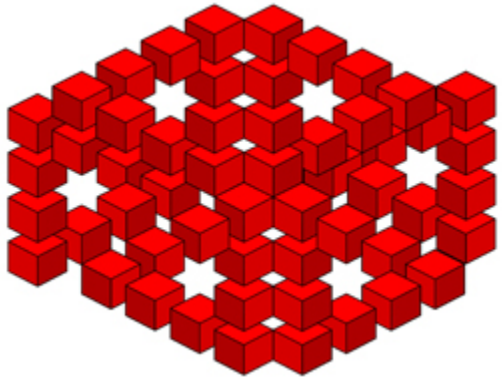
Paradoxes to Paradigms



Dr Shoumen Palit Austin Datta

Research Affiliate, School of Engineering, MIT ● Massachusetts Institute of Technology ● shoumen@mit.edu

Senior Vice President, Industrial Internet Consortium ● www.iiconsortium.org ● datta@iiconsortium.org

A2B

Atoms to Bits

My mobile phone in Boston can move a taxi in Beijing

Atoms to Bits

Design Metaphor

Atoms to Bits

Design Metaphor

Cannot transform design vision from the drawing board to customer reality without convergence of IT, OT and telecommunications (telco)

C world

Converge

- Complement
- Community
- Connect
- Curate
- Clone

CLOUDY. FOGGY. MISTY. XY

CONVERGENCE

IT

OT

TELCO

Cloud – (dumb) Pipe – Device

Atoms to Bits

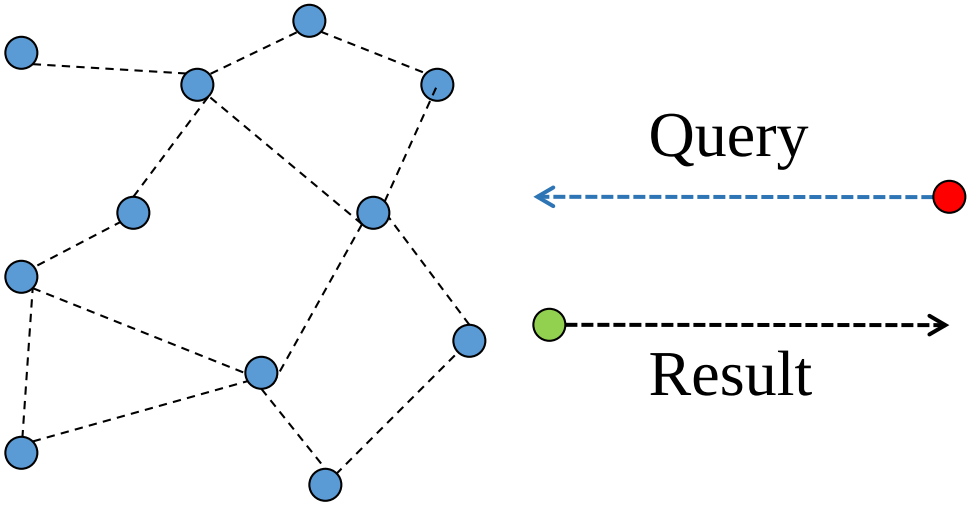
Apply design metaphor to drive paradigm shift

Prepare to deal with uncertainty & volatility

Strategize to connect, create, communicate

Cloud – intelligent Pipe/Platform – Device

OLD idea <> in-network Processing



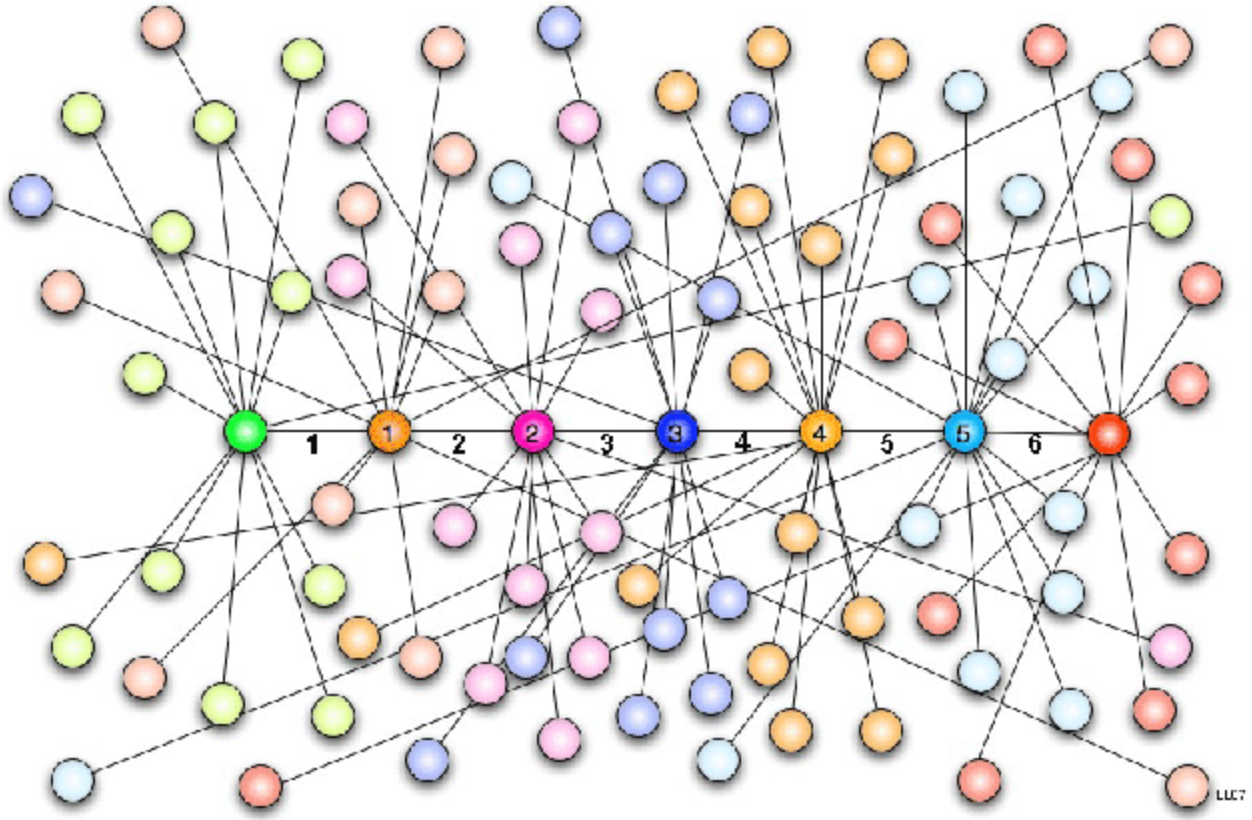
www.cs.colorado.edu/~rhan/CSCI_7143_001_Fall_2003/agr24.ps

Synapses connect, converge, coalesce data from various regions for contextual response

Syntactic Web

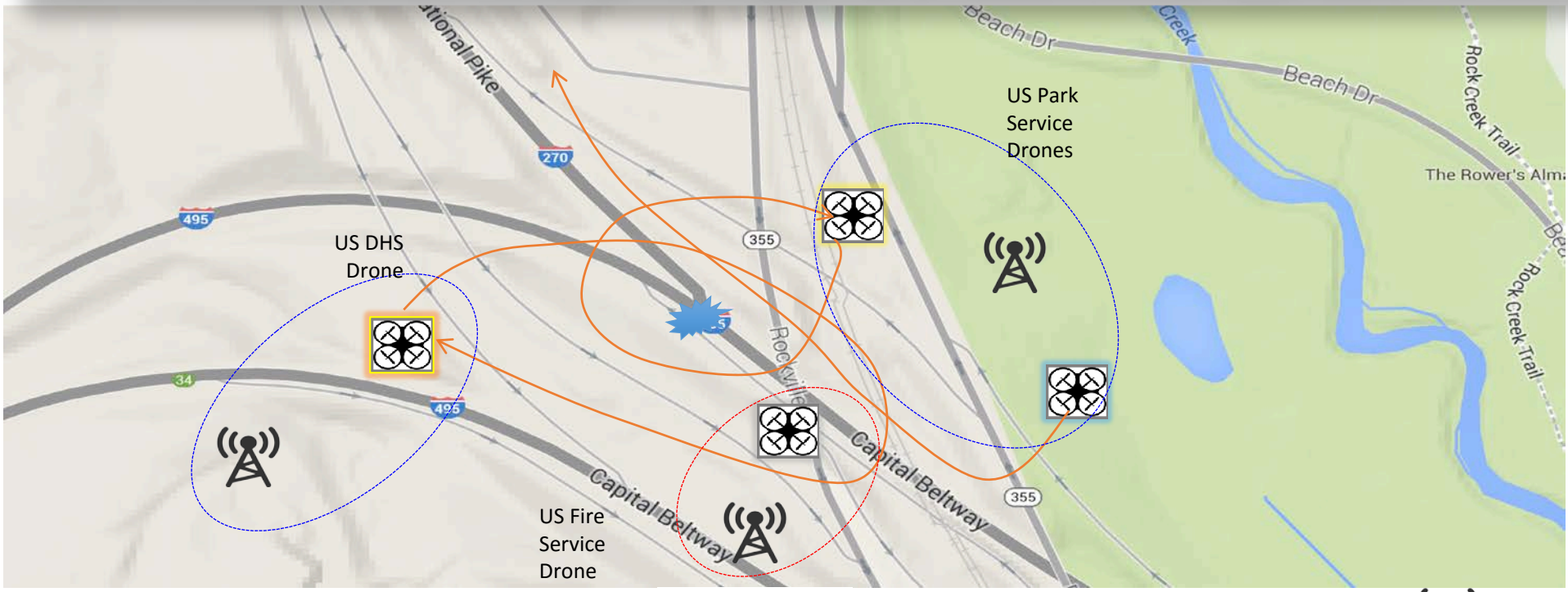
Semantic Web

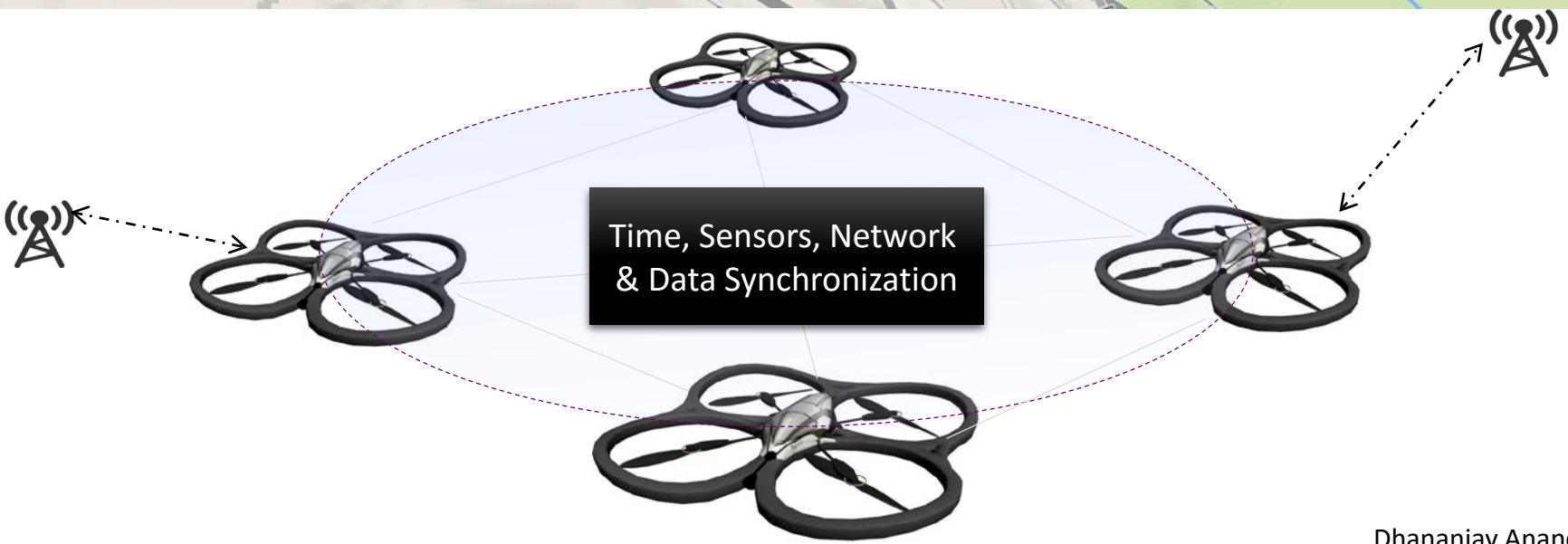
Synaptic Web



Transportation Coordination - Emergency “Crash to Care” Response

Sense and response – emergency trigger as an autonomous application driver





Dhananjay Anand, NIST

CONVERGE

COMPLEMENT

CONNECT

CURATE

COST

CONVERGENCE – WHY THE BIG PICTURE IS ESSENTIAL

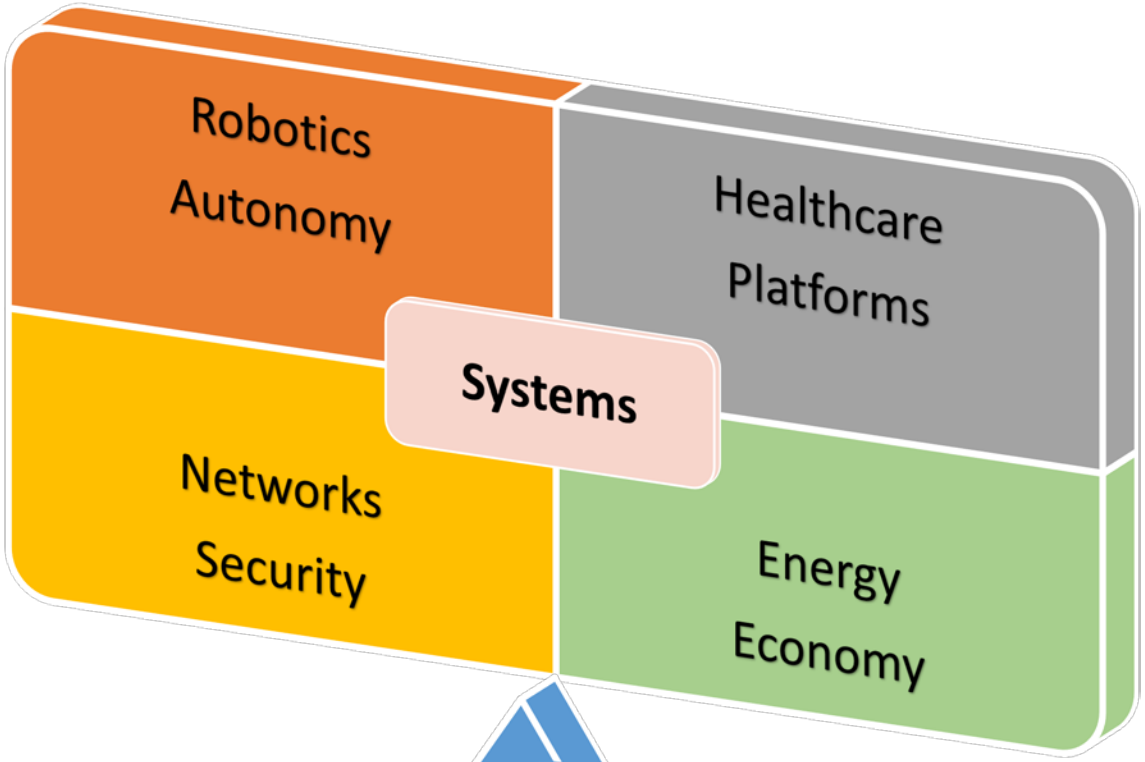
Eric Xu
Rotating CEO
Huawei

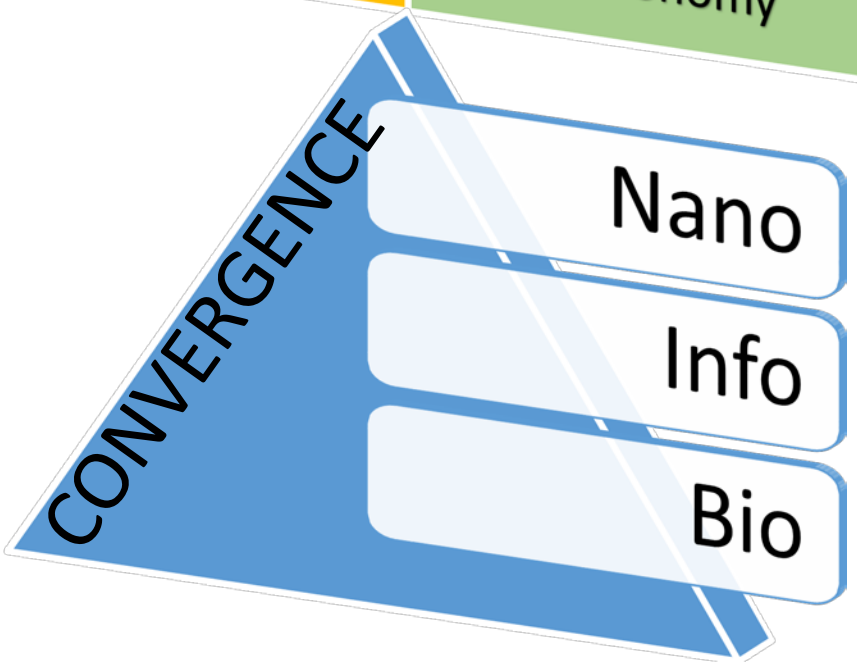
Shoumen Datta

YaFang Sabrina Sun
Chairwoman
Huawei

We want to create original research, new inventions, new theories, new ideas, new science, new ways to help customers, help people globally … the pursuit of frontiers without the fear of failure to lift the future plight of our community and humanity.

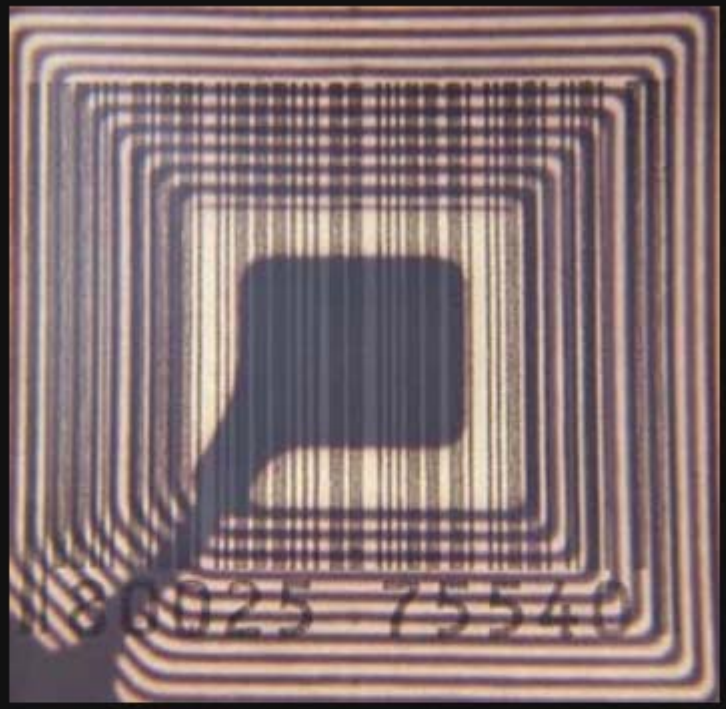
MR ERIC XU, CEO, Huawei
Huawei STW, 17 MAY 2016





The Auto-ID Center at MIT and Supply Chain RFID

1999-2000



RFID tag developed by the Auto-ID Center

Paving the way for commercialized RFID solutions

Los Alamos National Laboratory led RFID development efforts in the 70's and 80's with RFID tags for gate access into nuclear facilities and for tracking nuclear materials, and then passive RFID technology for identifying cows and their antibiotic levels for the US Department of Agriculture. Companies commercialized the 125-kHz systems pioneered by Los Alamos and then moved on to high-frequency RFID systems that operated at 13.56-MHz. These especially caught on in Europe,

Published October 1, 2000. Distribution restricted to Sponsors until January 1, 2001.

WHITE PAPER

The Networked Physical World

Proposals for Engineering the Next Generation of Computing, Commerce & Automatic-Identification

Sanjay Sarma, David L. Brock & Kevin Ashton

MIT AUTO-ID CENTER MASSACHUSETTS INSTITUTE OF TECHNOLOGY, 77 MASSACHUSETTS AVENUE, BUILDING 3-449G, CAMBRIDGE, MA 02139-4307

ABSTRACT

The Auto-ID Center at the Massachusetts Institute of Technology is a new industry sponsored lab charged with researching and developing automated identification technologies and applications. The Center is creating the infrastructure, recommending the standards, and identifying the automated identification applications for a networked physical world. All technologies and intellectual property developed at the Auto-ID Center are freely distributed. This white paper outlines the Auto-ID Center's key conclusions and research progress after its first year of research.

CONVERGENCE

COMPLEMENTARITY

CONNECTIVITY

is not a point, it is a fabric, if you cannot adapt, you die

2004

ADAPTER, OPTIMISER, PRÉVOIR
La convergence des concepts, des outils, des technologies et des normes peut-elle accélérer l'innovation ?

Not enough to connect objects, but how may we converge concepts, process, decisions, actions ("sense & response")

Dr Shoumen DATTA
Chercheur, Département Ingénierie des Systèmes, Forum pour l'Innovation dans la chaîne logistique
Directeur général de l'Ecole d'Ingénierie, Massachusetts Institute of Technology

MIT DSpace http://hdl.handle.net/1721.1/41907

COMPLEMENTARITY

- Bohr's principle of complementarity is the cornerstone of quantum mechanics.

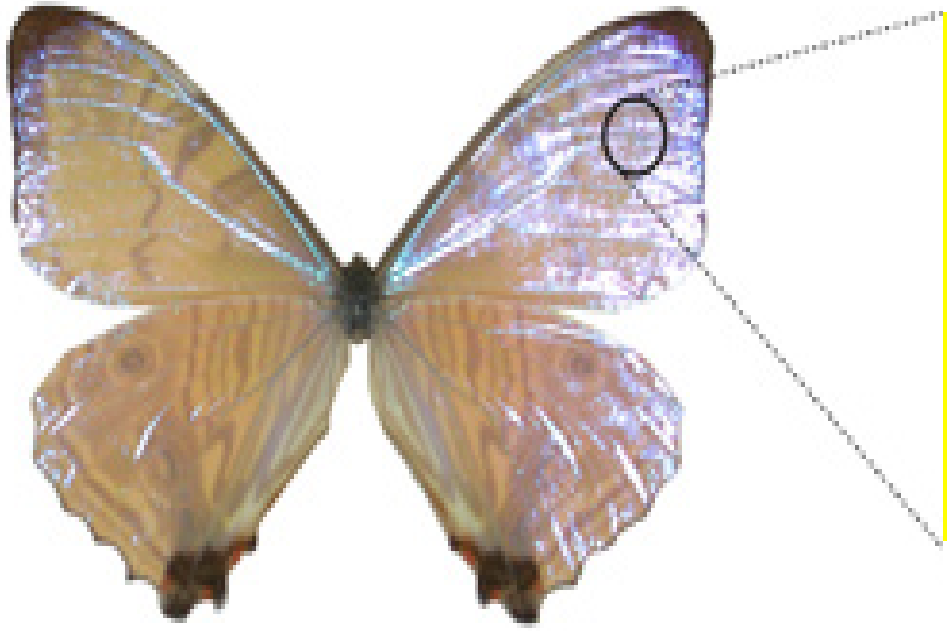
- Complementarity is fundamental to structure of DNA & biological regulation.

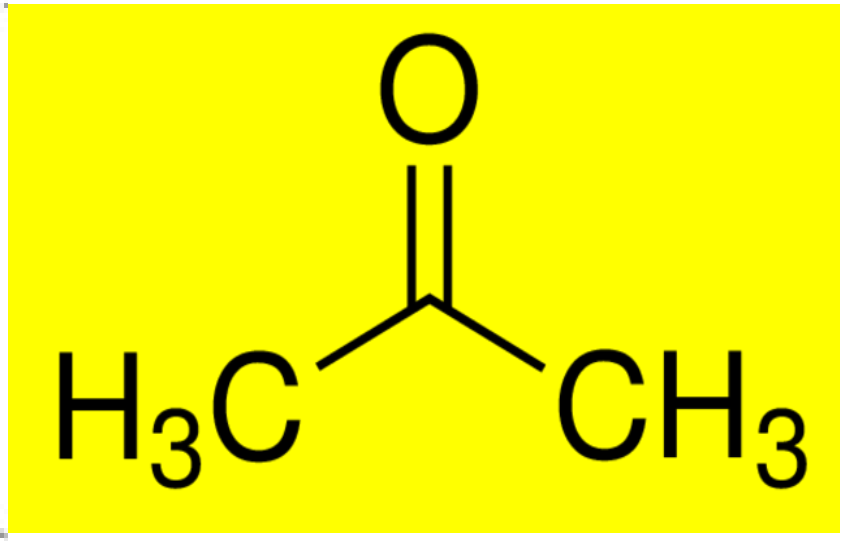
Complementarity is crucial to the future of business and profitability

Revisiting BPC with a quantum device ● Jian-Shun Tang, Yu-Long Li, Chuan-Feng Li and Guang-Can Guo
Phys. Rev. A 88, 014103 – Published 22 July 2013 – DOI: http://dx.doi.org/10.1103/PhysRevA.88.014103

Can Butterflies Help Prevent Diabetes?

This is only a suggestion by the author and not a fact or system which is under investigation or is available at present.





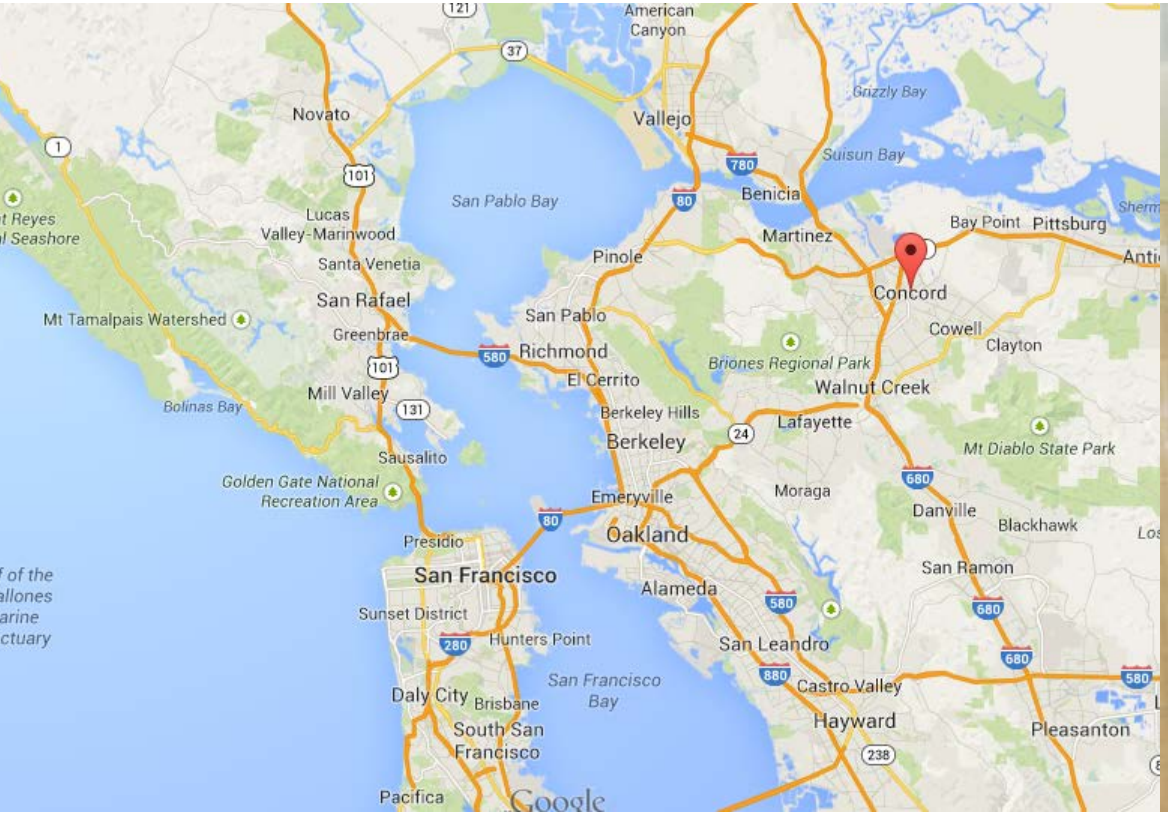
Dual Acetone Sensors on a single chip may differentiate between acetone in the environment vs acetone in the blood, breath or urine of diabetics. Subtractive analysis alerts to blood ketones. Occurs when body uses fat instead of glucose. It signals insulin dysfunction. If undiagnosed, it may lead to diabetic ketoacidosis (DKA) which may result in diabetic coma and may be fatal. The acetone (ketone bodies) sensors may be able to detect trace levels (nano milli moles eq) and may help preventive care to stem the clinical onset of type II diabetes mellitus (glucose >120 mg/dl).

Software is becoming Hard

COMPLEMENTARITY

Hardware is becoming Soft

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 - March 9, 1996)

Global Automobile Manufacturers in Silicon Valley

FT

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*).

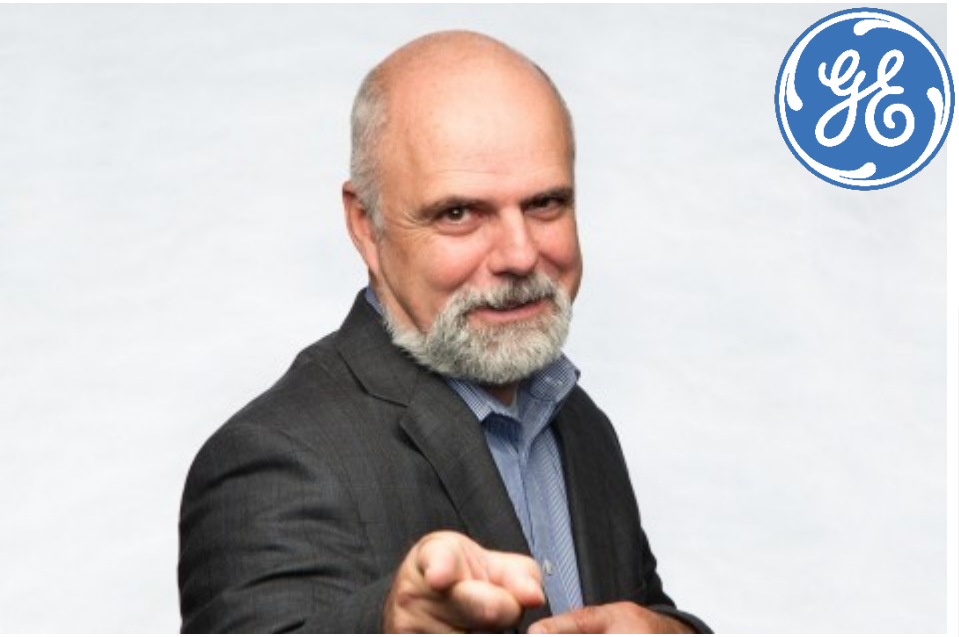
2000

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.

IIC



industrial internet CONSORTIUM

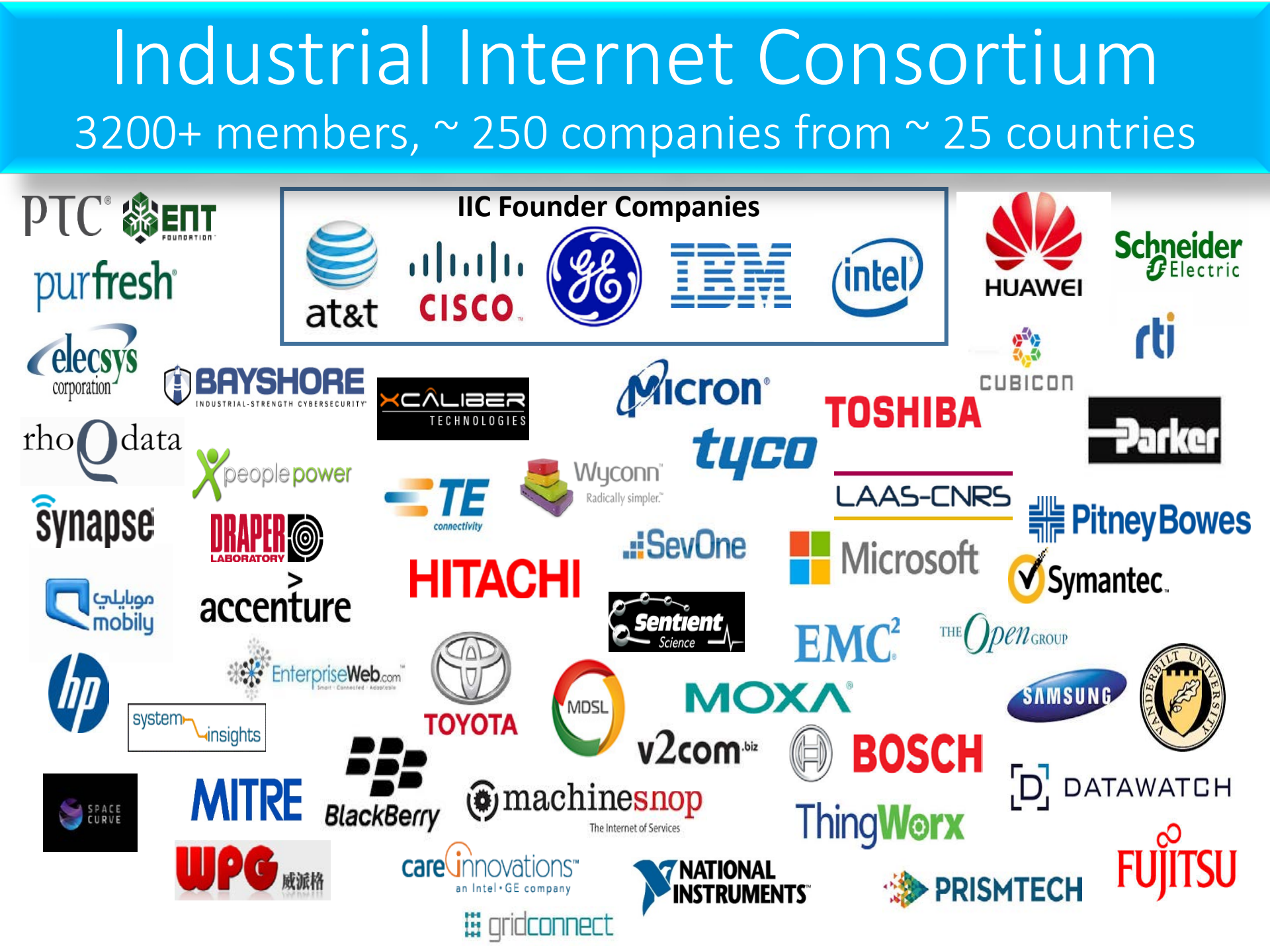
Dr Joseph James Salvo

Founder, IIC

Founder & Director IIC, GE

Industrial Internet Consortium

3200+ members, ~ 250 companies from ~ 25 countries



2014-2016

industrial internet
CONSORTIUM

2+ years old ● 250+ global members ● www.iiconsortium.org

REUTERS EDITION: U.S.

HOME BUSINESS MARKETS WORLD POLITICS TECH OPINION

2016

Technology | Wed Mar 2, 2016 8:43am EST

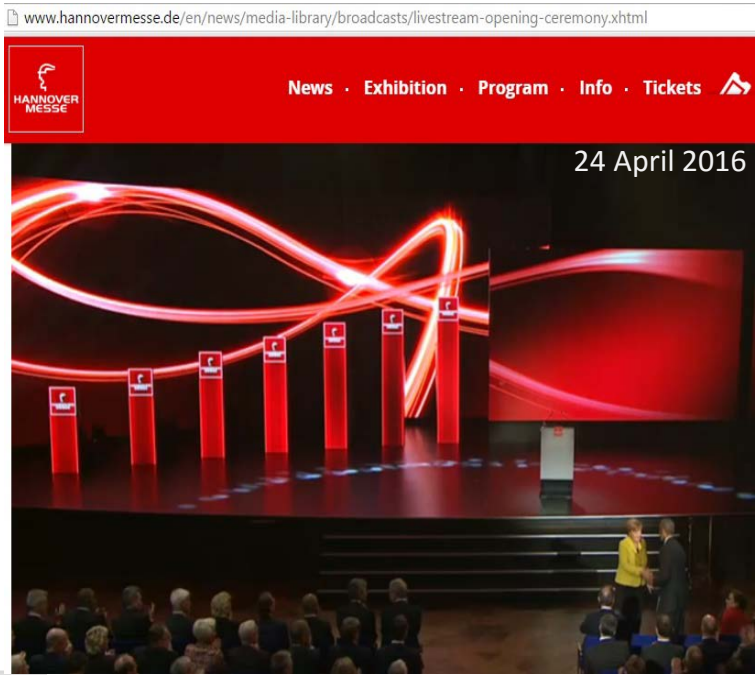
Germany to cooperate with U.S. on IT standards to reboot industry

Germany has agreed to work with the United States to find common standards to connect to the Internet as part of its plan to modernize its small and mid-sized businesses for the digital age and safeguard its industrial competitiveness.

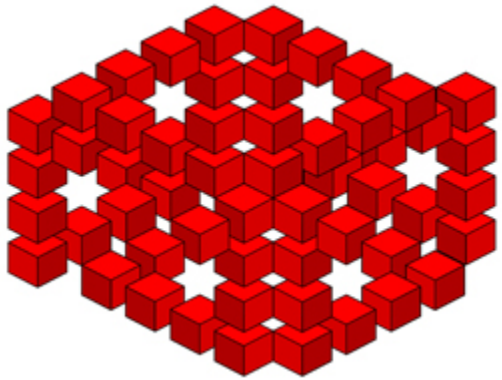
Europe's biggest economy owes much of its exporting prowess to its small-to-mid-sized, often family-owned manufacturers, many of which are latecomers to Internet-era technology.

Officials are concerned that a failure to capitalize on the latest digital trends will leave its industrial base exposed to new competitors in the United States and Asia.

Germany, which launched its "Industrie 4.0" platform in 2013 to promote the digitization of industry, will collaborate on common standards with the U.S.-based Industrial Internet Consortium (IIC). http://bit.do/MERKEL-IIC-426-428



Digital Twins



DIGITAL TWIN

THE FUTURE OF SERVICES FOR GE

Animated with real-world data, the Digital Twin is a virtual replica of any product, and is designed to help GE predict and respond to customer problems.

Challenge

There aren’t any granular sub-systems, semantic standards, tools to synthesize system of systems

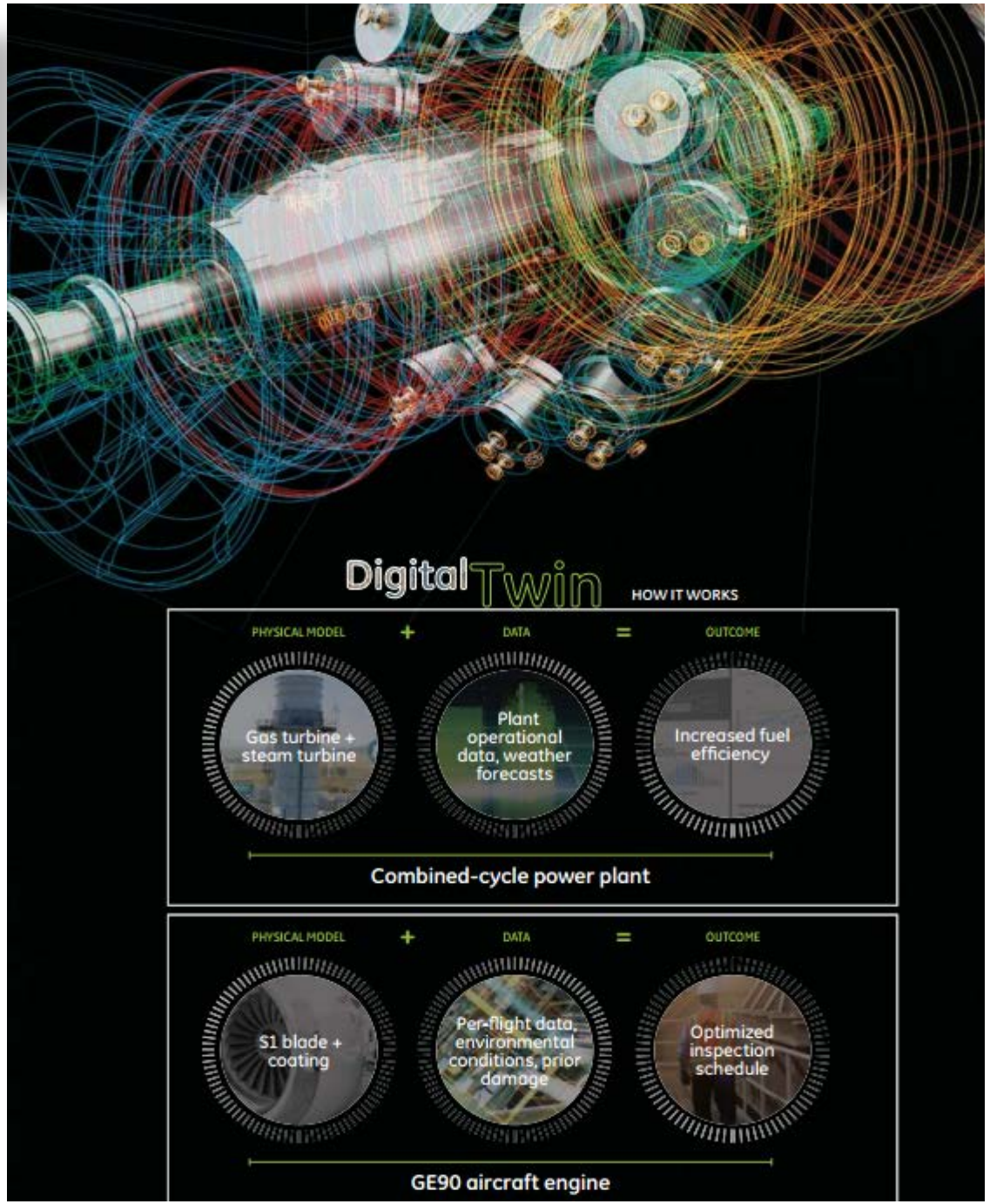
Expert Driven DT Instantiation

Physics of the Object

Equation of Operation

Populate Data for Variables

Compute & Analyze Outcome



Fleishmann, R.D. *et al.* Whole-genome random sequencing and assembly of *Haemophilus influenzae* Rd. *Science* **269**, 496-512 (7/28/95)

Equipment

ACME Sea Pump Off XC99-4711 Off shore Sea Pump Off XC99-4711

INFORMATION INSTRUCTIONS PARTS ATTACHMENTS ANNOUNCEMENTS

Characteristics

Sub Sea Pump

Sensor Picture:

Environment: off shore
Sensing principle: sonic
Detector communication: smart
Method of ventilation: advanced

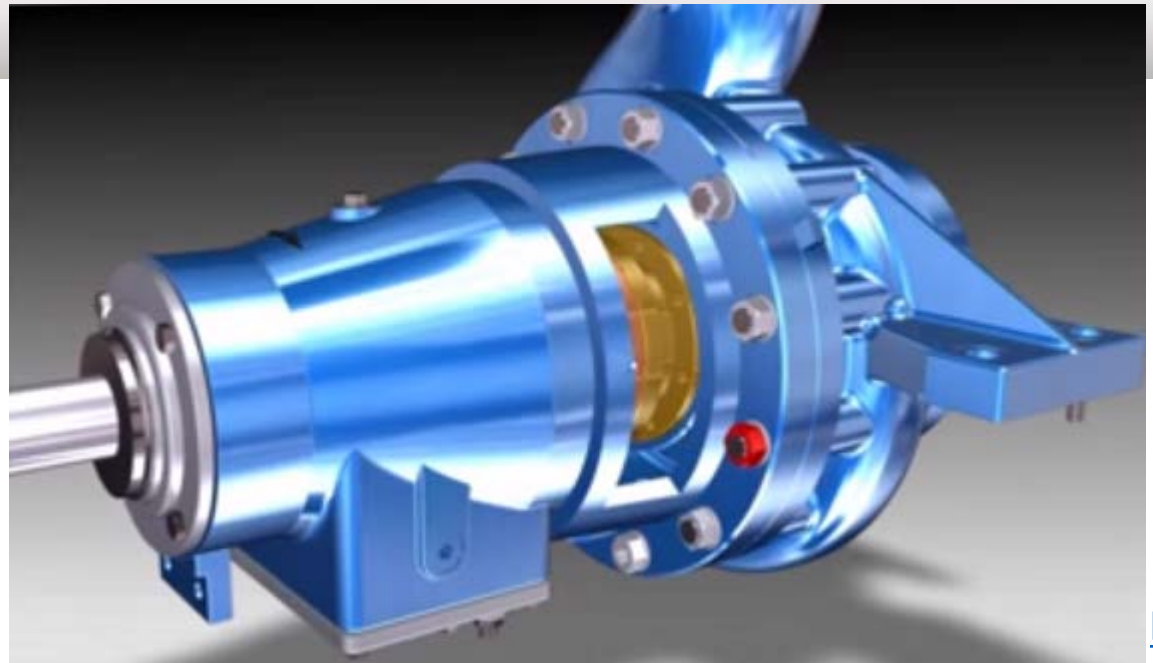
Subsea production control

Fault tolerance: Low
Safety class: Ex(i)
Fluid handled: sea water
distributed

See More

Installation Information

Save Cancel



http://bit.do/SAP-AIN

CONVERGENCE

IT

OT

TELCO

Design Change

Most Existing Tools are EBM

Digital Twins may flourish when we migrate from EBM to ABM design

Agent based approaches may parallel evolution of digital by design

ABM, Analytics, AI

Mass Market Adoption-Diffusion

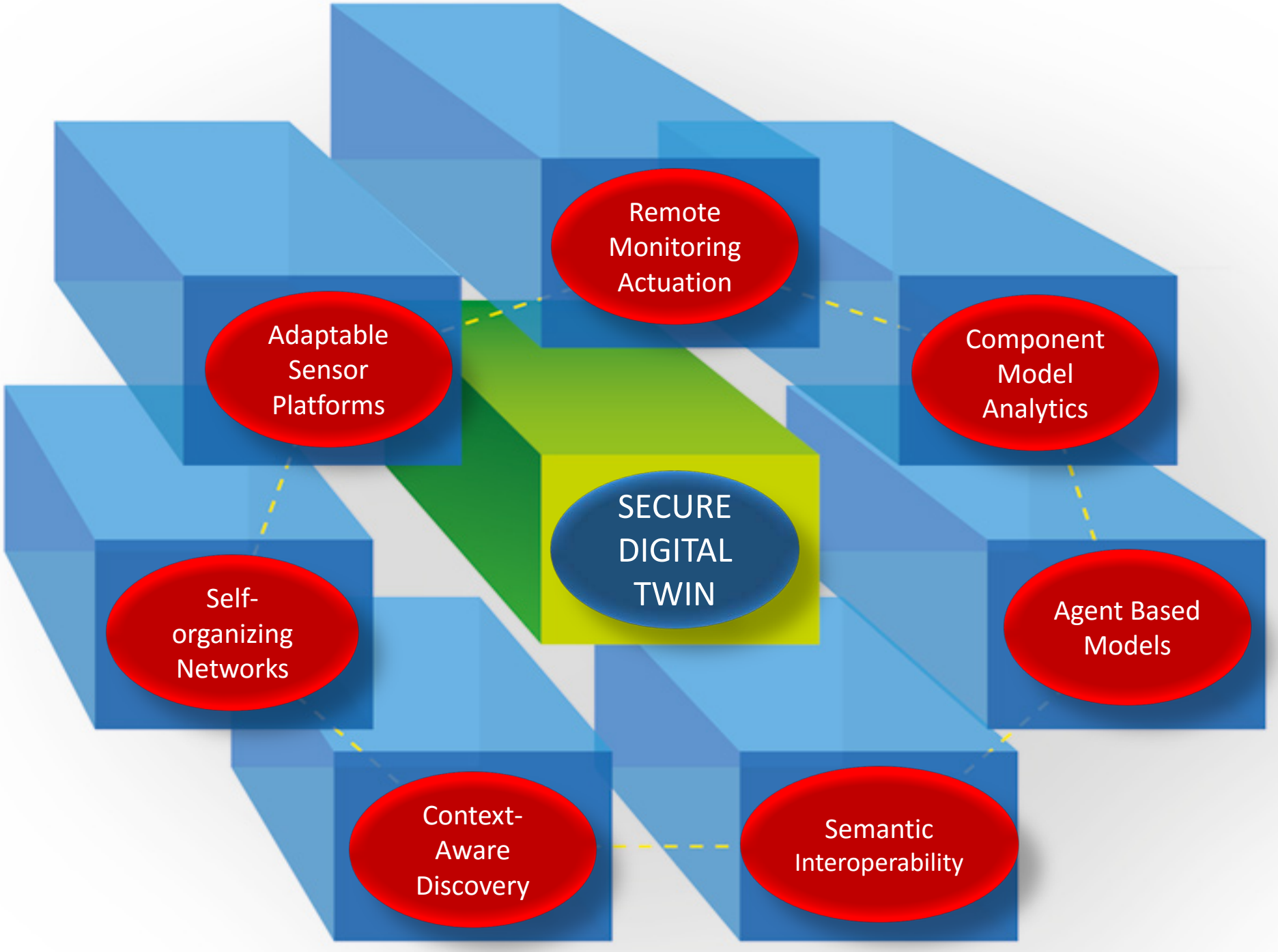
Digital Clones - Digital Twins

Digital Twin Direct

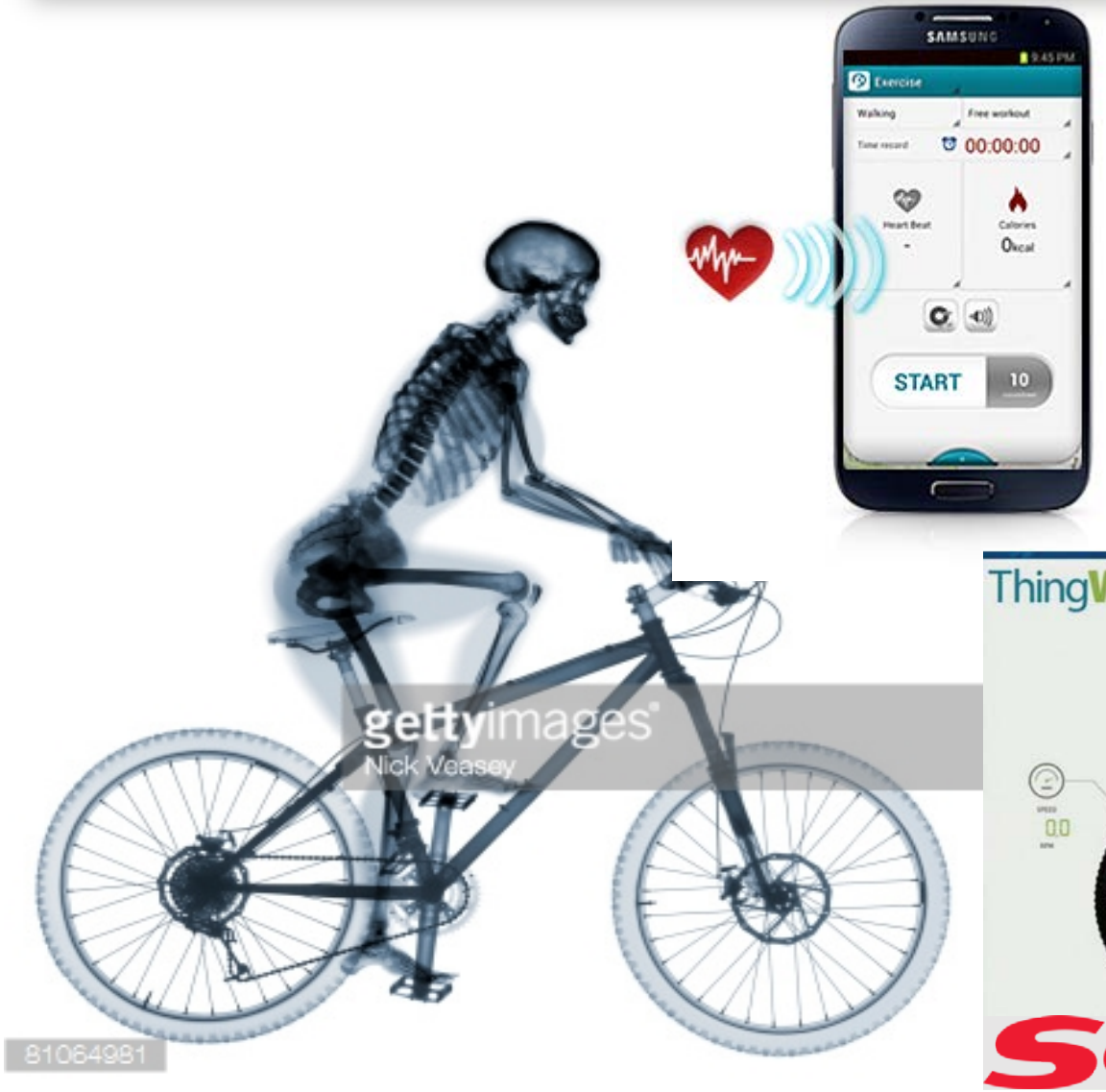
Digital Twin Dashboard

Digital Twin Drag & Drop

Digital Twin Plug and Play


Remote Monitoring Actuation
Adaptable Sensor Platforms
Component Model Analytics
SECURE DIGITAL TWIN
Self-organizing Networks
Agent Based Models
Context-Aware Discovery
Semantic Interoperability

Digital Twin – SAM and SCHWINN



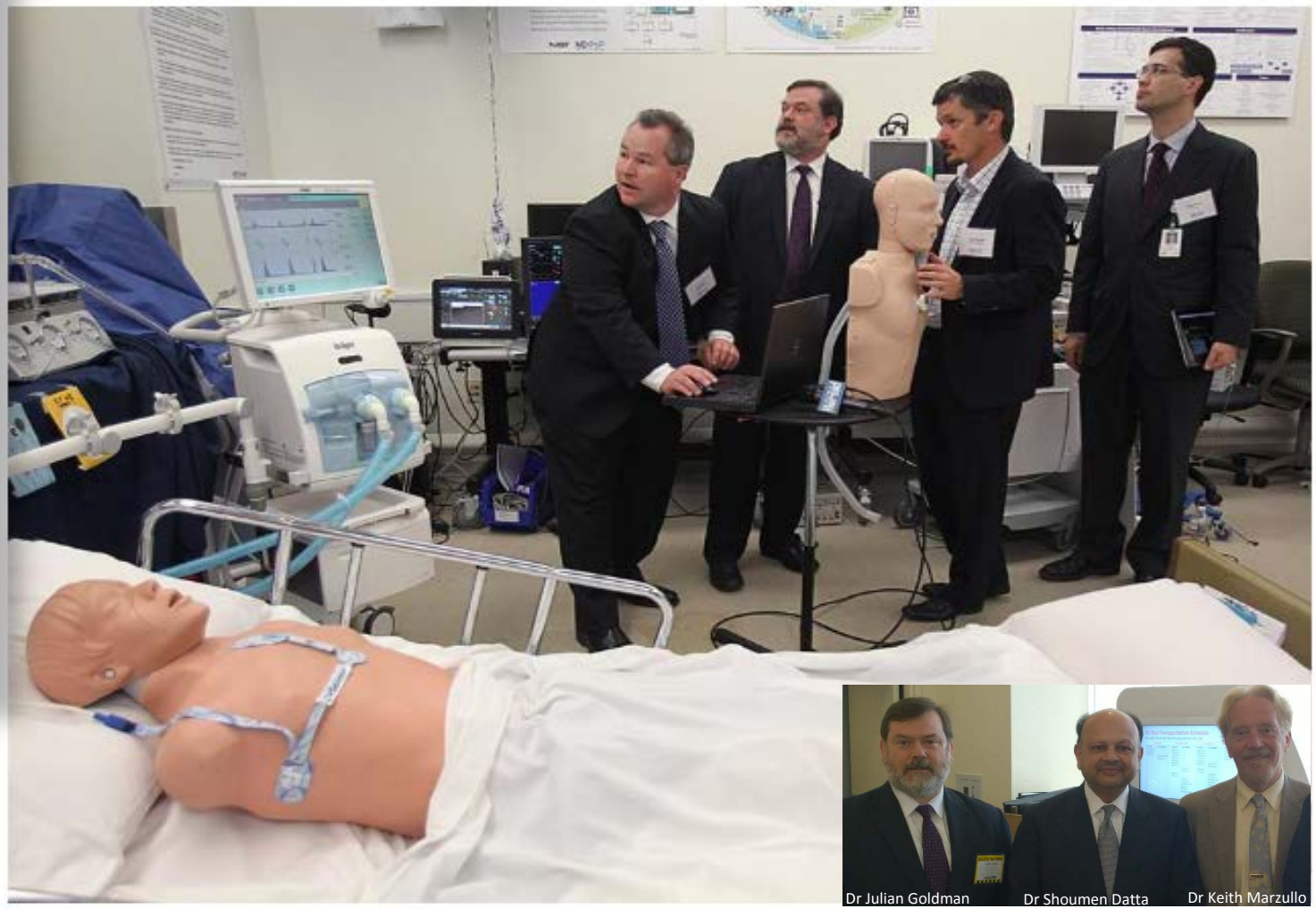
Monitor Ebola Patients via Digital Twins ?

Ebola spurs rethinking of devices at MGH

By Carolyn Y. Johnson | GLOBE STAFF NOVEMBER 07, 2014

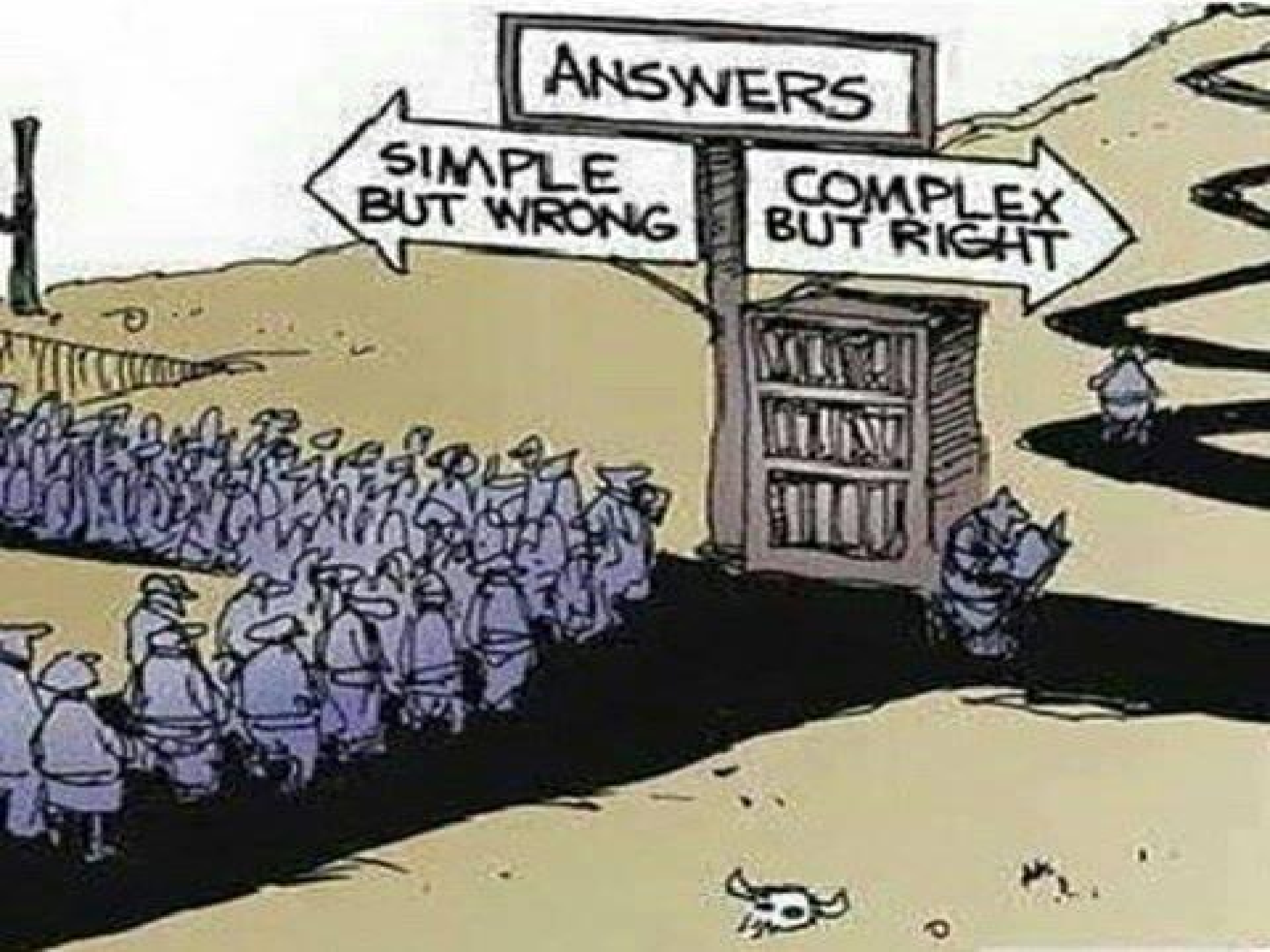
WCVB TV ● http://bit.ly/MDPNP-MGH-EBOLA-ROBOTICS

You cannot buy a TV without a remote. You cannot buy a medical device with a remote. Dr Julian M Goldman (MGH/HMS) MD PnP



SUZANNE KREITER/GLOBE STAFF

Health officials demonstrated treating an Ebola patient remotely in a mock ICU. Pictured, left to right: Eric Lynn, Julian M. Goldman, Brian Russell, and Dave Arney.


ANSWERS
SIMPLE BUT WRONG
COMPLEX BUT RIGHT

ten or even five years before, it would have failed. So it is with every new thing. Progress happens when all factors that make for it are ready and then it is inevitable. (Henry Ford)

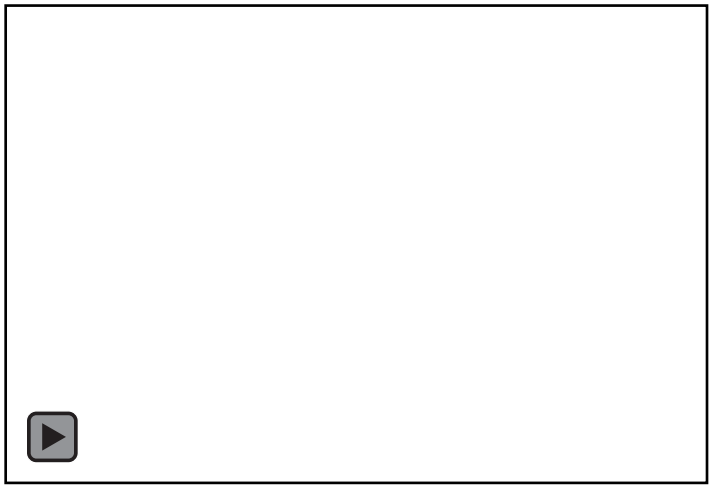
Target for IoT – digital by design services

- **Components (characteristics) in the online repository**
  - Each part (data / metric / state machine) can be an Agent model
    [1] based knowledge representation (semantic framework, OWL)
    [2] embedded with physics/chemistry/biology of the part/material
    [3] equation, logic, constraints (deterministic model) of operation
    [4] data kernel interface (API) to populate/refresh/transmit
    [5] analytics kernel (local or remote/cloud, fog, mist) to process object-specific, context-aware tools for data / applications
    [6] communications kernel (local, batch, remote, push-pull, publish-subscribe) capable of application driven networking (ADN) agnostic of network fabric (fixed, WiFi, SDN, NFV, LTE, 5G, SDR, CR)
    [7] Interoperability, discovery services, ecosystem standards (RDF)
    [8] software defined upgrade, var reconfig, modularity, reusability
    [9] cybersecurity (risk, intruder detection, repulsion, containment)
    [0] convergence by design - IT, OT, telco with autonomy/algorithms

Do we need all attributes for each model? No. For example, 5G latency limit crucial for autonomous driving functions but over-kill for retail shelf replenishment to reduce OOS

The Target – another accomplishment

- Component repository
- Configure
- Go Live



http://bit.do/OXYGEN-1999 ● MIT CSAIL Project Oxygen ● http://bit.do/Randall-Davis-06012002

The conceptual vision

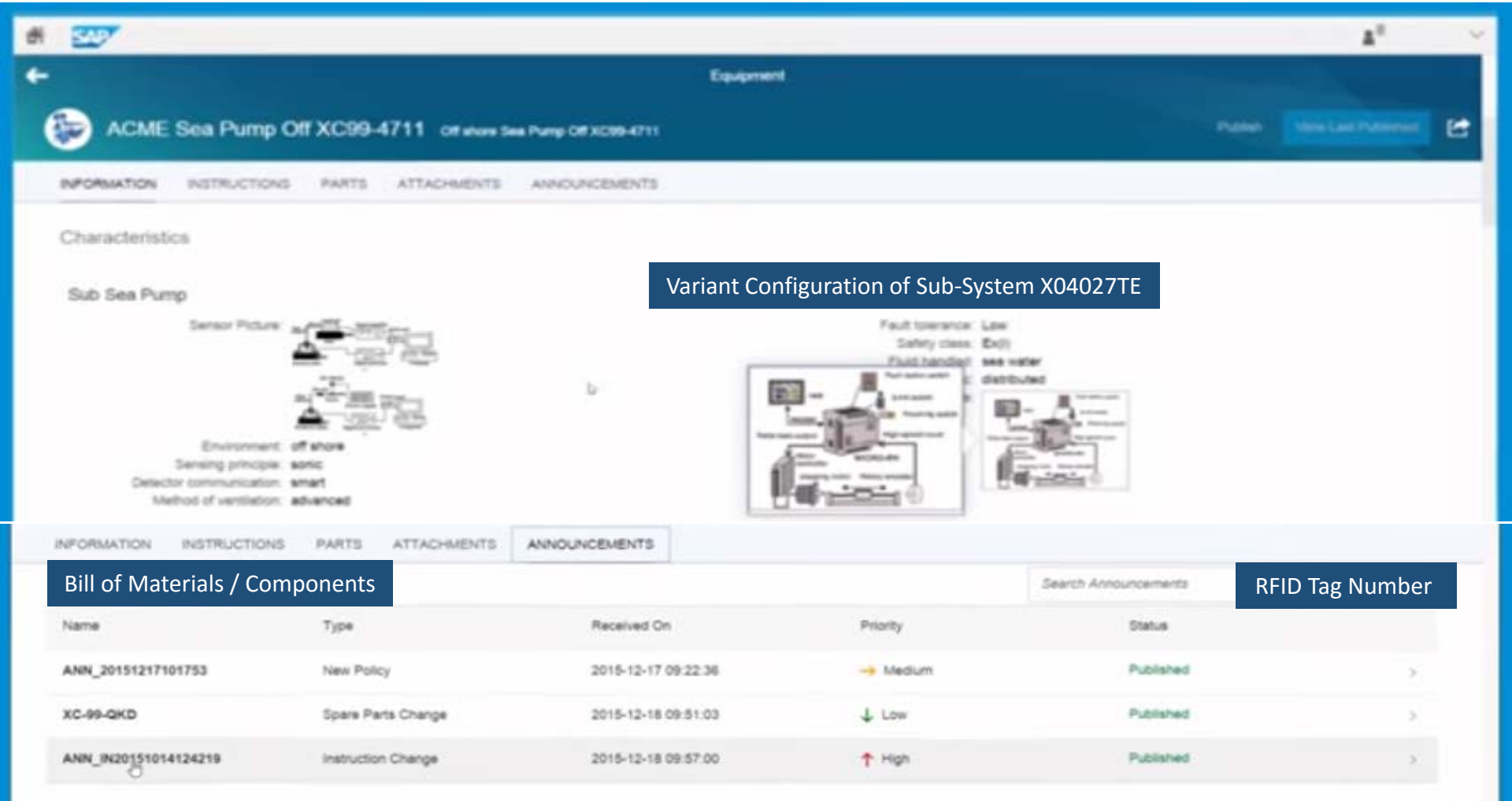
Connecting state machine agent models to configure complete systems and connect/transmit/analyze data

Convergence of IT, OT, telco with autonomy/actuation

Manager (Wind Turbine company) to create digital twins to monitor efficiency & energy output

The Target – for IoT era service providers

- **Components (online) repository**
  - Visualization – how it may "look" for customers

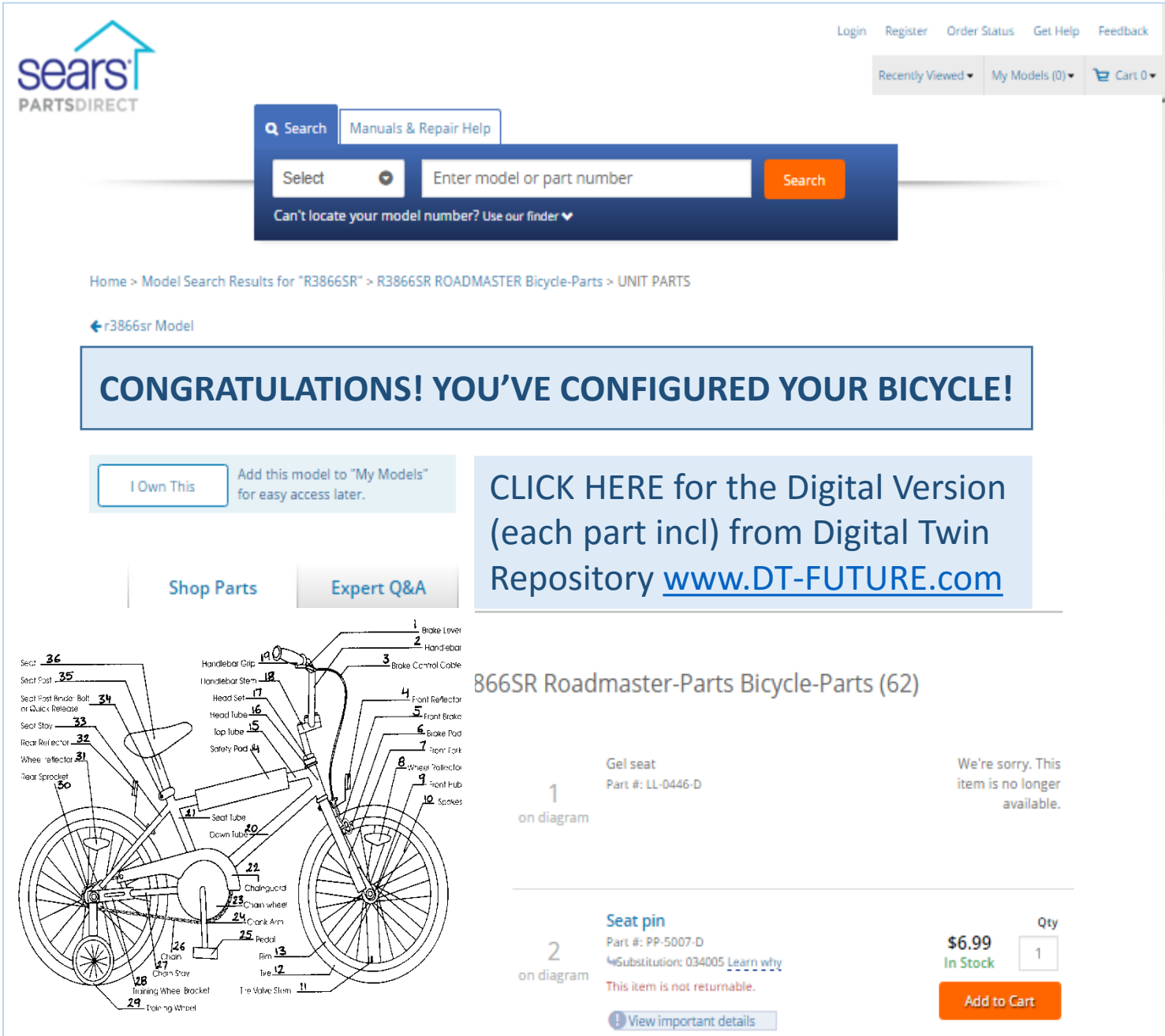


The Target – Outcome seeking Customers

- Component
- **Configure**
- Go Live

The Target – Outcome seeking Customers

- Component
- **Configure**
- Go Live



The Target – Outcome seeking Customers

- Component
- **Configure**
- Go Live

sears PARTSDIRECT

Login Register Order Status Get Help Feedback

Recently Viewed My Models (0) Cart 0

Search Manuals & Repair Help

Select Enter model or part number Search

Can't locate your model number? Use our finder

Home > Model Search Results for "R3866SR" > R3866SR ROADMASTER Bicycle-Parts > UNIT PARTS

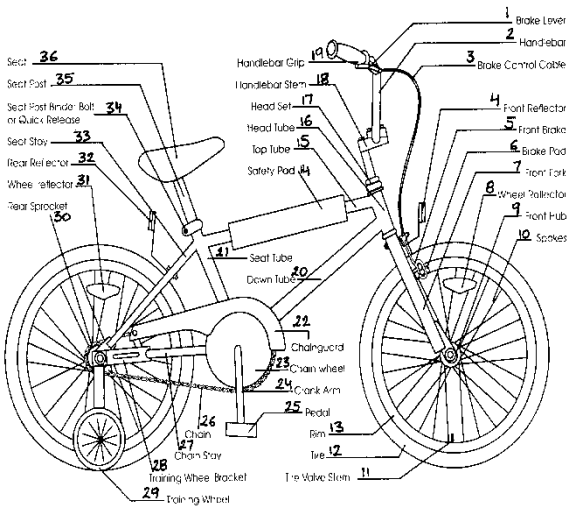
r3866sr Model

CONGRATULATIONS! YOU'VE CONFIGURED A DIGITAL TWIN

I Own This Add this model to "My Models" for easy access later.

CLICK "GO LIVE" to activate your Digital Twin bike and transport it to any smartphone - click DT App

Shop Parts Expert Q&A



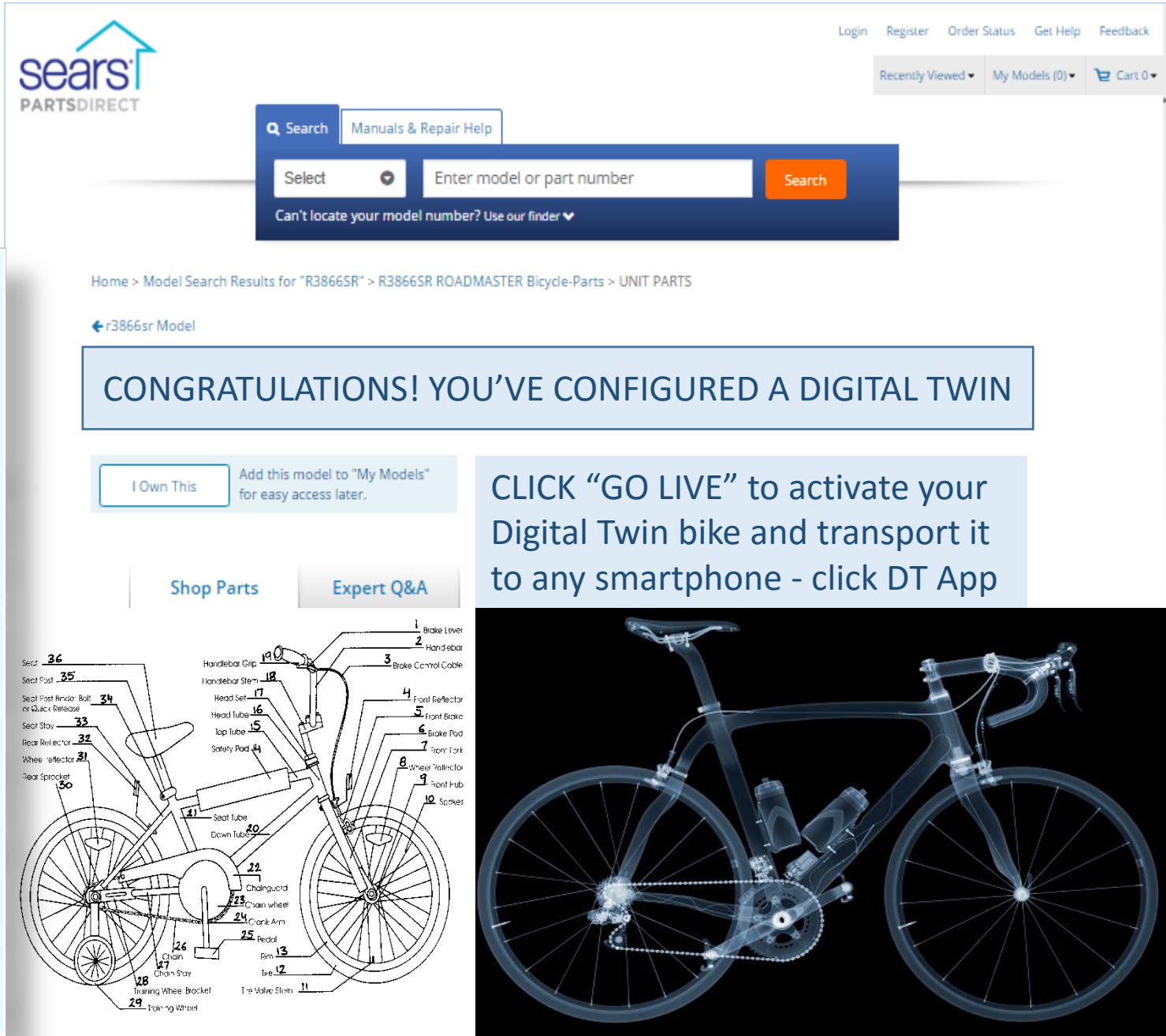
The Target – Outcome seeking Customers

- Component
- Configure
- **Go Live**

Go Live

Instructions

After you've configured the physical bicycle go to the Digital Twin site and authenticate the sensors to access your WiFi, BT, UWB gateway for mesh network to communicate between your bicycle and your devices (laptop, phone, tablets, wrist-watch). Allow auto-discovery mode to find context relevant data (weather)



The Target – Outcome seeking Customers

- Component
- Configure
- **Go Live**

Go Live

Instructions

S

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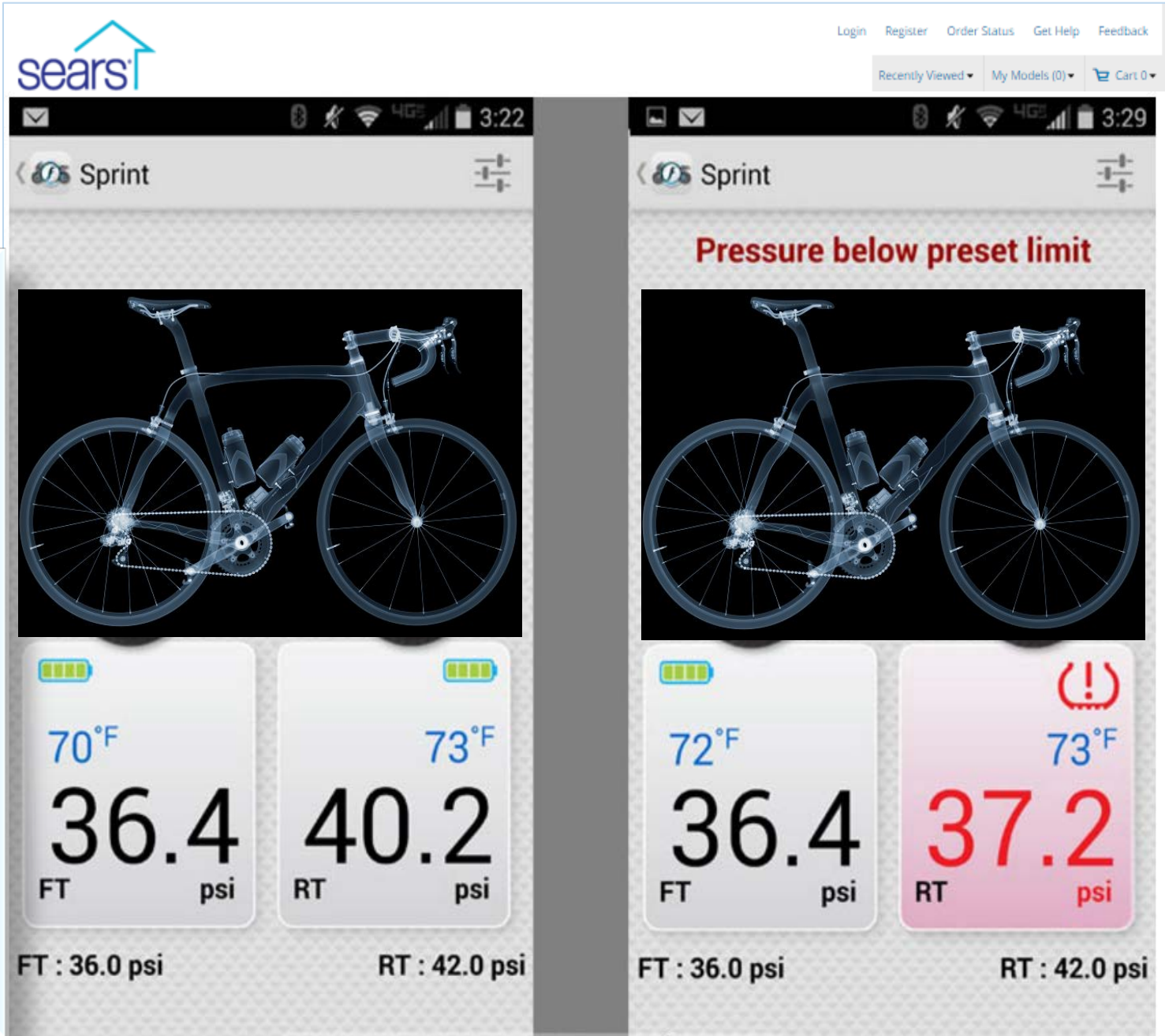


The Target – Outcome?

Computational Neuroscience

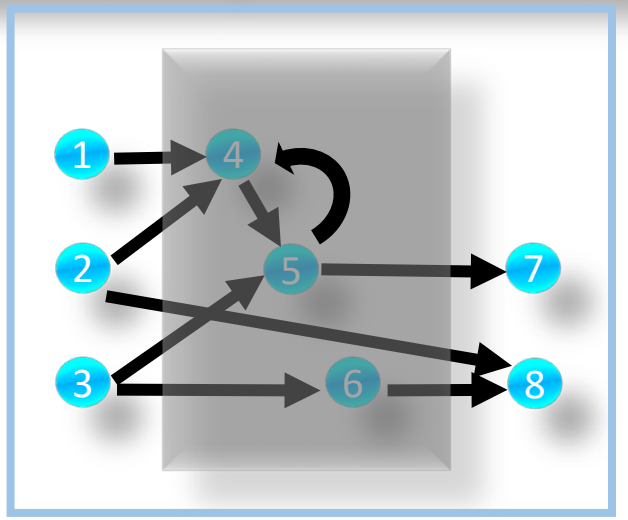
Neural Paradigm Shift

(this is not just semantics, this topic to be discussed in a separate presentation)

Neuroscientific Computation

Classical approach of ANN – predominantly inferential

Topological by design with generic weights generates inferential (obvious) output



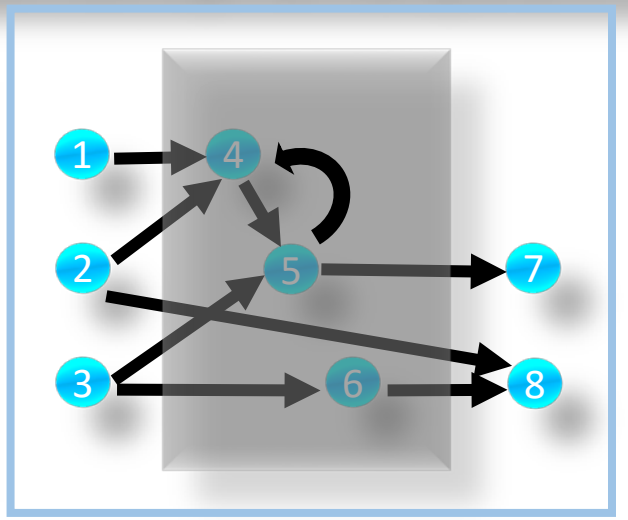
Recurrent Neural Network

	1	2	3	4	5	6	7	8
1	0	0	0	w_{14}	0	0	0	0
2	0	0	0	w_{24}	0	0	0	w_{28}
3	0	0	0	0	w_{35}	w_{36}	0	0
4	0	0	0	0	w_{45}	0	0	0
5	0	0	0	**w_{54}**	0	0	w_{57}	0
6	0	0	0	0	0	0	0	w_{68}
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0

$(1,4, w_{14})$,
$(2,4, w_{24})$,
$(3,5, w_{35})$,
$(3,6, w_{36})$,
$(4,5, w_{45})$,
$(5,4, w_{54})$,
$(5,7, w_{57})$,
$(2,8, w_{28})$,
$(6,8, w_{68})$,

Non-obvious (inferential) relationship analysis?

The weighted brain "ecosystem"
- epigenetic (seconds to days)
- ontogenic (days to years)
- phylogenic (generations)



Recurrent Neural Network

	1	2	3	4	5	6	7	8
1	0	0	0	w_{14}	0	0	0	0
2	0	0	0	w_{24}	0	0	0	w_{28}
3	0	0	0	0	w_{35}	w_{36}	0	0
4	0	0	0	0	w_{45}	0	0	0
5	0	0	0	w_{54}	0	0	w_{57}	0
6	0	0	0	0	0	0	0	w_{68}
7	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0

Evolve from ANN which emulates NN topology to developmentally inspired engineering design based on epigenetic simulation, neurogenesis and brain development modelling by creating programs which *generate* neural networks, hence adaptable, naturally.

COMPLEMENT
CONVERGE
CONNECT

Simulate, Automate

NATURAL LAWS, PARTS, SENSORS, ANALYTICS, ACTUATION

COMPLEMENT

SUGGESTION

If this is what Huawei is thinking

Eric Xu
Rotating CEO
Huawei

Shoumen Datta

YaFang Sabrina Sun
Chairwoman
Huawei

We want to create original research, new inventions, new theories, new ideas, new science, new ways to help customers, help people globally … the pursuit of frontiers without the fear of failure to lift the future plight of our community and humanity.

MR ERIC XU, CEO, Huawei
Huawei STW, 17 MAY 2016

HUAWEI

Huawei Institute for Thought

BIG HIT

COMPLEMENT

80,000 Huawei R&D

US$10 Billion in R&D

HIS

&

HERS

Huawei Institute for Science

HIS

Huawei Experimental Research Solutions

HERS

Thank you

Dr Shoumen Datta