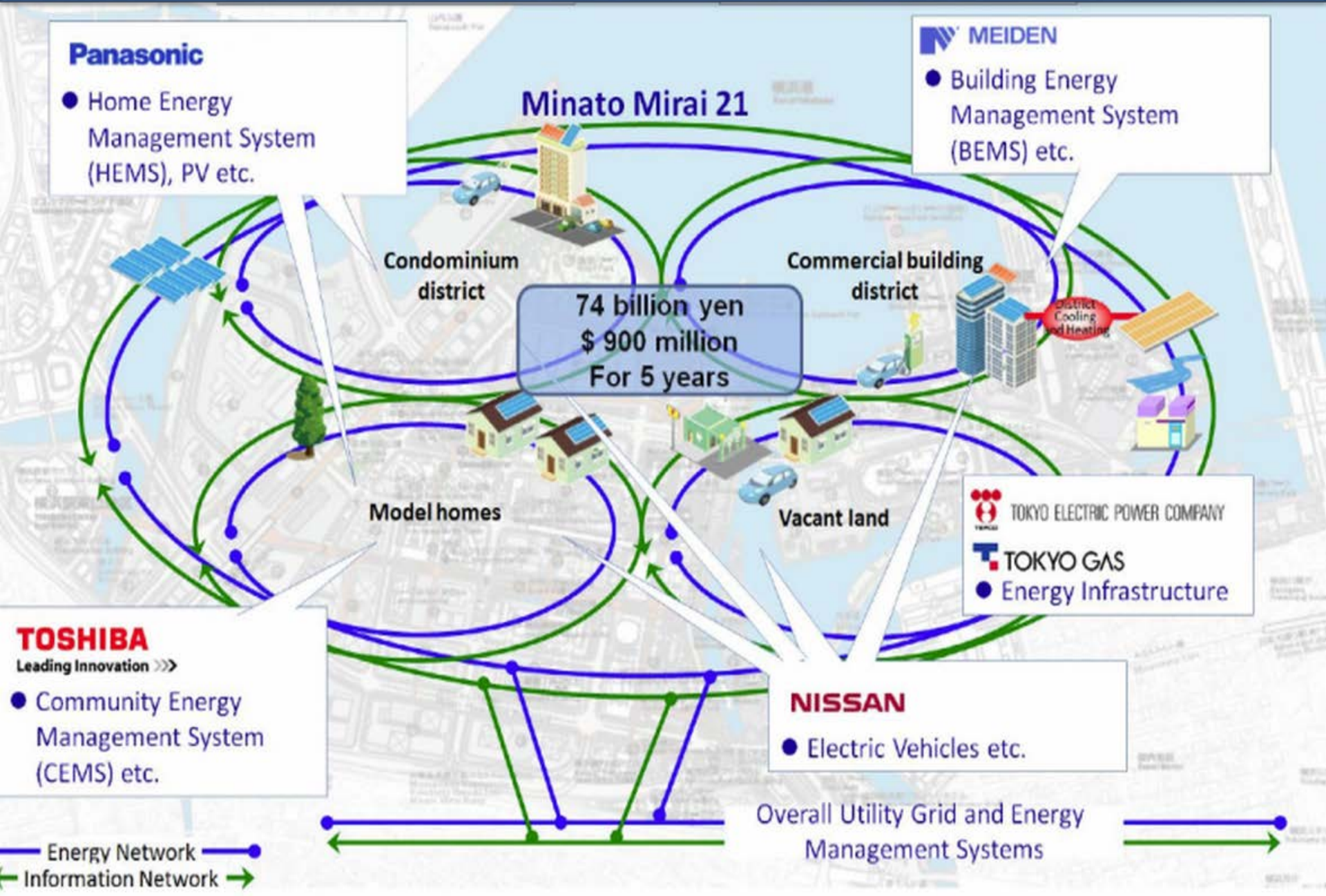


Google Earth photo of a plane flying over downtown San Jose, CA. Parking space sensors showing available car parking spaces using Parker™ by Streetline (Photo courtesy of Zia Yusuf, President & CEO, Streetline Inc)

• Smart City ● Santander



• Smart City ● Yokohama



A SMARTER PLANET begins with SMART CITIES

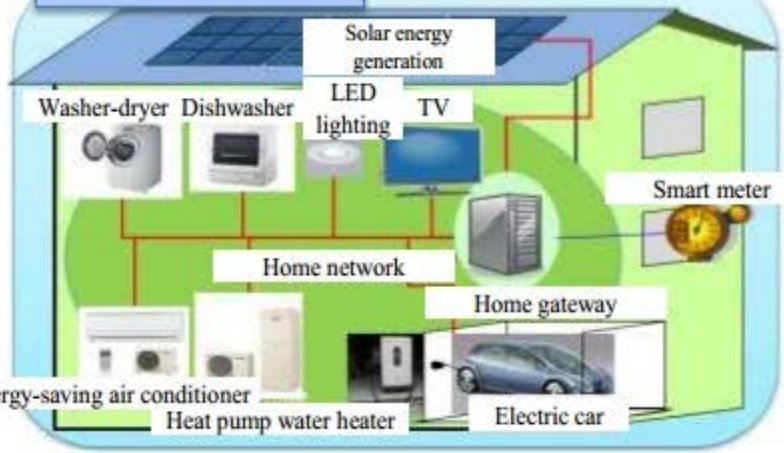
Control center

Control center that optimizes supply and demand of energy for the region

A new transport infrastructure integrated with the energy network

Drastically lowering carbon emissions and providing solutions for traffic accidents and traffic jams, by exchanging information between EVs and electric buses.

Smart houses



Electric bus (to be changed into streetcars in the future)

Electric buses with replacement-type batteries. Multiple buses will be connected to become a streetcar in the future.

METI
Ministry of Economy, Trade and Industry

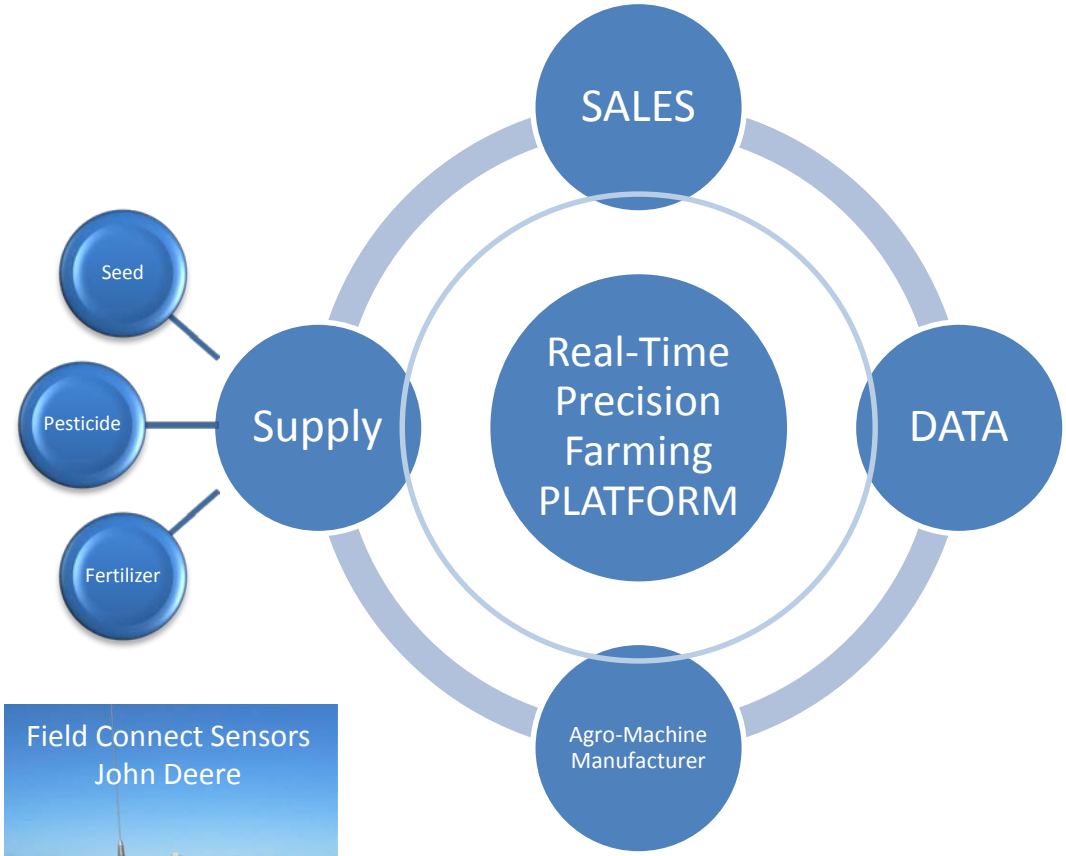
Grand Challenge – Convergence of ecosystem of inter-dependent systems

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.

Farming in California alone is a $50 billion industry

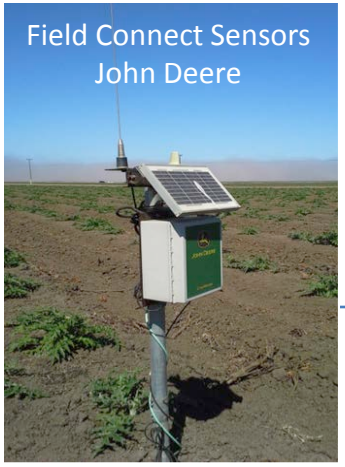
Retail Supply Chain – Sourcing / Distribution / Warehouse / Transportation
Track & Trace – Commodity Traders – Risk Management – Regulators (FDA)



-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

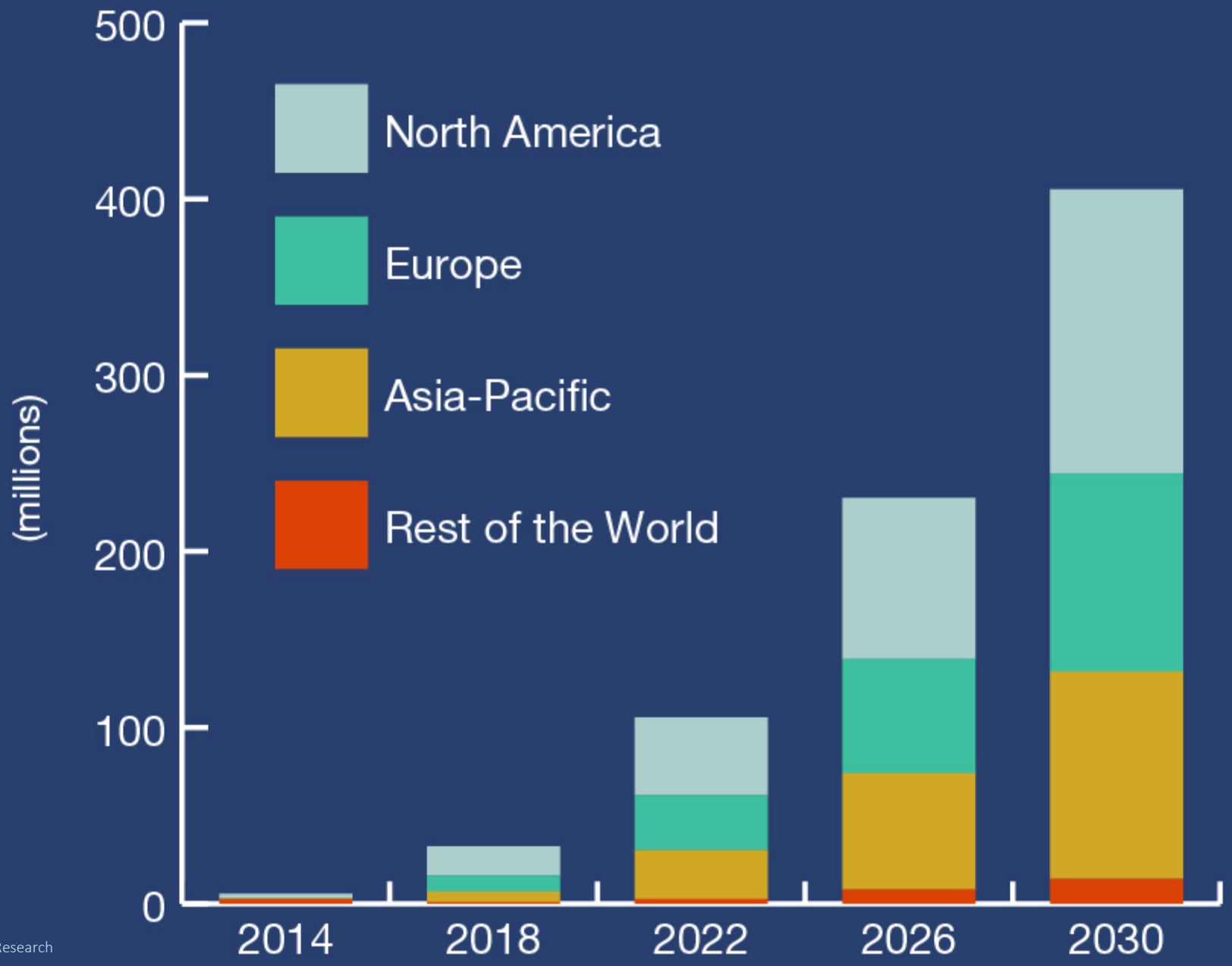


- Optimize MRO to improve asset uptime
- Mobile data collection and dissemination
  - soil sample / nutrient analysis (GCMS)
  - moisture monitors / field connect data
  - temperature / dielectric constant
  - color and chemistry of crops
  - growth rate / fertilizer distribution
  - weather micro-impact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

• Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

- Challenges
  - → In progress
    - ☑ Autonomous Transportation
      - Got Drone?
      - Semantics of Time
      - Roadmap - Cloud, Fog, Rain, Snow

Forecast → Vehicles with IoT Applications



Those who say it cannot be done should not interrupt those who are already doing it.

SAFT

Temporary Evidence

Semi-Autonomous Freight Transportation (SAFT)

(pronounce - safety)

SAFT

http://bit.ly/MB-AutoTruck

Setting a Goal

"Man on the Moon"

www.homeofheroes.com/presidents/speeches/kennedy_space.html

SCENARIO

"Man on the Moon" Address

President
John F. Kennedy's

A Special Address to Congress
On The Importance of Space

May 25, 1961

I therefore ask the Congress, above and beyond the increases I have earlier requested for space activities, to provide the funds which are needed to meet the following national goals:

First, I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to the Earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish.

JFK

SCENARIO

- Deployment of Semi-Autonomous Freight Transportation

Autonomous Transportation Challenge
Semi-Autonomous Freight Transportation

- **Less elegant than "man on the moon" but similar goal setting**

  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*

The focus of this goal / scenario may be sub-divided into 3 areas

Broad Deployment Packages (BDP)

Autonomous Transportation Sub-Challenge

Goal-Scenario → Semi-Autonomous Freight Transportation

Decompose the "goal / scenario" to 3 very broad deployment packages (BDP)

- *The semi-autonomously operable fleet of trucks or lorries (approx 1000-2000 physical units of freight carrier vehicles) invulnerable to cyber attacks.*
- *Operational infrastructure deployment in an environment where roads, traffic lights, bridges, tunnels, housing zones, pedestrian crossings are equipped to communicate (GIS, GPS, RF, SDRC) with autonomous objects as well as autonomous vehicle operation with mixed vehicles (Fedex ground hub). Transmission and analysis of data from users and operators (supply chain of goods, status of roads/bridges and cybersecurity)*
- *Intermodal port operator environment where these autonomous vehicles interact with humans and non-autonomous vehicles. Robotic handling of cargo containers (off-load, re-load) between ships to rail head and ground transportation (and air cargo link – Port of Elizabeth (NJ) plus EWR). Data transmission and monetization of pay per use analytics from users and operators (supply chain of goods, status of roads/bridges, security of goods in containers, micro-localization and highly granular identification of objects by products, containers, vehicles, distribution, logistics handling, DHS CBP compliant e-manifest and regulatory framework eg SOX409)*

Further decomposition of BDP

Let us break down each work package to large units

Autonomous Transportation Sub-Challenge

Goal-Scenario → Semi-Autonomous Freight Transportation

Decompose "goal/scenario" to broad deployment package (BDP)

- *The semi-autonomously operable fleet of trucks or lorries (approx 1000-2000 freight carrier vehicles) invulnerable to cyber attacks.*
  - *Calls for global partnership and globally interoperable standards*
  - *Pre-competitive standards based approach to vehicle "brain"*
  - *Semi-autonomous "brain" of the vehicle (robotic navigation) should be able to operate in Pittsburgh, Long Beach, Schiphol or Kaohsiung. In other words, traffic signal compliance in any country and collision avoidance in any geographic terrain under diverse range of weather.*
  - *Standard cybersecurity for run-time intruder detection and repulsion*
  - *Data flow/analytics about vehicle, environment and infrastructure*
  - *Network standards and compliance – worldwide interoperability*
  - *Funded by a collective pool contributed by the global partners*

Autonomous Transportation Sub-Challenge

Goal-Scenario → Semi-Autonomous Freight Transportation

Decompose "goal/scenario" to broad deployment package (BDP)

- *Operational infrastructure deployment in an environment where roads, traffic lights, bridges, tunnels, housing zones, pedestrian crossings are equipped to communicate (GIS, GPS, RF, SDRC) with autonomous objects as well as autonomous vehicle operation with mixed vehicles (Fedex ground hub). Transmission and analysis of data from users and operators (supply chain, status of roads/bridges, cyber-security)*
  - *Communications protocols with interoperable standards and cybersecurity*
  - *Physical infrastructure upgrades and equipment installation / monitoring*
  - *Logistics operators as a part of the real-world deployment to provide access to non-autonomous fleet of trucks/lorries for data acquisition*
  - *Data convergence from agencies dealing with traffic, weather, emergency*
  - *Monetization incentives for contribution of data and pay per use analytics*
  - *Deployment funded by each nation or country on their own soil but uses the semi-autonomous fleet of vehicles developed as a global partnership*

Autonomous Transportation Sub-Challenge

Goal-Scenario → Semi-Autonomous Freight Transportation

Decompose "goal/scenario" to broad deployment package (BDP)

- *Intermodal port operator environment where these autonomous vehicles interact with humans and non-autonomous vehicles. Robotic handling of cargo containers (off-load, re-load) between ships to rail head and ground transportation (and air cargo). Data transmission and monetization of pay per use analytics from users and operators (supply chain of goods, status of roads/bridges, security of goods in containers, micro-localization and highly granular identification of objects by products, containers, vehicles, distribution, logistics handling, DHS CBP compliant e-manifest, regulatory framework eg SOX-409 and other country specific regulations)*

  - *Funded by each nation on their soil as a joint effort by an air/sea port operator + group lead with technological capability (Long Beach, CA + Raj Rajkumar, CMU)*
  - *Robotic handling, precision transfers and secure transport A to B to C (ship to rail)*
  - *Highly granular data acquisition from operation for commercial visibility and transparency to enhance security as well as status of goods (perishable food)*
  - *Data analytics & monetization model as the business driver for data exchange*

If you want to deploy that and get there, then you have to do this, this and this

$IFDT_n$

Next layer of decomposition

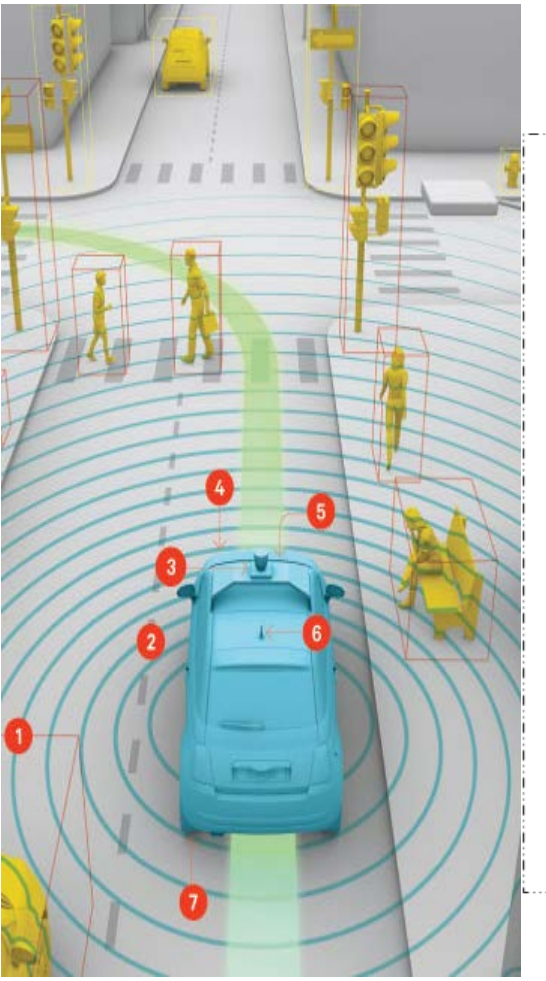
Capturing the context of the "object" and the object-dependent data flow

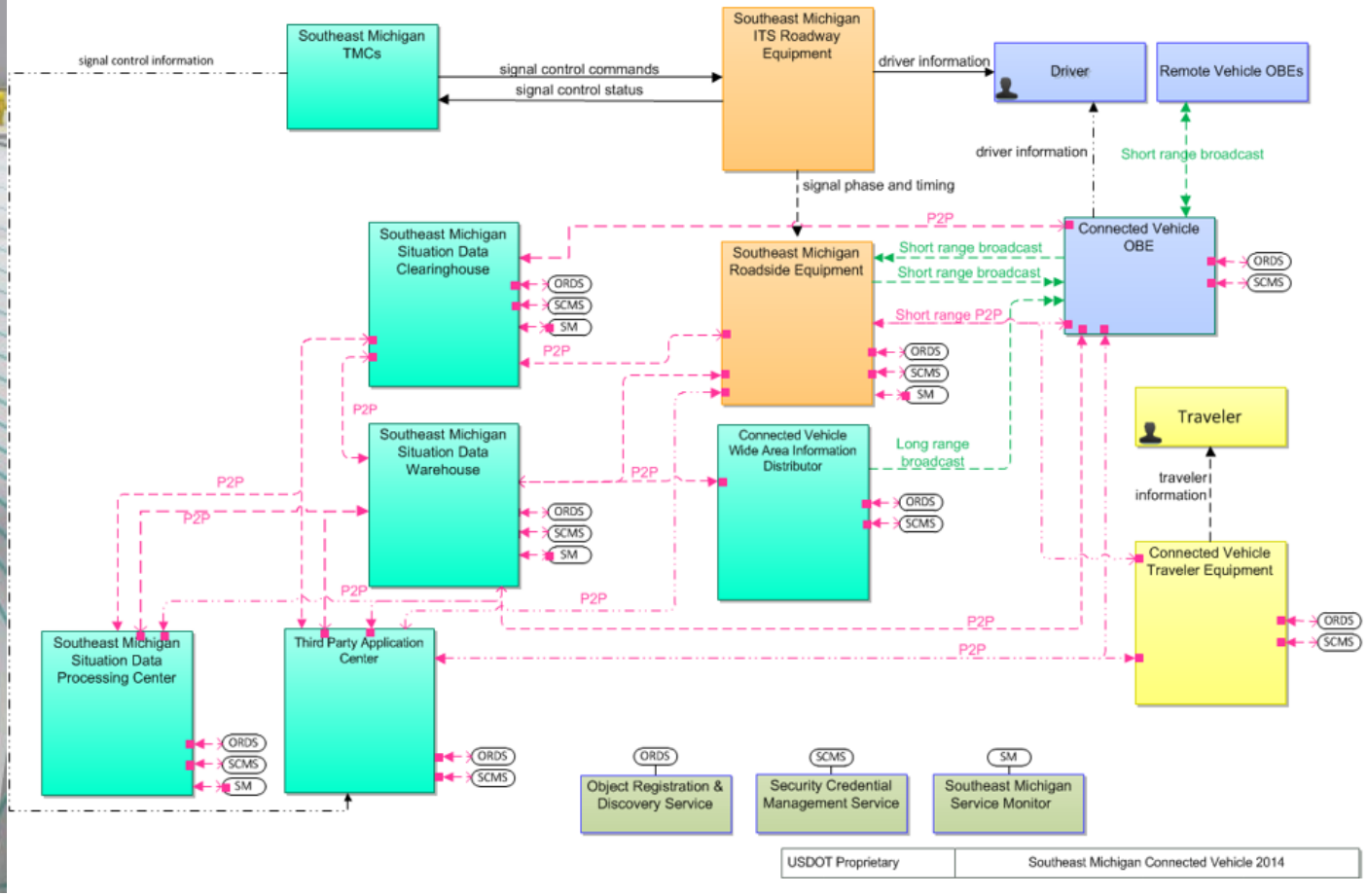
Standards for Transportation of Data ?

1.1. Data interoperability issues (NIST CPS PWG) and relevant standards for each topic to be discussed
1.2. Data fusion from multiple sensor or source types or use of a single data stream for diverse purposes
1.3. Real-time data fusion and analytics for predictive capabilities
1.4. Complex data paths that cross scales connecting architectural layers, dedicated systems, connected infrastructure, systems of systems and networks (at or upto global scale)
1.5. Data-driven interactions between dependent and independent cyber physical systems
1.6. Privacy-protecting data infrastructures (ubiquitous nature of IoT/CPS creates the potential for data in these environments to be intrusive)
1.7. Traditional data interoperability issues
1.7.1. Metadata
1.7.2. Identification of type and instance
1.7.3. Data quality and provenance
1.7.4. Governance
1.7.5. Privacy and cybersecurity
1.8. Data Interoperability issues from other CPSPWG Subgroups
1.8.1. Architecture
1.8.2. Cybersecurity
1.8.3. Timing

Interoperability and security of data exchange between core systems and edge devices

Hellabytes of data per second from deployment of autonomous vehicles





Temporary Summary

Semi-Autonomous Freight Transportation (SAFT)

(pronounce - safety)

The current goal of this initiative is
[1] to create a coalition of distinguished academia, global corporations, local standards organizations and government agencies
[2] to catalyze a highly credible global public-private partnership (PPP)
[3] to collectively work to deploy and integrate semi-autonomous freight vehicles for intermodal cargo operations within the business ecosystem of freight transportation.

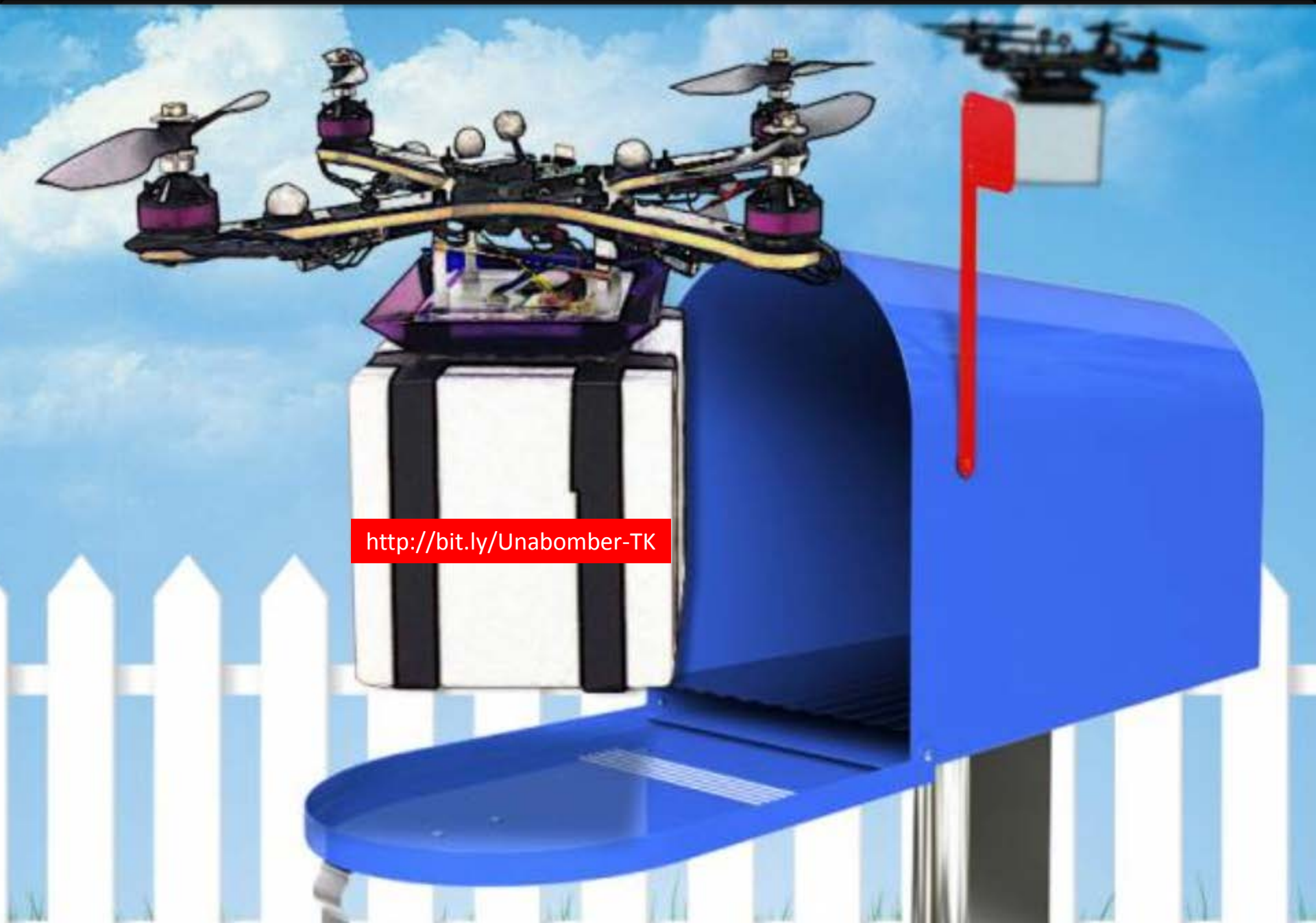
Project commences when pre-competitive global PPP begins construction of ~1000 units based on standards or interoperable standards (old, new, to be designed) which will be tested for operational safety, cyber security and communications compatibility.

Semi-autonomous vehicles produced by the global PPP will be deployed by country specific PPP on public roads in different geographies (US, EU, APAC) to integrate with existing freight transportation operations. Pre-deployment of local infrastructure (global standards of communications, networks, data) for semi-autonomous vehicle integration.

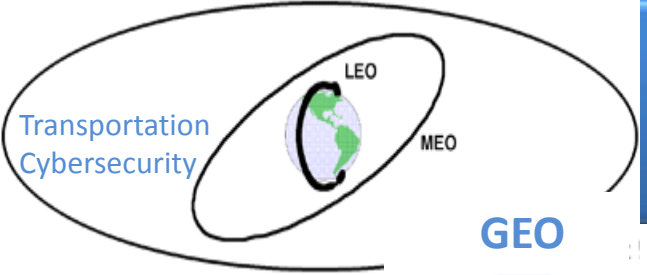
• Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

- Challenges
  - → In progress
    - ☑ Autonomous Transportation
      - Got Drone?
      - Semantics of Time
      - Roadmap - Cloud, Fog, Rain, Snow

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



What happens if the network is disrupted ?

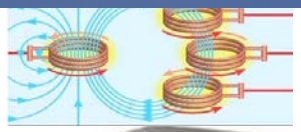


3

4

1

2

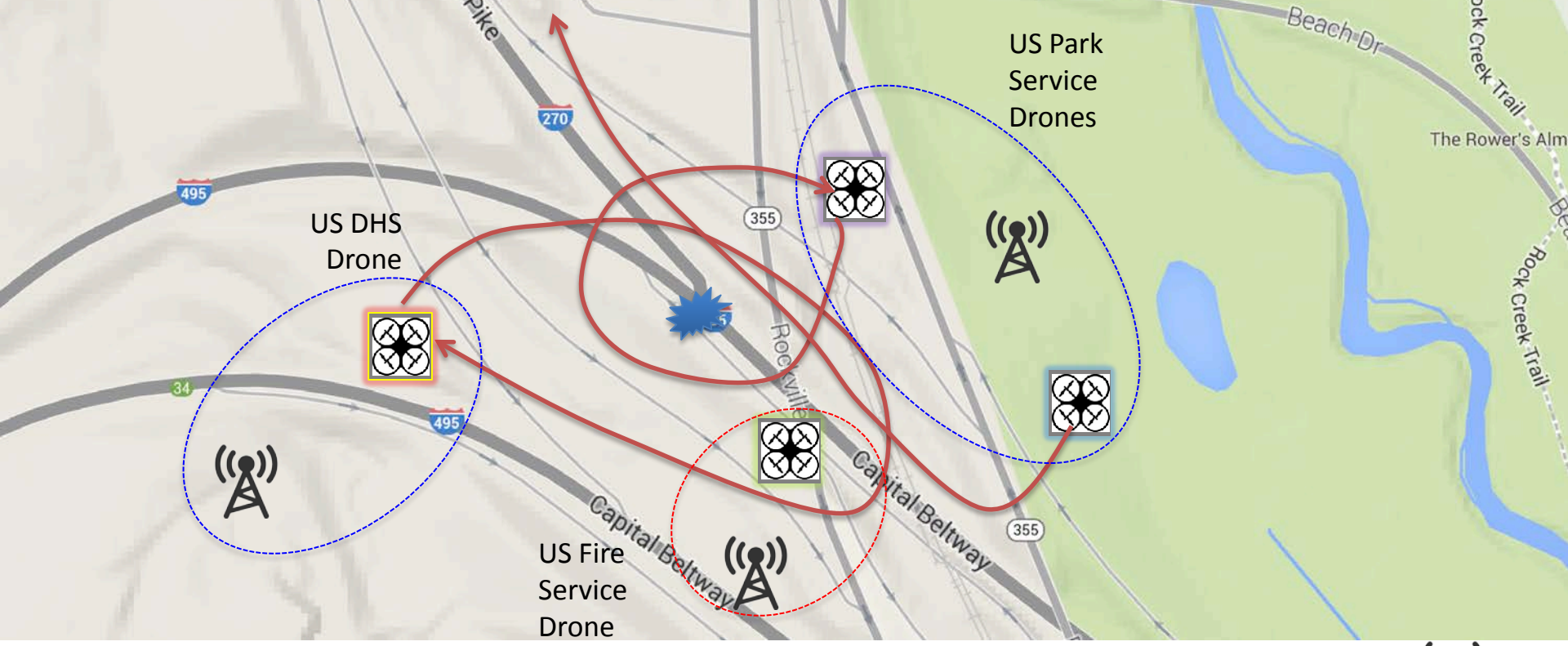


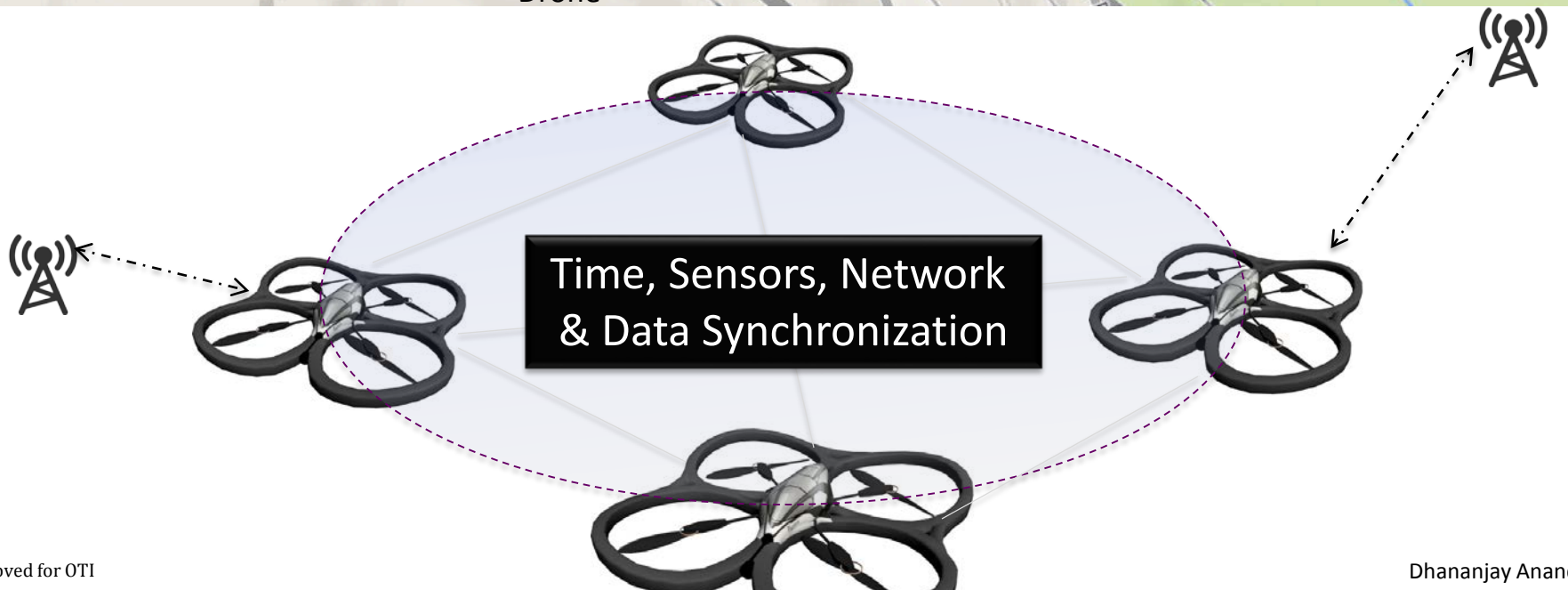
5

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

Terrestrial Transportation – Emergency “Crash to Care” Response System


US Park
Service
Drones
US DHS
Drone
US Fire
Service
Drone
Capital Beltway
Capital Beltway
Rockville Pike
Beach Dr
Rock Creek Trail
Rock Creek Trail
The Rower's Alm
270
495
355
34
495
355


Time, Sensors, Network
& Data Synchronization

How baby-sitting may be automated in the future …

Mobile Time Synchronization
NSF Funded Grand Challenge
Announced on June 13, 2014

Approved for OTI

News
News From the Field
For the News Media
Special Reports
Research Overviews
NSF-Wide Investments
Speeches & Lectures
NSF Current Newsletter
Multimedia Gallery
News Archive

News by Research Area
Arctic & Antarctic
Astronomy & Space
Biology
Chemistry & Materials
Computing
Earth & Environment
Education
Engineering
Mathematics
Nanoscience
People & Society
Physics

Email Print

Press Release 14-074

Revolutionizing how we keep track of time in cyber-physical systems

New five-year, $4 million Frontier award aims to improve the coordination of time in networked physical systems

NSF announces five-year, $4 million award to tackle the challenge of time in cyber-physical systems.
Credit and Larger Version

June 13, 2014

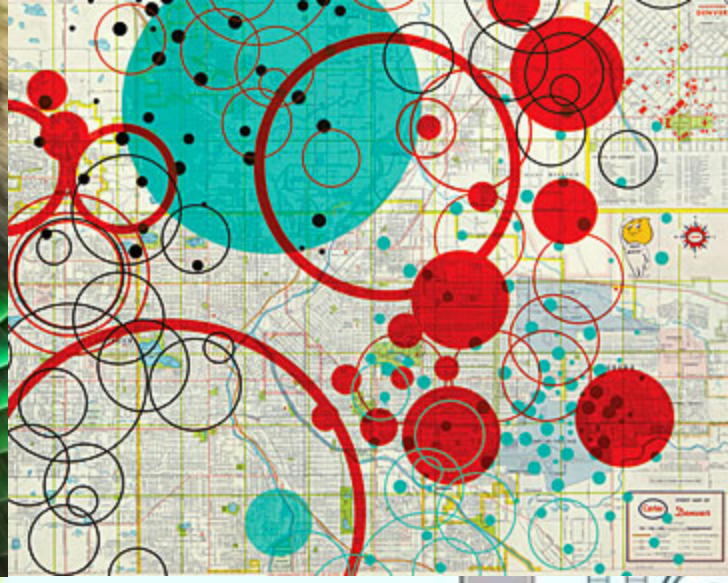
The National Science Foundation (NSF) today announced a five-year, $4 million award to tackle the challenge of synchronizing time in cyber-physical systems (CPS)--systems that integrate sensing, computation, control and networking into physical objects and infrastructure.

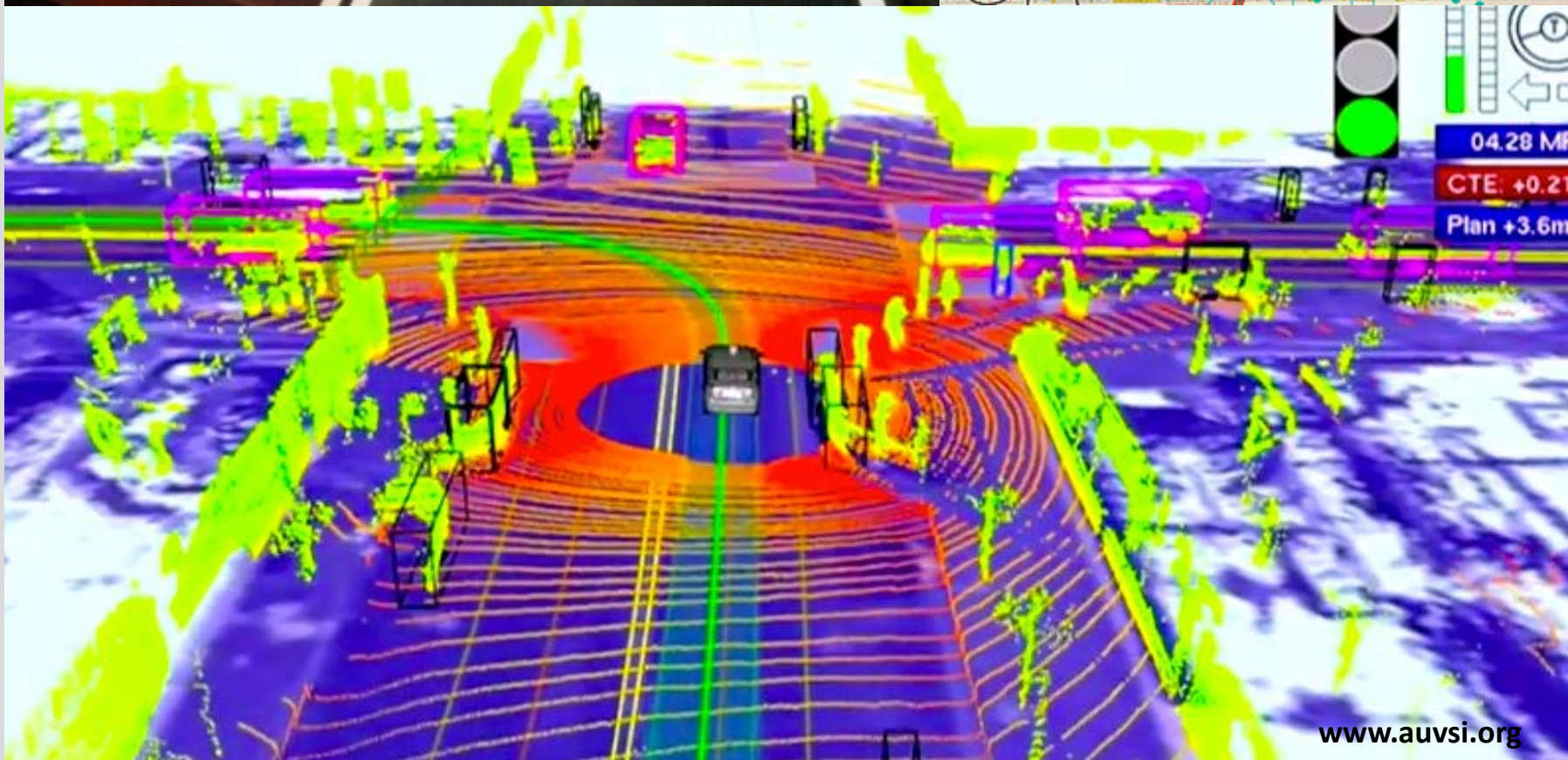
Examples of cyber-physical systems include autonomous cars, aircraft autopilot systems, tele-robotics devices and energy-efficient buildings, among many others.

The grant brings together expertise from five universities and establishes a center-scale research activity to improve the accuracy, efficiency, robustness and security with which computers maintain knowledge of time and synchronize it with other networked devices in the emerging "Internet of Things."

Time has always been a critical issue in science and technology. From pendulums to atomic clocks, the accurate measurement of time has helped drive scientific discovery and engineering innovation throughout history. For example, advances in distributed clock synchronization technology enabled GPS satellites to precisely measure distances. This, in turn, created new opportunities and even entirely new industries, enabling the development of mobile navigation systems. However,

AUTONOMOUS VEHICLES





www.auvsi.org

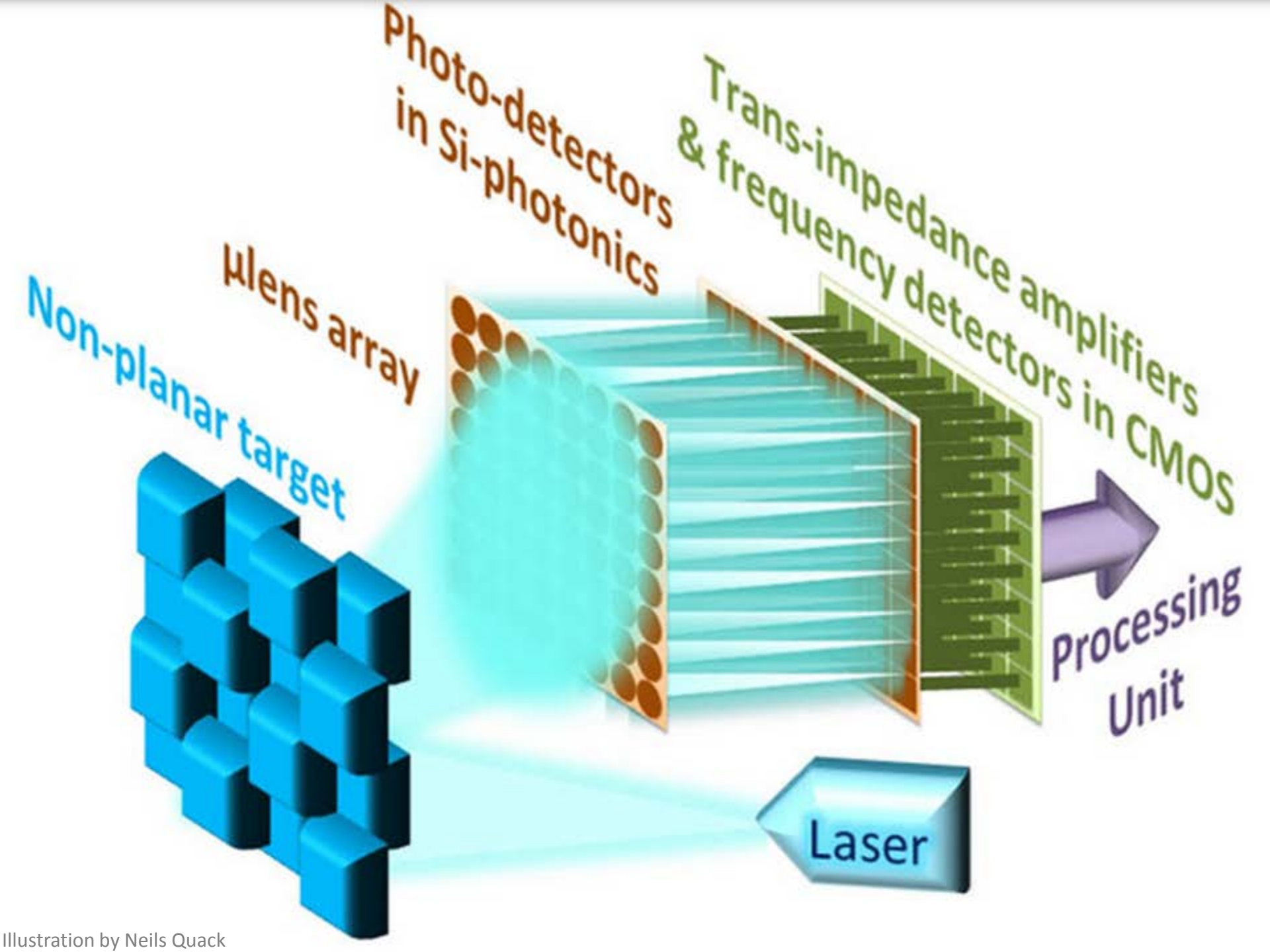
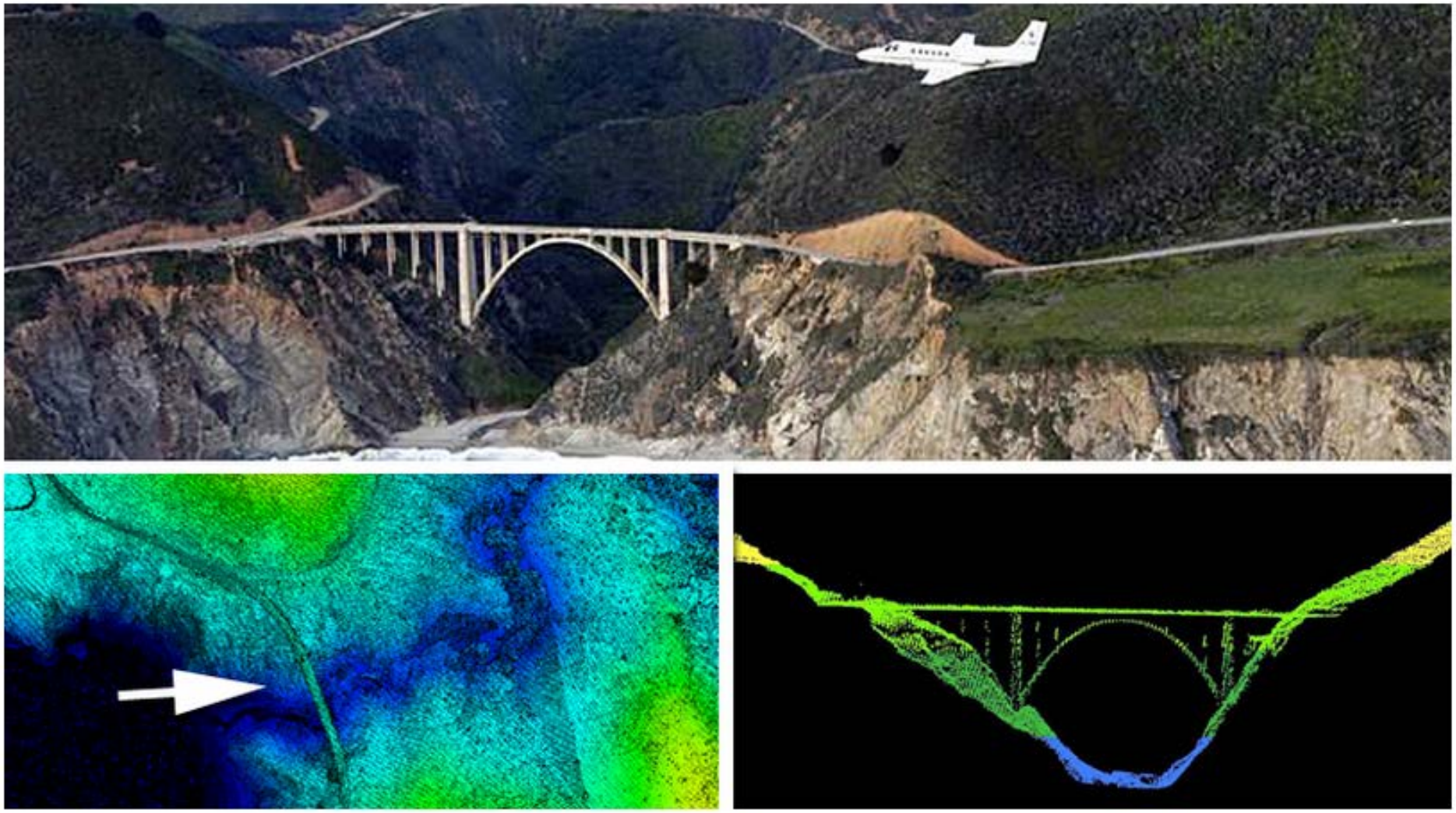


Illustration by Neils Quack

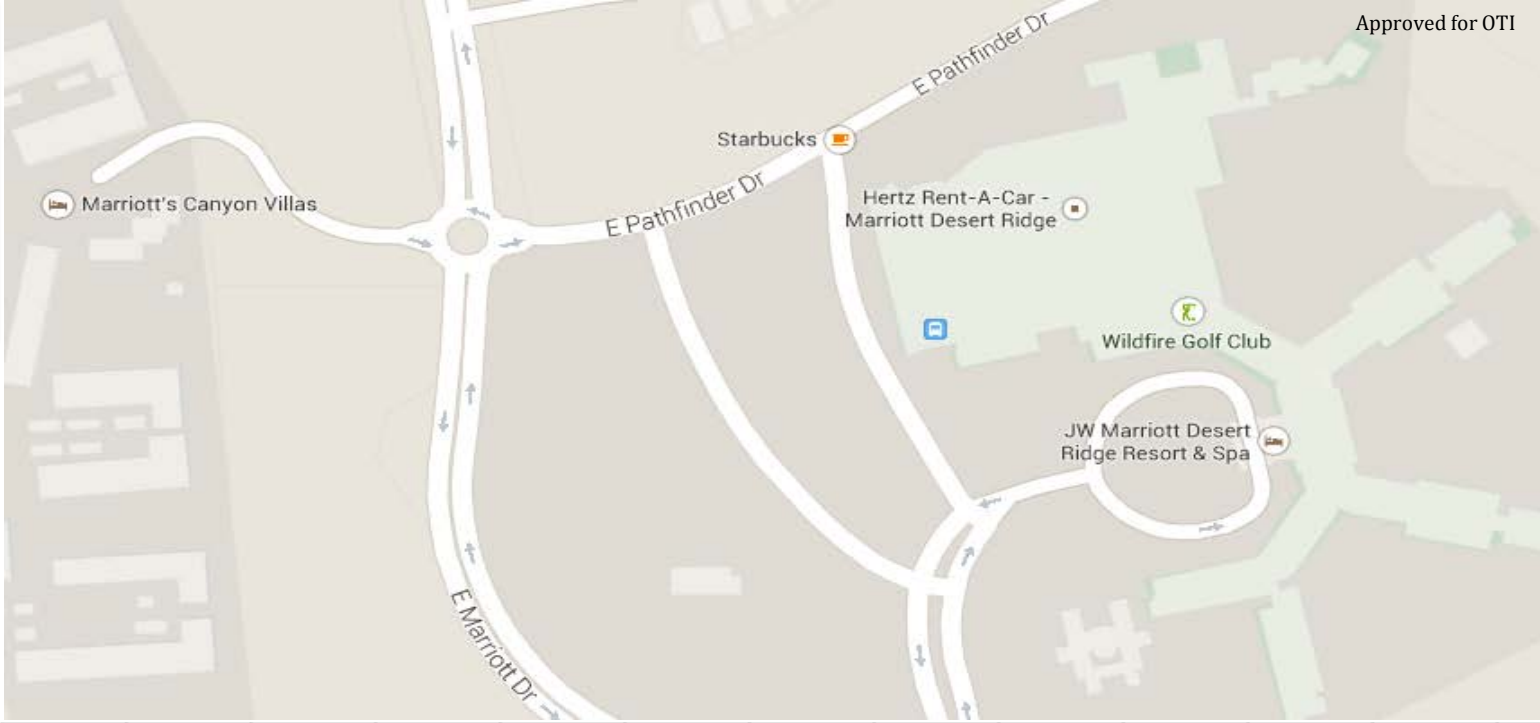
LIDAR is one part of the HD 3D Point Cloud for Immersive Mapping



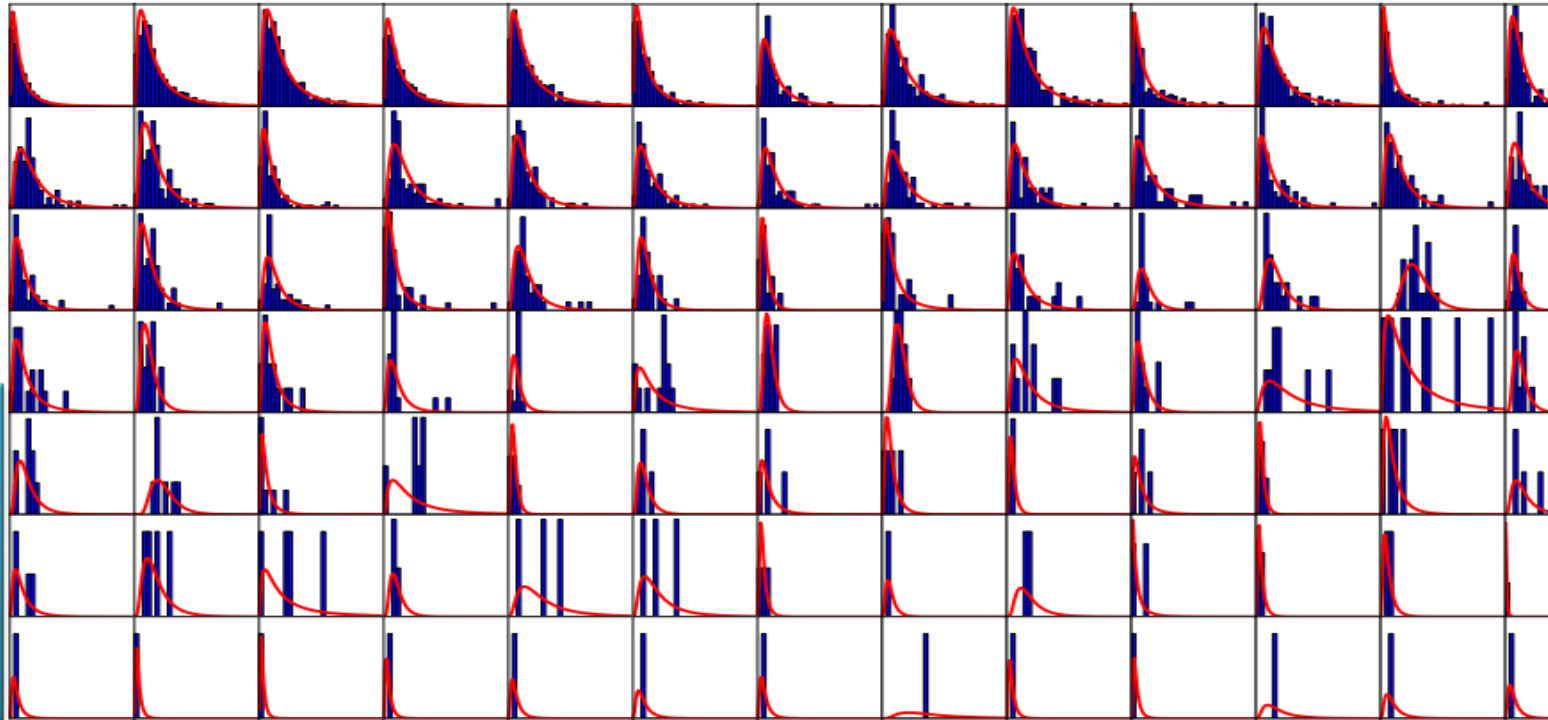
LIDAR data is often collected by air, such as with this NOAA survey aircraft (top) over Bixby Bridge in Big Sur, Calif. Here, LIDAR data reveals a top-down (bottom left) and profile view of Bixby Bridge. NOAA scientists use LIDAR-generated products to examine both natural and manmade environments. LIDAR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

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

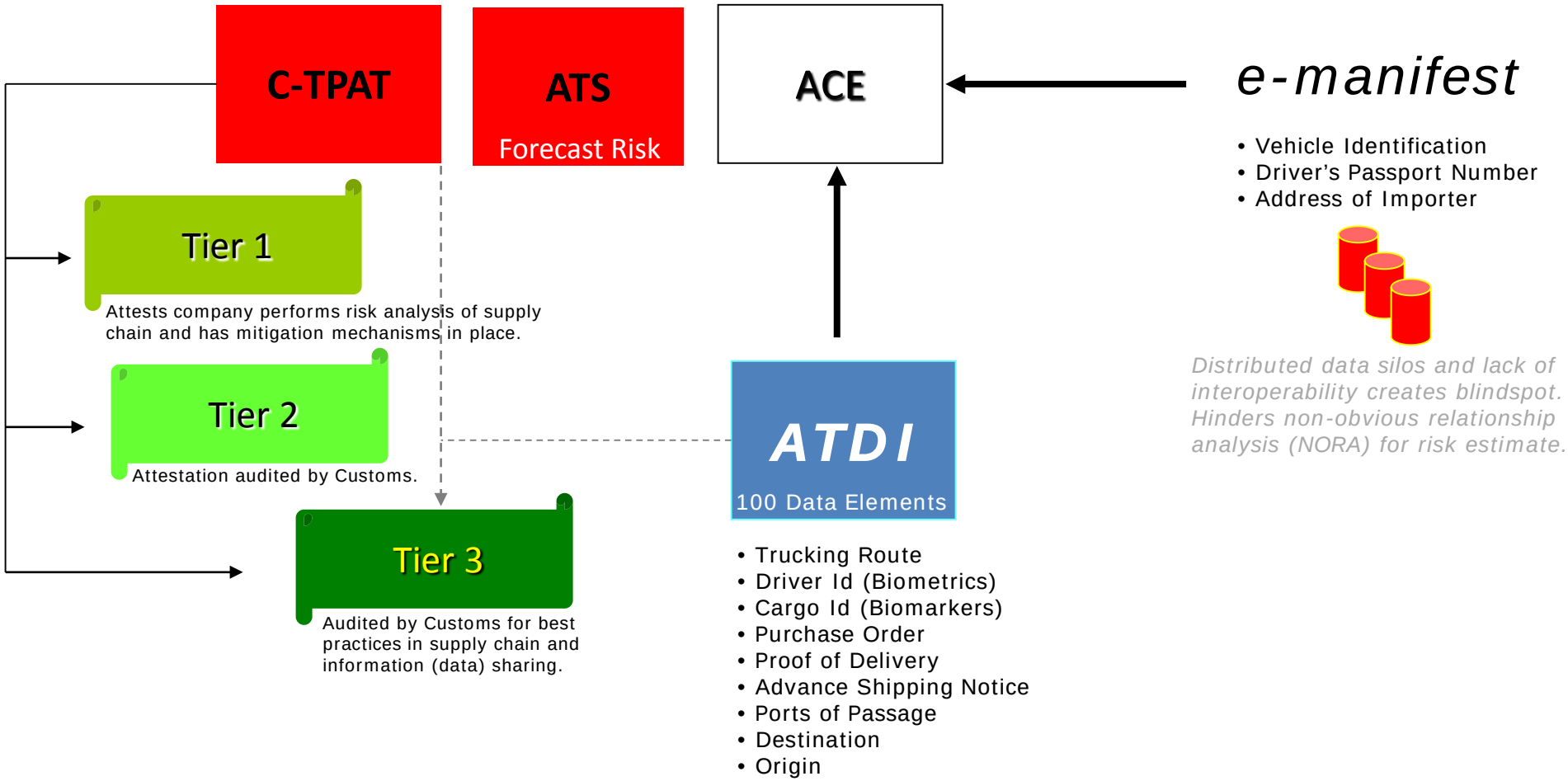
Streets



Streetlets



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)

• Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

- Challenges

→ In the wings

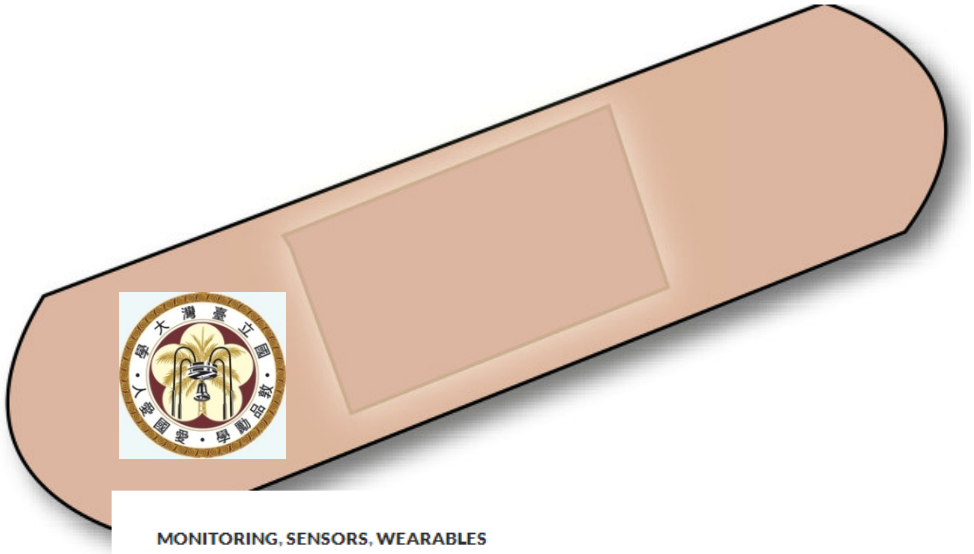
☑ Healthcare

Semantics
HL7 codes
Don't use my data
Data de-identification
Medical device interoperability

Domain Specific Scenario

Health Monitoring

- Paradox to Paradigms ☑ http://bit.ly/VANDERBILT



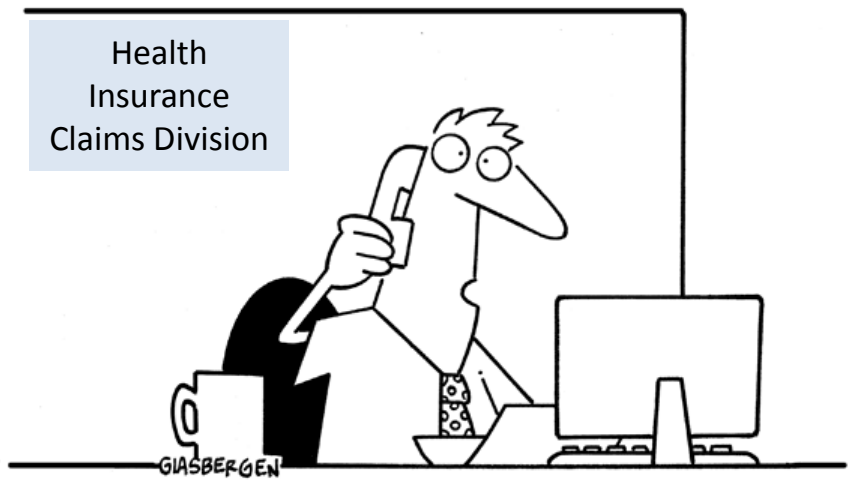
MONITORING, SENSORS, WEARABLES

SENSOR / 3D PRINTING / BANDAGE COMBINATION FOR CONTINUOUS MONITORING

JULY 18, 2014 LISAWEINER

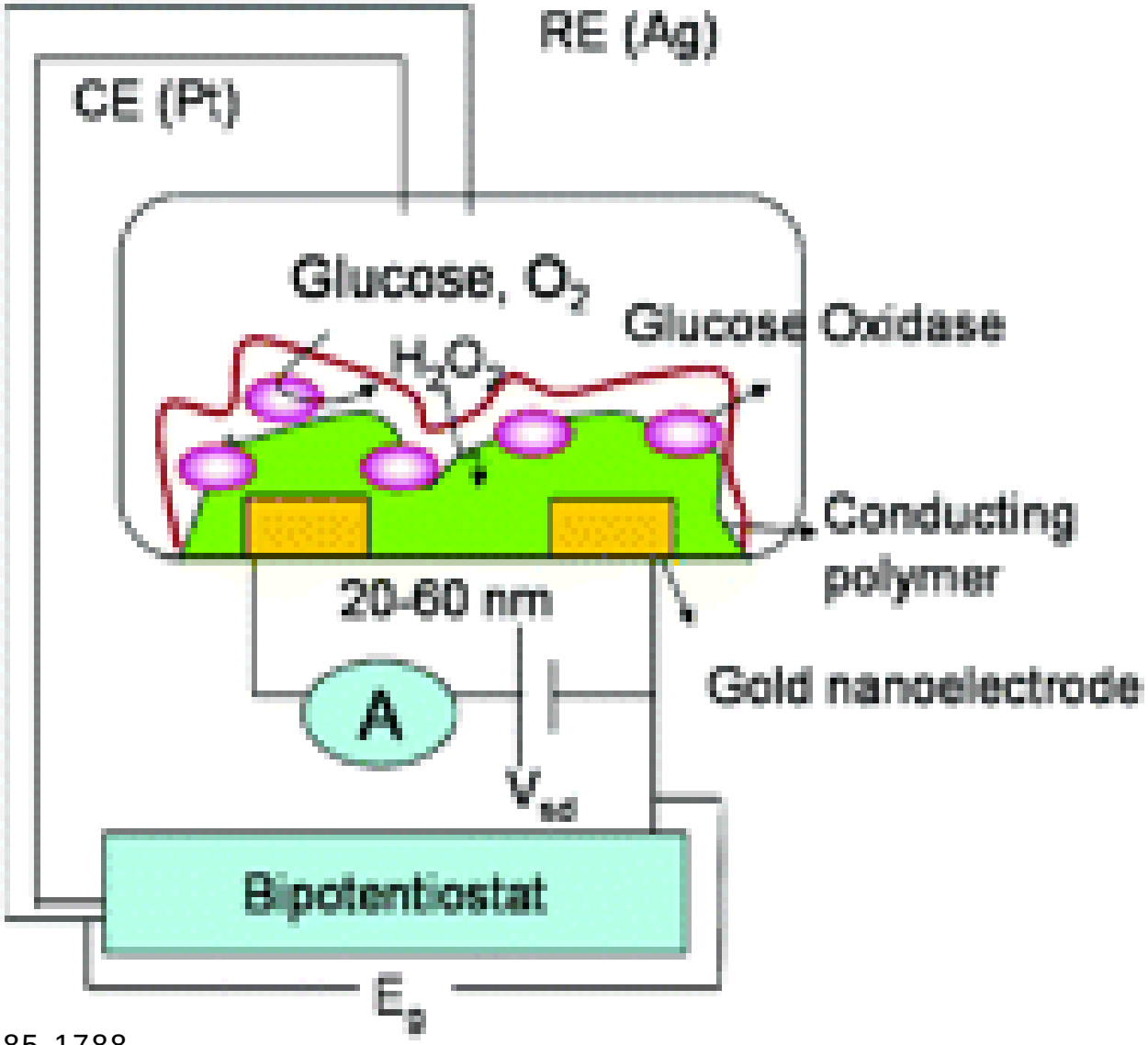
Bioscope bandages, developed at the National Taiwan University, wirelessly transmit temperature, heart rate, movement and vital sign data to doctors to monitor or remotely diagnose.

The bandage comes with an integrated thermometer, accelerometer, and sensors to measure electrical activity. A microphone can track organ sound patterns to detect disease. The area holding the modules is 3D printed for easy sensor additions or changes.



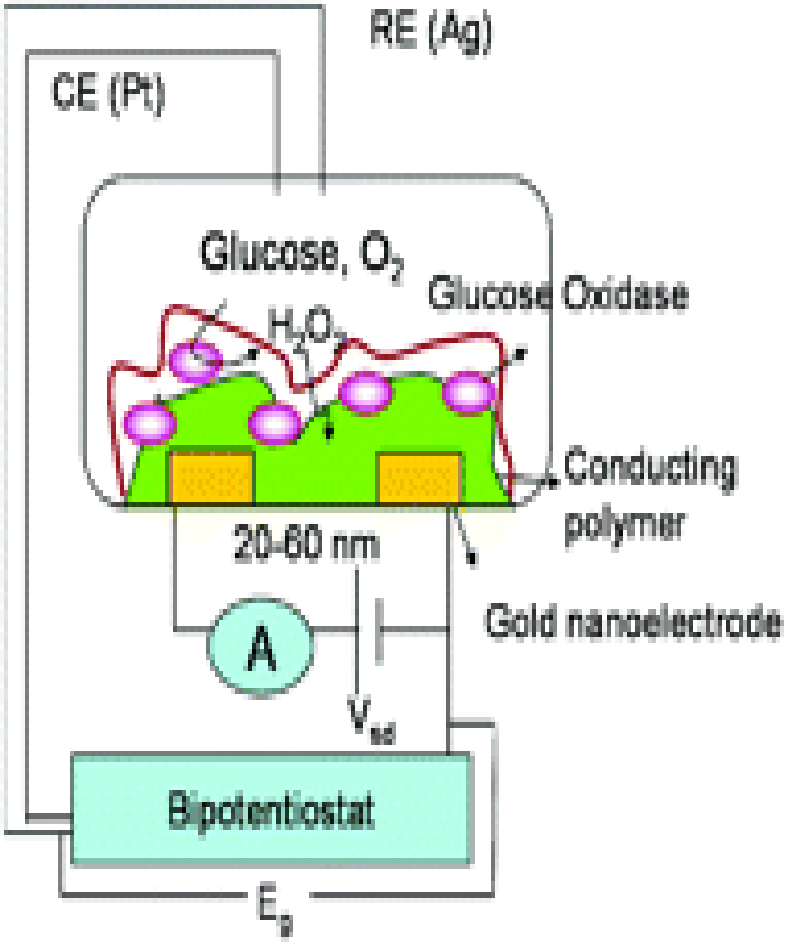
Laughter is the best indicator of this disease but the wireless sensors to detect laughter is not covered by your insurance

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



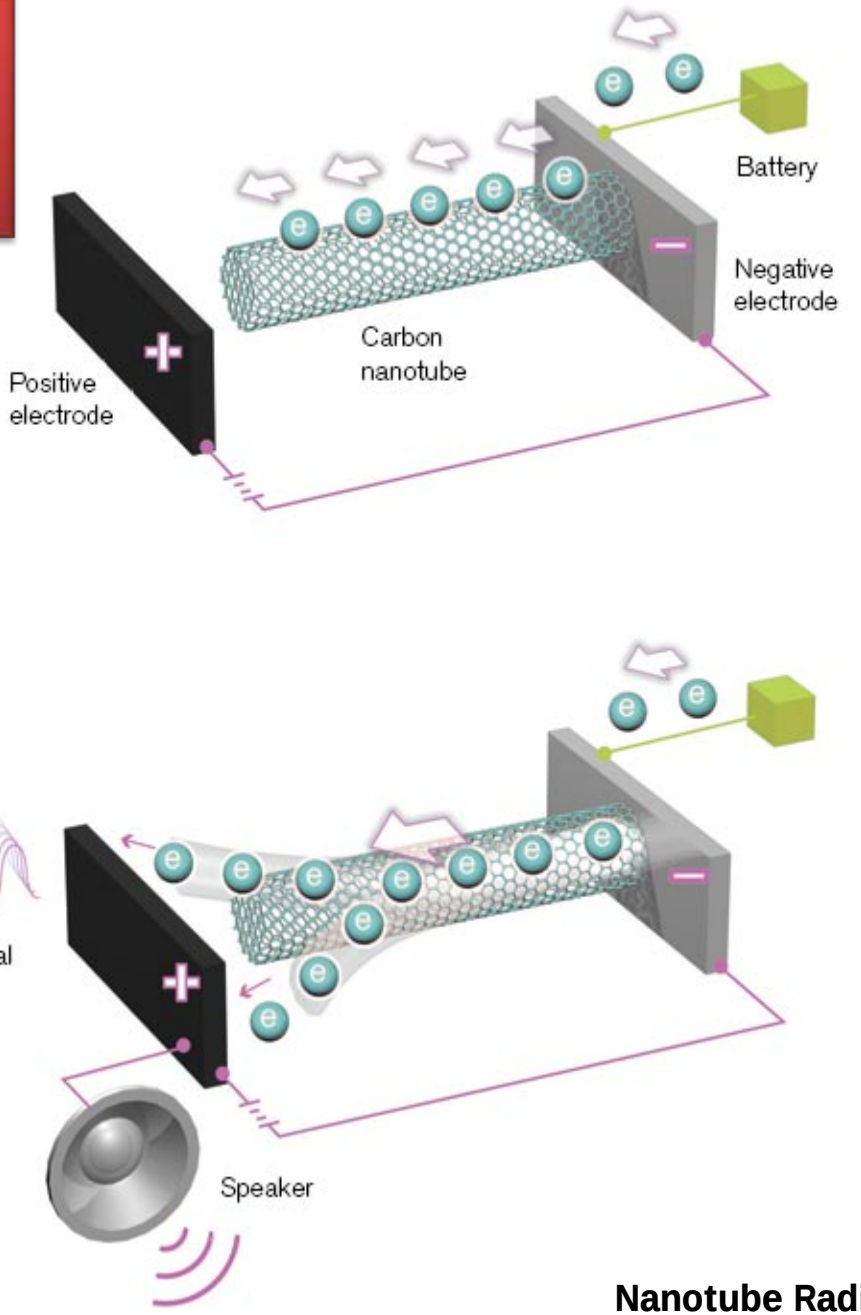
NanoLetters (2004) 4 1785-1788

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



Blood Glucose Nano-sensor

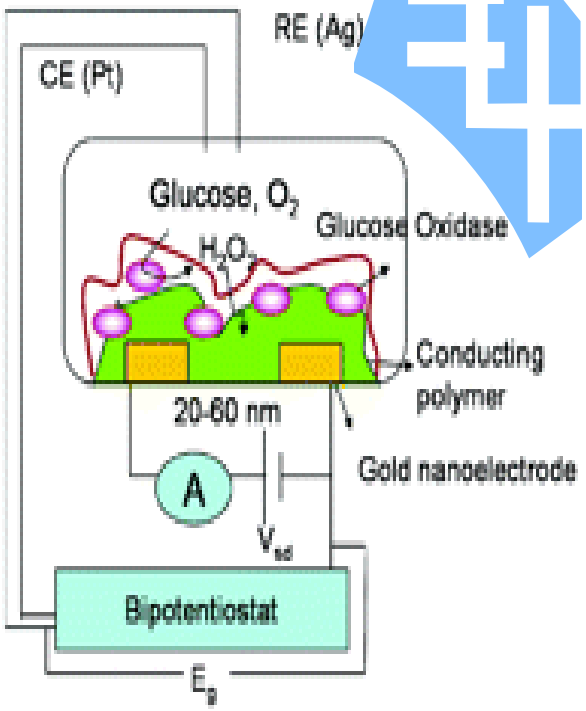
NanoLetters (2004) 4 1785-1788



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

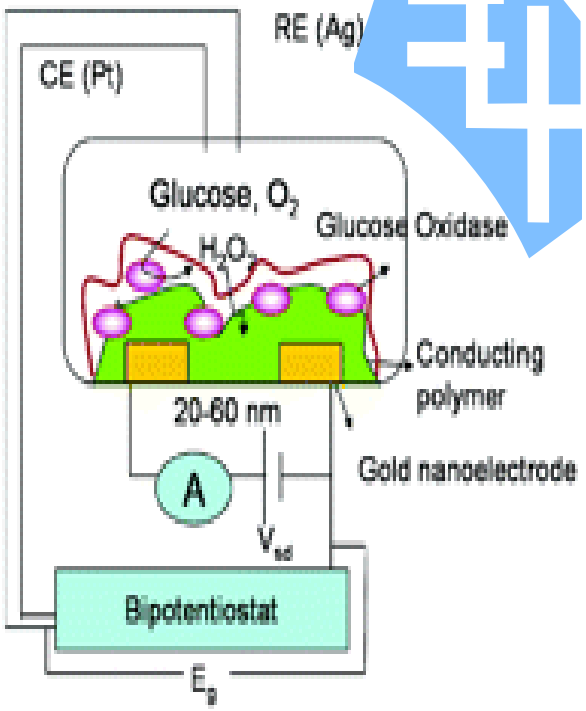
UNDIAGNOSED

7.0 million people

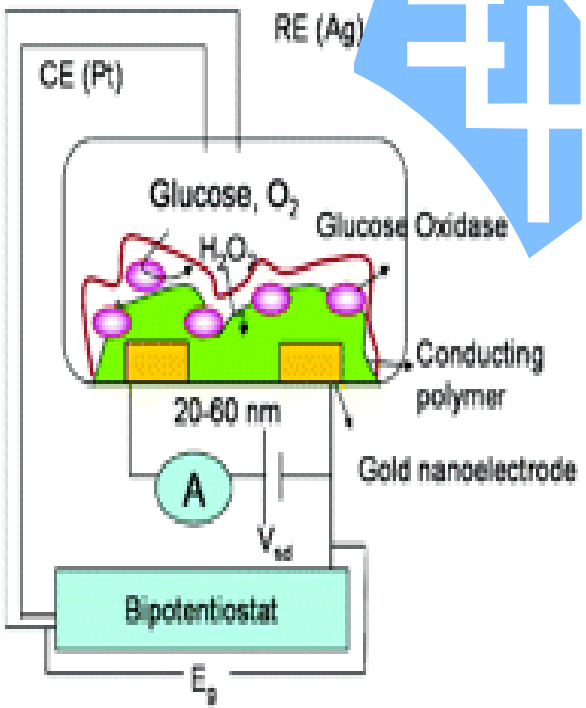
http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2011.pdf

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 healthcare monitoring



About 30 million individuals in US affected by diabetes

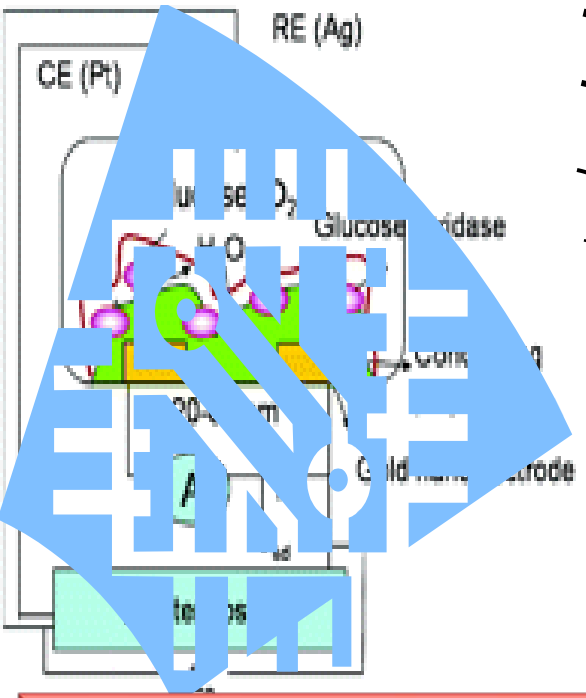
1. Implanted wireless sensor transmits blood glucose data from home or office or airport (WiFi/WAN/gateway)

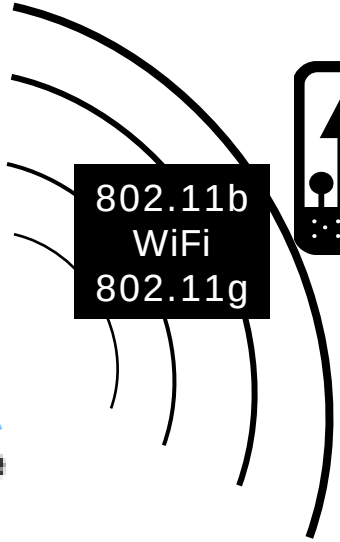
2. Data travels from you to your hospital or clinic (MAN)

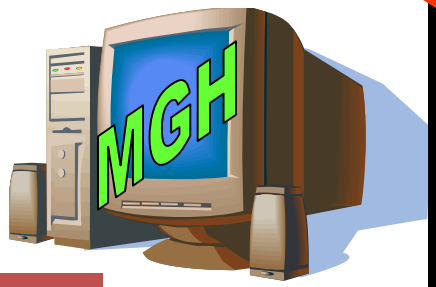
3. Blood glucose data updates risk and patient profile

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

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







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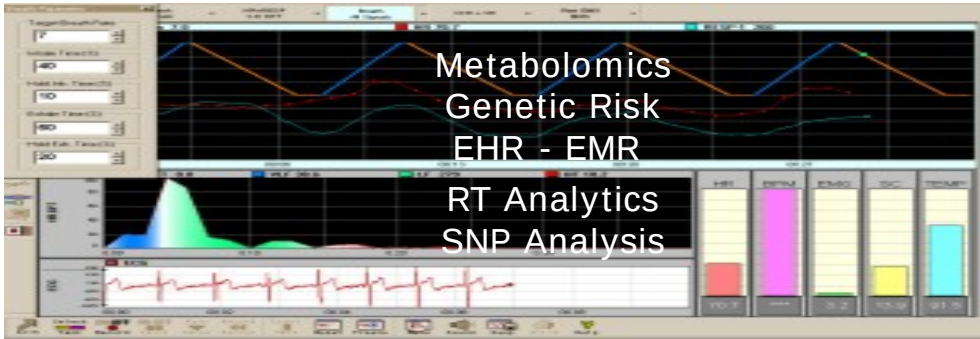
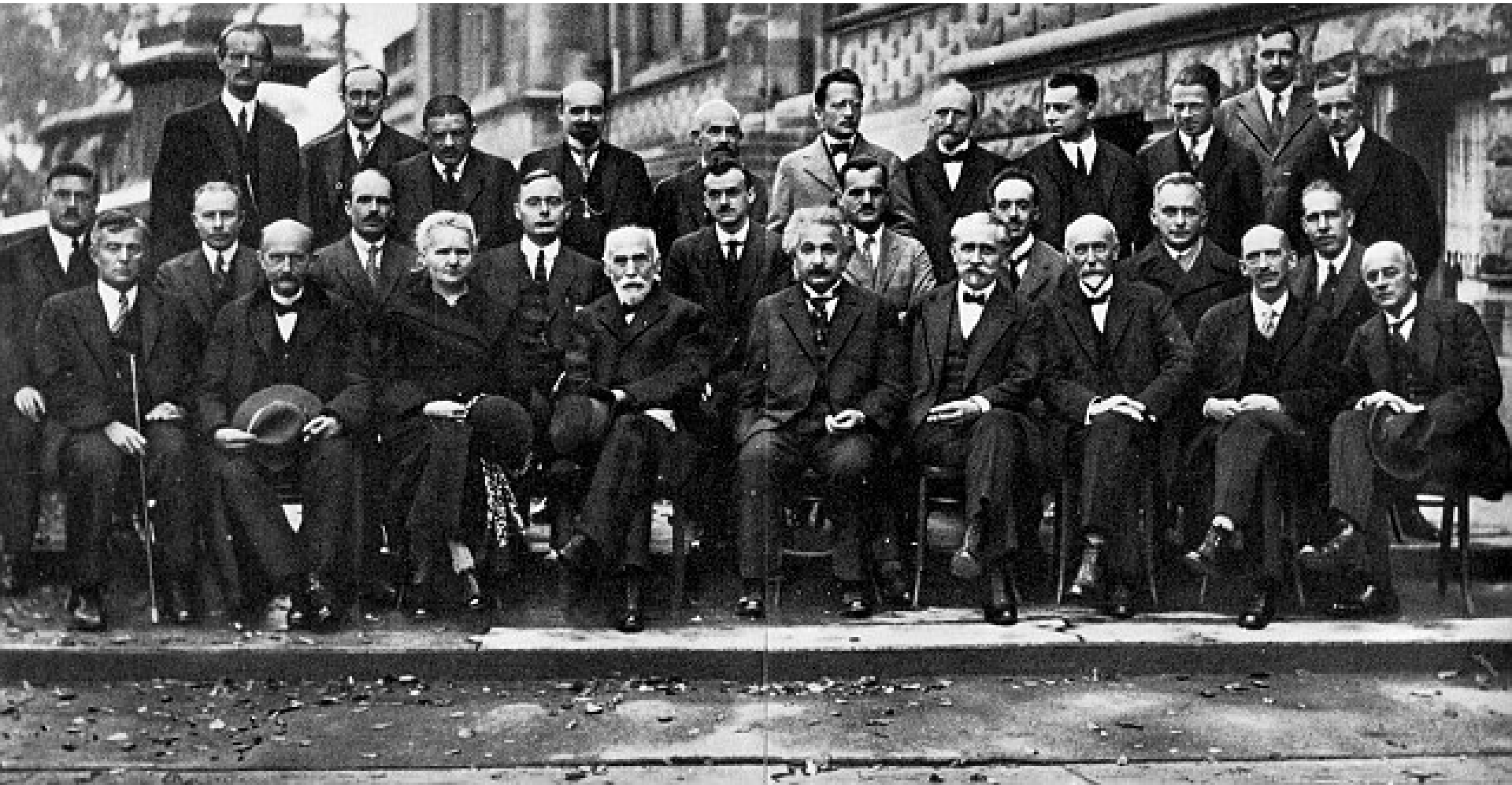


Improved healthcare services, savings, create jobs from new products, new services and potential to create as well as capture new emerging markets of billions (BRICS)

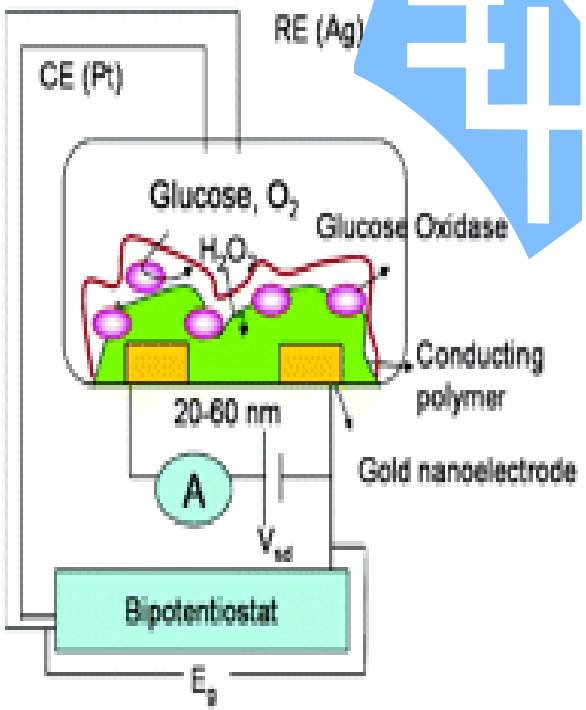
- 5th Solvay Conference on Photons and Electrons (October 1927, Brussels, BE)

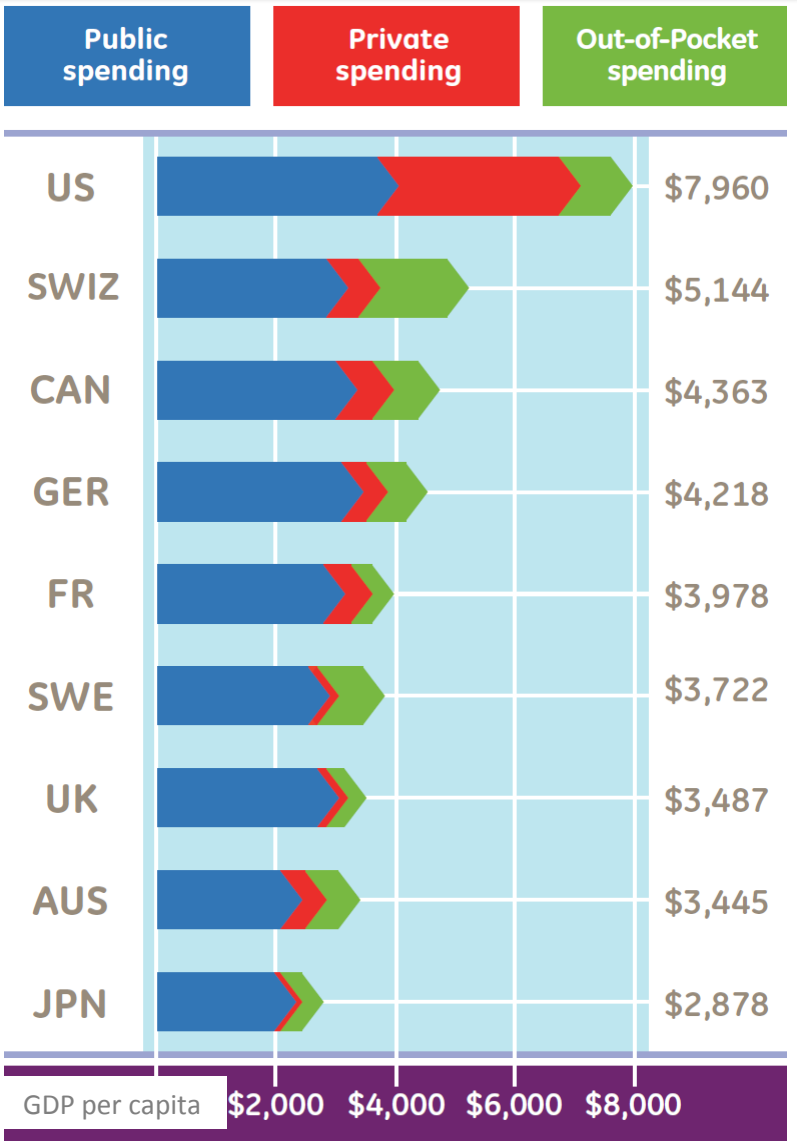


- 1997

Ève Denise Curie Labouisse (December 6, 1904 – October 22, 2007) in 1997, NY

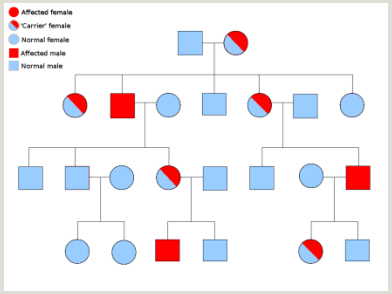
Glucose NanoSensor NanoRadio ecosystem of health-care monitoring may have a major economic impact





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

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



Genome

Transcriptome

Proteome

Metabolome

Microbiome

Epigenome

Exposome

Social graph

Biosensors

Imaging

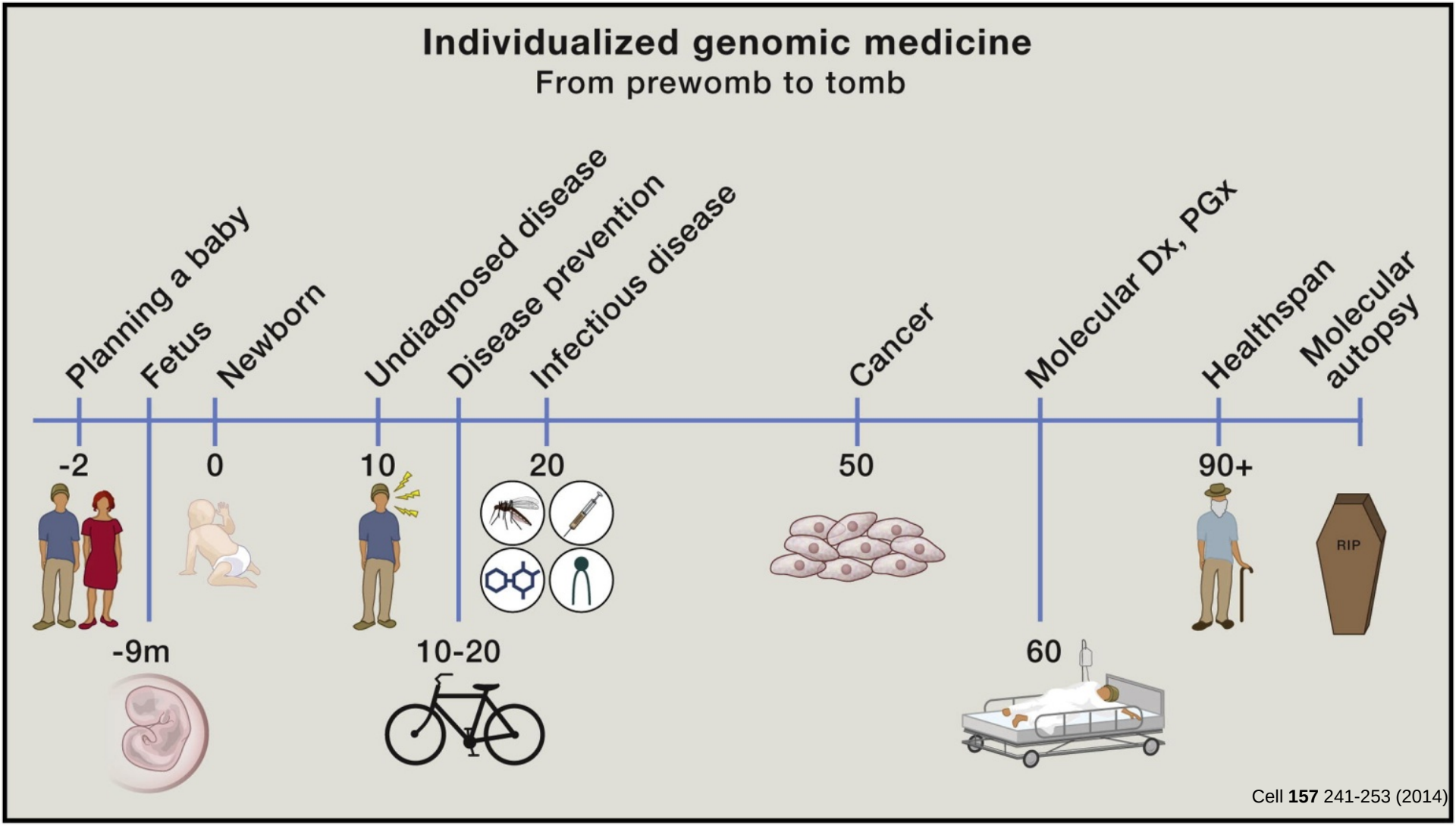
Glucose
NanoSensor
NanoRadio

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

Mendelian Inheritance in Man: A Catalog of Human Genes and Genetic Disorders by Victor A. McKusick

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

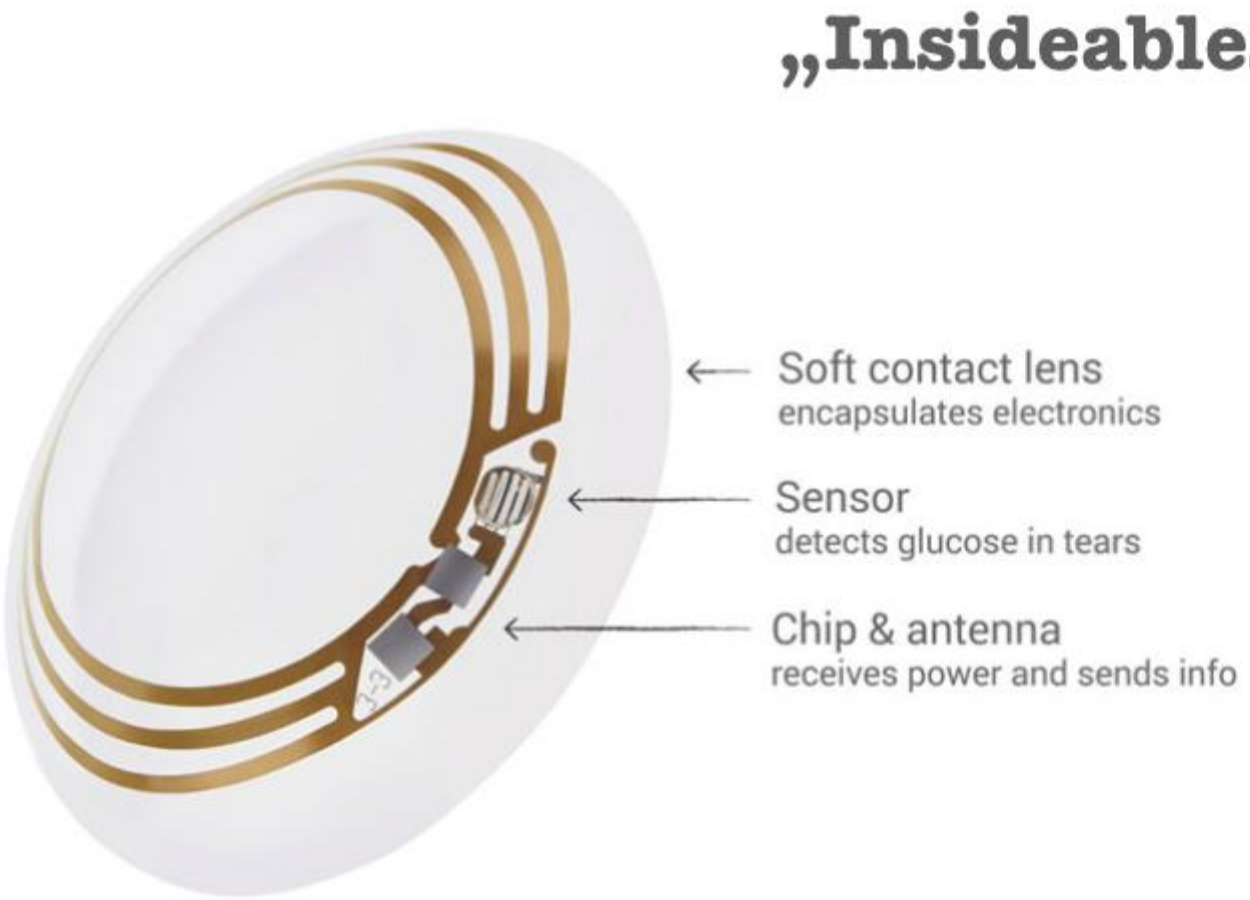
Environment -Aware
- GPS
- Accelerometer
- Compass
- Camera
- Microphone
- Other Sensors

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

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

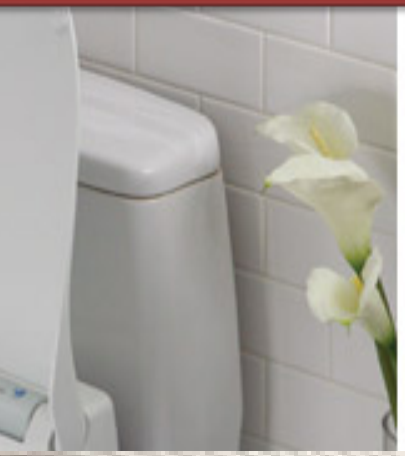
Development Platform
- 3rd party apps
- API partners
- Accessories

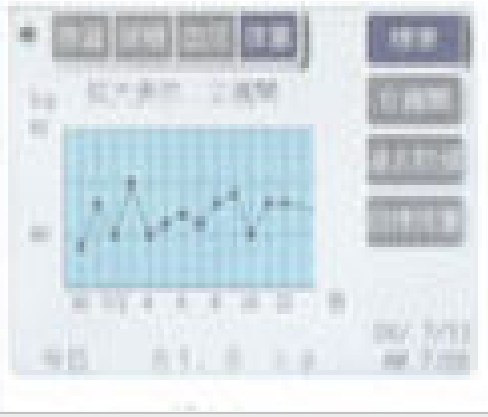
Glucose Sensors can reduce the morbidity due to Glaucoma



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

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

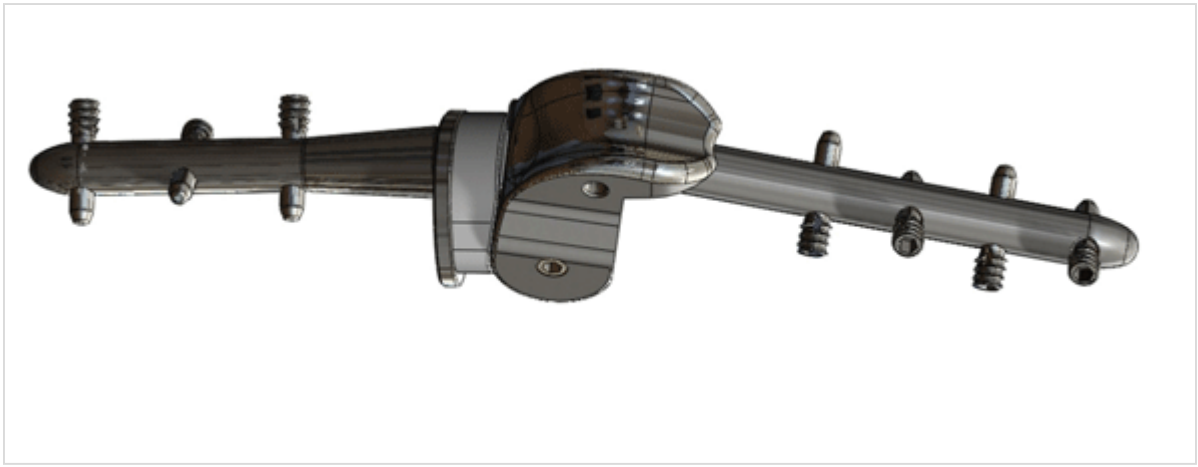
The micro-revenue earnings potential with 10% penetration for population of 3+ billion & aging!

Domain Specific Scenario

3-D Printing in Healthcare

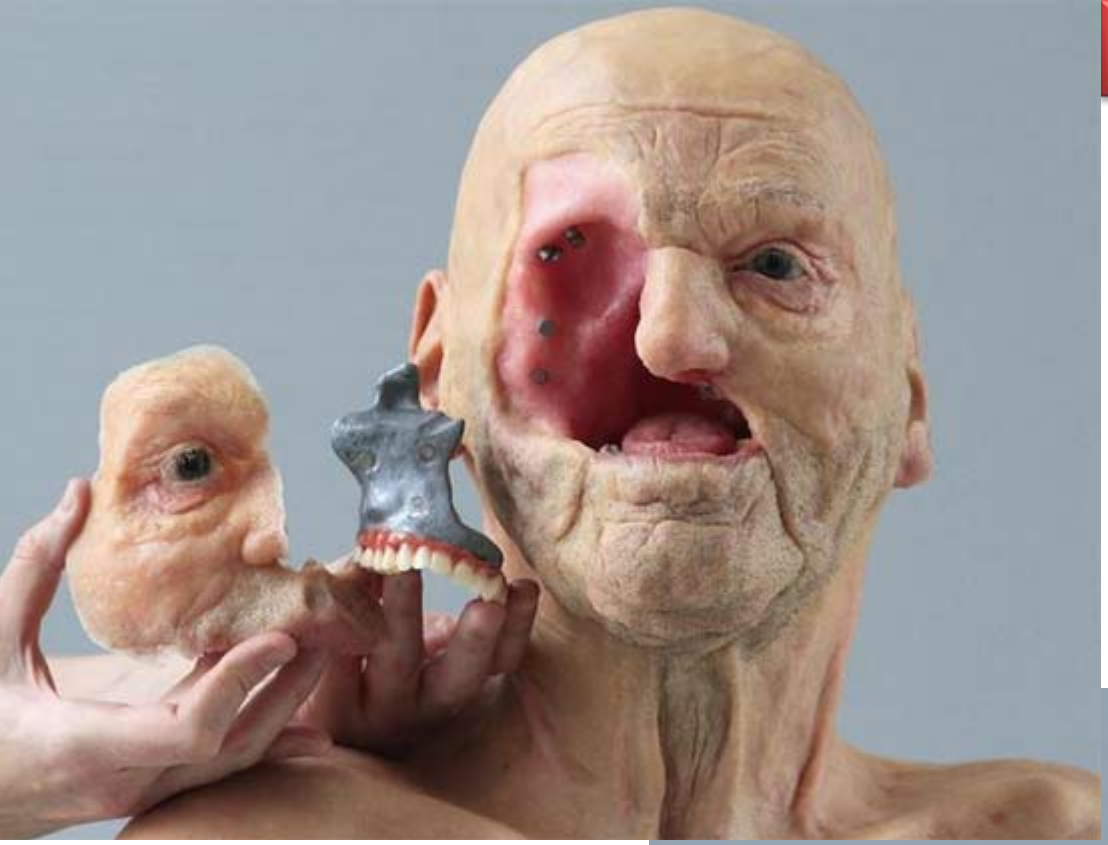
Innovation in manufacturing and digital design

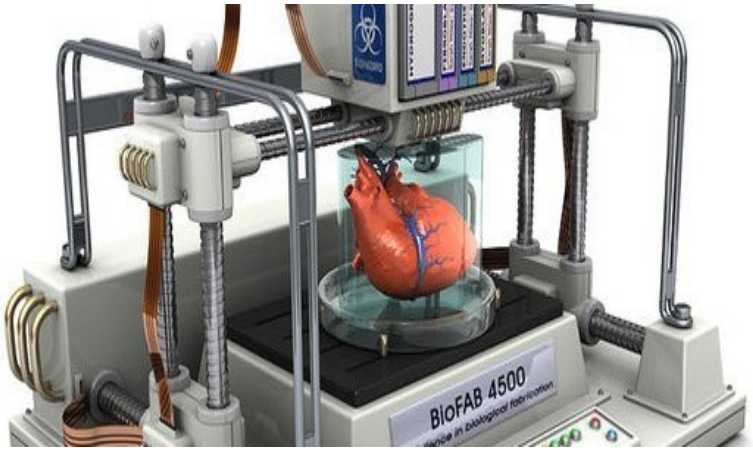
3-D Printing
Design of Prosthetics and Orthopedic Imaging



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).

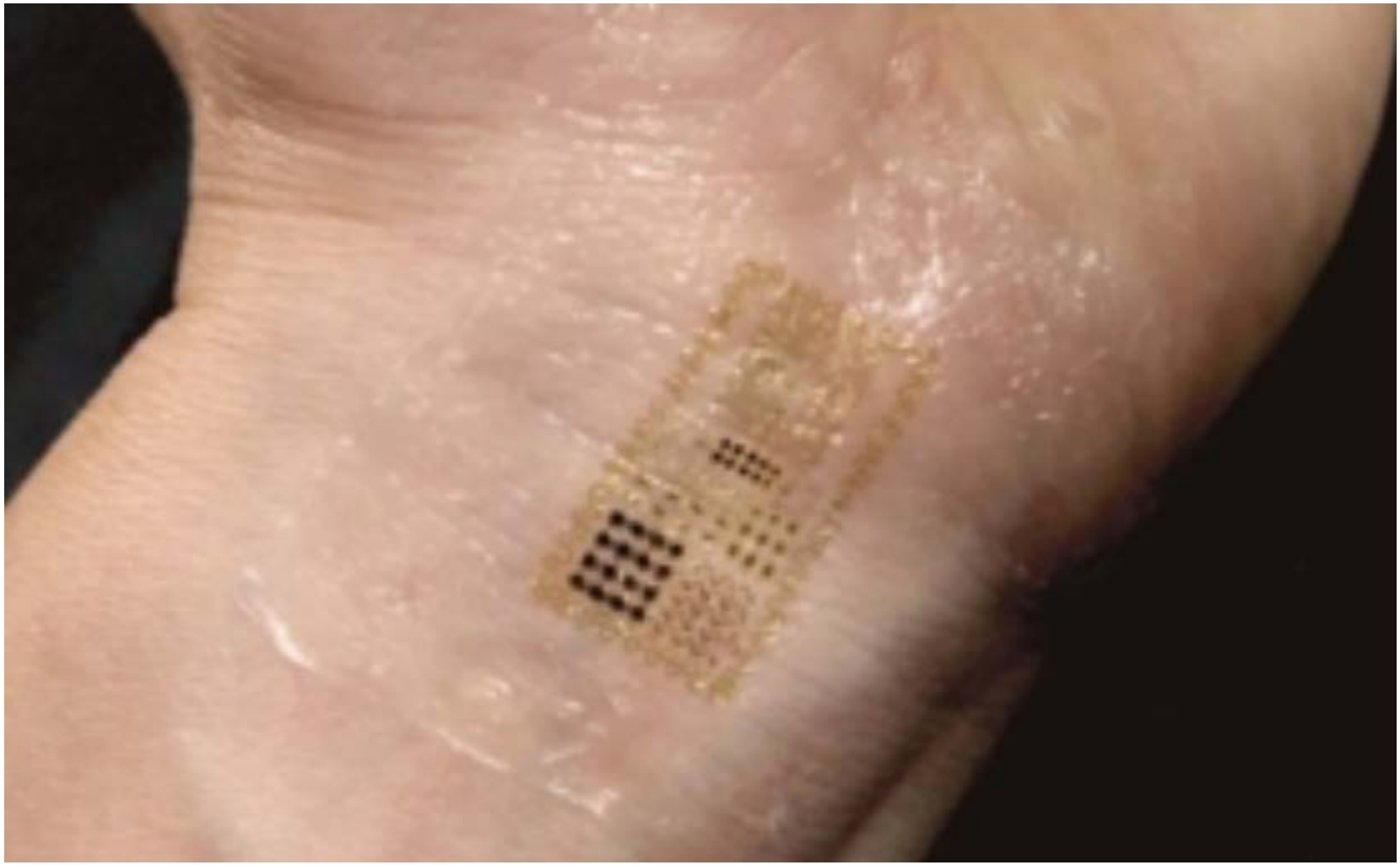
3-D Printing of Medical Devices





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

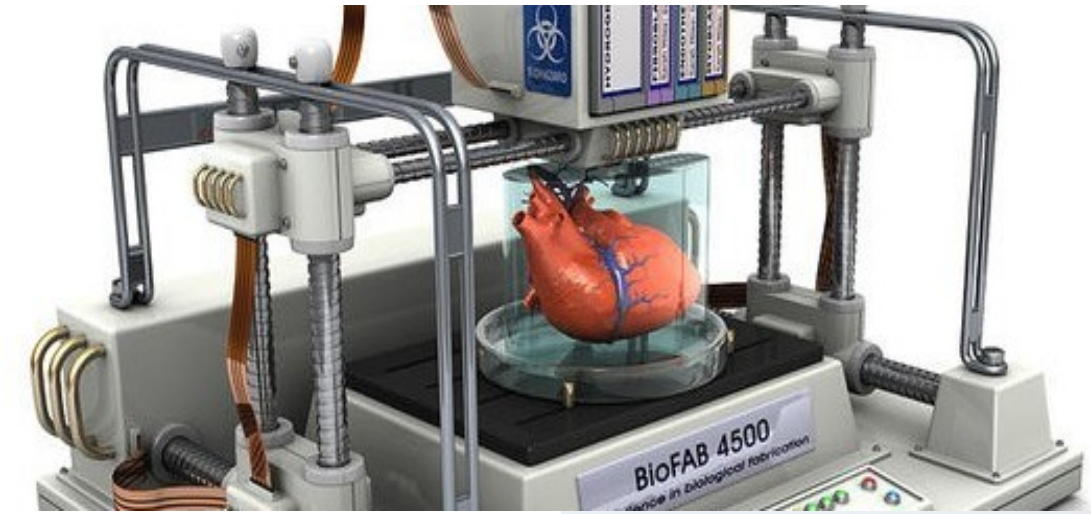
Artificial Skin with embedded sensory surface talks to smart phone via capacitive sensing using Touchcode adapted for printed i-Skin

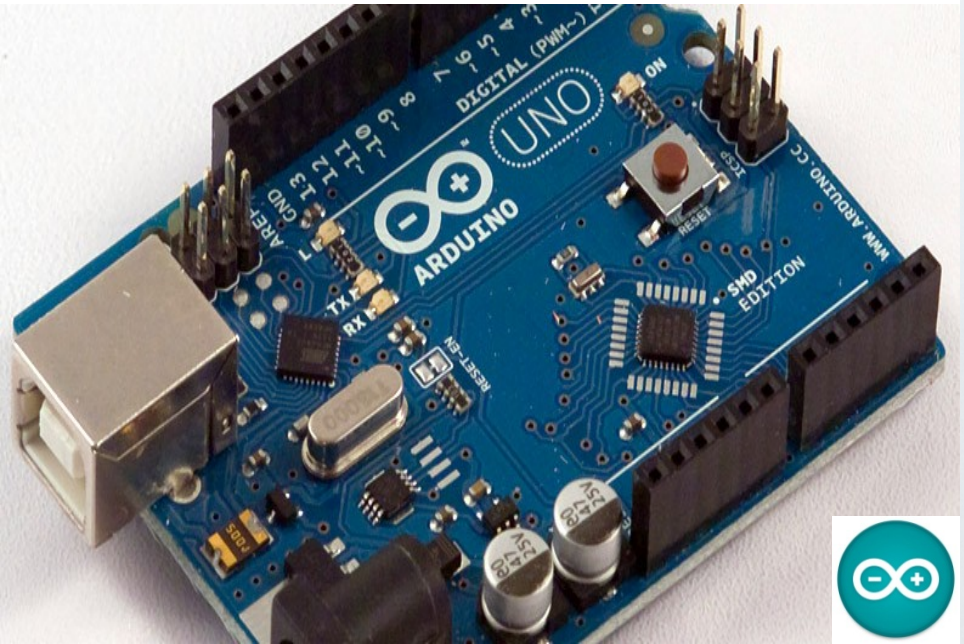


Your medicine can inform your doctor about its kinetics, bio-availability and side effects. It can alert your pharmacist about potential over-dose if multiple medications contain same or similar active ingredients. Your medicine can query and adjust dosage.

Paradigm Shift in Global Healthcare Economics

3D Printed Medical Devices + OS Hardware / Software

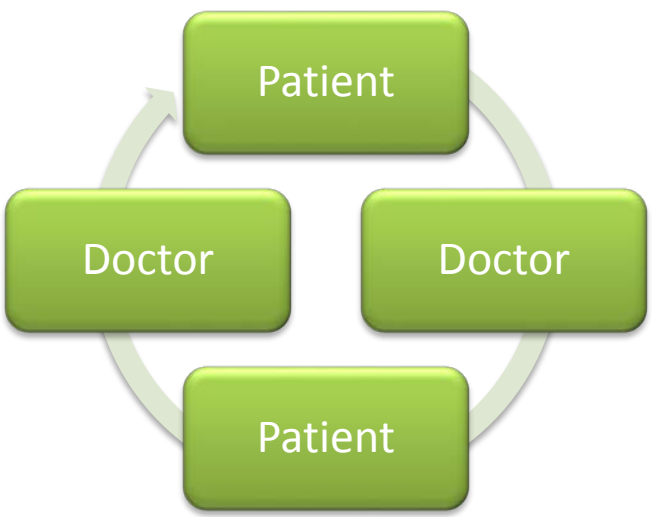


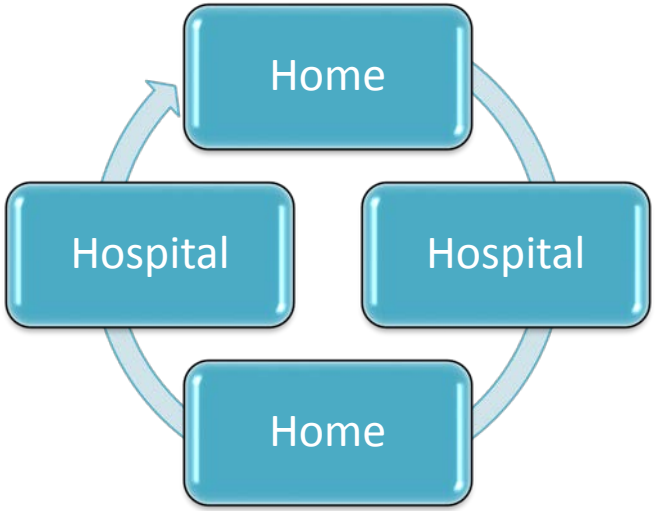


Domain Specific Scenario

Healthcare Management

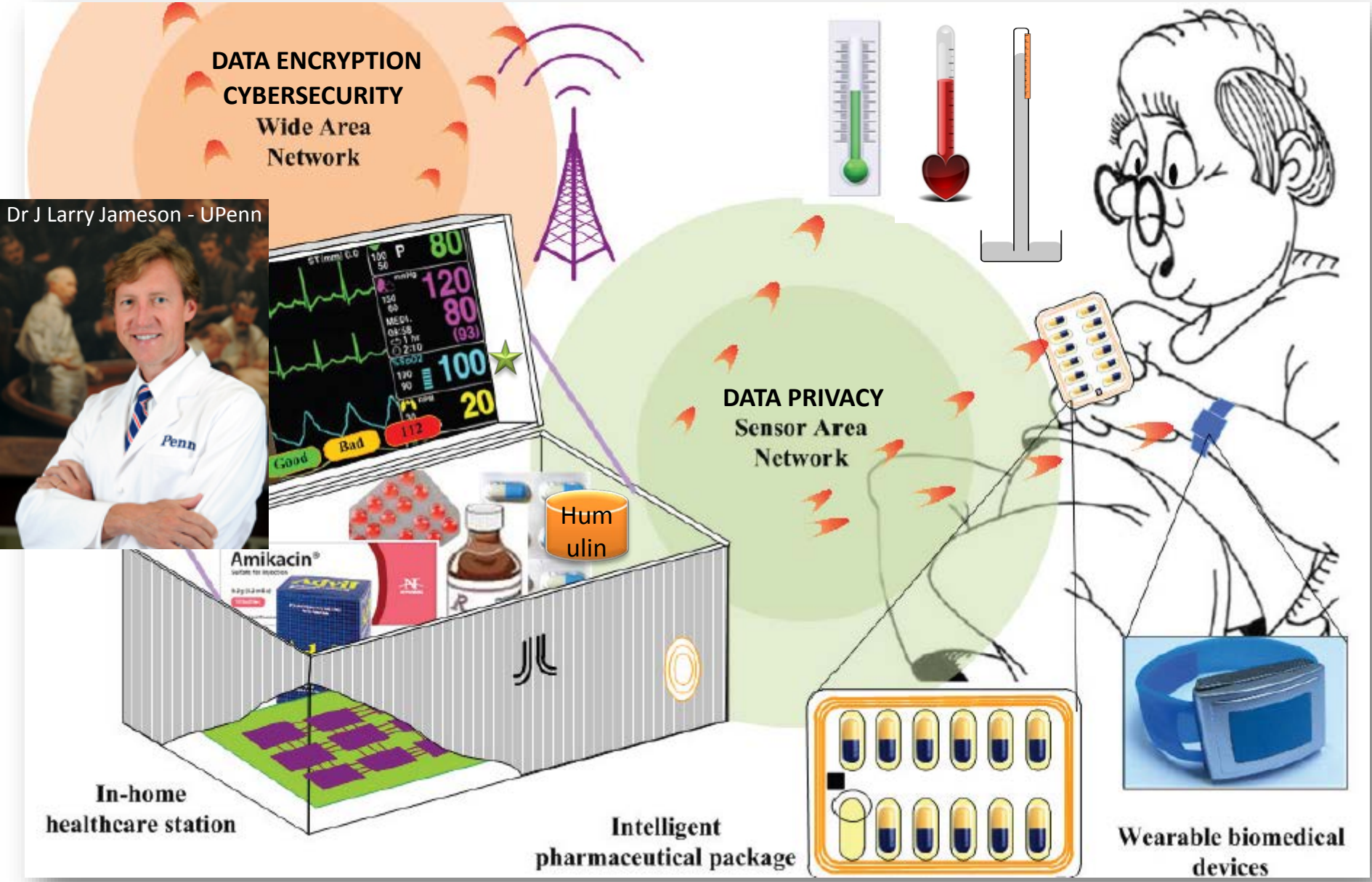
Healthcare Management - Fundamentally Closed Loop & Quintessentially Patient Specific





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 : Hi Dr Jameson - Do I need Lipitor today?



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

Healthcare Management - Fundamentally Closed Loop & Quintessentially Patient Specific

HOSPITAL

2. Robot dispatch alerts 911

Robot dispatch And 911

EHR

3. ER - Smart alarms utilize cloud data and EHR

Home Monitor

1. Fall Detected at home Randall doesn't get up

Cloud

PCP

4. Surgery

Datalogger

4. PCA risk of injury Reduced; reduce alarm fatigue

HOME

Safety Cert of interop

7. Discharge

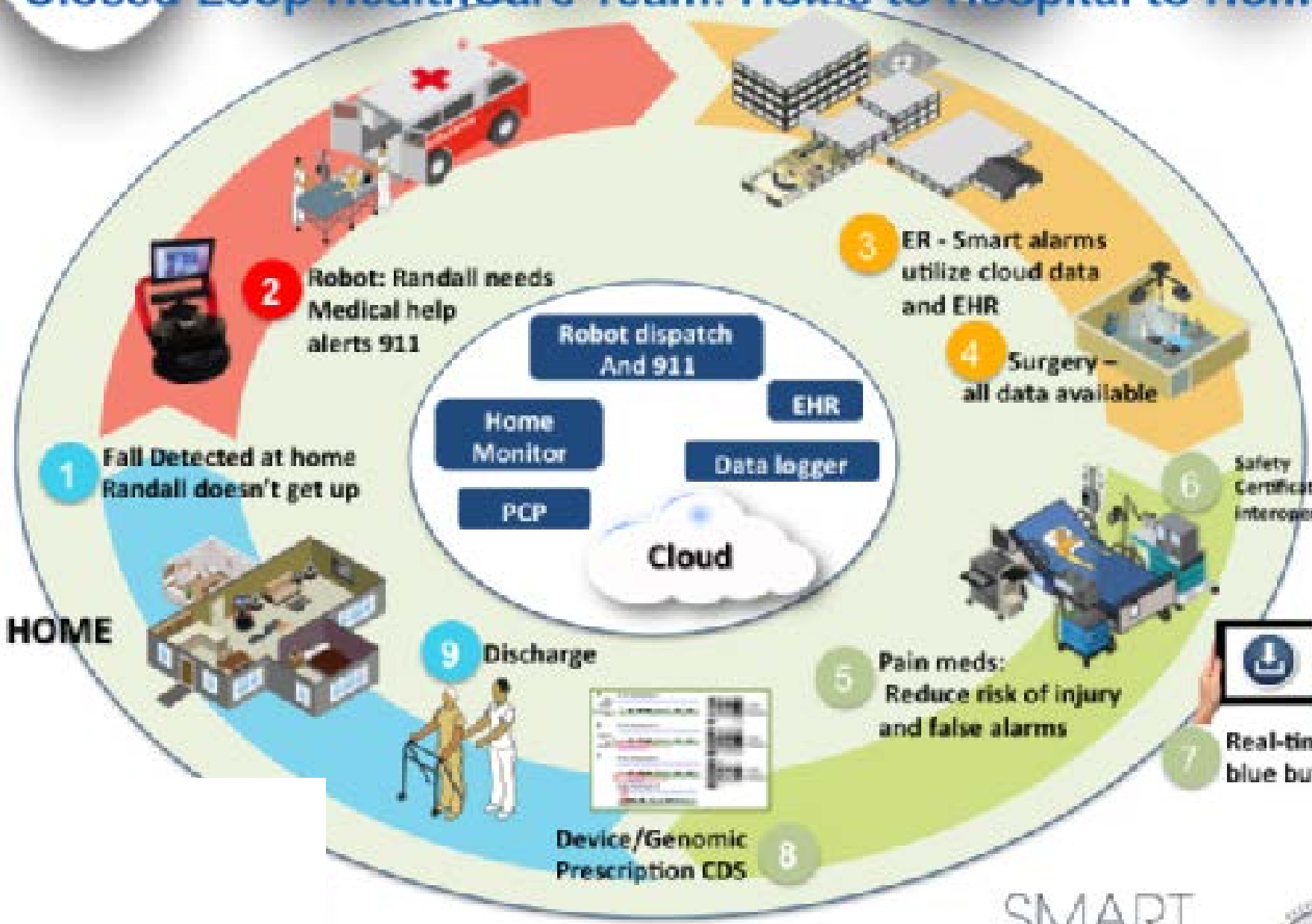
6. Real-time blue button

Key:

- Current
- June
- Proposed
- Patient movement

Dr Julian Goldman MD
MDPnP – MGH – HMS

Closed Loop HealthCare Team: Home to Hospital to Home



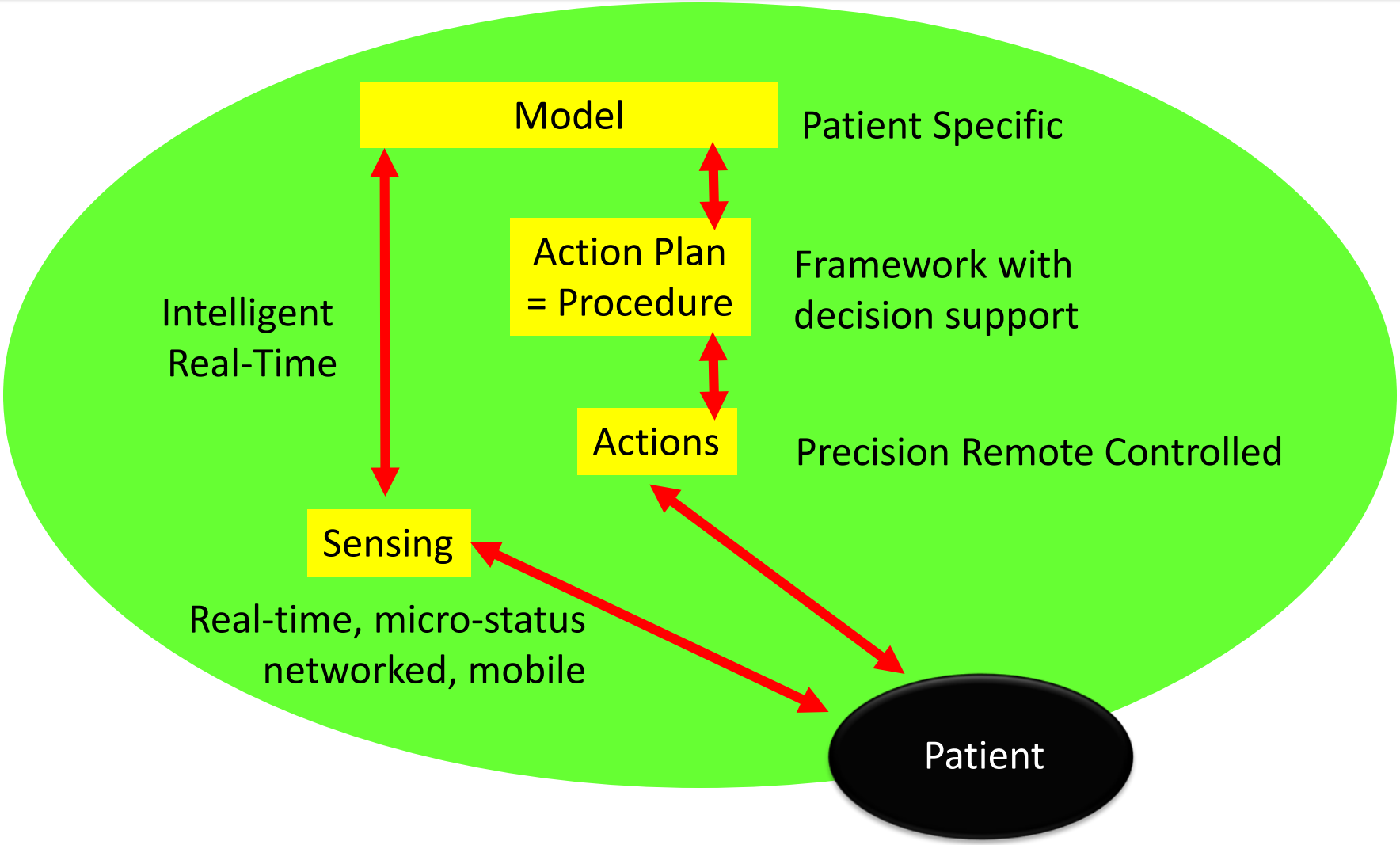
Dr Julian Goldman MD
MDPnP – MGH – HMS

SMART AMERICA

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.

- Medical Device Interoperability? ☑ http://bit.ly/VANDERBILT

Autonomous Control of Morphine Infusion Pump – Medical Device Integration Model

Infusion Pump

Capnometer

Patient Simulator
Ventilator

Intelligent Monitor

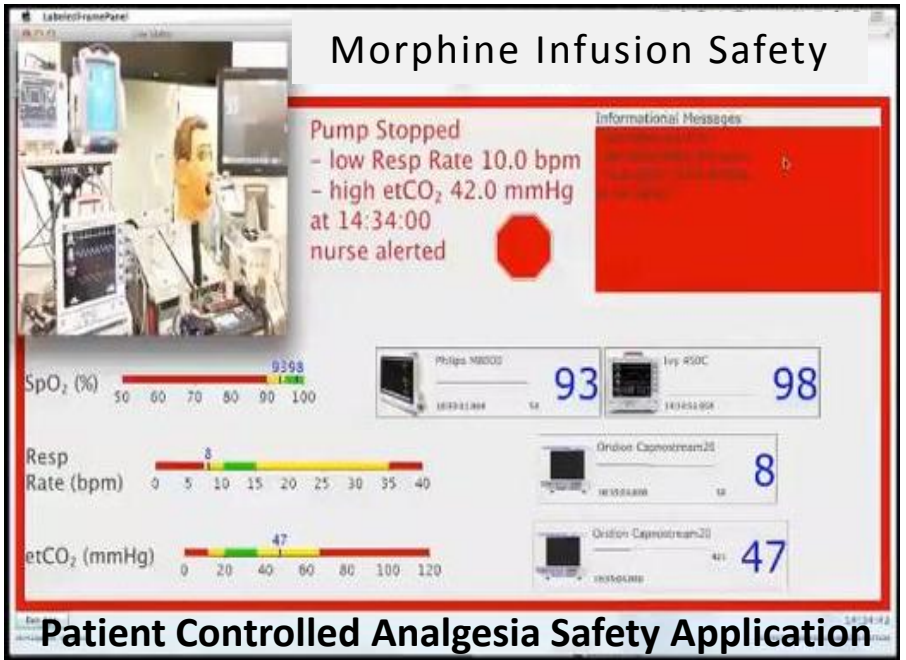
Vital Signs Monitor

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

For an extended discussion about medical ontology and semantics please download

Grand Challenges _ Collection

from

http://dspace.mit.edu/handle/1721.1/86935

Structure, Relations

```
<CompanyData>
   <CompanyName>
    MIT
   </CompanyName>
   <Location>
    Cambridge
   </location>
   <CallData>
     <RecordDate>
      Thu 7 Jun 2007
     </RecordDate>
     <CallsPerDay>
          536
     </CallsPerDay>
   </CallData>
</CompanyData>
```

• DIAGNOSIS CODES vs SEMANTICS AND MEDICAL ONTOLOGY

ICD-9

Sprained and Strained Ankles

845.00 Sprain and strain of ankle unspecied site
845.01 Sprain and strain of ankle, Deltoid ligament/ Internal collateral ligament
845.02 Sprain and strain of ankle, Calcaneobular (ligament)
845.03 Sprain and strain of ankle, Tibiobular (ligament) distal

ICD-10

Sprained and Strained Ankles

S93.401A Sprain of unspecied ligament of right ankle – initial encounter
S93.401D Sprain of unspecied ligament of right ankle – subsequent encounter
S93.401S Sprain of unspecied ligament of right ankle – sequela
S93.402A Sprain of unspecied ligament of left ankle – initial encounter
S93.402D Sprain of unspecied ligament of left ankle – subsequent encounter
S93.402S Sprain of unspecied ligament of left ankle – sequela
S93.409A Sprain of unspecied ligament of unspecied ankle – initial encounter
S93.409D Sprain of unspecied ligament of unspecied ankle - subsequent encounter
S93.409S Sprain of unspecied ligament of unspecied ankle – sequela
S93.412D Sprain of calcaneobular ligament of left ankle – subsequent encounter
S93.412S Sprain of calcaneobular ligament of left ankle – sequela
S93.419A Sprain of calcaneobular ligament of unspecied ankle – initial encounter
S93.419D Sprain of calcaneobular ligament of unspecied ankle – subsequent encounter
S93.419S Sprain of calcaneobular ligament of unspecied ankle
S93.431A Sprain of tibiobular ligament of right ankle – initial encounter
S93.431D Sprain of tibiobular ligament of right ankle – subsequent encounter
S93.431S Sprain of tibiobular ligament of right ankle – sequela
S93.432A Sprain of tibiobular ligament of left ankle – initial encounter
S93.432D Sprain of tibiobular ligament of left ankle – subsequent encounter
S93.432S Sprain of tibiobular ligament of left ankle – sequela
S93.439A Sprain of tibiobular ligament of unspecied ankle – initial encounter
S93.439D Sprain of tibiobular ligament of unspecied ankle – subsequent encounter
S93.439S Sprain of tibiobular ligament of unspecied ankle – sequela
S93.491A Sprain of other ligament of right ankle (Internal collateral/ talobular) initial encounter
S93.491D Sprain of other ligament of right ankle (Internal collateral/ talobular) subsequent encounter
S93.491S Sprain of other ligament of right ankle (Internal collateral/ talobular) sequela
S93.492A Sprain of other ligament of left ankle, initial encounter
S93.492D Sprain of other ligament of left ankle subsequent encounter
S93.492S Sprain of other ligament of left ankle sequela
S93.499A Sprain of other ligament of unspecied ankle initial encounter
S93.499D Sprain of other ligament of unspecied ankle subs encounter
S93.499S Sprain of other ligament of unspecied ankle (Internal collateral/talobular) sequela
S96.211A Strain of intrinsic muscle and tendon at right ankle and foot level initial encounter
S96.211D Strain of intrinsic muscle and tendon at right ankle and foot level subsequent encounter
S96.211S Strain of intrinsic muscle and tendon at right ankle and foot level sequela
S96.212A Strain of intrinsic muscle and tendon at left ankle and foot level initial encounter
S96.212D Strain of intrinsic muscle and tendon at left ankle and foot level subsequent encounter
S96.212S Strain of intrinsic muscle and tendon at left ankle and foot level sequela
S96.219A Strain of intrinsic muscle and tendon at ankle and foot level, unspecied side initial encounter
S96.219D Strain of intrinsic muscle and tendon at ankle and foot level, unspecied side subs encounter
S96.219S Strain of intrinsic muscle and tendon at ankle and foot level, unspecied side
S96.811A Strain of other muscles and tendons at right ankle and foot level initial encounter
S96.811D Strain of other muscles and tendons at right ankle and foot level subsequent encounter
S96.811S Strain of other muscles and tendons at right ankle and foot level sequela
S96.812A Strain of other muscles and tendons at left ankle and foot level initial encounter
S96.812D Strain of other muscles and tendons at left ankle and foot level subsequent encounter
S96.812S Strain of other muscles and tendons at left ankle and foot level sequela
S96.819A Strain of other muscles and tendons at ankle and foot level, unspecied side initial encounter
S96.819D Strain of other muscles and tendons at ankle and foot level, unspecied side subs encounter
S96.819S Strain of other muscles and tendons at ankle and foot level, unspecied side sequela
S96.911A Strain of unspecied muscle and tendon at right ankle and foot level initial encounter
S96.911D Strain of unspecied muscle and tendon at right ankle and foot level subs encounter
S96.911S Strain of unspecied muscle and tendon at right ankle and foot level sequela
S96.912A Strain of unspecied muscle and tendon at left ankle and foot level initial encounter
S96.912D Strain of unspecied muscle and tendon at left ankle and foot level subs encounter
S96.912S Strain of unspecied muscle and tendon at left ankle and foot level sequela
S96.919A Strain of unspecied muscle and tendon at ankle and foot level, unspec. side initial encounter
S96.919D Strain of unspecied muscle and tendon at ankle and foot level, unspec. side subs encounter
S96.919S Strain of unspecied muscle and tendon at ankle and foot level, unspec. side sequela

All data are not created equal

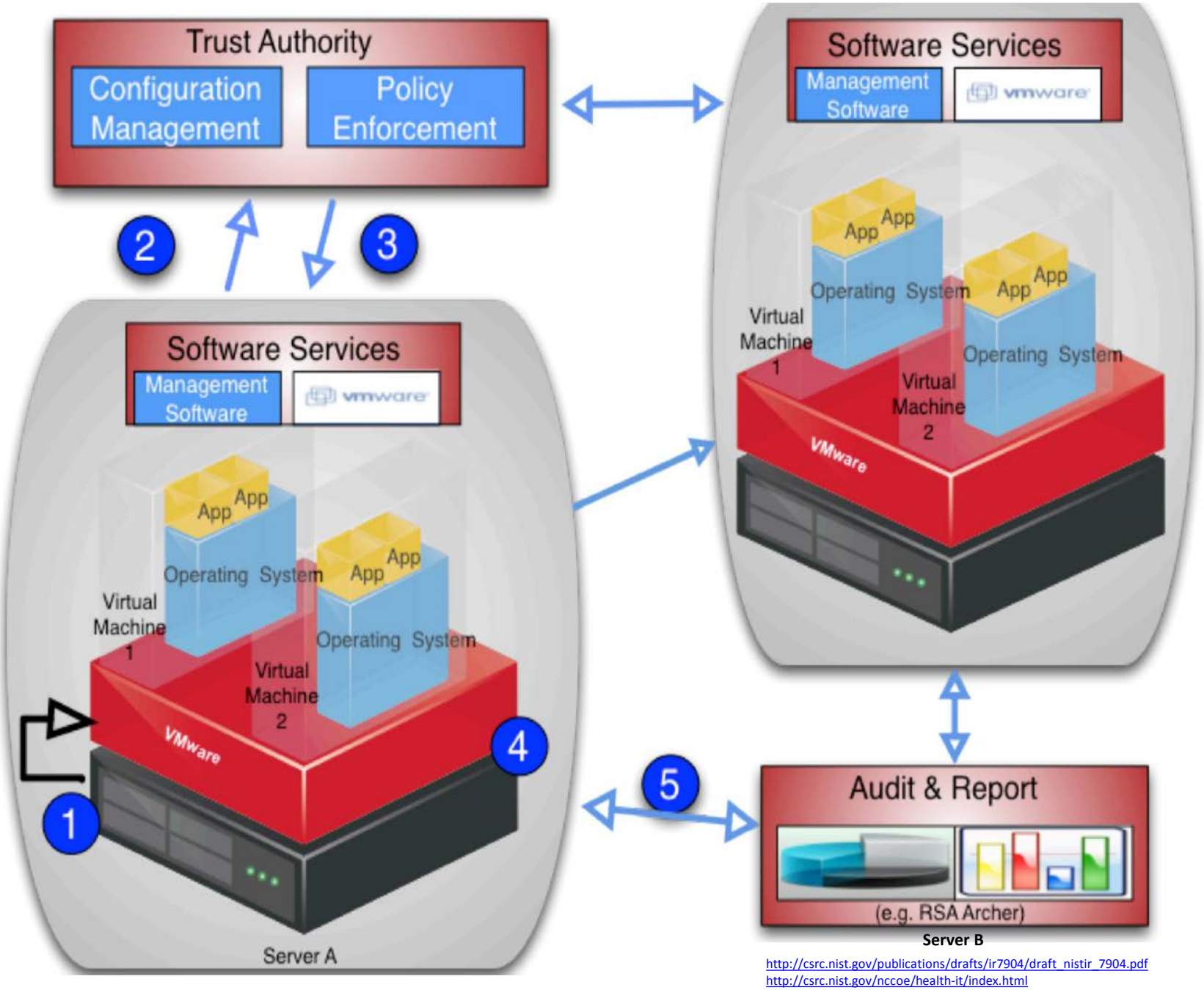
DON’T USE MY DATA

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

Healthcare Data Neutering

De-Identified Data

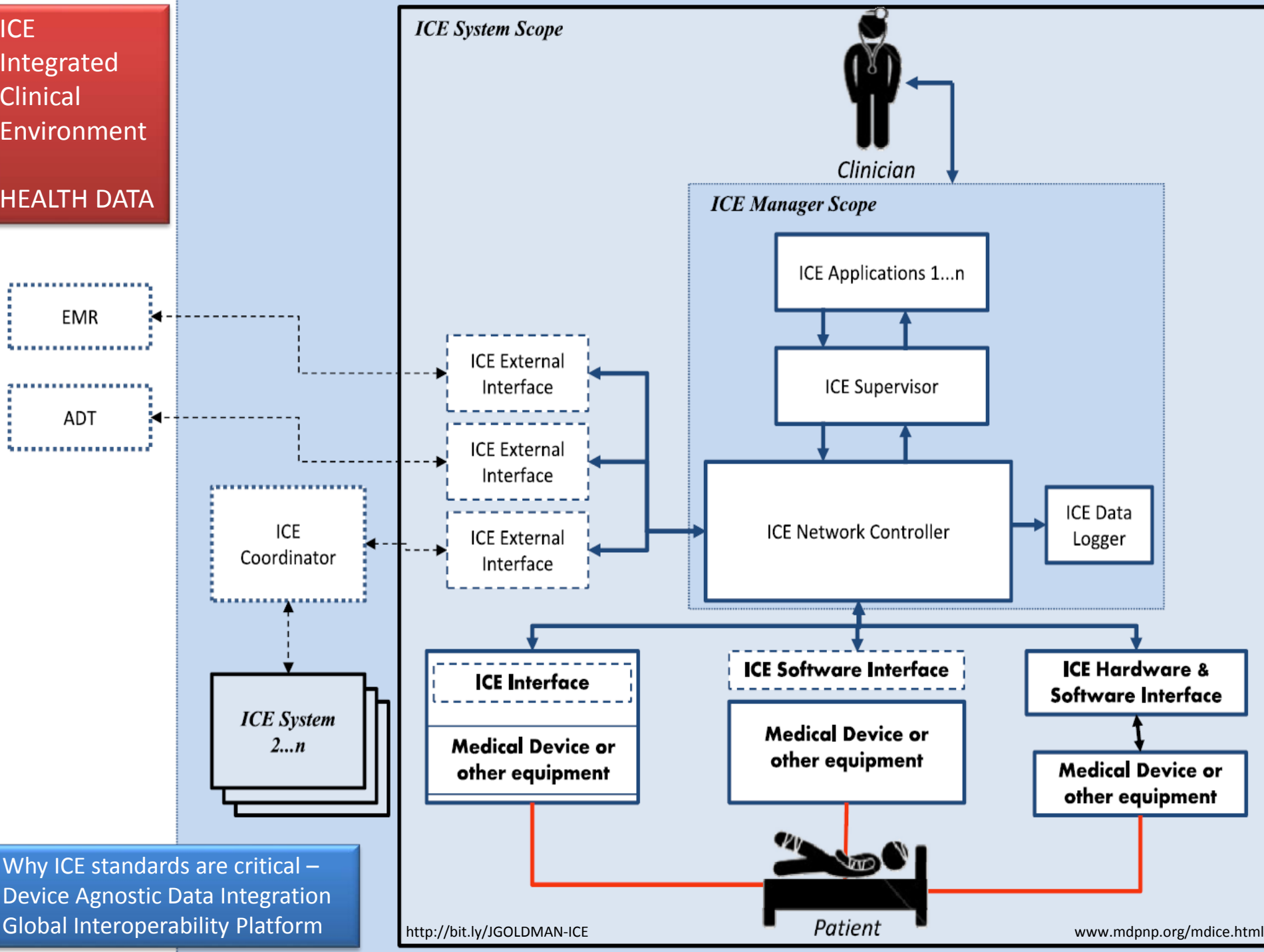
Trusted GeoLocation in the Cloud (NIST NCCOE) – Is this an adequate solution for health data?



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

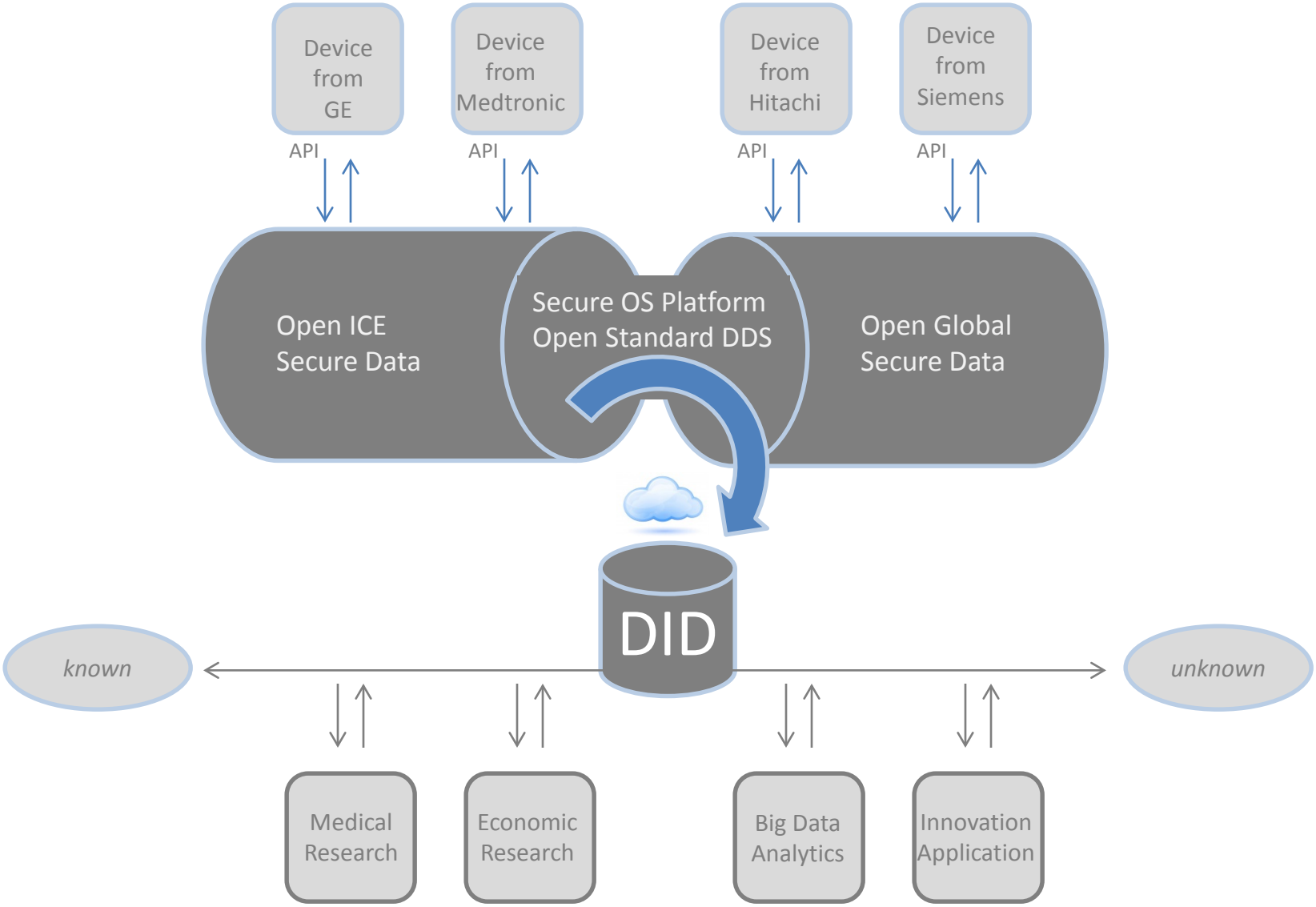
ICE Integrated Clinical Environment

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.

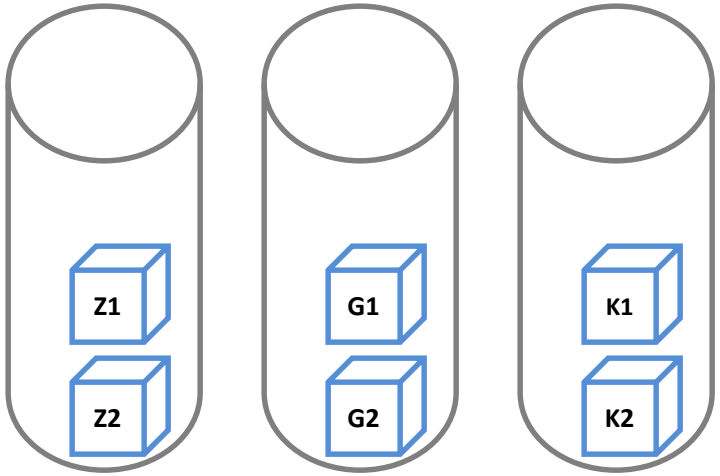
Data Dissociation using meta data to identify/label data type

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

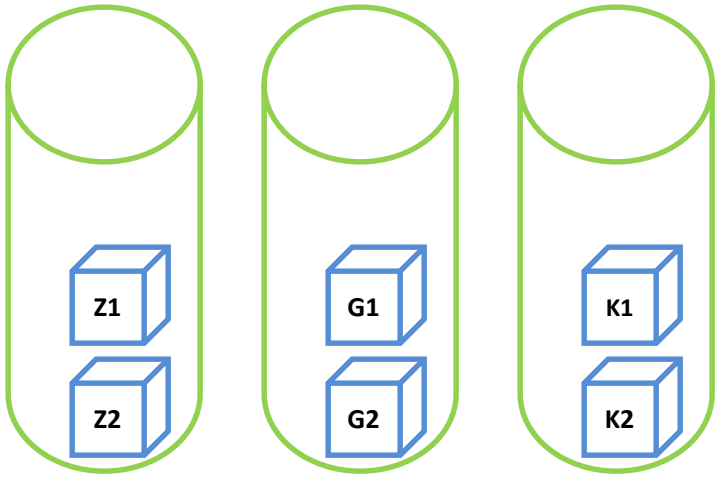
- Epedimiologists
- Economists
- Physician

What is the distribution of potential diabetics by zip code?

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

Can we correlate high blood glucose with increased body weight?

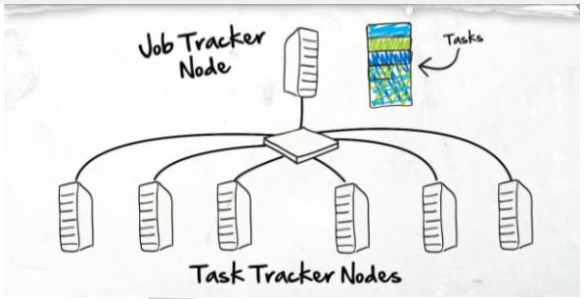
Name	SSN-UID	Street Address	Zip Code	Blood Glucose	Weight in kg
			02139 Tag Z1	190 mg/dl Tag G1	190 Tag K1
			02138 Tag Z2	109 mg/dl Tag G2	159 Tag K2

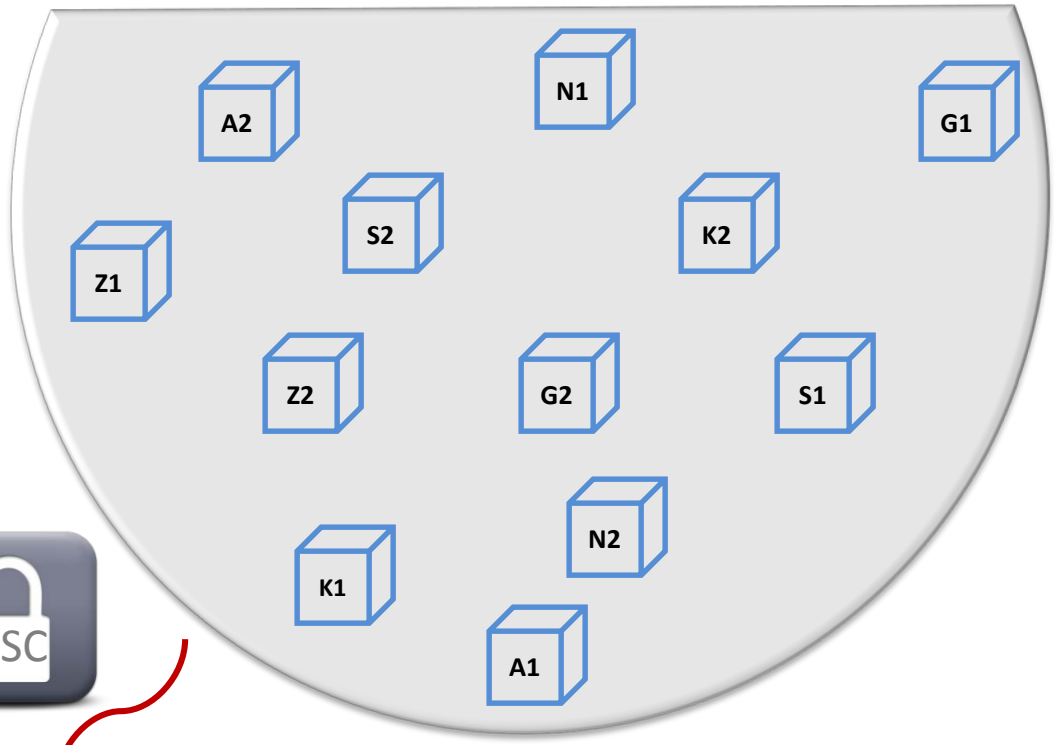


This is a suggestion by the author. Not a proven concept in practice.

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

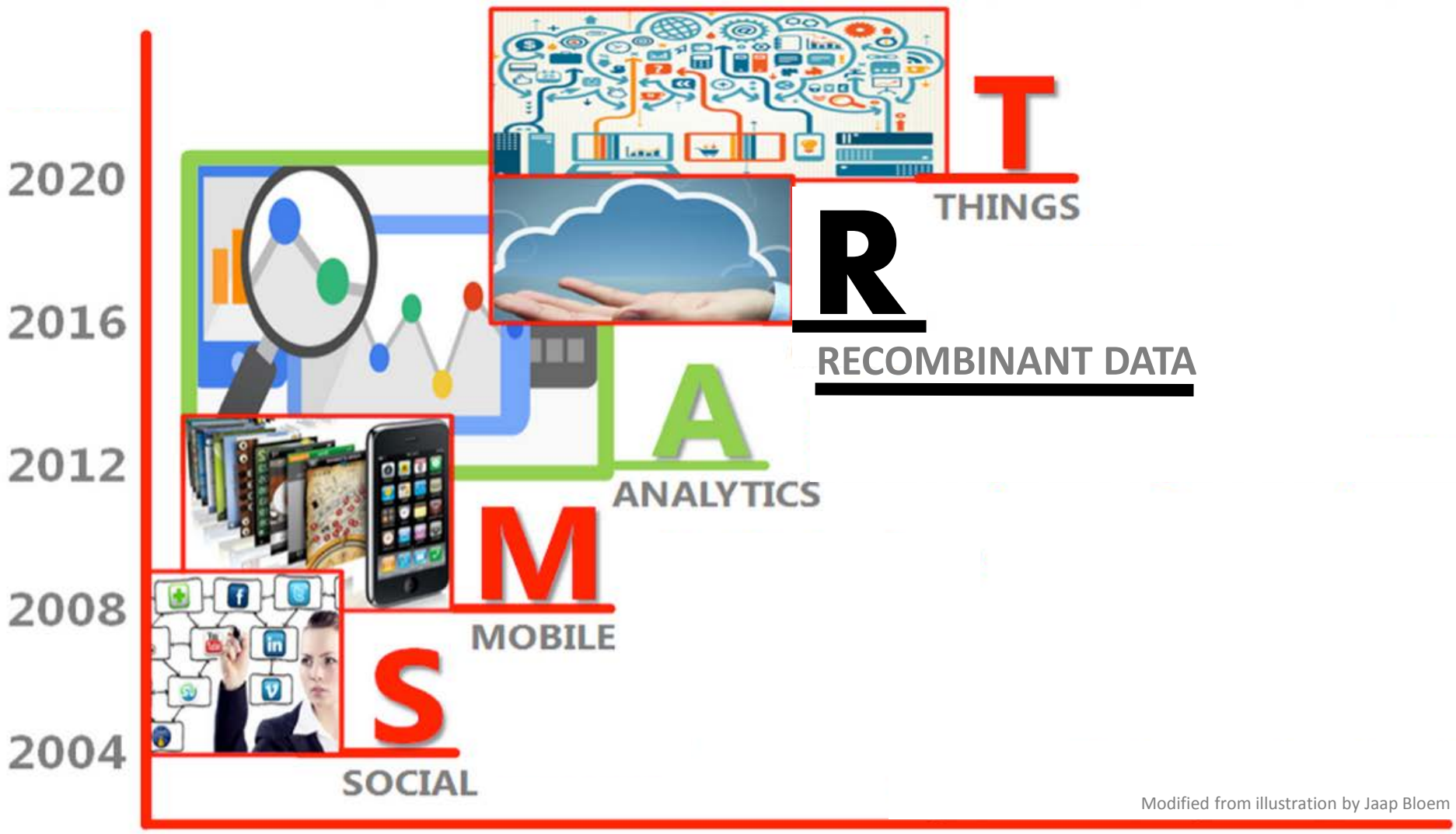
This is a suggestion by the author. Not a proven concept in practice.

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

Recombinant Data

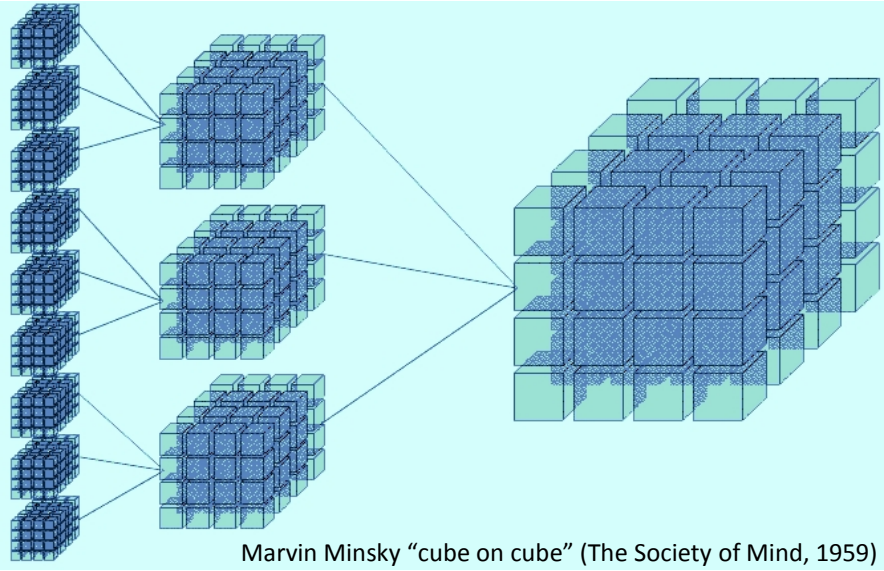
Data (by itself – in one silo) is of limited value unless analyzed in conjunction with other data in context of the application or in context of the problem-question

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



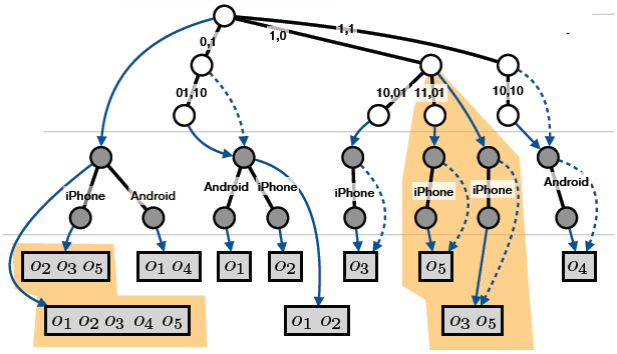
Modified from illustration by Jaap Bloem

The Industrial Internet may benefit from a Paradigm Shift

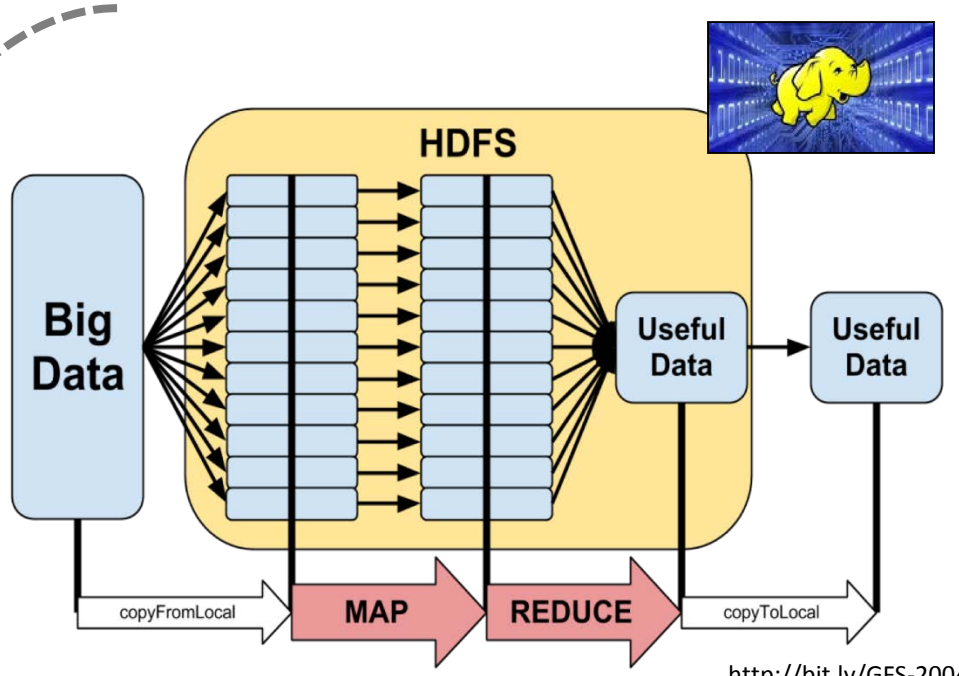


Marvin Minsky “cube on cube” (The Society of Mind, 1959)

nanocubes



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



http://bit.ly/GFS-2004

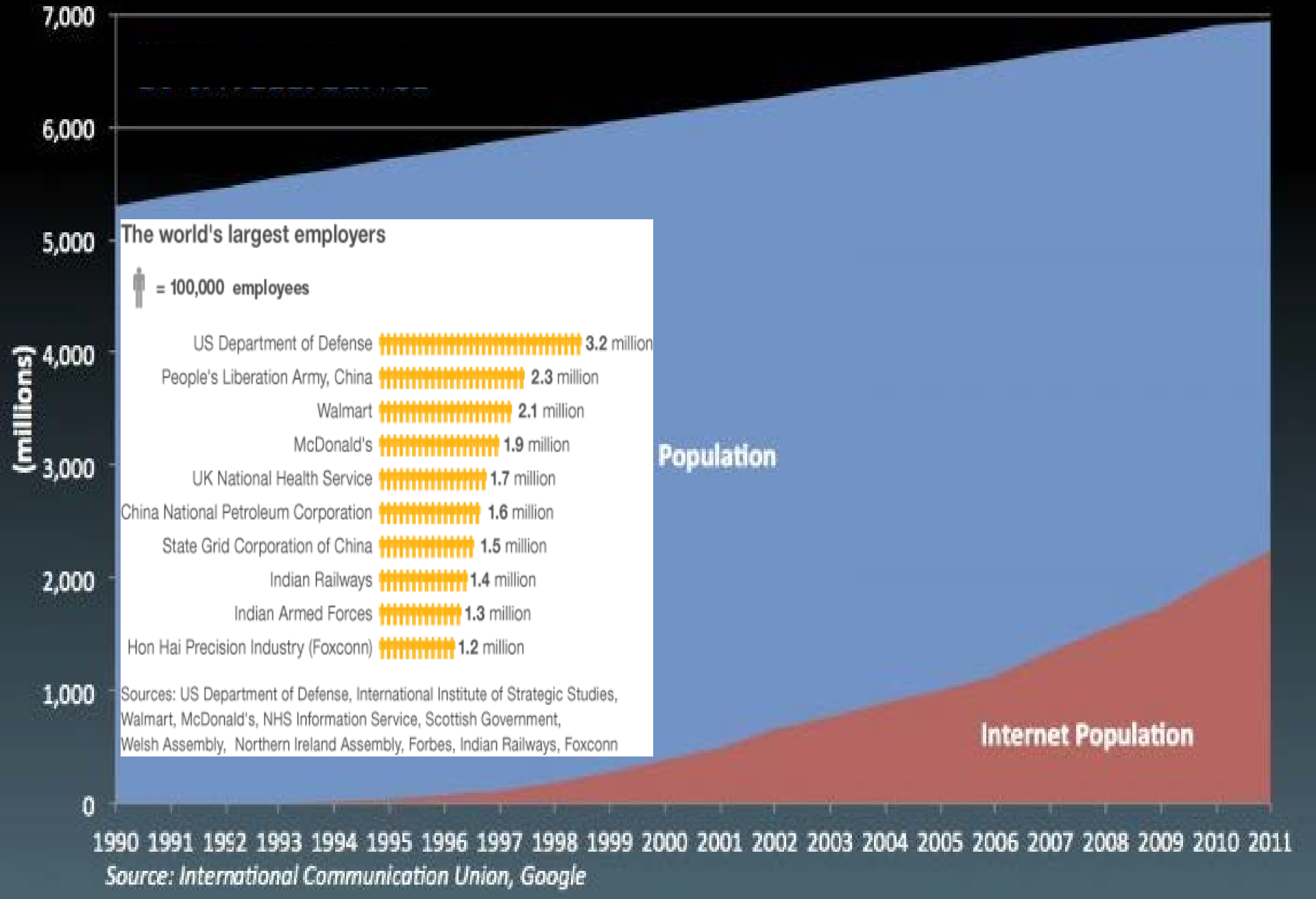
- Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

☑ Big Data

Bad name

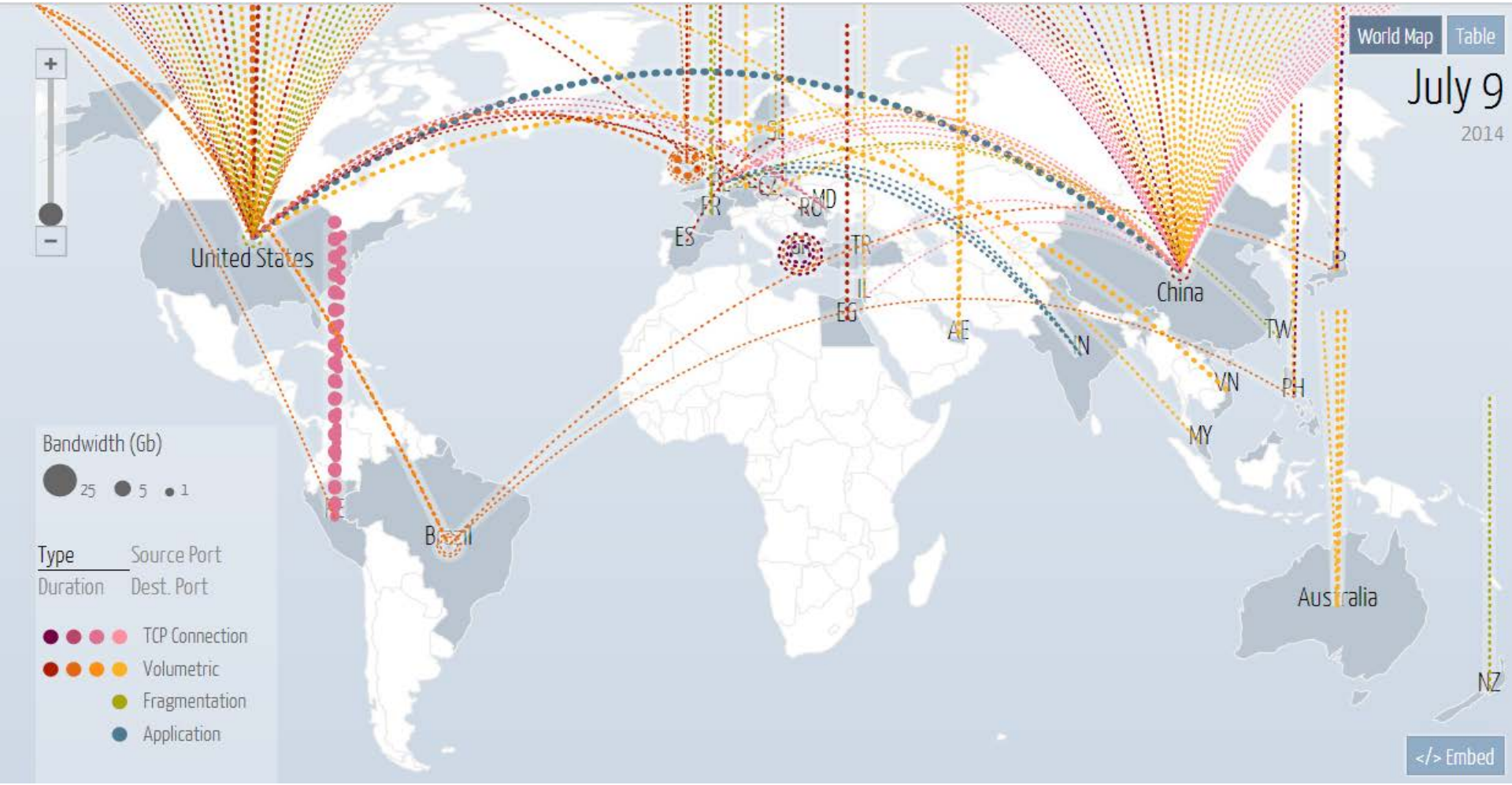
Elusive Quest for Monetization (EQM)

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



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

Data Cybersecurity – Digital Attack Map – The Prelude to Cyber Warfare



- **Connect, Converge, Combine → Obvious vs Non-Obvious**

  [a] Space-time-node engine

  [b] Stigmergic computation

  [c] Cognitive matrices

  [d] Dynamic networks

  [e] Semantics of time

  [f] Temporally integrated software systems

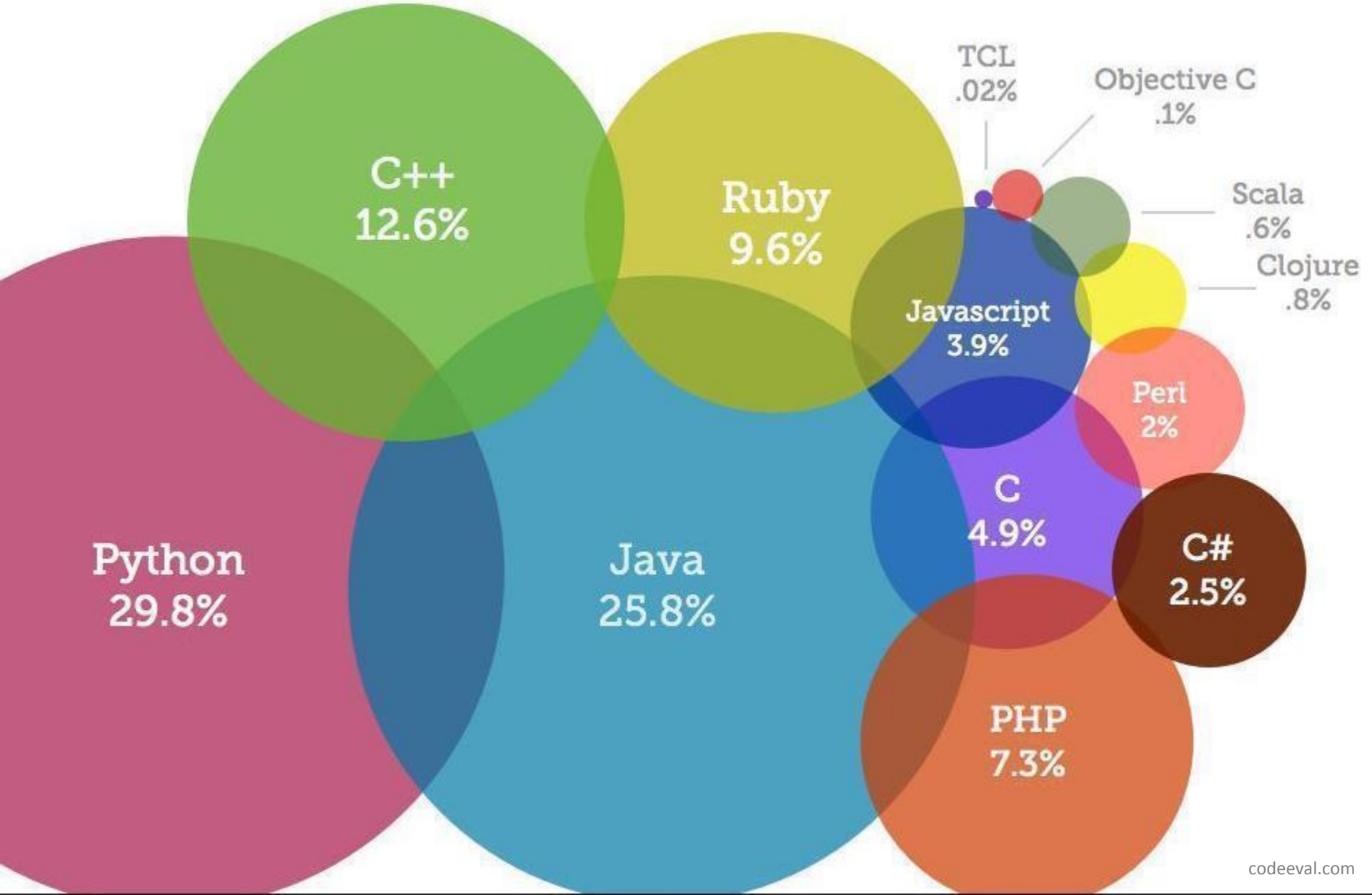
  [g] Artificial retina pattern recognition algorithm

  [h] Conventional (time series, GARCH, OR, AI, machine learning)

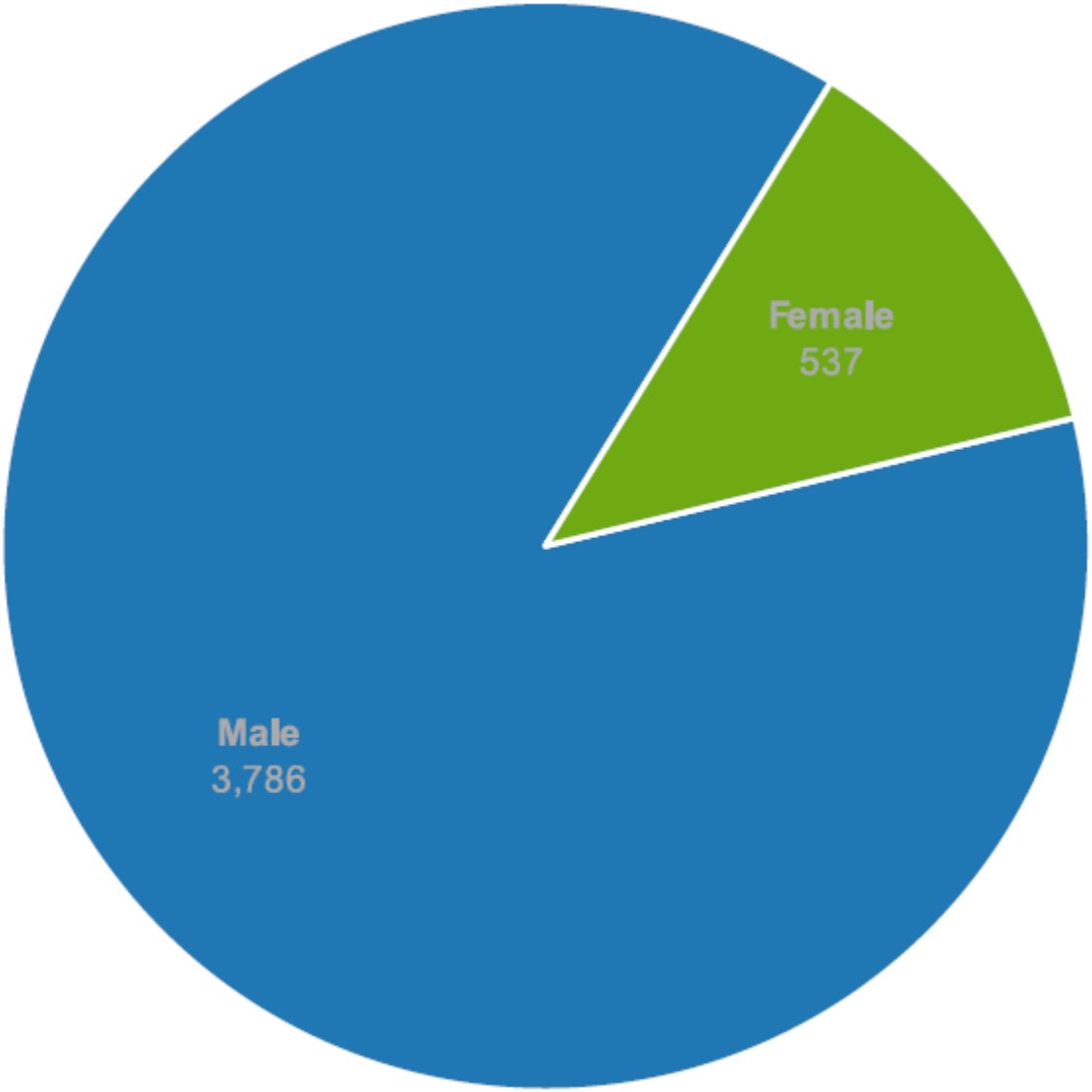
• Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

- Disequilibrium
  - Death of a Middleman
  - Girls Who Code
  - Gini Coefficient
  - Energy
  - Water
  - Willy Wonka and The Chocolate Factory

Girls Who Code



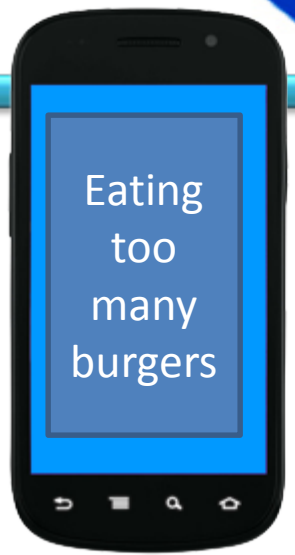
Silicon Valley's Gender Imbalance – The Rate Limiting Factor for Creativity and Entrepreneurship



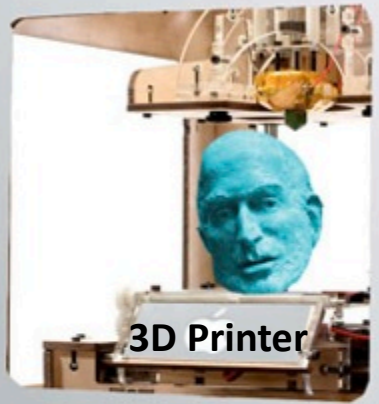
Women in Engineering Roles in Leadership and/or Management (updated 02-14-2014)

- Apple Developers Conference, Santa Clara Convention Center (March 2014)

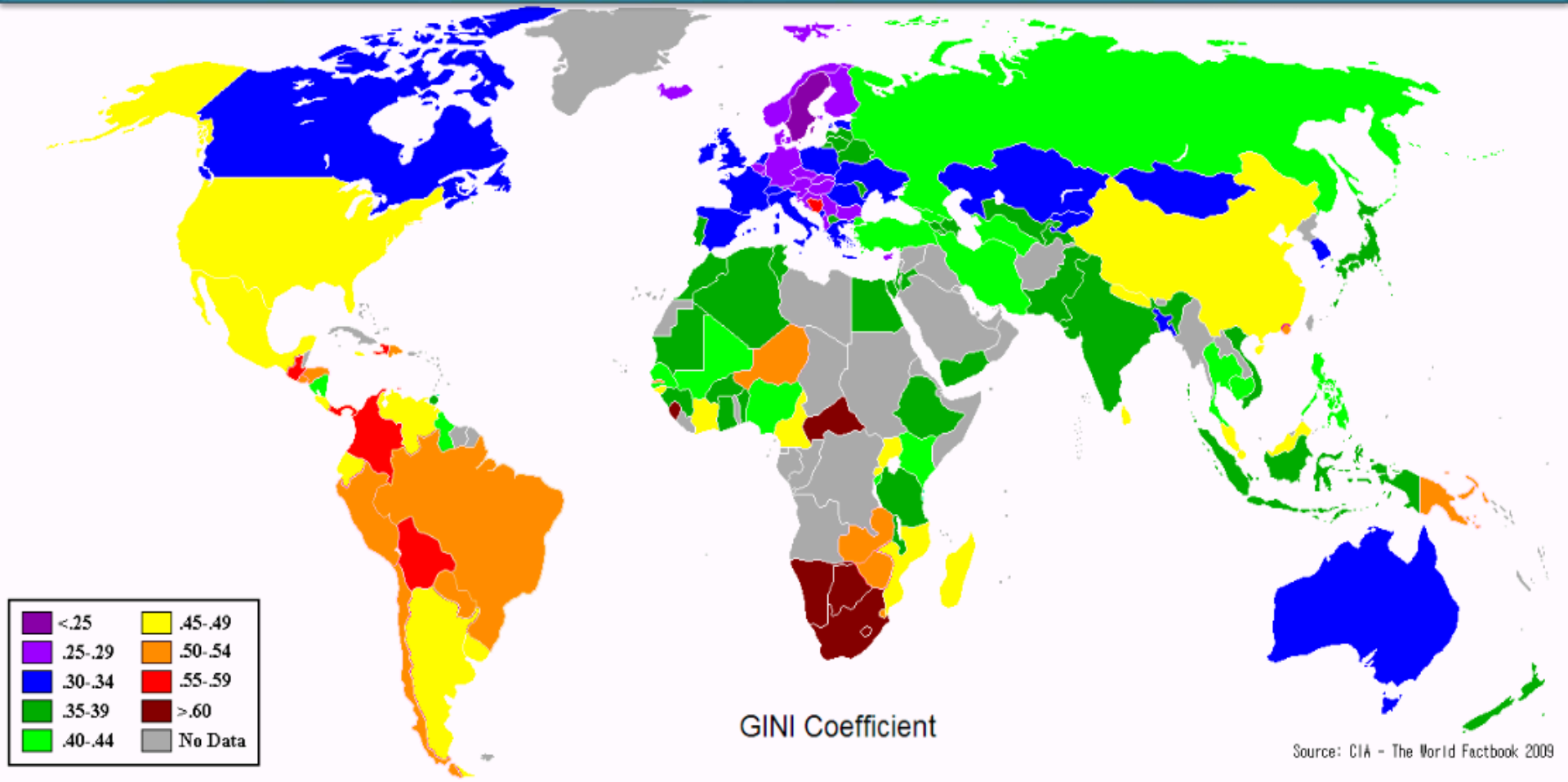
2050 – Printed hamburger wrapped in touch-code paper which can talk to your iPhone



Your burger calls your doctor to report that you are eating too many burgers.

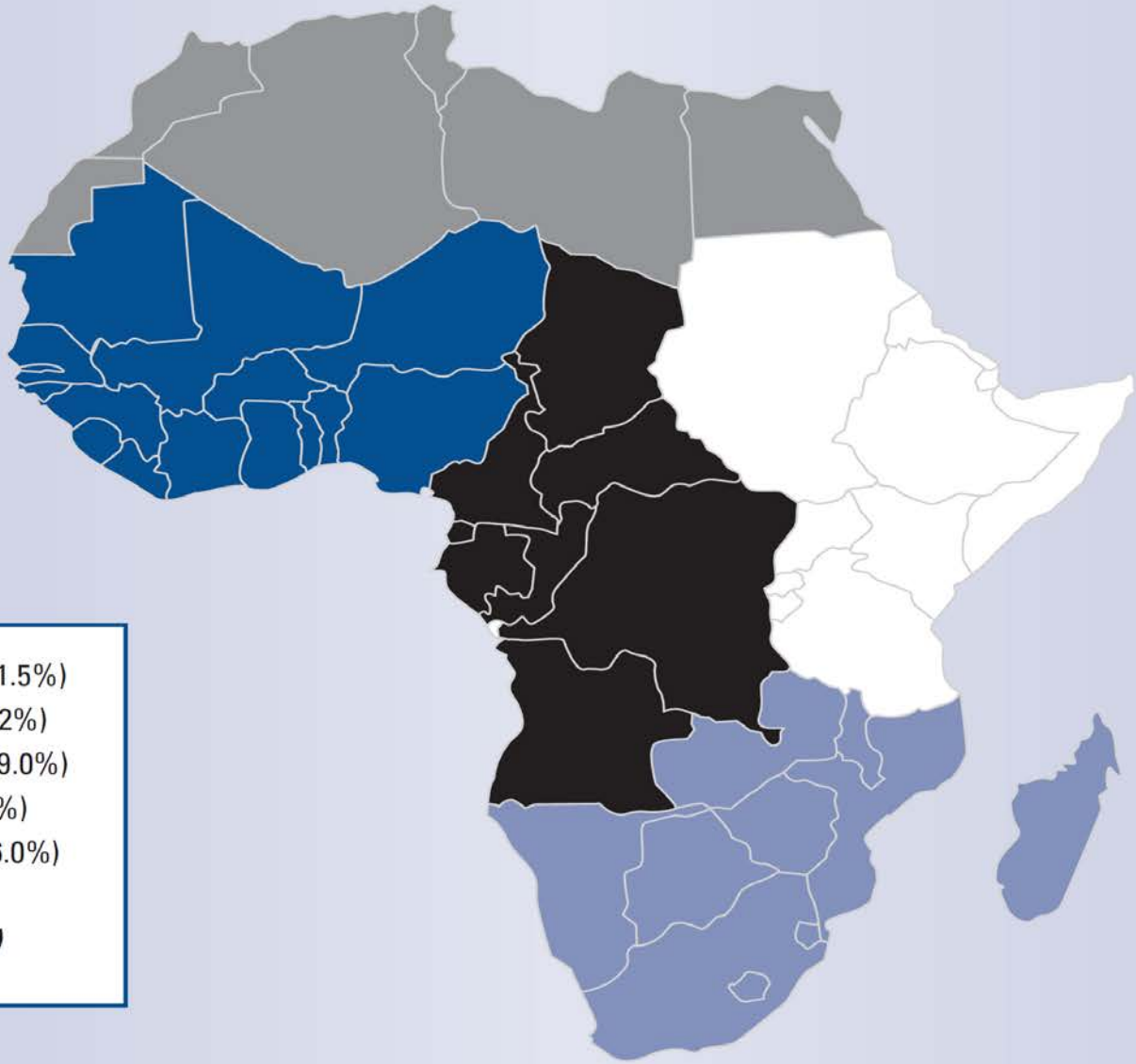


Talking Burgers are cute but the reality is different – Think Purchasing Power Inequality



Gini coefficient measures the inequality among values of a frequency distribution (for example levels of income). Coefficient = zero expresses perfect equality (everyone has an exactly equal income). Coefficient = 1 expresses maximal inequality (where only 1 person has all the income).

Emerging Frontier Markets – Non-Stop Daily Seats on scheduled air transport in Africa

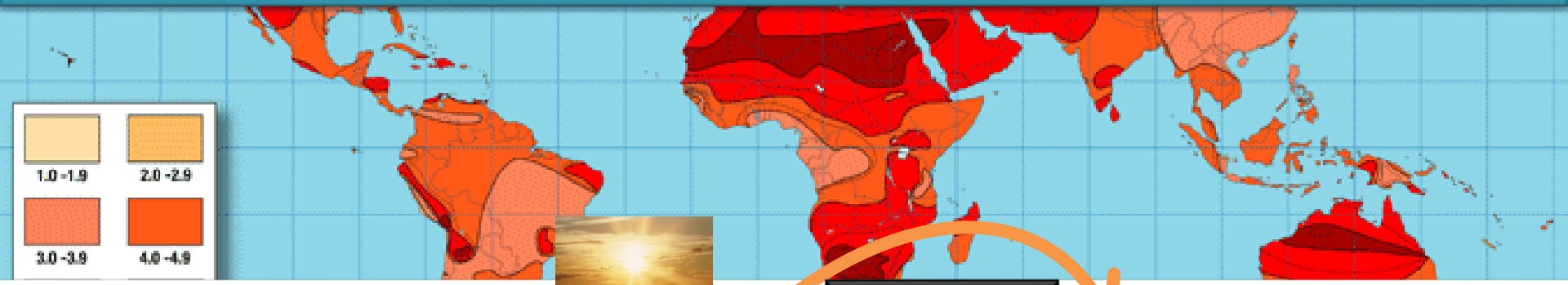


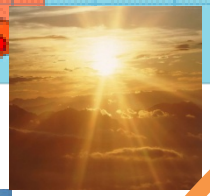
- Northern Africa (21.5%)
- Eastern Africa (14.2%)
- Southern Africa (29.0%)
- Central Africa (5.1%)
- Western Africa (16.0%)

Inter-regional (14.2%)

August 2010

Think Energy – Domestic Micro-Manufacturing Non-fossil Carbon-Neutral Liquid Fuel





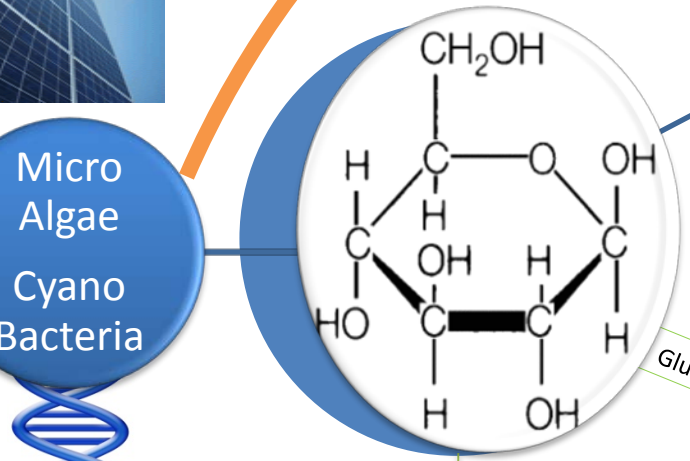
High Insolation

C 4
C 5

Butanol
Pentanol

Micro Algae

Cyano Bacteria



Glucose

C 6

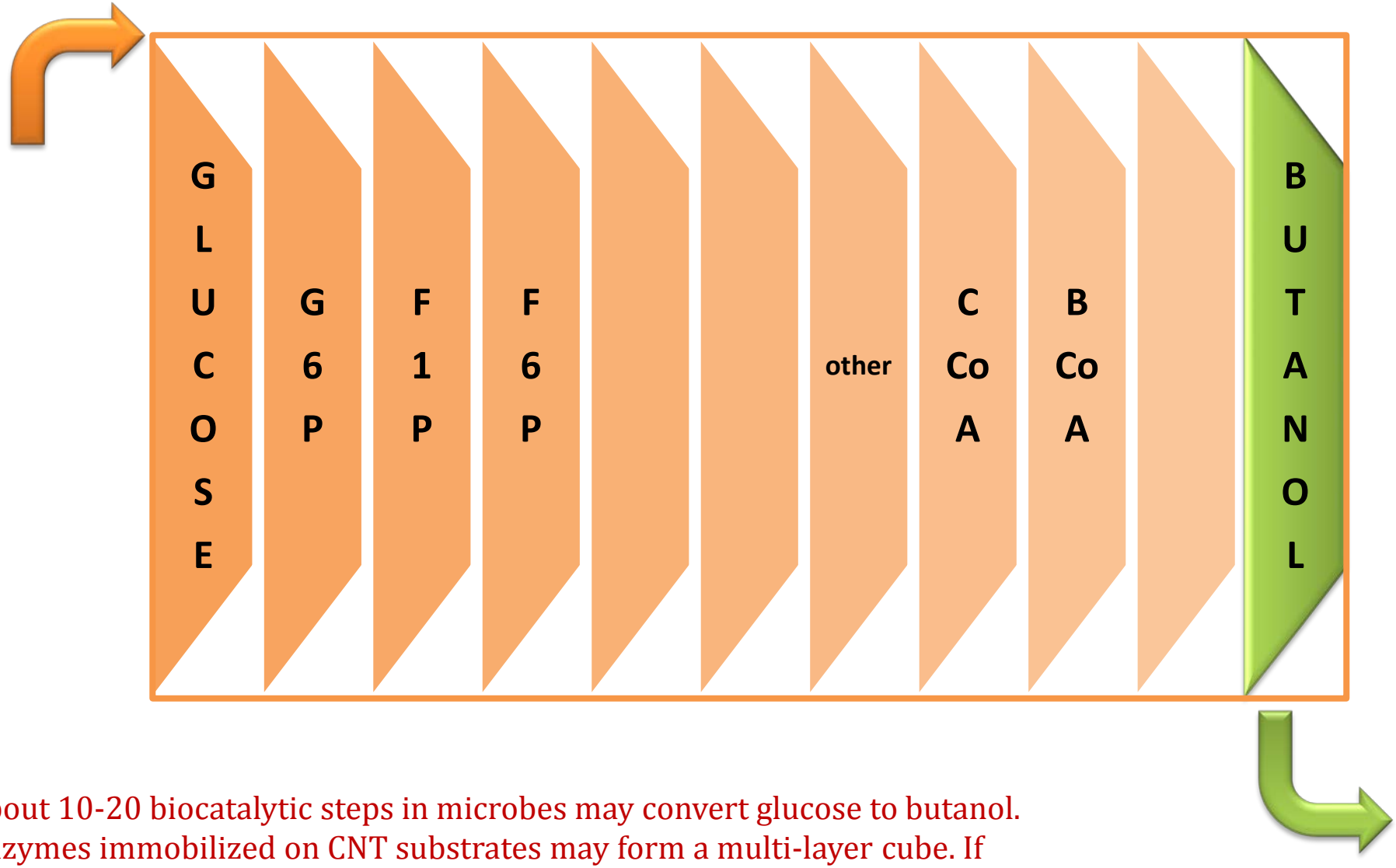
Glucose

Low Insolation Commodity

Glucose

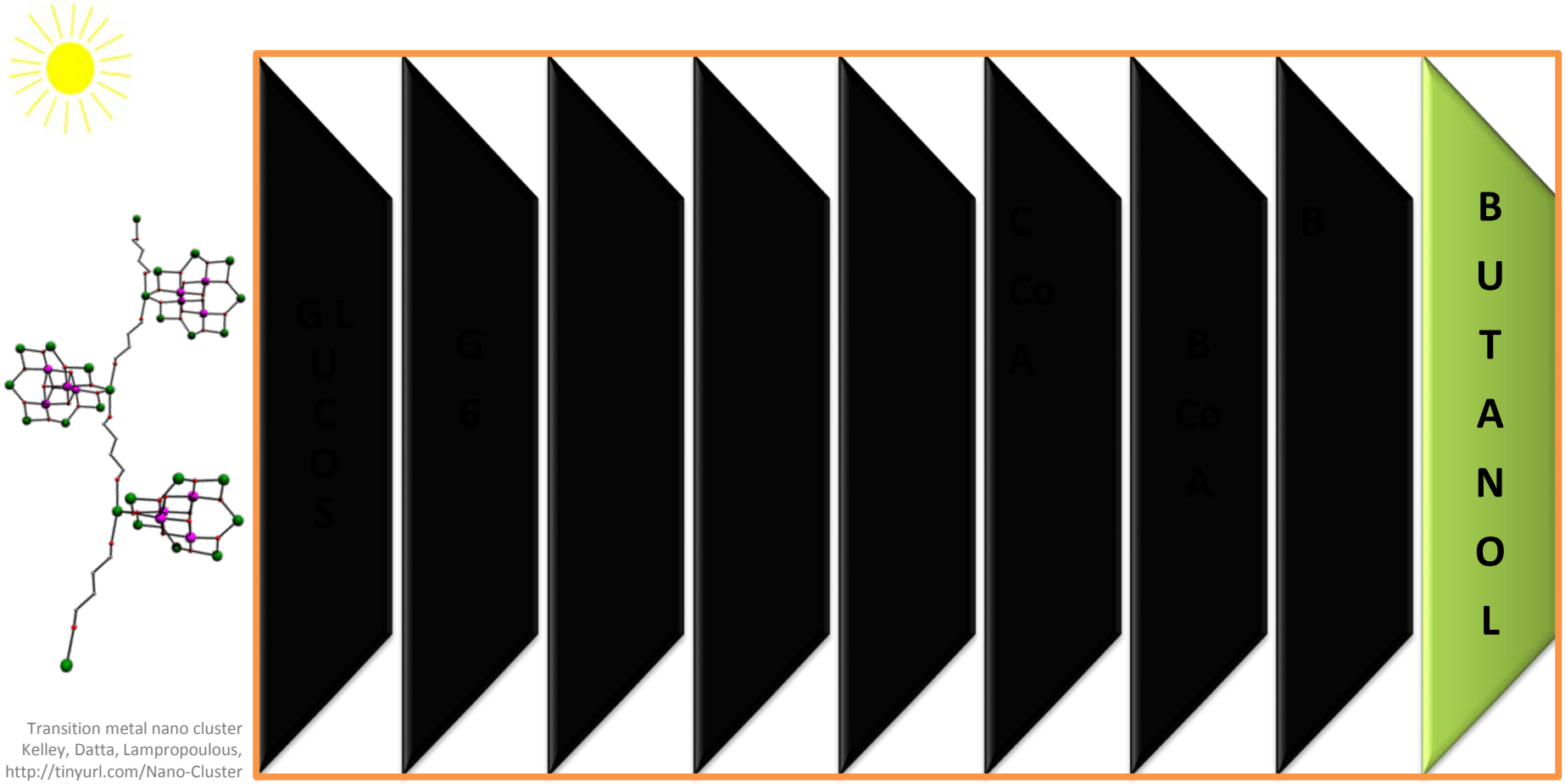
Liquid Fuel Generator

Butanol Battery 2050 • Enzymes adsorped on CNT tubes may catalyze glucose to butanol



About 10-20 biocatalytic steps in microbes may convert glucose to butanol. Enzymes immobilized on CNT substrates may form a multi-layer cube. If functional, the cascade may convert glucose (commodity) directly to butanol.

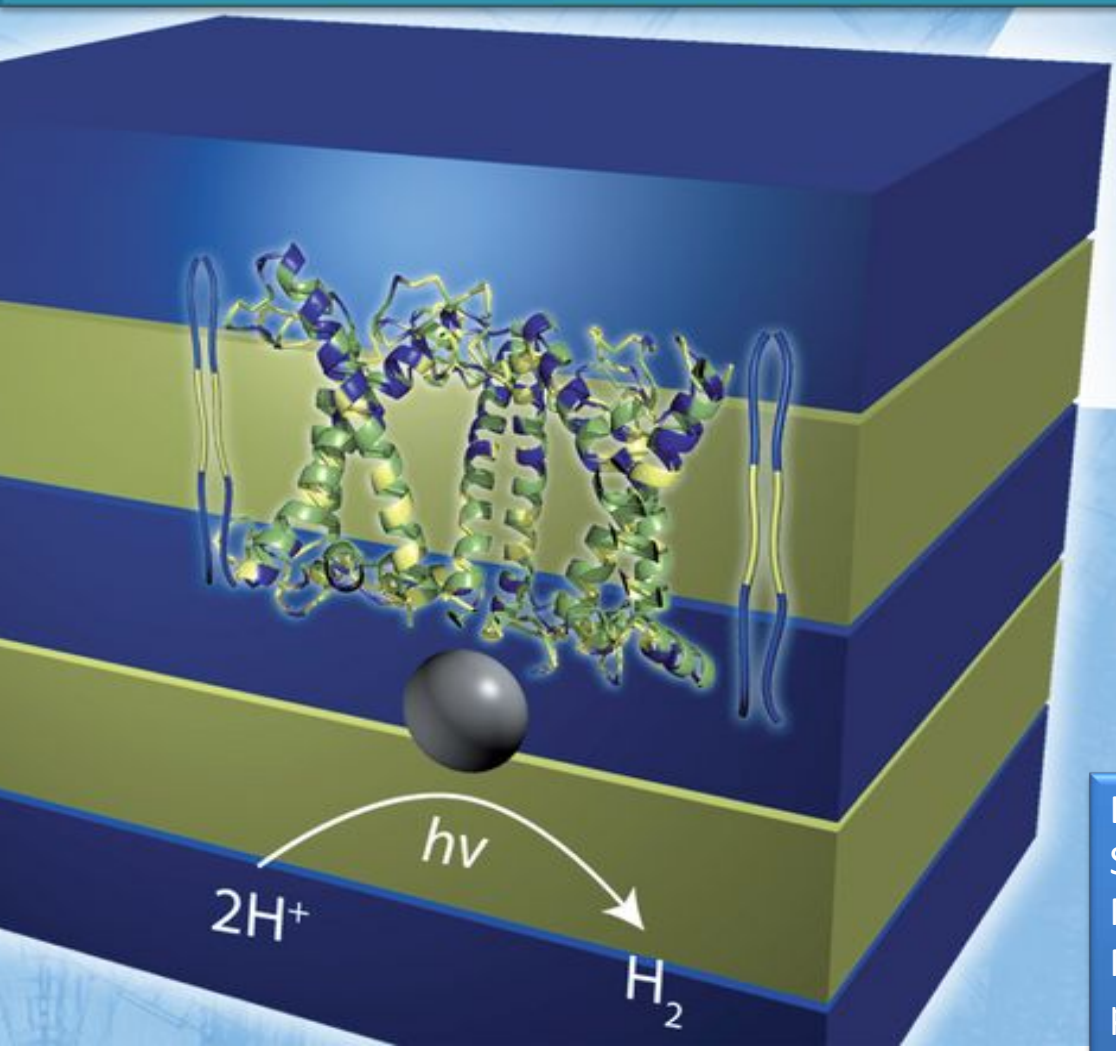
2100 → Mass Manufactured Nano-Chloroplasts ← Nano-Molecular Switched MOF



Transition metal nano cluster
Kelley, Datta, Lampropoulous,
http://tinyurl.com/Nano-Cluster

Light-dependent (photosystem I and II) and light-independent reactions of photosynthesis may be difficult (but not impossible) to functionalize due to the vast number of integral proteins in thylakoids in chloroplasts.
Black boxes [?] → embedded proteins in nano-clusters or metal organic frameworks (MOF)

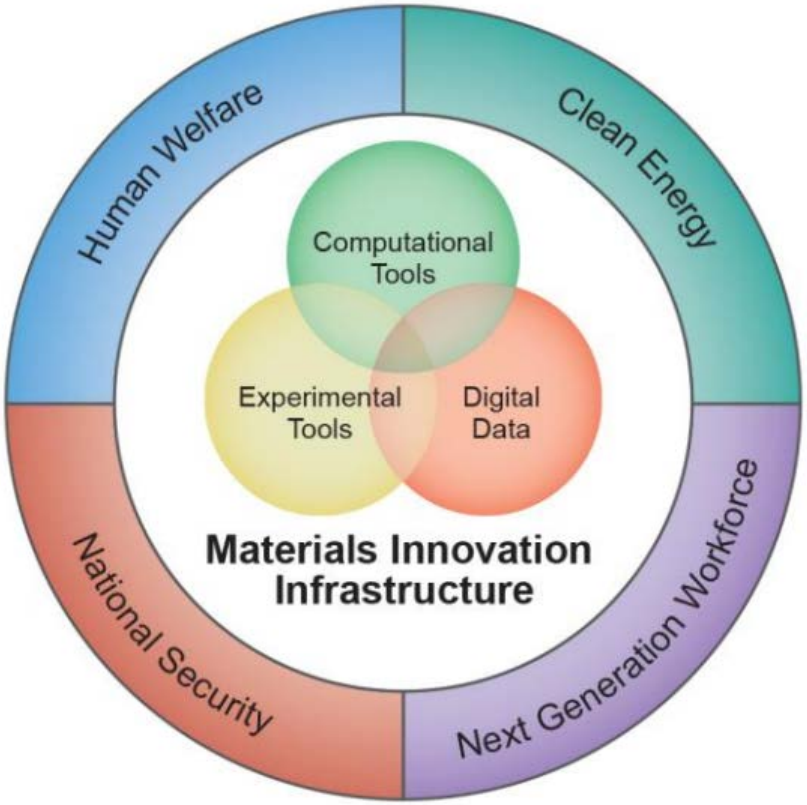
Supra-molecular Assembly of Bio-hybrid Photo-conversion System → To Nano-Chloroplast ?



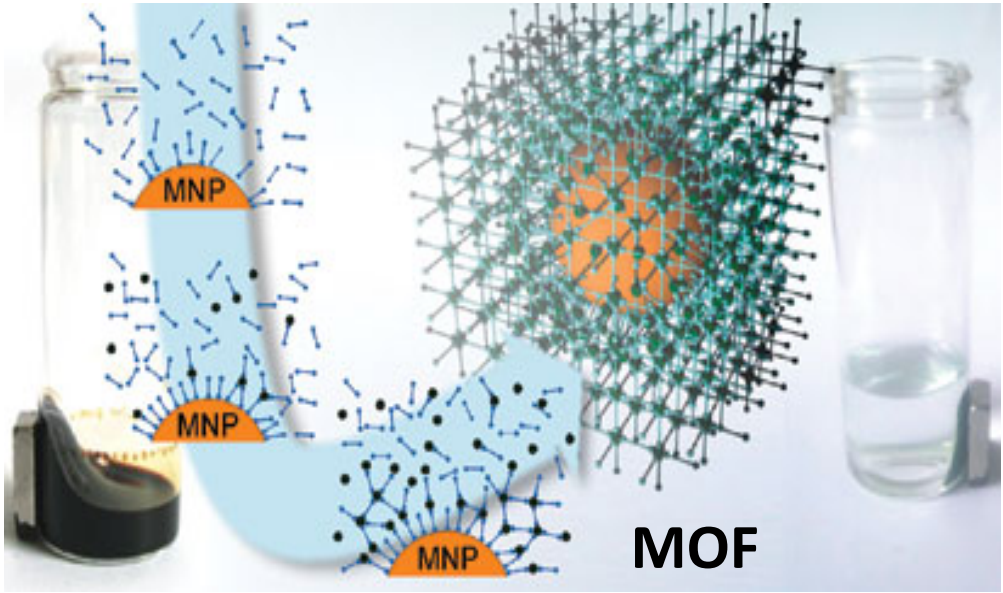
Supramolecular Assembly of Biohybrid Photoconversion Systems
Mateus B. Cardoso, Dmitriy Smolensky, William T. Heller, Kunlun Hong and Hugh O'Neill
Energy and Environmental Science (2011) **4** 181-188
DOI: 10.1039/C0EE00369G

Dr Hugh O'Neill *et al* at the ORNL Center for Structural Molecular Biology and Center for Nanophase Materials Sciences (Oak Ridge National Lab) have developed a bio-hybrid photo-conversion system based on the interaction of photo-synthetic plant proteins with synthetic polymers which can convert visible light into hydrogen fuel.

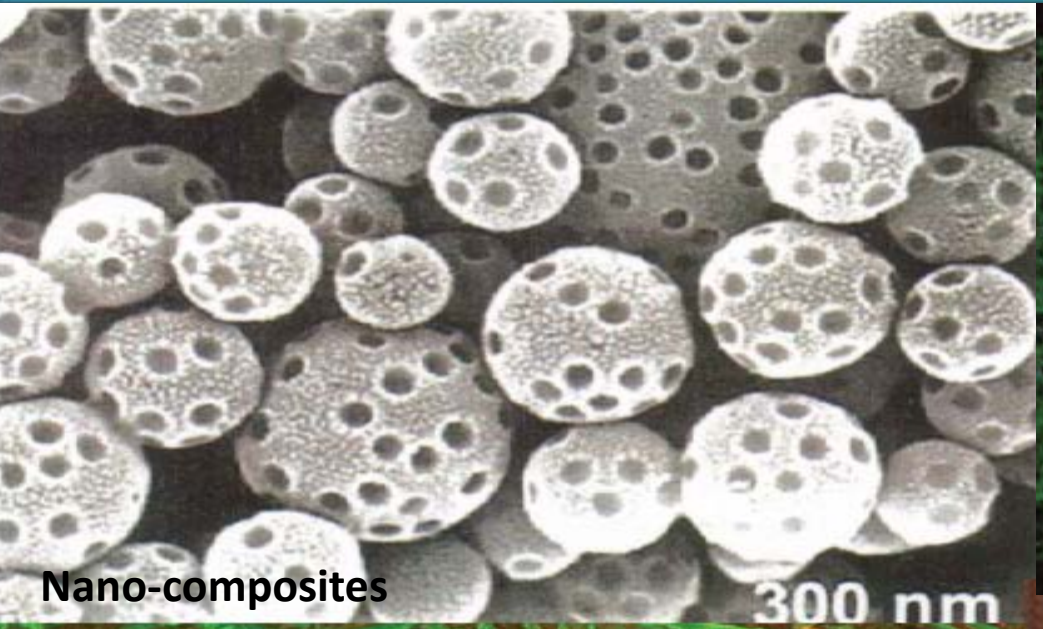
We live in a material world – think graphene, think metal-organic frameworks



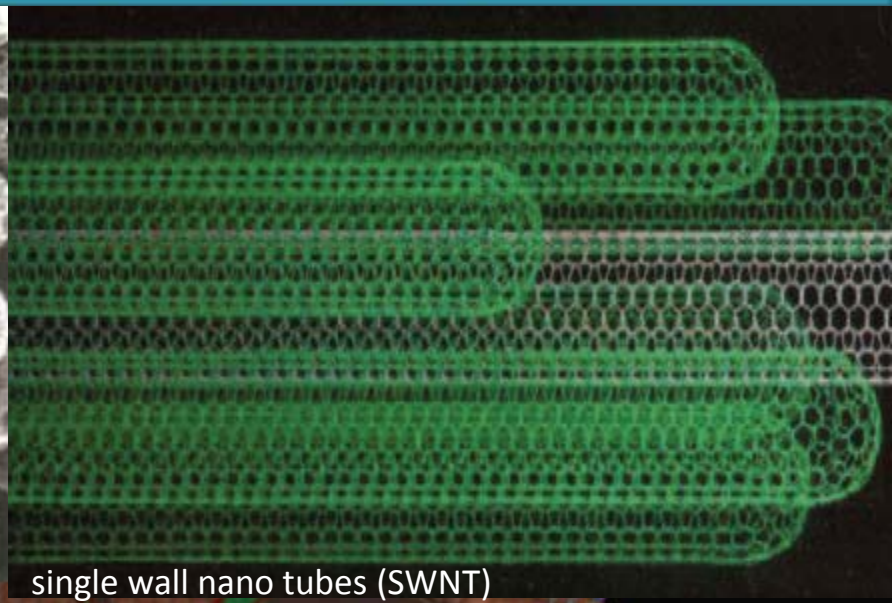
Material Genome Initiative (White House, June 2014)



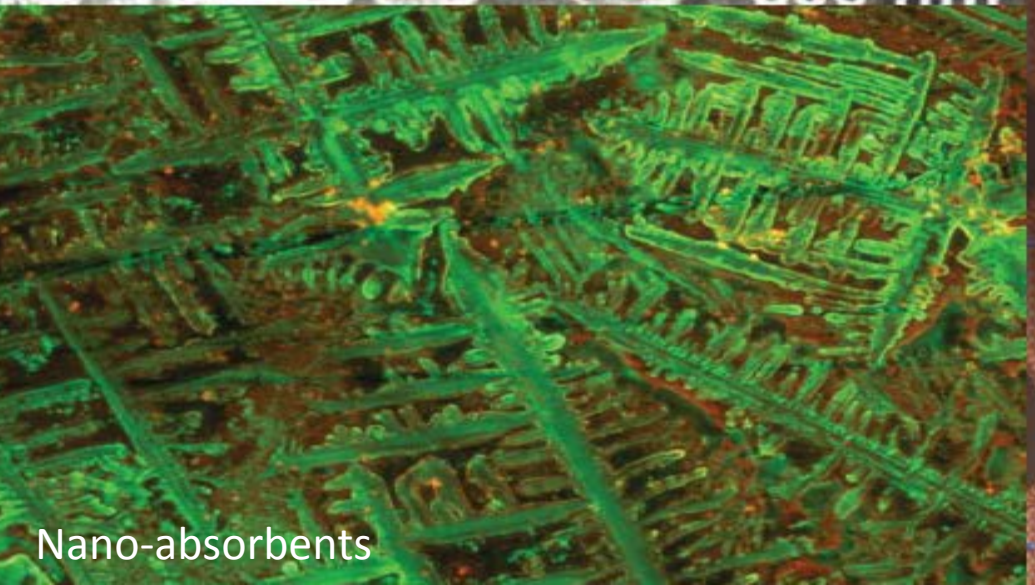
Think Water – The Next Oil – Purification, Desalination & Waste Water Management



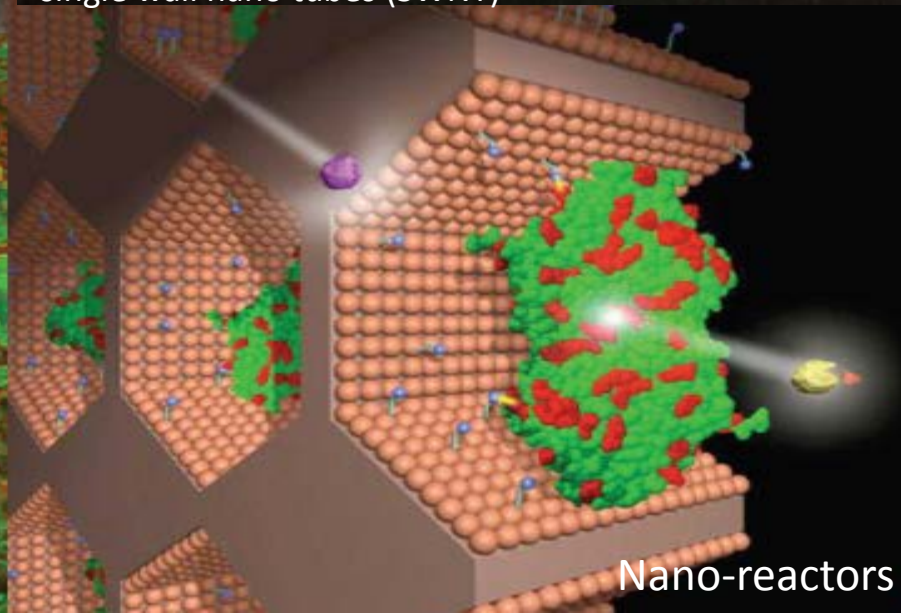
Nano-composites



single wall nano tubes (SWNT)



Nano-absorbents



Nano-reactors

Reality Check ☑ Water

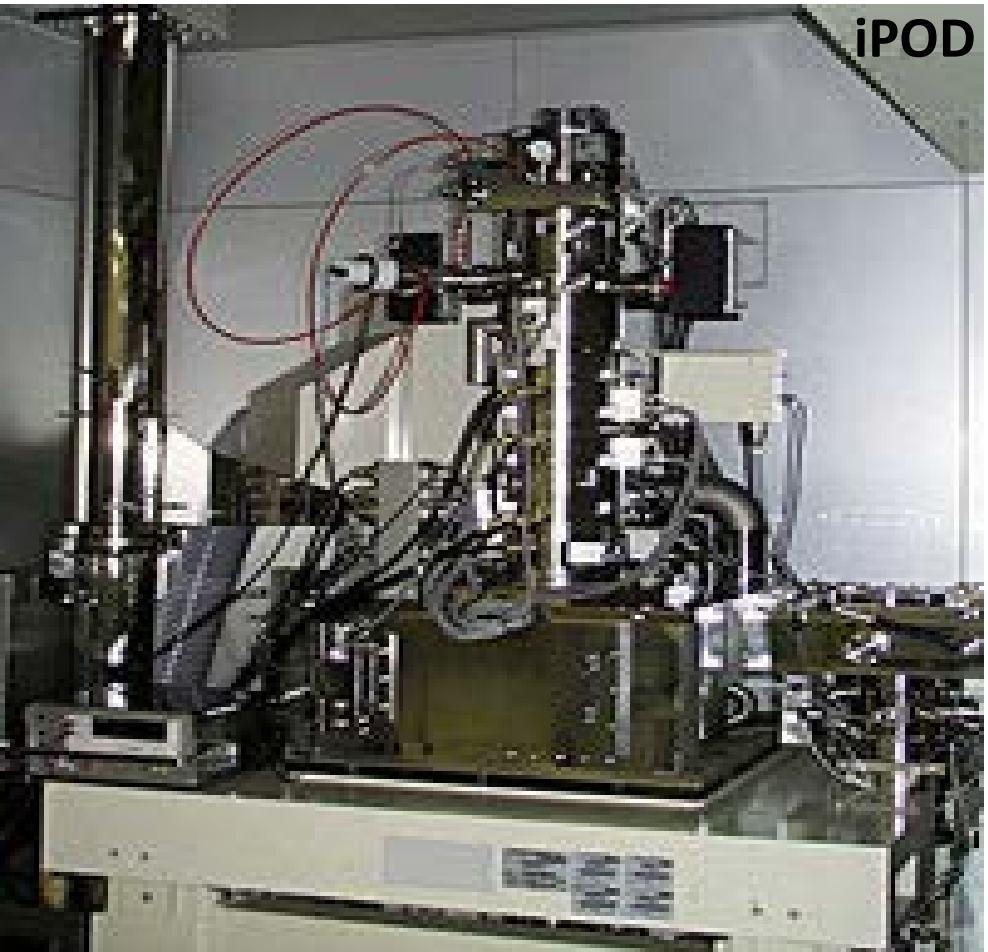
Reality Check ☑ Water

884 million	people lack access to safe water supplies — approximately one in eight people
6 kilometres	is the average distance African and Asian women walk to fetch water
3.6 million	people die each year from water-related diseases
98 per cent	of water-related deaths occur in the developing world
84 per cent	of water-related deaths are in children ages 0–14
43 per cent	of water-related deaths are due to diarrhoea
65 million	People are at risk of arsenic poisoning in the Bangladesh, India and Nepal area

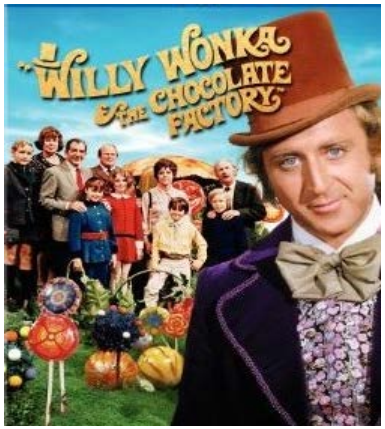
www.scidev.net/en/features/nanotechnology-for-clean-water-facts-and-figures.html

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)



- Paradox to Paradigms ☑ http://bit.ly/VANDERBILT

- The Bigger Picture
  - Women in Physics
  - Teachers in Classrooms
  - State of California Prisons

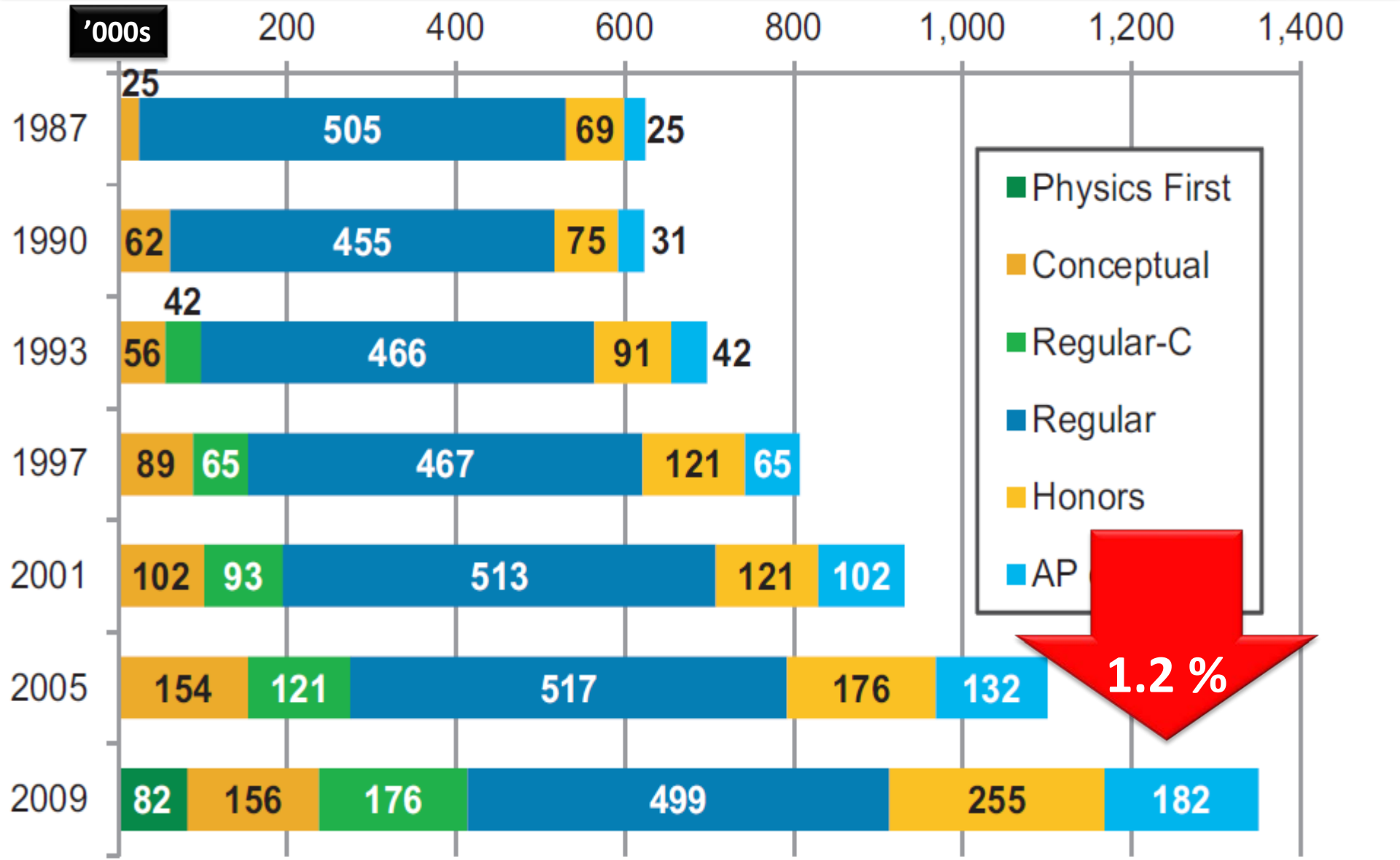
US Math-Science → School Teachers Lacking in Rigor in Math & Science

ies NATIONAL CENTER FOR EDUCATION STATISTICS Institute of Education Sciences

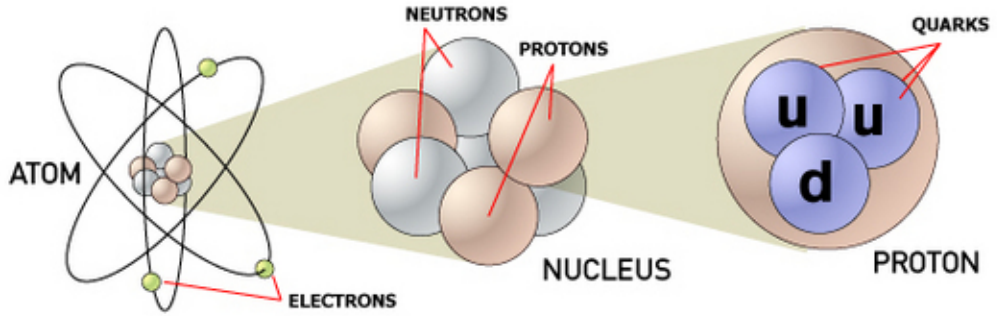
Number and percentage of grade 9–12 public school classes of various subjects taught by a teacher with a major and certification in that subject area, by selected subject areas: 2007–08

Selected subject area	Number of classes	Major in subject area			No major in subject area			Total certified
		Total	Certified	Not certified	Total	Certified	Not certified	
English	770,200	79.1	68.3	10.9	20.9	10.4	10.5	78.6
Mathematics	676,900	70.4	62.0	8.4	29.6	15.7	14.0	77.6
Science	562,700	81.7	71.2	10.4	18.3	11.4	6.9	82.7
Biology/life sciences	245,000	72.9	57.2	15.7	27.1	17.2	10.0	74.4
Physical science	289,300	43.2	35.4	7.8	56.8	29.1	27.7	64.5
Chemistry	106,900	46.0	35.3	10.7	54.0	33.9	20.1	69.2
Earth sciences	53,100	23.7	18.0	5.7!	76.3	22.1	54.2	40.1
Physics	43,200	46.7	31.4	15.4	53.3	28.3	25.0	59.6
Social science	565,000	81.2	70.6	10.6	18.8	11.0	7.8	81.6
Economics	39,800	11.0!	‡	‡	89.0	10.6	78.4	14.5
Geography	45,400	8.3!	‡	‡	91.7	16.2!	75.5	21.8
Government/civics	86,600	5.1	1.9!	3.2!	94.9	12.0	82.8	14.0
History	297,200	60.8	28.0	32.8	39.2	6.4	32.8	34.4
French	51,000	80.0	71.6	8.4!	20.0	13.7	‡	85.2
German	13,400	78.3	69.3	‡	21.7!	20.6!	‡	89.9
Latin	9,200	73.1	58.3	‡	26.9!	‡	‡	79.2
Spanish	189,700	73.3	57.4	15.9	26.7	19.4	7.3	76.8
Art/arts and crafts	139,800	88.9	79.6	9.3	11.1!	‡	3.4	87.2
Music	103,100	94.1	85.4	8.8	5.9	1.8!	4.0!	87.2
Dance/drama or theater	37,000	58.6	49.2	9.3!	41.4	16.6	24.9	65.8

US High School AP Physics → 182,000 out of 15,000,000 (grades 9-12)



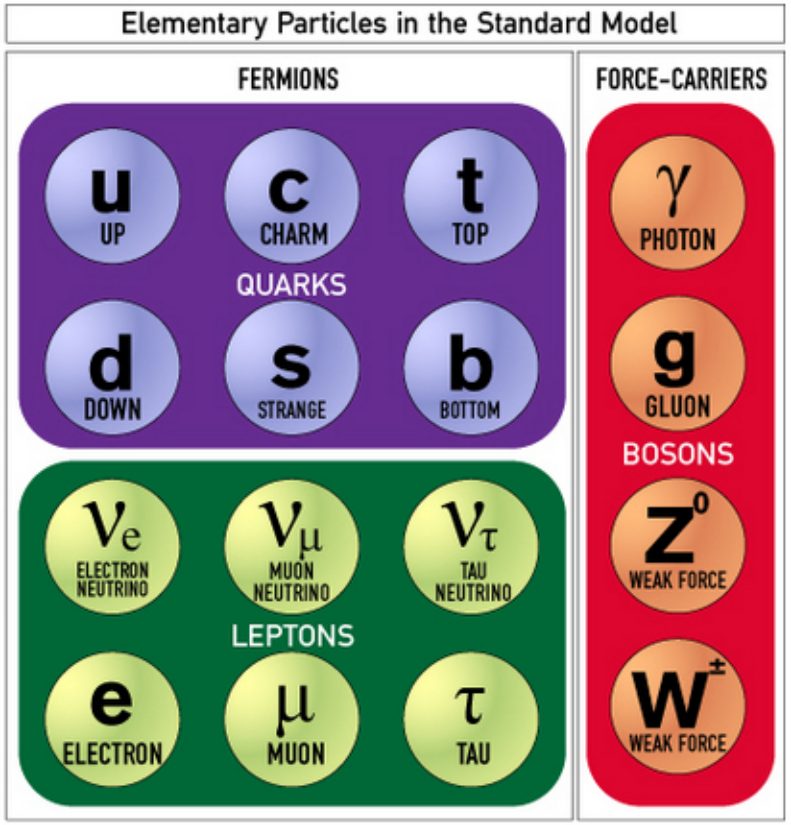
US Math-Science → Women BS Physics → 1,300 out of 1,000,000 (2011)

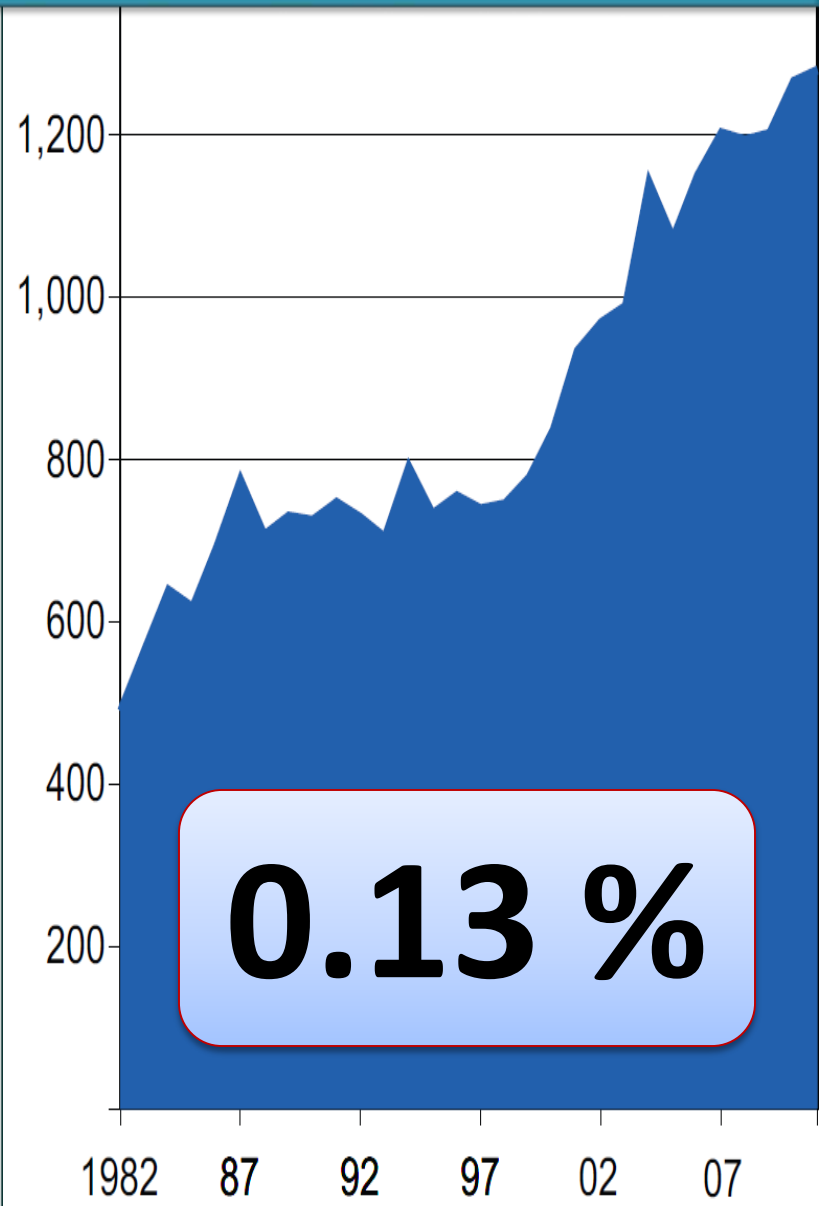


Three categories of particles form the **Standard Model**. Matter is composed of **fermions** (**quarks** and **leptons**). **Bosons** provide three forces: **electro-magnetism**, the **strong** nuclear force and the **weak** nuclear force.

Currently the Standard Model is incomplete and does not explain many important features of the known universe, such as:

- **gravity**
- **mass**
- **dark matter** (23% of the universe)
- **dark energy** (73% of the universe)






SINCE 1980
CALIFORNIA BUILT
22
PRISONS
1
UNIVERSITY

Back to the Future

Observing the World Around Us

… 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.

All advantages are 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.

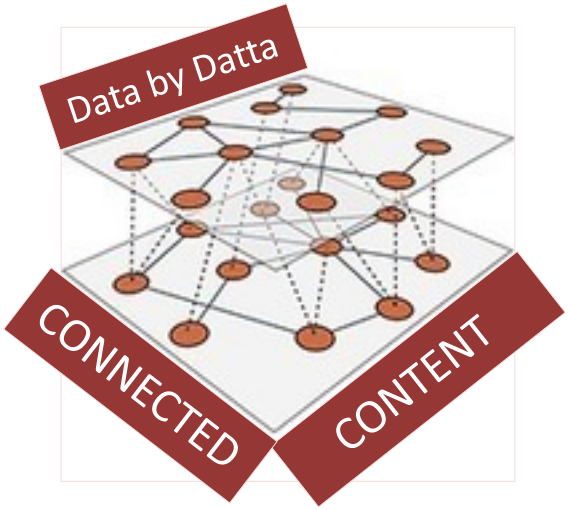
In June 2007, former CEO Steve Ballmer of Microsoft Corporation said in an interview with *USA Today* that there is "no chance that the iPhone is going to get any significant market share. No chance, at all. It's a $500 subsidized item". The iPhone is approaching 50% market share in the US.

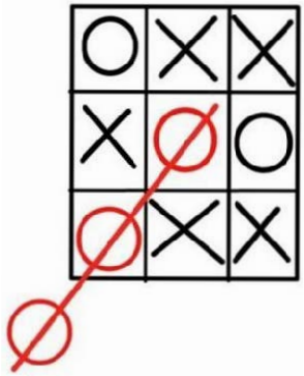
Mary Meeker of Kleiner Perkins Caufield & Byers produces a yearly report, Internet Trends, which is the tech bible. Its May 2013 report analyzed the leading players in social media and made predictions on the future of mobile technologies. It did not even mention WhatsApp. Facebook acquired WhatsApp 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?

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





depends on how you look at it …

Dr Shoumen Palit Austin Datta (shoumen@mit.edu)

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

L'humanité a besoin rêveurs

shoumen@mit.edu

- http://bit.ly/VANDERBILT

Dr Shoumen P Austin Datta ● Research Affiliate, School of Engineering, MIT ● SVP, Industrial Internet Consortium ● shoumen@mit.edu