THE PERSON

Dr Shoumen Palit Austin Datta, Ph.D.
PLEASE NOTE

The suggestions in this document are agnostic of any specific case or department or school or agency or state or nation. It is a set of perspectives, aspirations, and visions, albeit amorphous, related to the principles and practice of connectivity, their window on the connected world and the convergence and combination of tools for economic growth, to lift many boats.

The context of internet of things (IoT), is used as a metaphor for connectivity and as a digital by design paradigm. The emphasis on connectivity is perhaps a sign of globalization.

These ideas may serve as instruments for any institution, agency, nation or industry, to inculcate a blend of constructive disruption, entrepreneurial innovation and drive different dimensions of global solutions or social businesses.

Various segments may be applicable to advance the interests of global citizens, women in particular, which includes active workforce development, community job re-training, pre-college education, institutions of higher education, multi-disciplinary units, global agencies for academic missions, students in universities, online education and the pursuit of excellence, in general, for humanities, languages and basic research in science, engineering, medicine and mathematics.
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The Role

A leader with vision, experience and ability to build local and global bridges. Inclined to participate in agencies or institutions, research and education, for the next generation of STEM thinkers, doers, movers and shakers. A voice for economic development, workforce creation and an advocate for women in STEM. An active catalyst for academic-industry-government public-private partnerships (PPP) to support and sponsor R&D, build and deploy global solutions, create market opportunities for entrepreneurship and usher social innovation.
EMERGING DRIVER – EXPLANATION OF THE CONTEXT OF INTERNET OF THINGS

IoT (internet of things) is a concept, not a technology. The term IoT is generally assumed to originate from the MIT Auto ID Center, in 1999. I was a part of the MIT Auto ID Center, and hence, I was “present at the creation” of IoT (if, it was a “first”). I am a Senior Member of the Auto ID Labs, MIT, Department of Mechanical Engineering, and Senior Scientist, MDPnP Lab, Biomedical Engineering Program, Massachusetts General Hospital, Harvard Medical School.

IoT is a digital by design metaphor. IoT is applicable anywhere connectivity offers value. IoT is a concept, an “umbrella” idea which includes the principles and practice of connectivity. The thinking about IoT may be traced to Joe Licklider and Ivan Sutherland (student of Claude Shannon) circa 1959. One individual suggested it may have had its origins circa 1942, at the unveiling of the Atanasoff-Berry Computer (ABC). In 1986, Herbert Simon (CMU), presented IoT-esque thoughts in his talk “The Steam Engine and the Computer: What Makes Technology Revolutionary” [1] followed by “The Computer for the 21st Century” by Mark Weiser, XPARC, in 1991 [2]. The introduction of “atoms to bits” paradigm by Hiroshi Ishii (MIT) in “Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms” in 1997 [3] was elaborated by Neil Gershenfeld in his book “When Things Start to Think” and later in an article co-authored with his graduate student, Raffi Krikorian [4], who demonstrated IPv6 linked smartphone, may control switches and sensors in smart buildings, for “smart communities” and workplaces.

IoT ideas were rejuvenated by the Auto ID Center at MIT, co-founded by Sanjay Sarma, in 1999. Later, Kevin Ashton, marketing manager from P&G (Procter & Gamble), joined the Auto ID Center. During debates about the “networked physical world” dealing with “things” (toasters, pizza, detergent boxes), Kevin Ashton suggested the term IoT or internet of things.
The naming controversy aside, the marketing world was won over by Kevin Ashton and the origin of the term IoT is now attributed to Kevin Ashton. The conceptual white paper “The Networked Physical World” by Sanjay Sarma, David Brock and Kevin Ashton was published on October 1, 2000 [5]. However, there are other claims as to the origin of the “IoT” term [ref 8].

Another paradigm, atoms to bits, is percolating, and the movement is gaining momentum but remains in its infancy. The engine of economic growth and pervasive digital economy, which we expected [6] to accompany the principles and practice of connectivity (Figure 3 in [ref 6]), is taking shape, at a sluggish pace.

We may have been swept away by the “IoT” tsunami. Hence, we have ignored to adequately address the complexity of systems, semantics and security. Taken together, with telecommunication protocols, these are elements which must be orchestrated in a “connected” world, to work in seamless harmony, if we expect actionable interoperability between systems, locally and globally. This is an active area of research and has profound commercial value.

For some time, I have been immersed in this “soup” with a few key actors, global corporations, governments and thought leaders, for more than two decades, “book-ended“ between, “Being Digital” by Nicholas Negroponte (1995) [ref 7] and “The Inversion Factor: How to Thrive in the IoT Economy” by Sanjay Sarma and others, released on October 6, 2017 [ref 8].

It is this collective expertise, experience and a sense of the digital transformation, which I wish to contribute. My work, as an instrument for change, catalyst for education and voice for economic development, may usher in a new era of sustainable academic-industry-government-community convergence, for good, for science, for society, and as a compass, to help shape the future roadmap of the digital economy, and, in turn, the global economy, in general.
I: Leadership in IoT research and education in national and international context

Perhaps the common denominator, essential for combining scholarship with leadership, may require a breadth of interest, “the ability to construct fruitful analogies between fields” and healthy imagination.

In “Appendix A” I have presented select publications and provided comments on the context of the content, to highlight, in some cases, the thinking, which served to bridge the chasm, between domains, disciplines and real world solutions.

The development of the concepts of IoT and ubiquitous connectivity, in a networked physical world, depends on synthesis of ideas and re-viewing ideas with a “different” eye. In 2003, I encapsulated a version of the internet of things, a decade ahead of its time. These ideas now represent the current version of industrial internet of things and form the core elements in the German sponsored Industrie 4.0 endeavor (please see Appendix A for Datta, S. (2004) Adapter, optimiser, prévoir - La convergence des concepts, des outils, des technologies et des normes peut-elle accélérer l’innovation?).

The digital by design metaphor (IoT) is impotent without data. Hence, the central focus on tools must be inextricably linked to data. Analytics (diagnostic, predictive or prescriptive), hopefully, will generate actionable information, and will reach the user, before its value perishes. In one attempt, I have synthesized this bridge between data and decisions, using data from IoT type sources (radio frequency data from RFID tags and sensors) to feed time series, error correction tools from econometrics (generalized autoregressive conditional heteroscedasticity), to generate predictive analytics (forecast). This idea was first proposed in 2003 with co-author Sir Clive Granger, recipient of the 2003 Nobel Prize in Economics. The concept was later

The combination of data, intelligence, autonomy, telecommunications and mobility was captured, partially, in the proposal on autonomous transportation (2015). My central idea of autonomous freight transportation was deemed too radical by the US Dept of Transportation (in 2014). The original proposal was trimmed to “fit” an exploratory autonomous transportation test bed suitable for a small town in MI (please see Appendix A under “coordination of grants”).

The incredulous fact that medical errors are the third leading cause of death in the US, after cancer and heart disease, gives new urgency to address interoperability between medical devices, one reason for these deaths (as many as 440,000 individuals die in US hospitals due to medical errors). Closed, proprietary, semantic data dictionaries, in electronic health records (EHR/EMR) software, restrict interoperability, deliberately, by design. We need open source, yet secure platforms, in integrated clinical environments. The latter is possible in healthcare through the medical internet of things (please see Appendix A for Datta, S. and Goldman, J.M. (2017) Healthcare - Digital Transformation of Healthcare Value Chain: Emergence of Medical IoT).

Remote sensing for primary care, wellness and healthcare, can use open source platforms to aggregate data from sensors. Data analytics generated near real-time contextual physiological status may alert individuals, care-givers and medical professionals, with data and information to make better decisions about health and healthcare.

A tiny slice of this thinking along the lines of medical IoT is now a scientific research collaboration with UF and soon to be expanded in a thought leadership article (please see

Leadership activities and achievements offer evidence of my ability to lead and execute, within diverse and complex collaborative scenarios, engaging academia, industry, governments, global organizations and entrepreneurs. My activities in the context of IoT are outlined below.

Radio frequency identification (RFID) provided a method to retrieve bits from atoms, that is, data from physical objects. Low cost RFID tags transmitting only an unique id (64-bit electronic product code or EPC) was the bridge connecting things, and data about things, which could reside in the internet or “cloud” (data on the RFID tag increased the cost of the tag). This transparency ushered in the potential for a plethora of changes. The concept of IoT, which gained momentum from this activity, grasped the imagination of markets, industry, nations and people.
My activities with respect to the context:

The incomplete and select list, below, represents activities where I provided leadership, offered strategic vision and helped the transformation of the vision to reality, with respect to IoT:

1 Fast moving consumer goods (FMCG) and consumer services industry (largest global industry with market capitalization exceeding $4 trillion in 2015) related R&D and adoption of RFID as a tool, as a first step, to embrace ubiquitous data connectivity and the conceptual paradigms of IoT and atoms to bits. Initiatives involved corporations in US, UK, Germany, France and Japan, governments of Finland, Taiwan and Singapore, and the plight of the leaders to understand the information age.


3 Leadership for IoT and digital transformation with corporations in Japan; government agencies in EU, India, Chile, Taiwan; security with US Dept of Homeland Security and World Customs Organization, Brussels; US Dept of Defense [(US Army Materiel Command (AMC), Fort Belvoir, VA; Defense Logistics Agency; Army Aviation & Missile Command (AMCOM), Huntsville, AL; TRANSCOM-JECC (Joint Enabling Capabilities Command), Naval Station, Norfolk, VA)]; UN and UNDP South-South Partnership for Global Goods (China and Africa)

4 MIT Data Center exploring data, network of things (Metcalfe’s Law) and semantics

5 MIT School of Engineering and MIT Sloan School of Management initiatives in digital supply chain innovation, adaptability [ref 9] and forecasting using econometric tools [ref 10]. Engaging with corporations (aviation, manufacturing, automotive) and executive education.
MIT Energy Initiative for “internet of energy” to improve efficiency using sensors and IoT. Engaged with governments/agencies (Ireland, India, Finland, Spain and Thailand). Start-up in Ireland in collaboration with MIT and Oak Ridge National Lab, Knoxville, TN.

Industrial “internet of things” (IIoT vision in Figure 3 [ref 6]) transformed to reality, partially. Leadership, EU DG Connect, US government (NAS, GAO, NSF, DoT) and industry.

Catalyzing the digital agenda – public education in San Francisco; diffusion of internet in public high schools (Net Day 1996); helping to start Cisco Networking Academy (with Cisco Systems, Inc); helping to start K-12 biotech program (UCSF School of Medicine, Harvard Medical School, MIT); helping teacher advancement (with UC Berkeley and Whitehead Institute, MIT); helping K-12 student inspiration programs (San Francisco, Boston); State of California K-12 standards; US National Taskforce on Technology, Education and Workforce Development (US Department of Commerce, National Telecommunications and Information Administration, US Department of Labor, White House Council of Economic Advisors, ITAA).
II: Educating the next generation of thinkers – The Learning Organization

My zeal for teaching (Appendix A) induces me to be a part of research and education for the next generation of leaders. Exploration of nanotech, data analytics and sensors, in one or more combinations, in health, healthcare, energy, transport, aging communities, environment, and agriculture (including animal farming) are of interest. The sheer volume of research in even a fraction of a segment of any of these domains (for example http://bit.ly/PLASMONICS) makes it imperative for us to think different, to think how to harvest the outcome for economic growth.

Educating the next generation of thought leaders and protagonists for convergence and connectivity is a fundamental priority. Equally important is engaging more women to pursue STEM. Digital transformation, due to IoT across verticals, may be helpful to attract diverse groups of students and those who are interested in learning by doing (IoT applications).

The “Pursuit of Ideas” (Appendix B) outlines an example of my comprehensive problem based approach to creating centers of excellence, institutes to advance grand challenges and consortia, to catalyze cross-pollination of ideas to fertilize future projects. Additional examples may be found in the pdf marked “18.Commencement” in the folder marked “CHAPTERS” which may be downloaded from the MIT Library https://dspace.mit.edu/handle/1721.1/111021.

My unconventional experiences should be an asset to traditional institutions and not a liability. Universities value faculty for depth, in specific micro-domains. More and more papers, in fewer and fewer specialties, are better suited to gain recognition. But, the new economy demands one who can connect the world, synthesize solutions, a practitioner of breadth, capable of promoting scholarship through trans-disciplinarity. Individuals with exceptional depth, may offer great insight, tools and techniques, which, if combined and converged, may yield solutions, with favorable economic outcomes, to benefit humanity.
Organizations may find in me the ability to be catalytic to structure use cases with industry, help with proof of concepts in real world testbed implementations and evaluation, identify potential funding sources, bring corporate R&D collaborators to the table, stimulate corporate business unit partnerships and liaise with government programs for funding small (I/UCRC type) or large (FFRDC, ERC type) centers.

My breadth of understanding extends from science and engineering to medicine and economics, including domains germane to digital transformation [IoT, IIoT, RF, 3D, AI/ML, CPS, data, analytics, electronics, networks, telecom, robotics]. Familiarity with verticals include healthcare, communities, auto, aerospace, manufacturing, energy, security, governments and smart ag.


I can work effectively across departments, agencies and institutions, to find common grounds, identify or structure creative collaborations or propose new initiatives, if the ideas are indeed transformational. My lack of any personal “agenda” makes me highly receptive and open to what is new, needed and necessary, for advancement or institutional or national excellence.
III: Tasks Ahead

Multi-dimensional adaptability, agility and fluidity must be pervasive. Plans and projects can rapidly evolve, cost and value can rapidly escalate, markets and applications can rapidly evaporate. Uncertainty or volatility of the real world can be jittery, even for a perfect plan.

Working through chaos is a service I offer. There are no standard operating procedures. My to-do list, itemized below, is simply a suggestion. It is neither sequential nor arranged by priority and certainly far from complete.

1. Identify existing industry collaborations and explore if the agency/individuals may
   [a] be interested to build additional bridges to the existing platform
   [b] create new initiatives by extending the platform or group
   [c] wish to explore entrepreneurial opportunities if there are potential market outcomes

2. Identify groups interested in activities related to
   [a] corporate R&D, the so-called “open innovation” and crowd-sourced innovation
   [b] corporate partnerships focused on translational engineering for products/services
   [c] government funding options in US, EU, APAC through global academia/corporations
   [d] development activities through foundations, donors and networks (alumni?)
   [e] industrial R&D fellowships, visiting scientists (donations, grants, sponsored research)

3. Institutional funding opportunities (department, school, agency) for
   [a] basic science (NSF) driven small (I/UCRC) and large (ERC) centers, for example in sensing, telecom, biomedical engineering (as well as STEM outreach for secondary education)
   [b] applied R&D – student research and workforce development – DoD (DARPA, ONR, AFRC), DoE (NNSA, NNMI?), DoC (NIST, NTIA), DoHS (CSD), DoT (ITS); SBIR/STTR
   [c] target areas for advancement, create team and then design funding approach for:
[i] additive manufacturing and MRO for turbines (3D metal)

[ii] energy including nano PV, fuel cells, graphene batteries, nano-copper CO₂ to fuel, mobile energy distribution, remote energy efficiency, renewable sources for internet of energy.

[iii] mining / oil and gas exploration – hyperspectral remote sensing of pipelines, sensor network management by drones, AI and automation (eg, copper mines in Chile, RioTinto)

[iv] robotics and transport – collaborative robotics, autonomous transport, software as robots, AI in decision systems, cloud/fog/mist computing for low latency “sense and response”

[v] biomedical engineering including sensor-less remote sensing; wearables; non-invasive data; nano-bio-sensors for humans, animals, agriculture; RF guided robotic manipulation in vivo; robotic surgery; self-organizing nano-robot / micro-robot networks for maintenance (cleaning arteries, intestine, removal of polyps, detection/dissolution of clots, knee/ hip joint replacement)

[vi] data analytics – boost complex systems analysis using Digital Twins, remote imaging (machines, humans, animals, earth, space), commercial applications for use of ML/AI in retail, security (cognitive firewall), insurance and financial tech eg blockchain.


[viii] telecommunications – protocol agnostic seamless interoperability between external & internal environments (machine shop, hospitals), 5G, latency, mm wave, RF reflection, 802.xy

[a] online Bachelorette (mini-BE), MicroMasters program, nano-degrees

[b] on-site executive education (may be company specific or agnostic)

[c] institutional exchanges with Middle East, India, China, Indonesia, South America

[d] multi-national engineering projects through UNDP, WHO, FAO, EBRD, World Bank
The diverse nature of activities, many of which may operate in parallel, requires
[i] hard connections and “soft” relationship building exercise, with nodes, to gain trust
[ii] plumb the wealth of depth in the organization (catalyze information arbitrage)
[iii] transfer “soft” relationships to stimulate growth of synaptic credibility

The classical formula for funding will yield incremental gains and we need that approach.
The non-formulaic personal bridges are key to larger investments, major donor programs, which, enables excellence and program development. This process works for private institutions and their endowments are proof. I can help germinate long term relationships, engage to build more bridges. It is an amorphous, asynchronous and ad hoc process, but once, started, it requires nourishment through personal meetings, visits, invitations, events, platforms to interact with the agency or institution. The donor must grasp that she is not giving to the institution, but through the institution, to enable the talented, to help the world, to lift many boats, seed global economic growth, create a sense of the future and act as a purveyor of civilization.

The nature of the “work” may happen in many different forms. My role will be that of an instrument, when appropriate, perhaps synthesize diverse strands to coalesce a multi-disciplinary team, may engage in scholastic endeavors with groups, inculcate ways to induce momentum for platform ideas, essentially large and amorphous problems with multi-layered projects to improve science, society and life, in general. These efforts will require a combination of approaches and expected to serve a broad spectrum of platforms for engagements, across schools, agencies and departments, to contribute expertise, collaborate, and co-create, to generate solutions, not just tools or technologies. Testing, deploying and evaluating these solutions may occur in the context of social business, entrepreneurial innovation or public-private partnerships, agnostic of location.
Concluding Comments

My professional endeavors, since 1999, are inextricably linked to the global evolution of digital transformation, widely regarded as a revolution, ignited, in part, through connectivity and the concept of internet of things (IoT). The latter is based on ideas, which were percolating for at least half a century, with respect to the emerging nature of the networked physical world.

What have I done, specifically, in this context?

I have, for the most part, thought about problems, synthesized potential solutions and disseminated a sense of the connected future, worldwide, to students, academics, corporate executives, bureaucrats, technocrats and organizations or agencies charged with the task of promoting public goods.

I have created opportunities, through specific interactions with individual decision makers or teams, in academia, industry and governments, to pursue challenges, grand challenges and translate ideas into reality. My ability to view the “big picture” is an asset, in this context.

I have sought resources and funding from corporations and governments to create, fuel and sustain activities, to promote the ethical globalization of the digital economy.

I have connected diverse groups to explore common problems, and enabled them to view solutions with a “different” eye, solutions through convergence and solutions to improve lives.

I have often served as a catalyst, behind the scenes, to help advance ideas, connect the “dots” and suggest solutions, but stepped away from taking any credit or marketing my personal contribution or drawing attention to my role.

When others find success and feel empowered, due to my activities, as an instrument, I win, albeit, in silence. A preferred approach. Hence, I have adopted the motto, esse, non videri.

## 1] Teaching and Student Engagements (1981-2018)

<table>
<thead>
<tr>
<th>Year(s)</th>
<th>Course - Type, Description, Comments</th>
<th>Institution / Organization</th>
<th># of Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018-2006</td>
<td>Technology and Innovation in Decision Systems; Strategy and Management of Operations: Supply Chain, RFID, IoT (annual short course)</td>
<td>Master of Science and MBA students at KEDGE, Bordeaux, France</td>
<td>600 approx</td>
</tr>
<tr>
<td>2017</td>
<td>Biomedical Systems Engineering and Medical IoT Platform – An Integrated Clinical Environment for Sensing (short course for graduate students)</td>
<td>Organized by NCKU, Taiwan for ICGEC, KUAS, TAJEN, NDHU, NTUT, SOOCHOW Univ</td>
<td>500 approx</td>
</tr>
<tr>
<td>2017</td>
<td>Energy by Design – Swappable Batteries for IoT and IIoT Mobility (guest lecture for senior executives)</td>
<td>Kaison Green Energy Technology Company, Taipei, Taiwan</td>
<td>20 approx</td>
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<tr>
<td>2013-2010</td>
<td>Chemistry (1025, 2045, 2046) semester courses</td>
<td>Undergraduate colleges</td>
<td>200 approx</td>
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<tr>
<td>2007-2006</td>
<td>IoT and Connectivity in Digital Supply Chain Transformation (guest lecturer)</td>
<td>MBA and PhD students at IIM Ahmedabad, IN</td>
<td>500 approx</td>
</tr>
<tr>
<td>2007-2006</td>
<td>Technology and Innovation in Decision Systems; Strategy and Management of Operations: Supply Chain, RFID, IoT (Visiting Professor, semester course)</td>
<td>Master’s students (MSc) at Chalmers University of Technology, Gothenberg, Sweden</td>
<td>100 approx</td>
</tr>
<tr>
<td>2007-2006</td>
<td>Innovation and Digital Transformation (guest lecture series designed for industrial executives)</td>
<td>Executive Education for senior management at Volvo (Volvo R&amp;D, Gothenberg, Sweden)</td>
<td>50 approx</td>
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<tr>
<td>2007-2005</td>
<td>Digital Transformation, SCM Operations and Entrepreneurial Innovation (annual guest lecturer)</td>
<td>MBA students at Trinity College, Dublin, Ireland and University College Dublin (UCD, Ireland)</td>
<td>200 approx</td>
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<tr>
<td>2004</td>
<td>Auto ID (RFID) in Forthcoming Digital Transformation of SCM (guest lecturer)</td>
<td>Master’s and MBA students at HEC (École des hautes études commerciales de Montréal, Université de Montréal, Canada)</td>
<td>200 approx</td>
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<td>2004-2002</td>
<td>Operations in SCM, Radio Frequency Identification (RFID), Electronic Product Code (EPC), Standards and IoT (semester course, guest lecture)</td>
<td>MIT Engineering Systems Graduate Course 1.270/ESD.273 at MIT and MIT-Singapore Alliance</td>
<td>100 approx</td>
</tr>
<tr>
<td>Year(s)</td>
<td>Course - Type, Description, Comments</td>
<td>Institution / Organization</td>
<td># of Students</td>
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<tr>
<td>2003</td>
<td>Innovation and Digital Transformation (lectures designed for executives)</td>
<td>Executive Education for senior management at Saint-Gobain organized by MIT School of Engineering and MIT Sloan School of Management, MIT</td>
<td>50 approx</td>
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<tr>
<td>2001</td>
<td>Auto-ID, RFID and IoT in Enterprise Systems (annual guest for short course)</td>
<td>Engineering Tripos, University of Cambridge, Cambridge, UK</td>
<td>50 approx</td>
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<tr>
<td>2000</td>
<td>Auto-ID, RFID and IoT in our Future (annual guest lecture)</td>
<td>MBA students, Haas School of Business, UC Berkeley, Berkeley, CA</td>
<td>100 approx</td>
</tr>
<tr>
<td>2000</td>
<td>Auto-ID, RFID and IoT in Enterprise Systems (annual guest for short course)</td>
<td>Master’s and MBA students at L’Ecole Supérieure des Sciences Economiques et Commerciales (ESSEC), Paris, France</td>
<td>200 approx</td>
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<td>1995</td>
<td>Molecular Genetics of Inherited Disorders and Medicine (semester course, weekly meetings)</td>
<td>1st and 2nd year medical students, University of California San Francisco (UCSF), School of Medicine, San Francisco</td>
<td>50 approx</td>
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<tr>
<td>1993-1990</td>
<td>Molecular Medicine, Metabolism and Biochemical Genetics – Case Analysis for Physiology, Biochemistry and Metabolism (course leader (tutor) for semester classes for medical students)</td>
<td>1st year MD students at Harvard Medical School, Boston, MA and Harvard University, Cambridge, MA</td>
<td>160 approx</td>
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<tr>
<td>1988-1985</td>
<td>Molecular Biology and Microbiology (instructor for semester courses)</td>
<td>Undergraduate students (juniors and seniors) at Rutgers University, NJ</td>
<td>200 approx</td>
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<tr>
<td>1984-1981</td>
<td>Genetics and Microbiology (semester courses as a Teaching Assistant)</td>
<td>Undergraduate students (biology majors) at the University of Pittsburgh, Pittsburgh, PA</td>
<td>600 approx</td>
</tr>
<tr>
<td>Year</td>
<td>Project Description</td>
<td>Institution</td>
<td>Student</td>
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<tr>
<td>1981-1982</td>
<td>Analysis of SV40 mutants by DNA sequencing</td>
<td>University of Pittsburgh, Pittsburgh, PA</td>
<td>LAP</td>
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<tr>
<td>1987-1988</td>
<td>Transcriptional (in vitro) Regulation by DNA Tumor Viruses</td>
<td>Rutgers University School of Medicine, NJ</td>
<td>MCL</td>
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<td>1990-1991</td>
<td>Thyroid Hormone Receptor Gene Expression in Thyroid Carcinoma</td>
<td>Harvard Medical School, Massachusetts General Hospital, Boston, MA</td>
<td>SNM</td>
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<td>1992</td>
<td>Genetics of Transcription Factor Mutants of <em>Saccharomyces cerevisiae</em></td>
<td>Whitehead Institute, MIT</td>
<td>TCG</td>
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<td>1994</td>
<td>Optimizing the packaging of Human Genomic DNA in Yeast Artificial Chromosomes (YAC)</td>
<td>Human Genome Project, MIT, Cambridge, MA</td>
<td>CXS</td>
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<td>1995</td>
<td>Transcription in <em>Trypanosoma cruzi</em></td>
<td>UCSF School of Medicine, San Francisco, CA</td>
<td>LOB</td>
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<td>1987-2015</td>
<td>Student Advising <a href="https://dspace.mit.edu/handle/1721.1/111021">Link</a></td>
<td>Please see complete CV ← please use URL</td>
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</tr>
</tbody>
</table>
2] Select Publications with contextual comments


**COMMENTS** – Partnership with University of Florida, Professor Eric S. McLamore. 2017 paper is a partial solution to the problem of detecting Hg contamination in drinking water.

**Datta, S.** (2017) Digital Transformation • [https://dspace.mit.edu/handle/1721.1/111021](https://dspace.mit.edu/handle/1721.1/111021)

**COMMENTS** – Past, Present & Future of IoT - Digital Transformation (albeit incomplete)


**COMMENTS** – Cybersecurity by engineering design at the fundamental TCP/IP layer to secure the communication at the routing protocol level and suggested “cascading gates” for intruder detection as well as the development of a pay per use cybersecurity as a service.


See “Healthcare” MIT Library [https://dspace.mit.edu/handle/1721.1/107893](https://dspace.mit.edu/handle/1721.1/107893)

**COMMENTS** – Comprehensive view of medical IoT and healthcare platform as a part of the biomedical systems re-engineering necessary for medical device interoperability.


**COMMENTS** – Manufacturing systems transparency for industrial internet of things (IoT) and what it will take for pervasive diffusion of digital proxies for any/all system of systems


**COMMENTS** – Analysis of the scope of topological extrapolation of biological neural systems representing structure, but not function, in the context of “intelligence” in AI.

**Datta, S.** (2015) Dynamic Socio-Economic Disequilibrium. *Journal of Innovation Management 3* 3 4-9 [French, Spanish and Mandarin (Chinese interpretation) are available in “CHAPTERS” folder from MIT Library [https://dspace.mit.edu/handle/1721.1/111021](https://dspace.mit.edu/handle/1721.1/111021)]


**COMMENTS** – Economics of change spurred by the principles and practice of connectivity and convergence (IoT) which will influence transaction costs and deepen the skills gap.
http://dspace.mit.edu/handle/1721.1/41902 & https://dspace.mit.edu/handle/1721.1/111021


**COMMENTS** – How IPv6 formatting scheme may create unique identification to map every instance (state change) for every event, everywhere, any time. The potential use as a digital ledger (blockchain) and implications for pay-per-use billing in the IoT economy as well as cybersecurity. The context of this idea may be found in the recent surge of tools and technologies in the bitcoin industry, referred to as blockchain. This is pre-blockchain.


**COMMENTS** – Suggestions for a digital mitochondria in the context of internet of energy.

http://www.crcpress.com/product/isbn/9781439807361


**COMMENTS** – Book chapter outlining use of sensors and data for metabolomics analyses.

Datta, S. (2008) AUTO ID PARADIGM SHIFTS FROM INTERNET OF THINGS TO THE UNIQUE IDENTIFICATION OF INDIVIDUAL DECISIONS IN SYSTEM OF SYSTEMS. *Supply Chain Europe* 17 38-43 (May-June 2008)
https://dspace.mit.edu/bitstream/handle/1721.1/57508/Auto%20ID%20%20Frequency%20Agnostic.pdf?sequence=2


**COMMENTS** – Figure 1 on page 42 of this article re-emphasizes the 2003 concept of the future of IoT (figure was also published in 2004 http://dspace.mit.edu/handle/1721.1/41907 and in a book chapter in 2003 www.wkap.nl/prod/b/1-4020-7812-9?a=1). This article suggests that identification of connectivity includes not limited to atoms (things or objects) but may include bits (decisions). Hence, the idea of connecting information to information.


**IDEA PRESENTED IN THE PAPER (ABOVE) FOLLOWED BY PROOF OF CONCEPT**


**COMMENTS** – Time series error correction econometric technique of Generalized Auto Regressive Conditional Heteroskedasticity (GARCH) modified to respond to high volume (“big” data) RFID data or IoT data, for example, digital supply chain. Paper is co-authored by Sir Clive Granger, 2003 Nobel Prize for Economics. My contribution was to re-frame and re-position GARCH not only for financial operations but to serve as an analytical tool for any high volume data stream, for example, IoT, RFID and “big” data. The idea presented in this thought paper was verified (see 2009 book chapter, above) through an industrial application of data which resulted in commercial profit due to improved predictive analytics.


**COMMENTS** – Two working papers combined in the published version to highlight the need for open data dictionaries, semantic structures and shared ontological frameworks to support interoperability between systems. The rate limiting step in the pervasive diffusion of connectivity and convergence is the inability to communicate between systems and integrate data from different relevant domains to synthesize actionable information from real time data. Problems with systems architecture, proprietary software languages, system specific tools and lack of common API, are detrimental for connectivity and convergence (IoT/IIoT).


**COMMENTS** – In this invited article, I predict (in 2005) the forthcoming iPhone (2007), mobile pay systems, the use of “iPod” for navigation and energy for mobility (cars, trains, planes) based on energy by design in a USB thumb drive format (swappable bits and atoms).

COMMENTS – Prediction about growth of IoT, predictive data analytics and tools. The illustration (Figure 3) in this article (2003) is the current form of the industrial internet (IoT).


COMMENTS – A collaboration between major industries and academia to capture the future of digital transformation, made possible by data, and information extraction from data, to fuel real-time decision support systems, induce transparency and hence, greater adaptability. The book chapter influenced students at the MIT Sloan School of Management and one former student / reviewer (current CEO of Amazon) commented that “these ideas were never before synthesized in this manner” and what industry should follow in the future. These ideas created two books which were published by SAP (where I contributed) “Adapt or Die” and “RFID and Beyond” (book cover author SAP executive / SAP Board Member).


COMMENTS – A review of the use of software agents and ant based algorithms in swarm intelligence for agile decision systems. Use of artificial intelligence, if and when applicable.


COMMENTS – The context of radio frequency identification data in decision systems.


COMMENTS – Uncovered the molecular mechanisms of thyroid hormone resistant forms of thyroid carcinoma in humans. First evidence of thyroid hormone receptor interactions with the transcripational machinery to differentially regulate gene expression of TH receptors
3] Involvement with Grants and Funding

1996-1997  Award from US Department of Commerce, NTIIA
Project ● Interactive University Program (online university – high school partnership for students and teachers)
Collaborators ● University of California, Berkeley and City and County of San Francisco Public Schools
Amount ● $700,000 (approx)

2006-2009  Award from European Union (EU) Commission on Intelligent Systems • FP6
Project ● RFID Integration • http://cordis.europa.eu/projects/rcn/80467_en.html
Collaborators ● Trinity College, Dublin and MIT Forum, MIT
Amount ● €120,000 (approx.)

2017  Submitted
Cybersecurity for Medical Devices ● Dept of Homeland Security and FDA (PI Dr Julian Goldman, Massachusetts General Hospital, Harvard Medical School)

<table>
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<tr>
<th>Proposal Related Documentation</th>
<th>Government Agency (submission/preparation)</th>
<th>Funding Approved</th>
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<td>Autonomous Transportation</td>
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CONSORTIA, COALITION and COORDINATION OF GRANTS
### 4] Liaison with Industry and Governments (incomplete list)

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<td>Volvo</td>
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<td>Tata / Tata Steel</td>
<td>Supply Chain Planning and Optimization</td>
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<td>Workforce and Education for Economic Growth (National Task Force for Clinton Administration)</td>
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Appendix B: Pursuit of Ideas – Open for Global Innovation

WORLD SENSOR ORGANIZATION

THIS IS A PROPOSAL

To create the World Sensor Organization, WSO, a global collaborative entity where scientists and engineers may contribute their findings, and methods, for sensors. WSO will try to transform proof of concepts to field deployable sensor systems. Successful sensor systems may be converted to market ready phase and implemented for designated use, if feasible.

VISION

Thousands of publications, perhaps millions, are generated each year on topics related to sensors. Scientists and engineers are producing laboratory versions of sensors for humans and healthcare, veterinary medicine, environmental and industrial purposes. From this wealth of knowledge, (see http://bit.ly/PLASMONICS) few sensors make it to the market, if transaction costs spell profit. What happens to the outcome of sensor related research? It may collect dust or loiter in cyberspace or found hidden on the second page of Google search. Yet, critical issues for detection, which could save lives or improve the environment, remain unsolved. Translation from vision to market reality, is the rate limiting factor, for many sensor related research results. World Sensor Organization (WSO) aims to partially alleviate this problem through a global consortia (center). WSO will catalyze the convergence of expertise necessary for the sensor to evolve as an integrated sensor system including, but not limited to, signal transduction/capture, data collection software, mobile interface, analytics, visualization, secure access via smartphone apps, delivery of information to the user, cybersecurity and transmission for global connectivity.
RATIONALE

The infectious enthusiasm for entrepreneurial innovation calls for confluence of multiple factors to create the optimum ecosystem. Few locations in the world are able to capture the key factors. Even fewer scientists and engineers possesses the attributes necessary to shepherd their research results to a market deployable product, or service, through the entrepreneurial grind.

Grand imagination often generates great inventions but too many good inventions die without a proper path to innovation. The latter may not succeed without entrepreneurial skills. We are left with an embarrassment of riches, millions of published papers and unpublished ideas, but the fruits of labor are few, and far between, because the continuum is difficult to coalesce. What can we do to drive more ideas to fruition?

Inventors are keen to patent their findings and rush to create start-ups. Stand-alone start-ups ignore the fact that a sensor, no matter how profound in scope, is simply a tool for detection. The ecosystem and local/global connectivity is germane to function. Sensor data/information must trigger action, based on appropriate data analysis after sensor data is available to the system. If the sensor data does not contribute to the decision, its value may perish, rapidly. The integrated system of systems, and transaction costs associated with each event in this cascade, reflects a convergence of technical issues with economics, which must be navigated, in order to arrive at a feasible solution, affordable by the end user and the end-user community.

Solutions, for example, GE Pharmacia BiaCore (old) and Genalyte (new), are marketed as high cost products, suitable for affluent users in wealthy nations (about 10% of the world population). Investors and inventors of sensors, are keen to follow the patent protected profitable path, vying for the 10% of the global population in US, EU and JP (approx. 700 million), in their elusive quest for personal wealth, as a reward for their imagination, invention and innovation.
THE ROAD NOT TAKEN

WSO wishes to “think different” but as an initiative in the US, its germination may face hurdles. World Sensor Organization (WSO) wants to remind the women and men, involved in sensor research, that their work, and outcome, may not have to bite the dust. There is a path to immortality. By contributing their research to WSO and pursuing a collaborative “open source” approach, for translating their sensor ideas, to a deployable sensor system, they may reap the reward of gratification, the reward for enabling science to serve society, the reward for their labor to improve quality of life, the reward for contributing to global public goods.

Few efforts survive in the public domain, without economic incentives. WSO is cognizant of this fact and wishes to introduce the financial reward named “Miss Moneypenny.”

For every sensor event, triggered by every user, WSO will attempt to find a path to extract one penny, in profit, from every transaction. In other words, extracting 1 penny (US one cent) as net profit, by using the “pay-per-use” concept, we monetize “sensor-as-a-service” rather than the sensor-as-a-product, sold as an one-time product. By reducing the barrier to entry into world markets, WSO promotes social business entrepreneurship. WSO can penetrate the global market of 7 billion people. WSO envisions a paradigm shift from the product lifecycle mindset to arrive at the user lifecycle paradigm. The user does not pay for the product but pays for “service” as long as the user lives and uses the service based on this or related products. The product lifecycle may be 2-10 years but the user lifecycle may be 50 years. Hence, micro-payments and micro-revenue for services, provided as micro-payments, during the life of the user, ~50 years.

WSO “sensor-as-a-service” aims to rake in net profit of one penny per use, per person, per day. That translates to 700 million pennies per day, or US$7 million per day in revenue, if only 10% of the global population (700 million) uses a WSO certified sensor, once, each day.
ETHICAL GLOBALIZATION AND ETHICAL PROFITABILITY

In this example, the micro-revenue from ethical profitability, due to economies of scale, from only 10% market penetration, may exceed US$2.5 billion per year.

Development and modularization of product, segmentation of the sequence, work unit synthesis and structuring the alliances to aggregate the end-to-end ecosystem to capture the pay per use billing granularity, are difficult tasks, but nothing that violates any laws of physics or thermodynamics. Hence, it is possible.

Micro-payment based pay-per-use service model can be applied to almost any product if analyzed and dissected with the tools of transaction cost economics. The billing granularity and evidence of use may be captured in a digital ledger. Unique id of each transaction may use the internet protocol version 6 (IPv6) format using a 128-bit hexadecimal system which is capable of generating $2^{128}$ or 3.4X10^{38} unique addresses [ref 13].

The technical convergence in combination with the business model paradigm shift has the immense potential to unlock the power of social business entrepreneurship. The benefits due to WSO may reach remote corners of the world. The barrier to entry is probably low enough to penetrate markets of billions where the per capita earning barely approaches US$1.90 per day.

One cent profit may be too much or too little, depending on the value delivered by the sensor data, demographics of the market and economic bandwidth of the end user community.

The micro-payment model is nothing new and originates from micro-loans and micro-investment practices. It is the dominant model for business wealth created by MacDonald’s and PayPal. Grameen Bank of Dhaka, Bangladesh pioneered micro-loans to women, only. In recognition, Dr Yunus, Chairman of the Grameen Bank, was awarded the 2006 Nobel Prize.
Micro-payments may lead to mega-profits and the model is not limited to sensors. It can be applied to 3D printed automobile or aviation industry spare parts, transplanted hip or knee joints, bidirectional energy arbitrage, autonomous vehicle services, energy storage, home appliances, jet engines, and security-as-a-service for modular, mobile, retail cybersecurity offerings, delivered online or purchased from a corner grocery store or neighborhood Walmart. For related ideas, please explore “18. Commencement” which is a PDF in the zipped folder ‘CHAPTERS’ available from the MIT Library https://dspace.mit.edu/handle/1721.1/111021.

FINANCIAL INCENTIVES

WSO proposes that [a] a quarter of the earnings are distributed to scientists and engineers involved in the sensor system development [b] a quarter of the earnings are re-invested in WSO and its affiliated institutional R&D and [c] a quarter of the earnings are used in projects to spur education and economic growth in the less fortunate nations (our future markets, the emerging economies, for example, sub-Saharan Africa) and [d] a quarter of the earnings are used to strengthen the WSO organization, its foundation or endowment, to ensure uninhibited progress.

WSO is a solution for the vast majority of the global sensor scientists whose work may serve humanity. Aggregating sensor data on open source platforms, with adequate cybersecurity and data analytic tools, will allow sensor information arbitrage in near real-time, at the point of need. What happens when we can measure? We can establish metrics, generate quantitative performance indicators, inform decisions to direct policy, structure appropriations based on information rather than the pork barrel approach practiced by politicians. Policy measures, if pursued ethically, can lead to social re-engineering of communities through distribution of social services, prioritized restructuring of access to healthcare, education and workforce development.
EXTENDED MISSION

WSO is an idea, which, if implemented, may change the world through ubiquitous sensing, at a cost which will grow the global economy, rather than sap its economy by charging $100 for a sensor. It will lift many boats, not just a few yachts. It will empower social business.

WSO will serve as an educational platform, for inspiring undergraduate and graduate students, to train for the steps necessary to transform ideas into reality. The collaboration of global scientists may enable paths to include rigor, innovation and exposure to diverse problems. The potential for successful outcomes through WSO will remind students that completion of their degrees and graduation may lead to that proverbial “light” at the end of the tunnel. The impact of student motivation on graduation rates and research funding may be significant.

WSO may serve secondary education outreach. Almost every discipline, and their convergence, may be exemplified by sensors, sensor systems and sensor networks (similar to the significance of “energy” as a theme for science and engineering). In a manner similar to the Cisco Networking Academy (CNA), which commenced in 1996, as a high school networking lab project (I helped to start CNA at Thurgood Marshall High School in San Francisco, CA), WSO can help to start the Sensor Networking Academy Program (SNAP) in high schools, worldwide.

Hence, WSO is a tool for workforce development through SNAP for secondary and tertiary education. WSO may offer students a variety of opportunities for research in basic sciences, materials science, nanotech, biotech, medical instrumentation, electronics, ASICS, devices, systems engineering, embedded systems, sensors, time sensitive networks, signal transduction, networking, data, analytics, statistics, mathematics, simulation, computer science, programming, AI, telecommunications, cyberphysical systems, standards, cybersecurity and IoT.
BUILDING ORGANIZATIONS

World Sensor Organization is a grand challenge, an idea which will only grow if fertilized with credibility, cooperativity and collaboration. Global community of scientists and engineers, must work with industry, government and non-government organizations (NGOs). Support from the parent institution must be uncompromising and unequivocal.

Building the structure of the infrastructure, necessary to create this organization, in a sustainable manner, will require greed-free leadership. Individuals who are oblivious to not receiving credit, individuals who are dedicated to serve as an instrument, individuals who are committed to science as a tool for social progress, individuals who are not prioritizing personal wealth creation, individuals who believe in creating economic growth, individuals who are capable of excellence in communication across a very diverse spectrum of stakeholders, globally, at multiple levels, including science and engineering, engaging the public, as well as cultural respect, diplomatic finesse and political-context awareness. Building trust is the secret sauce.

As with any consortia, seed funding for organizational nodes may be quintessential for lift-off. The primary step is to build the foundational coalition with appropriate credibility and “hooks” to reflect the vision of the World Sensor Organization, at a global scale. Unlike traditional consortia, WSO may not operate on an “entry fee” mechanism, in order to uphold its claim for public goods. Hence, “joining” the consortia and “member finances” for the WSO, must be separate operations, without dependencies. This will make our task hard, financially. The leadership must remain cognizant of the steep path which we must scale for future success.

WSO members are expected to be individual engineers/scientists/students, institutions, NGOs, organizations, corporations, government agencies, governments, international standards bodies and associations.
WSO may be financed by gifts, seed funding, endowments, grants, foundations, and these categories (listed to show increasing amounts) “friends” ($1K+), “partners” ($10K+), “contributors” ($100K+), “patrons” ($1M+), “sponsors” ($10M+) and “donors” ($100M+).

Working groups (WG) and special interest groups (SIG) will be created to modularize and distribute the operations, starting with sourcing (when an idea is contributed) and extending to systems oversight.

Liaison with standards bodies may be required to ensure that the work and outcome from WSO is in compliance, or creates new standards, which must be interoperable with other existing standards, or possesses the requisite characteristics for pursuing global adoption.

WSO use cases for sensor research, development and applications must offer a broad portfolio, to attract membership from diverse industries and government agencies, for example, [a] machine, tools, 3D manufacturing [b] oil, gas, water, energy, desalination, natural resources [c] environment, communities, smart cities, sewer systems, emergency management systems [d] healthcare and medical IoT (https://dspace.mit.edu/handle/1721.1/107893) [e] Digital Twins in manufacturing systems, maintenance, transportation, aviation, (please see “04.Digital Twins” PDF in the “CHAPTERS” folder accessible from https://dspace.mit.edu/handle/1721.1/111021) and [f] agriculture including animal farming (micro-robots in cows to monitor metabolomics of lactation).

WSO may evolve in ways we may not anticipate due to the plethora of unknown unknowns. But, WSO must be capable of generating value from research, education, students and applications. The primary goal of the coalition is to advance research outcomes and promote education which can create new leaders, endowed equally with scholarship and leadership.
RISK

The central thesis of WSO is to “apply” the research outcome from scientists, and shape it through further R&D, to serve a purpose, which generates value through sensing. By connecting the sensor data with the sensor ecosystem, we make sense of the data and extract actionable information. The information may improve a function or performance, in near real-time. By connecting this data and/or information to real world situations or by connecting a “swarm” of sensors, we may optimize processes, workflows, automation or improve accuracy, and/or precision, of diagnostic, predictive or prescriptive analytics. Taken together, using control feedback loops or decision support, we deliver dynamic optimization, due to the sensor.

The central problem in this proposed concept of WSO is the assumption of the existence of trust and altruism, not only in sourcing the sensor idea or scheme, but also in working with the partners in the ecosystem, which is salient to the delivery of value from sensing to the end user. [a] Why will an engineer or scientist trust WSO to contribute her/his research? [b] Why will the partners of the ecosystem (for example, manufacturing execution systems or MES) allow WSO to work with its systems? [c] Can we identify and define the transaction costs associated with each stage? [d] What degree of systems interoperability do we need, to uniquely track and trace every change of state, in order to bill the client for the service used, according to pay-per-use?

Question [a] is crucial. If WSO cannot be trusted serve as the global sensor research repository, then the central thesis is null and void. Explicit institutional support and the ability to bring together a team of pioneering global leaders, as co-founders, may be the first step to earn trust. For question [b], gaining agreement to create a few real world test beds with industry and corporations, may elevate the trust level. The latter may help to engage with governments and agencies, at home and abroad. Can we get a critical mass of pioneers to support the WSO vision?
References


