Paradoxes to Paradigms

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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)
Converge

• Complement
• Community
• Connect
• Curate
• Clone
CONVERGENCE
Atoms to Bits

Apply design metaphor to drive paradigm shift
Prepare to deal with uncertainty & volatility
Strategize to connect, create, communicate
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.
Transportation Coordination - Emergency “Crash to Care” Response
Sense and response – emergency trigger as an autonomous application driver

Time, Sensors, Network & Data Synchronization
CONVERGE

COMPLEMENT

CONNECT

CURATE

COST
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

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,

Connecting atoms to bits - convergence of the networked physical world with the digital supply chain
WHITE PAPER

The Networked Physical World
Proposals for Engineering the Next Generation of Computing, Commerce & Automatic-Identification

Sanjay Sarma, David L. Brock & Kevin Ashton

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*
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
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.
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
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
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)

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.”

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).*

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.

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.
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
Physics of the Object
Equation of Operation
Populate Data for Variables
Compute & Analyze Outcome

Characteristics

Sub Sea Pump

Sensor Picture:

Environment: off shore

Detector communication: smart

Method of ventilation: advanced

Subsea production control

Fault tolerance: Low

Safety class: Exd

Fluid handled: sea water
distributed

Installation Information

http://bit.do/SAP-AIN
CONVERGENCE

IT
OT
TELCO
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*
Mass Market Adoption-Diffusion

Digital Clones - Digital Twins

Digital Twin Direct
Digital Twin Dashboard
Digital Twin Drag & Drop
Digital Twin Plug and Play
Digital Twin – SAM and SCHWINN
Ebola spurs rethinking of devices at MGH

By Carolyn Y. Johnson

GLOBE STAFF NOVEMBER 07, 2014


Dr Julian M Goldman (MGH/HMS) MD PnP

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

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.
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
nothing new ... I simply assembled the discoveries of others (Henry Ford)

The Target – another accomplishment

- Component repository
- Configure
- Go Live

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

CONGRATULATIONS! YOU’VE CONFIGURED YOUR BICYCLE!

CLICK HERE for the Digital Version (each part incl) from Digital Twin Repository www.DT-FUTURE.com

866SR Roadmaster-Parts Bicycle-Parts (62)

<table>
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<tr>
<td>Seat pin</td>
<td>2</td>
<td>$6.99</td>
</tr>
</tbody>
</table>

We’re sorry. This item is no longer available.
The Target – Outcome seeking Customers

• Component
• Configure
• Go Live

CONGRATULATIONS! YOU’VE CONFIGURED A DIGITAL TWIN

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

CLICK “GO LIVE” to activate your Digital Twin bike and transport it to any smartphone - click DT App
The Target – Outcome seeking Customers

• Component
• Configure

• Go Live

Instructions

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The Target – Outcome?

- Component repository
- Configure
- Go Live
Neural Paradigm Shift

(this is not just semantics, this topic to be discussed in a separate presentation)
Classical approach of ANN – predominantly inferential

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

![Recurrent Neural Network](image)

$$
\begin{bmatrix}
0 & 0 & 0 & w_{14} & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & w_{24} & 0 & 0 & 0 & w_{28} \\
0 & 0 & 0 & 0 & w_{35} & w_{36} & 0 & 0 \\
0 & 0 & 0 & 0 & w_{45} & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & w_{54} & 0 & w_{57} \\
0 & 0 & 0 & 0 & 0 & 0 & w_{68} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{bmatrix}
$$

(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)

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
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 Institute for Thought

BIG HIT
COMPLEMENT
80,000 Huawei R&D
US$10 Billion in R&D

HIS
&
HERS
Huawei Institute for Science
Thank you

Dr Shoumen Datta