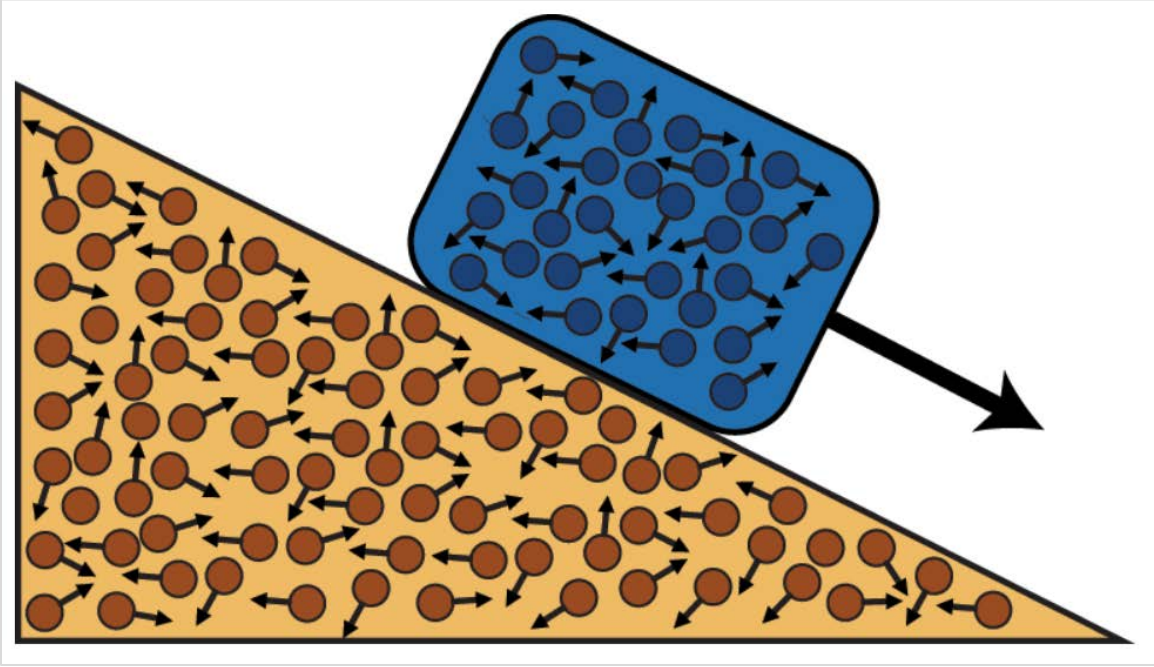
CONNECTING ATOMS TO BITS – WHY IT MAY NOT BE ENOUGH ?

IOT IS A DESIGN METAPHOR for DIGITAL TRANSFORMATION X.0

Shoumen Palit Austin Datta



ESSAY

CONNECTING ATOMS TO BITS

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ABSTRACT

Threads of amorphous discussions, historical references and atypical examples, the author admits, is unconventional. In one prior engagement, the author was repeatedly excoriated for garrulity. Some people do not like to read more than a page, managers seek executive summaries, executives limit reading to bullet points and VCs prefer elevator pitches, under thirty seconds. The trend in this article may disappoint those individuals.

Synthesis of information helps us to illustrate the evolution of thought. Digital transformation, is a pragmatic topic of interest to industry and business, but it is vast. The scope of digital penetration remains unfathomable. Innovation is quintessential in this context. Old ideas must be viewed by the youth with a set of different eyes. Hence, the "think different" adage rings true. Pursuit of ideas, must reflect on a large number of issues, combined and connected with diverse domains. Leaders must resist the "hype begets hype" trend and ignore slick marketing attempts to perpetuate hype cycles.

If this approach discombobulates your comfort zone, or if you prefer convention, then, you are at the mental stage possessed by billions. *That* stage will change, sooner or later. In some regions, we are almost at the end of the lag, and ready to begin a climb. The metaphorical climb is not magical. It is due to the evolution of IoT and digital transformation. On this journey, rational digital economics will serve as our compass, as we navigate through the sign posts of progress, and attempt to map the road, ahead.

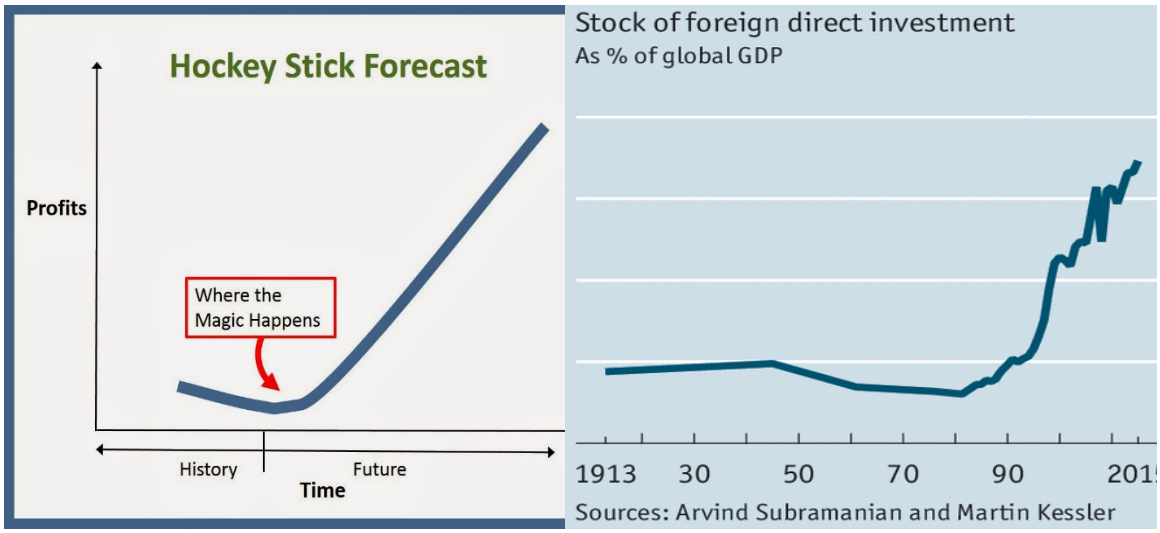


Fig 0: *Hockey stick* model illustrating a preparatory phase followed by rapid growth.

PREFACE

The ideas relevant to the internet of things (IoT) has a rich history. Perhaps, it was seeded by the short stories authored by Isaac Asimov. In 1953, Asimov's "Sally" was conceived as an autonomous vehicle[1], cruising our streets in 2057. Herbert Simon[2] in 1986 and Mark Weiser[3] in 1991 are notable visionaries who contributed to the evolution of our thoughts, related to the metaphor of internet of things (IoT). In 1999, at the MIT Auto ID Center, Kevin Ashton, a marketing expert, loaned to MIT from Procter and Gamble (P&G), proposed the term internet of things[4] or IoT. In the past few years, it has been suggested[5] that the exact term (IoT) was first used by Peter Lewis[6] in 1985, which was even before the seminal talk by Herbert Simon in 1986. Parallel observations and discoveries are nothing new, as acknowledged in a recent publication[7] by Sanjay Sarma.

In this discussion, I have offered "my version" of a sense of the future, partially with respect to IoT. My purpose is not to be correct or right about these ideas, but to propose them, try to disseminate these ideas, allow experts to dig deeper and provide students with a few clues, about the principles and practice of connectivity and convergence. It is a sentiment borrowed[8] from Pierre-Gilles de Gennes (1932-2007).

This article is aimed at informing [a] experts, who may talk, generally, to other experts in their field, most of the time, [b] faculty, who are digging deeper and deeper, into fewer and fewer micro-domains, accumulating vast repertoire of knowledge and research publications, but may not have the time to explore the connected world, or the networked society, or the chasm precipitated by the socio-economic disequilibrium catalyzed by the quantum leaps of technology, [c] industry executives, forced to focus on financials, but eager to view the big picture, yet handicapped to provide leadership due to the alarming frequency with which the next quarter rapidly approaches, and P&L results which influences the 'writing on the wall' by analysts, peddling prosperity [d] heads of government agencies or aides to legislative bodies or think tank gurus or the heads of governments, in quest of ideas or vision for public goods, or tools for economic growth, [e] administrators of global organizations, institutions, non-governmental organizations and multi-national platforms (standards bodies, policy roundtables, economic forums), who may influence the direction of future growth, development of science as a service to society, the pursuit of human values, and the elusive quest for égalité.

The most important purpose of this article is to inform students, about known unknowns, clues to unknown unknowns, and how to challenge conventional wisdom, about IoT concepts, in order to develop a broad spectrum of IoT umbrella initiatives. But, in conclusion, I point out that digital transformation and IoT is only a part of the picture.

My purpose is not to provide answers, even if the content may appear, in parts, to offer suggestions/solutions. Ideas in the article, often disjointed, may trigger the reader to delve into her own thoughts on the topic. The content is supposed to act as "hooks" or unfinished structures, the reader may choose to extend, or continue to build, or demolish, the idea. The failure of my ideas may be considered a success if it triggers new ideas.

My emphasis on debate, dissent and discussion of ideas, is due to my belief that IoT, a digital-by-design metaphor, represents connectivity and convergence, partially, in a plethora ways, known and unknown, at this time. Scientists, engineers, professors and professionals, cannot provide all the answers, cannot imagine the future where students may travel, and cannot address tomorrow's initiatives, armed only with yesterday's tools.

Hence, my zeal to distribute these and other 'different' thoughts, not to be revered, but to serve as whipping blocks, to be proven incorrect, to be questioned. Perhaps, in an attempt to prove them wrong, or in questioning the suggestions, the next generation of leaders, and students, may find the triggers to ignite their imagination. They may invent and innovate solutions, with tangible benefits, which could lift many boats.

Commodities makes the world go around. Energy, water, food, health, education, sanitation, communication and civil safety, are the pillars of life on earth, as we know.

GDP, CMOS, IPv6, SVM, GARCH, RBC, ANN, are parts of the "Alphabet" *soup* which the primary care nurse recommends, in addition to an *Apple* a day, to keep the doctor away. This *soup*, and its many ingredients, may help to deliver the commodities.

IoT is a metaphor for solutions and applications, in the *'service'* of these and other commodities, to the global population, for socio-economic progress of humanity. Multi-domain application of the IoT metaphor has the potential to catalyze social re-engineering. By lowering transaction costs, IoT lowers the barrier to entry. Hence, IoT may penetrate markets of billions, rather than a few nations, with the affluent millions. The tsunami of changes on the road ahead will not be fostered by didactic pedagogy in closed loop disciplines or any one nation or a few institutions or corporate oligopolies.

Mobility has, and will continue to redefine, security, energy, education, health, finance and emergency response systems. Conglomerates and products may be reformed by personalization, experiences and services. Vertical integration may regress in the face of horizontal platform aggregation, for consumers and industries. Consumption of things and objects may be substituted by data of things. Consumers may only pay for integrated information at the point of need or point of care or point of transaction. Subscriptions to services and premiums (insurance) may be transformed by pay-per-use micro-payments. The penchant for next quarter earnings may no longer be a key performance indicator.

Decisions[9] and processes may be optimized by humans in the loop, using tools from AI, ML and DL, but humans may not be replaced by AI *avatars*, much to the chagrin of Hollywood. AI and automation will accelerate repetitive manufacturing, may aid humans in dangerous jobs (cleaning nuclear leaks, spills), improve precision and accuracy in certain domains, offer assistance to people immersed in monotonous tasks, provide occasional relief to workers for bio-breaks, assist the transportation industry and serve laughter, through comic relief, by winning against humans in GO or may jeopardize George Alexander "Alex" Trebek's job as the host for Jeopardy. In the world at large, except the space station, automation may not serve us tea via robots, deliver palliative care to geriatric patients or care for pre-term infants in the neonatal intensive care unit.

The metaphor of IoT, and ideas in this article, may seem haphazard, yet real. This is borrowed from *Haphazard Reality* by Hendrik Brugt Gerhard Casimir (1909-2000), the famed Dutch physicist, known for the eponymous Casimir effect and the Casimir-operator in quantum mechanics. Part of the ideas are also borrowed, from the past, present and the future. It is presented here after processing through a different lens, often synthesized in the context of different thinking and hopefully, may be reviewed by different audiences. Part of the problem is my inclination to write in complete sentences and not in bullet points or executive summaries with a predicted "time stamp" of how long it will take an "average" reader to read the material (as often found "stamped" on articles published by the august Harvard Business Review and McKinsey Quarterly).

If *reading* was equivalent to comprehension, then we may not have witnessed the impact of invention of printing, for example, on poetry. When a poem can be read, and re-read, the emphasis shifts from the rhyme and the rhythm, to the allusion and the allegory. The latter is akin to a painting, it adds color to our *imagination*.

Part of the strength of this approach (you may choose to disagree) are its frequent, and haphazard, digressions, to connect the dots, from a myriad of sources, disciplines, and history. This is not a conventional mechanism to *teach* you any subject, but it may help you to *think*, *learn*, *connect* and, ask *questions*, hopefully, the *correct questions*. Asking the correct questions, remains the most difficult task, through the ages.

"In the 1970's, atomic energy [will be] replaced by solar energy as an inexhaustible source of new power...solar energy [will] revolutionize the world through supplying man with an inexhaustible and previously largely untapped source of cheap power. The amount of such cheap power available to the world in 2000 will be beyond comprehension."

Source: Henry C. Nicholas, "Cheer Up! World to be Wonderful 50 Years From Now, Savants Say," Kentucky New Era, Wednesday, **March 5, 1952**, p. 10, about meeting of the International Congress of Astronautics (London) and the Convention of the American Chemical Society (New York)

'Streetcar' Is Movie Winner

Cheer Up! World To Be Wonderful 50 Years From Now, Savants Say

It Happened In Kentucky

Fig 1: Article by Henry C. Nicholas in *Delta Democrat-Times* (Greenville, MS) on February 8, 1952. The article quotes James Bryant Conant, then President of Harvard University. Courtesy of Alain Louchez. Source: www.smithsonianmag.com/history/the-world-will-be-wonderful-in-the-year-2000-110060404/

INTRODUCTION

The thorn in any transformation is the perspective of the leadership. Pre-set mental boundaries, in some humans, once imprinted, engages in a herculean attempt to gain comfort, and then, controls the metaphorical *turf* or territory. It clings desperately and tries very hard, to remain oblivious of change, it prefers to stay cloistered, remain inside the *box* and try to disregard advances, as fads, soon to evaporate from reality.

The 'hockey stick' illustration (Fig 0) and generic sigmoidal curves, exhibit an initial period of diminished activity, or lag, represented by a slow growth (flat) trajectory. This is contributed by, among other things, the resistance to change. The latter weighs down attempts to adopt change, even when necessary. It creates barriers to embrace the *next new* economy. Digital economics, at this time, perhaps, is the next "new" economy.

Figure 2 reflects a 'hockey stick' embedded in the sigmoidal trajectory, emerging from the work of Norman Poire[10], an economist and economic historian. Poire's model uses observations attributed to Austrian economist Joseph Schumpeter, circa 1940, who noted a 50+ year cycle of ebb and flow, accompanying "new economies" leading to global economic growth and developments.

In the illustration below (Fig 2), I have included my projections (circa 2000), to highlight the progression from the physical world of atoms, to the transformation, in terms of the digital economy, where information about atoms may be represented by bits (**Digital Twins**) or bits, *per se*, may be information or data from decisions, processes and things, referring to the internet of things or IoT and industrial IoT. A few projections[11] did not materialize[12] but exceptions may prove the rule, albeit, partially. Other models by Poire (see Figure 24) suggests that the 2020's may witness transformative changes.

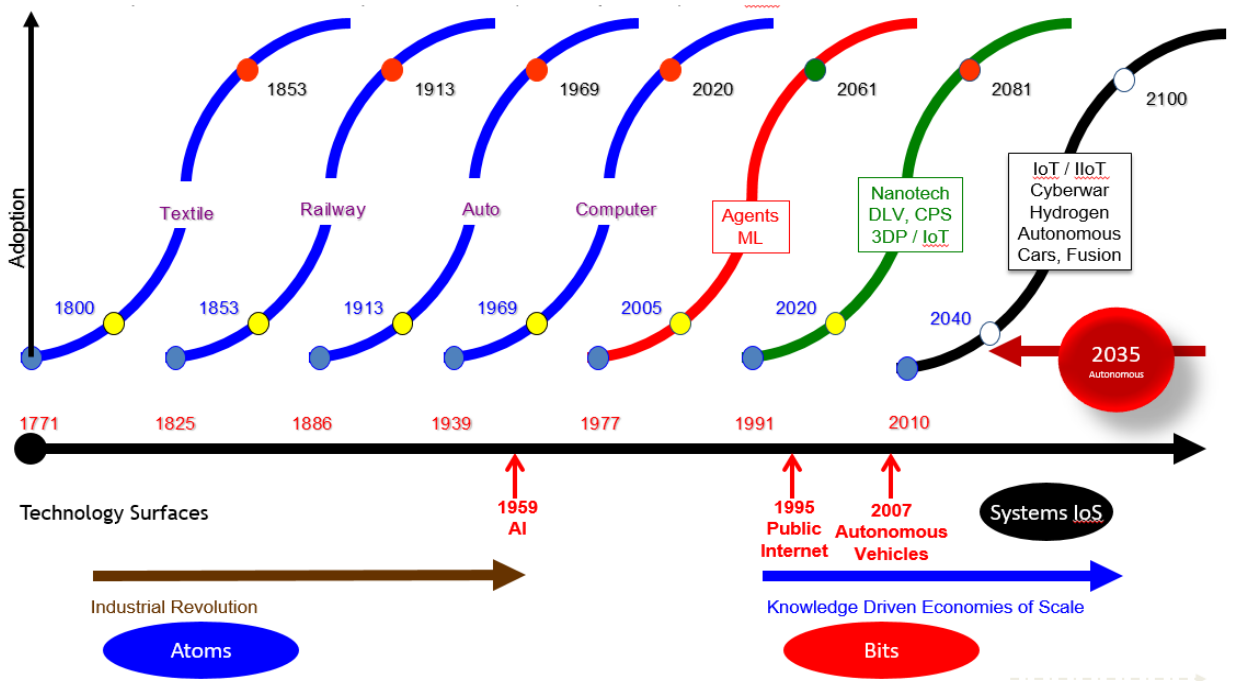


Fig 2: Advances follow a pattern, punctuated by certain intervals, in models by Poire.

THE PROPHASE FOR DIGITAL TRANSFORMATION

Before eukaryotic cells can replicate (cell division in plants, animals, including humans), the cell undergoes a prolonged phase of internal changes. The cell takes time to prepare, prior to the commencement of active phases, preceding the actual division of the cell. This phase is referred to as the prophase in the cell's cycle of replication or division.

As an analogy, the prophase for digital transformation may be divided into two parts, prophase 1 and prophase 2. Prophase 1 starts with hand stencils, which appears to be about 35,000 years old. The culmination of prophase 1 may be the Cuneiform script, circa 3500 BC, in Sumeria (Mesopotamia). It was probably the first time that thoughts or ideas, were transferred from the mind, via the stencils and then the scripts or pictographs, to tablets. Prophase 2 started in the Far East, with wood block printing circa 200 AD, but sprang to life with the discovery of the printing press by Johannes Gutenberg, circa 1440.

From the cuneiform script to the printing press spans about 5,000 years. This is the time it took to create tools for democratization of information. How many people read the Epic of Gilgamesh, which was written in cuneiform and carved on the Deluge tablet[13] circa 2000 BC? How many read "If" by Joseph Rudyard Kipling? One had to be a Queen to have the resources, to read the Epic of Gilgamesh. The transaction cost, was too high. In the post-printing press society, 'If" was accessible to people during Kipling's lifetime (born on 30 December 1865 in Bombay and died on 18 January 1936, in London). In the 21st Century, 'If' may be downloaded for free. If the transaction cost is approaching zero, then please thank the digital economy, for lowering the barriers to market penetration.

Transaction cost[14], pioneered as an economic staple by Ronald Coase (1937), is not the only lubricant for digital transformation. The human transformation to capture information and replicate information (stone tablets, papyrus, paper, books, bits) have had profound impact. The King as well as the citizen, the CEO as well as the clerk, the President as well as the janitor, can, now, access the ***same*** information. Ideas by Marshall McLuhan[15] promotes that anyone, anywhere, may consume the same information. We are now able to democratize data due to advances in digitization and digital transformation.

Fig 3: The President and janitor may access the same information in a digital democracy.

The broad spectrum of digital transformation, which includes a future where Digital Twins[16] may exist, may transform Marshall McLuhan's suggestion to reality, for diverse verticals, ranging from manufacturing to robotics, energy systems to healthcare.

The preparation for digital transformation, the prophase, is nearing its concluding segment in OECD nations, but still struggling, in pockets, within ASEAN and USAN nations. The discrepancy between the economic zones is mostly due to structure of investments in infrastructure. Meaningful convergence of technologies is catalytic for digital transformation to grow sufficient roots, adequately fertilize markets in order to boost economies of scale, and improve profitable outcomes for economic development.

TOOLS FOR DIGITAL TRANSFORMATION

It bears reminding that the plural of anecdote is not evidence. This observation concerns Microsoft and the context is the infrastructure for digital transformation. In other words, the tools we need, must evolve and be available to the masses, in order to support digital transformation. Figure 4 shows the market cap of top 10 companies from 2001-2011. During this period[17], US companies faced a return to the economic phase of 17th century England when NASDAQ lost 78% of its value (5046.86 to 1114.11) between March 11, 2000 and October 9, 2002. The "dot com" bubble was attributed, by some observers, to laissez faire economics. In contrast, the collapse of the Lehman Brothers in the US, ignited a global recession. The collapse was manufactured by deliberately structuring financial instruments, to peddle greed, by a few financial institutions. The S&P 500 declined 57% from its high in October 2007 of 1576 to its low in March 2009 of 676. Only Microsoft (and ExxonMobil) remained in the top 10, by market cap, during this decade (2001-2011) of "dot com" and "sub-prime" mediated financial turbulence.

2001	Name	HQ	Industry	Market Cap USD million
1	GE	US	Various	477,406
2	Cisco	US	Network	304,699
3	Exxon Mobil	US	Oil & Gas	286,367
4	Pfizer	US	Pharma	263,996
5	Microsoft	US	Software	258,436
6	Wal-Mart	US	Retail	250,955
7	Citigroup	US	Banking	250,143
8	Vodafone	UK	Telco	227,175
9	Intel	US	Computer	227,048
10	Royal Dutch Shell	NL/UK	Oil & Gas	206,340

2008 [3]	Name	HQ	Industry	Market Cap USD m
1	Exxon Mobil	US	Oil and gas	403,366
2	Petrochina	China	Oil and gas	325,320
3	GE	US	Various	253,674
4	Microsoft	US	Software	243,687
5	Wal-Mart	US	Retail	235,605
6	P&G	US	Retail	211,460
7	Industrial Commercial Bank of China	China	Banking	208,397
8	Berkshire Hathaway	US	Insurance	202,901
9	China Mobile	China	Telco	198,558
10	J & J	US	Health care	193,602

	2011 [1]
1	Exxon Mobil 417,166.7
2	PetroChina 326,199.2
3	Apple Inc. 321,072.1
4	Industrial and Commercial Bank of China 251,078.1
5	Petrobras 247,417.6
6	BHP Billiton 247,079.5
7	China Construction Bank 232,608.6
8	Royal Dutch Shell 226,128.7
9	Chevron Corporation 215,780.6
10	Microsoft 213,336.4

Fig 4: Microsoft survived the economic turbulence (Top 10 list by market capitalization)

In another analysis (Fig 5), which covers about a decade (from 2005 to 2015), economic volatility created a sinusoidal path, but failed to eject Microsoft (and ExxonMobil) from the top 10 list[18] of globally dominant companies.

2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
General Electric	General Electric	Exxon Mobil	Petrochina	Exxon Mobil	Petrochina	Apple Inc	Apple Inc	Apple Inc	Apple Inc	Apple Inc
Exxon Mobil	Exxon Mobil	General Electric	Exxon Mobil	Petrochina	Exxon Mobil	Exxon Mobil	Exxon Mobil	Exxon Mobil	Exxon Mobil	Alphabet Inc
Microsoft	Citigroup Inc	Microsoft	General Electric	Microsoft	Apple Inc	Petrochina	Petrochina	Microsoft	Alphabet Inc	Microsoft
Citigroup Inc	Microsoft	Citigroup Inc	China Mobile	China Mobile	ICBC	BHP Billiton	Microsoft	Petrochina	Microsoft	Berkshire Hathaway
Wal-Mart	BP Plc	Gazprom Pao	ICBC	Wal-Mart	Wal-Mart	ICBC	ICBC	ICBC	Berkshire Hathaway	Exxon Mobil
BP Plc	Wal-Mart	Petrochina	Gazprom Pao	ICBC	CCB	Petrobras	IBM	China Mobile	General Electric	Amazon.com
Pfizer Inc	Bank Of America	ICBC	Microsoft	General Electric	Microsoft	CCB	Chevron	Alphabet Inc	Johnson & Johnson	Facebook
Bank Of America	HSBC	Bank Of America	AT&T	AT&T	HSBC	Microsoft	Alphabet Inc	Wal-Mart	Wal-Mart	General Electric
Johnson & Johnson	Johnson & Johnson	AT&T	Petrobras	Apple Inc	Petrobras	BHP Billiton	Wal-Mart	Berkshire Hathaway	Chevron	Johnson & Johnson
HSBC	Toyota Motor	BP Plc	BP Plc	Johnson & Johnson	Alphabet Inc	China Mobile	China Mobile	General Electric	Wells Fargo	Wells Fargo

Fig 5: Global tech dominance by US companies (illustration from Goldman Sachs)

Can we make any sense about digital transformation from these illustrations? It may be a bit heretic to arrive at any conclusion, but perhaps there is a suggestion lurking between the lines. The only other US company that kept pace with Microsoft in these lists, is ExxonMobil. It is a commodity company. Will it be too much of a stretch to suggest that Microsoft, too, may be viewed as "digital" commodity company?

Technology companies are producing and servicing the *digital commodities* necessary to pursue digital transformation. Tech companies are purveyor of tools, to accelerate the adoption and diffusion of digital transformation. Tech companies servicing *digital commodities* may continue to amplify their profitability, seed global economic growth and lead the digital economy. If digital economy were to grow deeper roots, all forms of digital transformation must be pervasive and form a part of our daily lives. The latter is one definition of a commodity. If WiFi isn't a commodity, then what is it?

Digital tools and their applications are commodities, for citizens in a connected world, the networked physical world of things or objects and the networked society. From that perspective, the portfolio representing the primary source of revenue, for five tech behemoths (Fig 6), suggests why Microsoft, as a purveyor of digital commodities, may weather storms, endure turbulence and survive economic volatility. Connectivity and commodities (products) are essential, hence, continued optimism for Apple and Amazon.

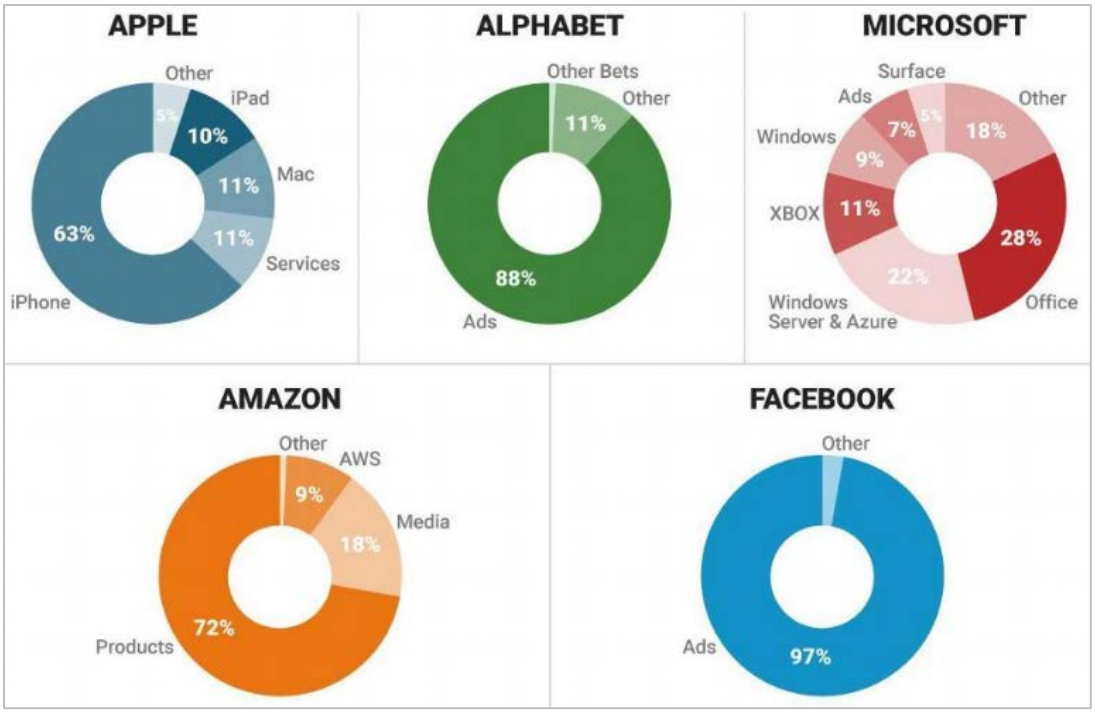


Fig 6: Revenue streams[19] of US technology behemoths and the “ads” percentage in each.

Products may be simplified into two categories – push and pull. Products in the pull category are “things” (products, services) which are consumed (B2B, B2C, C2C). Push is distributed, almost irrespective of demand. Microsoft (Fig 6) produces and serves the digital commodities sector, the “pull” category because consumers consume.

Advertisement (ads), which are pushed, may have restricted viability. In other words, there is only so much that an advertisement can expect to achieve. Hence, the dependence on ads, sooner or later, may approach its growth limit. Disproportionate reliance on ads as a revenue stream, offers room for doubt about the viability of such a business model. Yet, in the short term, both tech giants (Fig 6) seem infallible, in their approach. Perhaps there is still enough advertising budget yet to move from print and other audio-visual media to the digital domain, which can tailor customer-specific ads.

The question of how much advertisements can achieve, in terms of sales, is worth exploring. Perhaps a model can be created (may exist) where a product or service (being advertised) may be assigned a penetration score based on [1] cost of product or service [2] purchasing power parity vs the “need” for the product/service [3] demographic spread of income vs disposable income or discretionary spending by households/individuals and [4] other factors, for example, brand recognition, social trajectory (status), philanthropy.

Using an “area under the ROC curve” tool, the model may suggest the boundaries of buying power. No matter how much you advertise, the outcome may be restricted within a buying power “area” under the ROC (Receiver Operating Characteristic) curve.

ROC analysis is part of "Signal Detection Theory" developed during World War II for analyses of radar images. Its current usage spans a vast spectrum of applications, including medical applications[20] pioneered[21] by Charles Metz[22].

DATA IN DIGITAL TRANSFORMATION: INFORMATION ARBITRAGE

The importance of data in decision making is not a new facet for the 21st century. Bargaining was the key *modus operandi* to negotiate dynamic pricing, in the bazaars of Mohenjo-Daro[23] and Harappa[24], during the "modern part" (3500 BCE-1800 BCE) of the Indus Valley Civilization which dates back[25] to 7000 BCE. Bargaining was the life blood of commerce for traders on the Silk Roads[26] and Silk Routes (500 BCE to 500 CE).

From 2nd century BC to end of 14th century AD, a trade route originated from Chang'an (now Xian) in the east and ended at the Mediterranean in the west, beyond Venice. Hence, linking China with the Roman Empire. The Great Bazaar[27] in Istanbul is rooted in the Silk Route. Kapalıçarşı[28] or Büyük Çarşı, began as a small strong room, the Bedestan, built in 1461. It grew to cover 100 acres, and now has 18 gates and about 4000 shops, drawing about 91 million annual visitors. All kinds of bargaining behavior evolved; complex negotiations done simply by hand gestures, carried out beneath the cover of a shawl to prevent prying eyes from knowing what deals were being struck.

Bargaining, hence, was the first form of data arbitrage or information arbitrage. The importance of data is neither unique to digital transformation nor did it dawn upon us in the recent past. Data and decisions are inextricably linked and has always been, even ***before*** the evolution of human speech. Imagine humans using gestures to signal or warn that an animal is approaching.

It is ironic that pre-Neanderthalic gesture communication is being re-invented by BMW[29] to enhance the ultimate driving experience. Gesture appears to be the new toy[30] in the connected world but has the potential to serve humans with speech impediments.

Fig 7: Silk Roads and Silk Routes – trading valid for the period 500 BCE to 500 CE. In 1877 the term "Seidenstraße" (Die Seidenstrassen, literally "Silk Road") was coined[31] by the German geographer, cartographer and explorer Ferdinand von Richthofen.

Perhaps even more incredible, is the use by the United States, the ethos of the messengers on the Persian Royal Road. During the Achaemenid Empire (500-330 BCE), the Persian Royal Road ran from Susa (modern day Iran), to the Mediterranean Sea in Asia Minor (modern day Turkey). It served as one of the main arteries of the Silk Road, the network of trade routes, formally established during the Han Dynasty of China, which linked the regions of the ancient world, for commerce. The Persians maintained the Royal Road carefully and, in time, expanded it through smaller side roads. These paths eventually crossed down into India, across Mesopotamia, and over into Egypt.

The Persian Royal Road featured postal stations[32] along the route, with fresh horses, for envoys to quickly deliver messages throughout the empire. Herodotus, writing of the speed and efficiency of the Persian messengers, stated:

"There is nothing in the world that travels faster than these Persian couriers. Neither snow, nor rain, nor heat, nor darkness of night prevents these couriers from completing their designated stages with utmost speed."

These lines, from his Histories, 8.98, would, centuries later, form the creed of the United States of America's postal service[33](USPS).

Data, and its time-sensitive arbitrage, as well as exchange and communication, are central to human evolution. The amount of data, its visual representation and extracting its contextual significance, has evolved over time. Digital transformation is yet another chapter in this evolution, as we sharpen our repertoire of analytical tools and continue to add new techniques for analysis of data, to make sense of its meaning and visualize data.

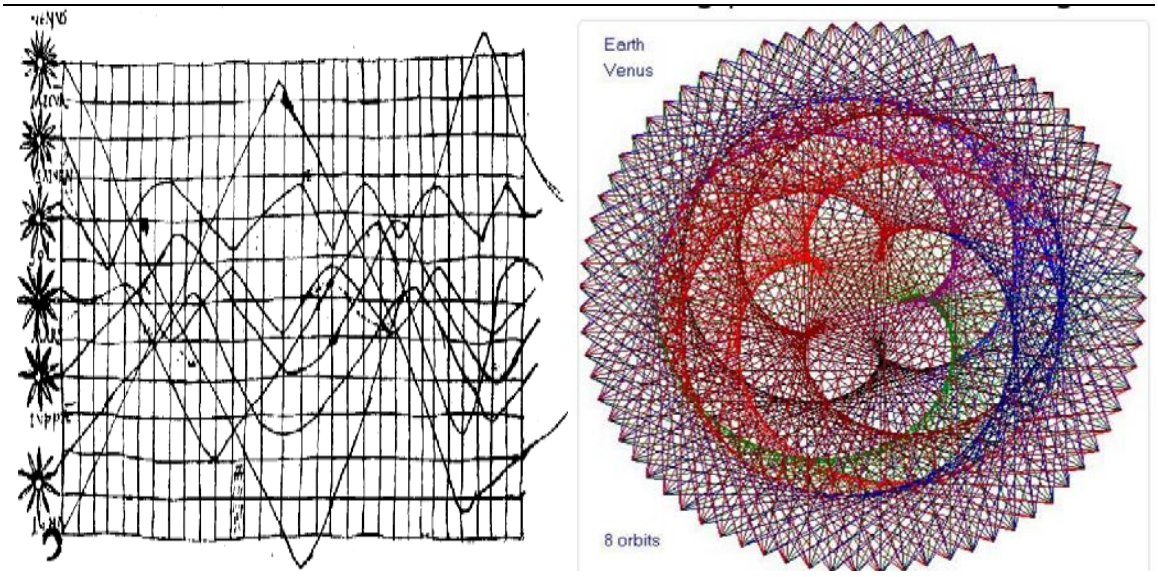


Fig 8: Visualization – (Left) Positions[34] of Sun, Moon, Planets, from 950 AD, Europe. (Right) Positions[35] of Earth and Venus (?) over 8 years (science[36]). A fractal[37] pattern?

In the evolution of internet of things, the principal emphasis is on data. In other words, we can think of IoT, to serve as a design metaphor for DoT or “data of things” implied in the principle of connecting bits to bits. That is, connecting not only data about things (bits about atoms) but also data about data or information store (bits about bits).

Because these data stores and things must be connected to be a part of a system or ecosystem, the network of the internet serves as the connectivity medium and gives rise to the recent concept of NoT or network of things[38] advocated by NIST. NoT reinvents a concept which shares common grounds with Metcalfe’s Law.

Metcalfe's law[39] states the value of a telecommunications network is proportional to the square of the number of connected users of the system (n^2). Attributed to Robert Metcalfe in regard to Ethernet, Metcalfe's law was originally presented, circa 1980, not in terms of users, but rather of "compatible communicating devices" (for example, fax machines, telephones, etc.). Later, with the globalization of the internet and the rapid diffusion of the concept of IoT, the idea was carried over to include, perhaps erroneously, users and networks. Its original intent was to describe Ethernet connectivity.

The significance of the “network effect” in these concepts relates to the value of information from one node versus a network of nodes. A multitude of nodes can act as a *swarm*. Data from such *swarm*s may lend itself to analysis using the principles of swarm intelligence, for example, ant-based algorithms, used in network optimization routines[40] and sensor networks[41] in addition to emerging applications in digital twins (see Chapter 3 in *Haphazard Reality – IoT is a Metaphor*[42]).

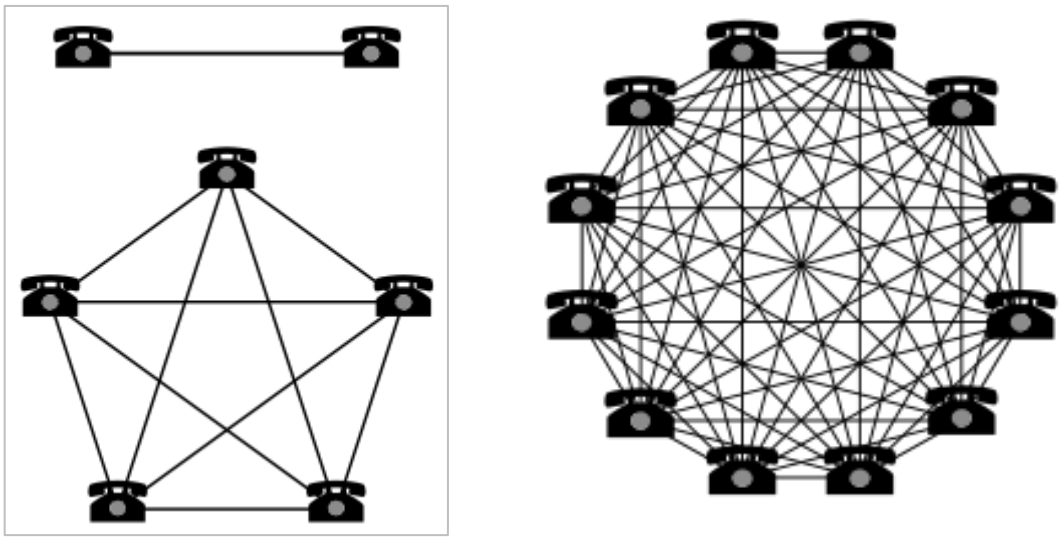


Fig 9: Two phones can make one connection, 5 can make 10 connections, and 12 can make 66 connections [12(12-1)/2]. Metcalfe's Law is related to the fact that the number of unique connections in a network of a number of nodes (n) can be expressed as the triangular number $n(n − 1)/2$, which is proportional to n^2 asymptotically (ref 39). In other words, the apparent value of the network increases with the number of connections. Hence, Metcalfe’s Law, adapted to serve special interests, highlights the “value” of social networks. The latter has created grand illusions, catalyzes various forms of delusions and increasingly, we witness the transmutation of tabloid fodder, from speculation, to truth.

HYPE OF ARTIFICIAL INTELLIGENCE IN DIGITAL TRANSFORMATION

The present day unscrupulous marketing, about the power of, and benefits from, artificial intelligence, is reminiscent of the campaign of lies orchestrated by the US sugar industry. These "lies" stretch over the past 50 years[43] and the most egregious act[44] by the sugar industry was to bribe Harvard researchers[45] to publish false results, to shield the ill effects of excessive use of sugar[46], exposed in a JAMA[47] paper on September 12, 2016.

The exponential volume of deliberate false marketing and claims about AI by certain corporate behemoths, is increasingly amplified through ill-informed "me-too" social networkers, craving self-promotion.

This disingenuous AI barrage has all but drowned out the reasoned voices of credible scientists and genuine thought leaders, who are reluctant to be pro-active and abide by a code of decorum, prefers understatement, and are generally not narcissistic.

Artificial Intelligence (AI) and its lack of intelligence, is neither news nor new (see Chapter 4 in *Haphazard Reality – IoT is a Metaphor*[48]). The term AI is a misnomer but has caught the public imagination. John McCarthy coined the term and used it in the August 31, 1955, proposal for the Dartmouth Conference[49] to be held during the Summer of 1956. The usefulness of AI is a fact but not in the manner advertised, at present.

Making sense of data is central to profitability in the digital economy. Traders who were bargaining in the ancient bazaars had a limited set of data (for example, price of goods). The data set was sufficient for humans, with good memory, to develop astute bargaining skills, through data arbitrage, and excel in dynamic price optimization.

Even super-humans, with photographic memory, may not be able to navigate the pricing data from one single vendor, Amazon[50], which sells over 480 million products in the US. Amazon's product selection expanded by 235 million since Q1 of 2016. It has added, approximately half a million new products (485,000 SKUs), per day.

Dealing with such immense data volume is a major handicap for humans and the primary benefit from computation and data analytic tools, including AI type applications. Imagine the delivery planning[51] optimization problem for goods delivery from Amazon.

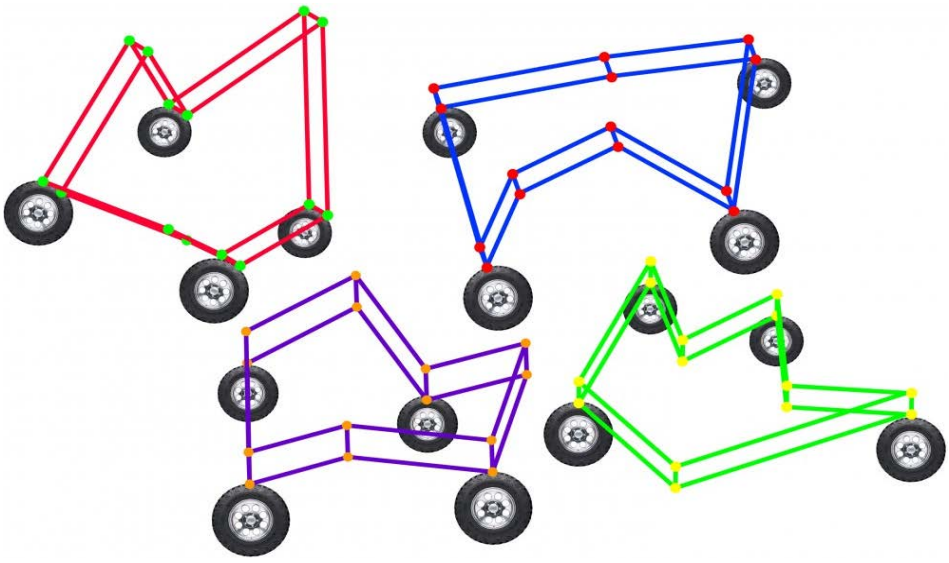
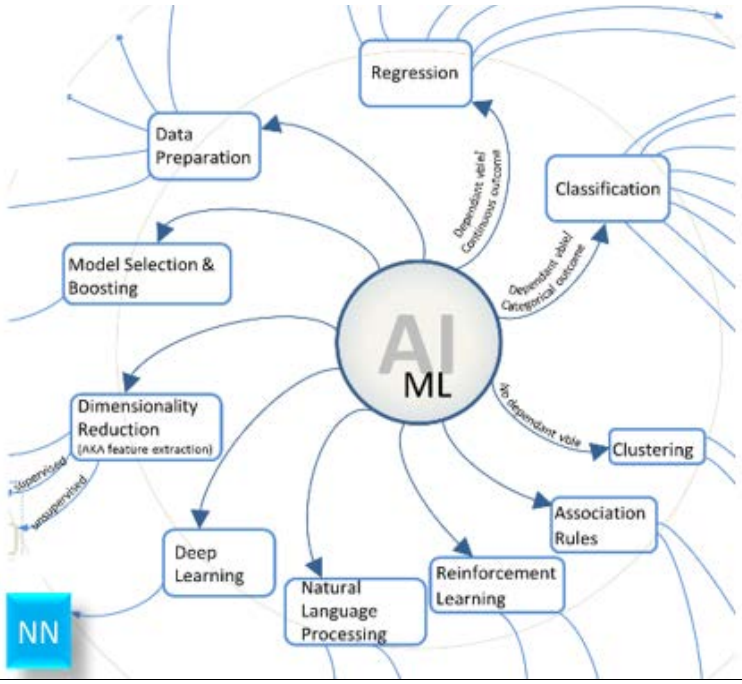
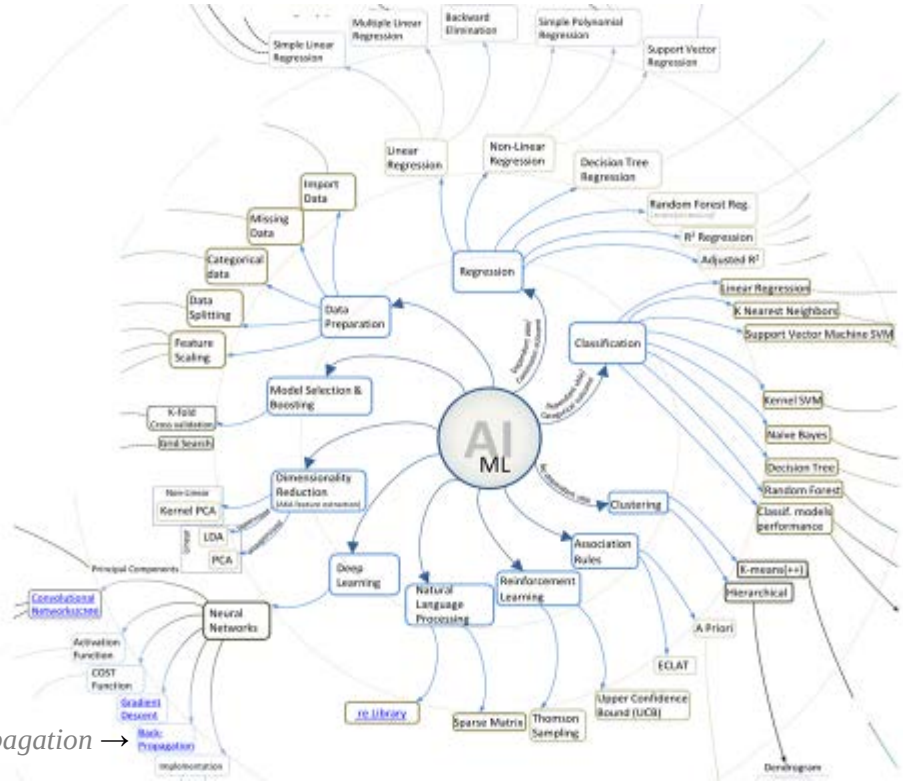


Fig 10: Algorithms are key for transportation routes and sequence for delivery (ref 51)





Backpropagation →

Fig 11: Artificial Intelligence and Machine Learning are umbrella terms for many different tool sets and subsets. Knowledge of the problem space, context of the data, structure and quality of data, feature engineering and deep conceptual understanding of convergence, holds the key, in selecting the appropriate portfolio of techniques[52] and algorithms, which, if combined, in proper sequence, may deliver an optimal outcome.

In the real world application space, selection of AI/ML tools must be context-dependent. In practice, the individuals who have industry knowledge, for example, in retail and fast moving consumer goods, may not be skilled as supply chain optimization analysts. The latter is classically the domain of specialists in operations research (OR). The retail industry may employ OR experts, to grasp the nuances of the retail business, in the ***context*** of the markets (understanding demand, demographics, distribution, etc).

In the realm of digital supply chain, the retail analyst is expected to use or apply AI/ML tools to optimize outcomes (for example, Fig 12). The confluence of knowledge, understanding of data, and selection of algorithms, must converge, for harmonization of the processes. Analysts must frame the correct questions, expect actionable information, and use it to improve decision systems, *before* the value of the data/information perishes.

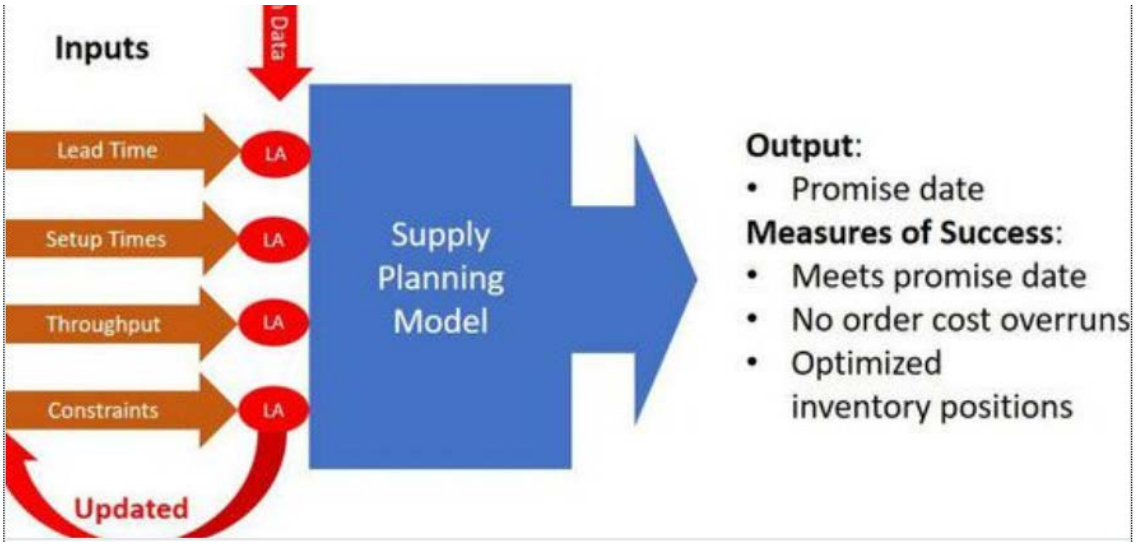


Fig 12: Supply Chain Production, Planning and Optimization, using AI/ML tools. The coordination of these tasks within the enterprise, in the context of digital transformation, may be, still, largely in a "power-point" phase. Connecting data acquisition tools (RFID, sensors, market data) with the data curation domain, followed by the data analytics tools, in ***context*** of feature selection, with respect to the business/market logic, is the essence of the design at the heart of the internet of things concept. Connecting data about things, processes and decisions, is a part of the broad spectrum of the ***atoms to bits*** paradigm.

Transforming enterprises to digital enterprises is a herculean undertaking. It may take ***decades*** before actual transformation takes hold, survives the "pilot" phase and is accepted by business units, as a part of ***their*** operations. Human resource changes are necessary to transform ideas into reality, and, the seat of greatest uncertainty. Perspective of the leadership, and the ability of the executive management to lead these changes, are often in doubt. Even when the leaders seem to understand and champion the change, the pace of change is, at best, sluggish, or contained within a specific domain or business unit. Diffusion of change throughout the organization is difficult. The latter created buzz about "change management" and "open innovation" which are often lame and bit vague.

To add insult to injury, big consulting firms take advantage of these “gaps” and rake in billable hours. Publicists and marketing moguls, in pursuit of sound bites and media attention, create and disseminate, fantasies, which are empty, vapid and callous (Fig 13).

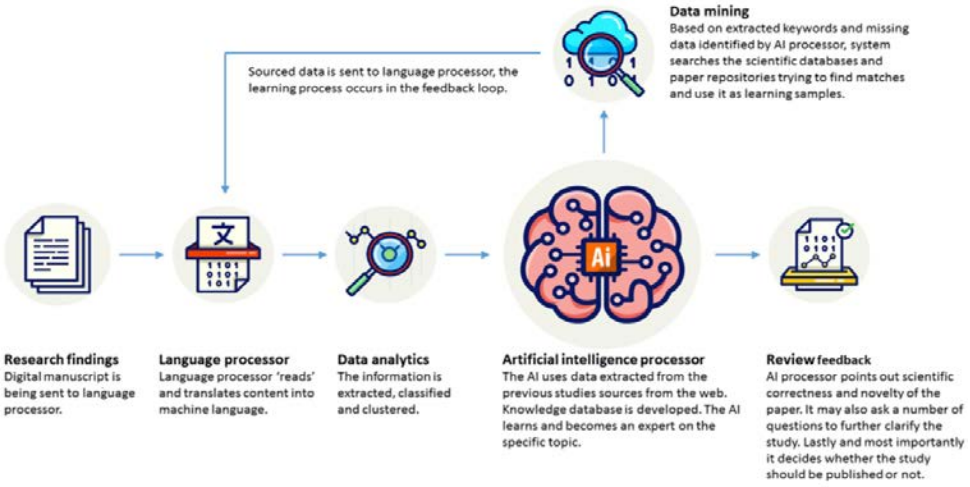


Fig 13: Mindless drivel created[53] as AI and sourced by a “show-biz” organization[54] as a window dressing, to peddle AI tools and enhance the “optics” of erudite imagery.

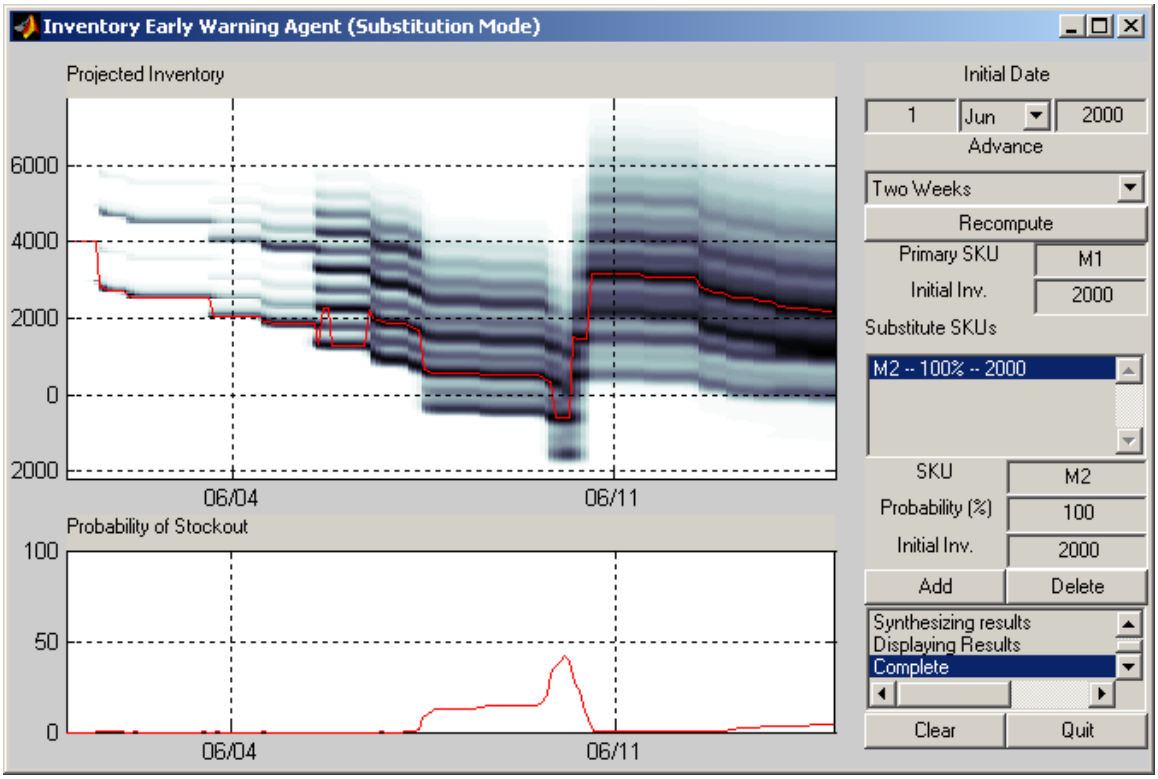


Fig 14: Model application using AI tools (SAP screen shot taken on June 1, 2000). Use of RFID, sensor data, and software agents, to reduce out of stock for inventory management.

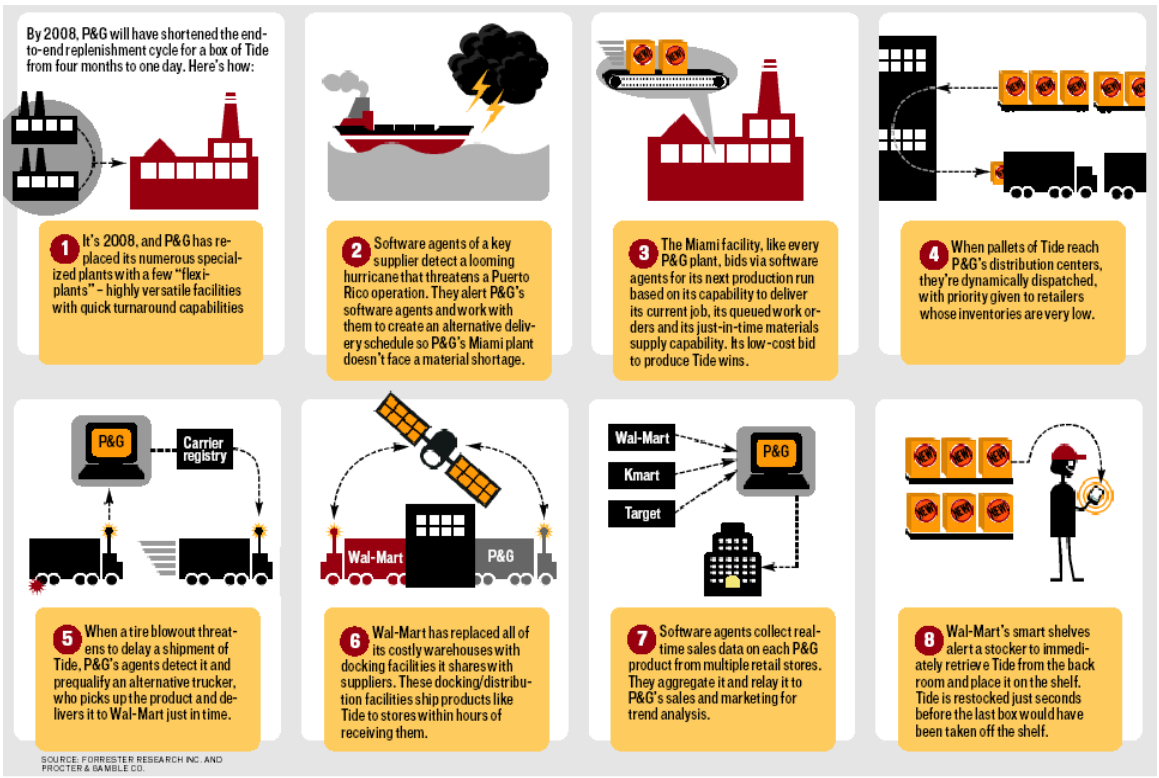


Fig 15: An example from circa 2001, which did not happen. Created by a consulting firm for a retail behemoth, the cartoon shows *digital transformation by "power-point"* based on RFID EPC advances from MIT Auto ID Center and the model application in Fig 14.

Figure 14 illustrates the pragmatic benefits of digital transformation, one may expect, from reasonable use of tools (given their limitations), sourced from the portfolio of techniques, broadly referred to as AI/ML (artificial intelligence / machine learning). AI lacks intelligence, naturally. That is not the problem. The lack of the ability of humans, to understand *why* AI lacks intelligence, is the fuel which perpetuates the conundrum. But, enigma sells news, pseudo-sensational news accelerates publicity and the combination, spells profit. Hence, the penchant for industry to prolong the myth of intelligence in AI.

Figure 15 was created with great fanfare but failed to be functionalized due to business reasons. Open Source Interconnect (OSI) model shown in Figure 16 (bottom) is the structure of the infrastructure which makes it possible for us to access bits. But access is not the same as connectivity, in the ***context of process***. Connecting business partners and domains (Figure 15) with business processes (Figure 16, IoT layers,) may be far more difficult. Access and analysis of bits, from *intra-enterprise* data silos, is impotent.

Failure to implement the AI application (outlined in Figure 14) or execute the P&G vision (Figure 15) is due to the immense procedural difficulties and intrinsic human resistance, to link process, and data flow, in ***context*** of the business ***relationships***, which must converge, to generate the outcome (illustrated in Fig 16, top; seven layers of IoT). Connecting bits (Fig 16, bottom) to atoms (Fig 16, top) is a simple design metaphor, in principle, but difficult to execute in practice. We are still in the *"power-point"* phase.

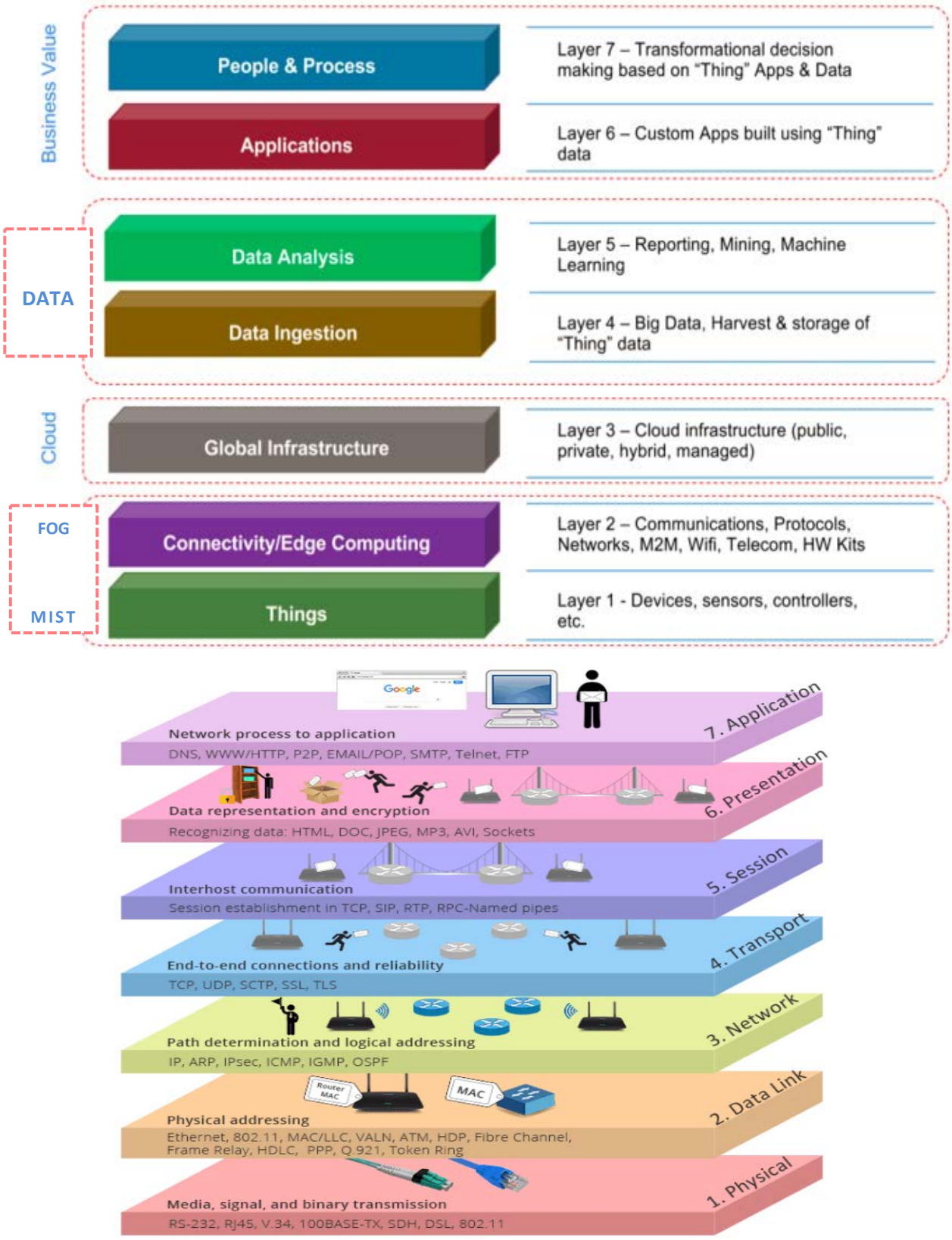


Fig 16: Structure of connectivity (atoms to bits) - OSI[55] vs IoT (top). Dynamics of cloud, fog and mist computing, and QoS[56], will be influenced[57] by bandwidth, latency and jitter.

Systems integration of AI tools at various data analytical nodes (core vs edge, cloud vs fog computing, real-time mist computing) within an ecosystem, is far from reality. Add-on or external data analytical engines are, logically, the first point of entry for new tools, including AI/ML. The analytical outcome is fed back into the system or the decision process. Processing high volume unstructured data is immersed in trial and error.

Application of AI/ML tools are a part of this "learning" process. The learning process itself is bereft with problems. The algorithms are plagued with misconceptions about how the human brain works, in particular, the neural networks (see Chapter 4 in *Haphazard Reality – IoT is a Metaphor*[58]), which generates artificial neural networks.

An example is the backpropagation algorithm[59] which is a staple in the AI world. In 1986, Geoffrey Hinton co-authored the seminal paper, which, three decades later, is central to the marketing explosion of AI. In YYZ, on Sep 13, 2017, Hinton said[60] his method should be dispensed with and he is *"deeply suspicious"* of the back-propagation[61] method, which underlies the hype marketed as AI, including the capacity to sort through photos and talk to Siri. *"My view is throw it all away and start again,"* Hinton said.

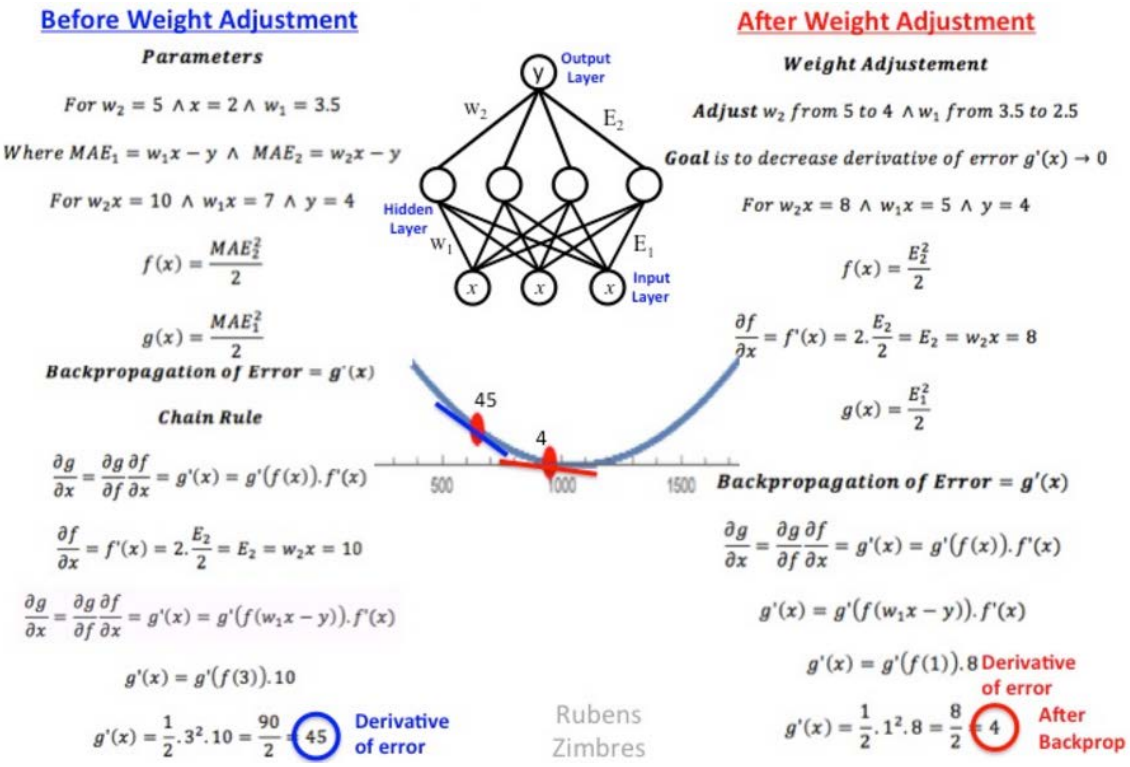


Fig 17: Backpropagation algorithm[62] (see Figure 11), in principle, is an error correction routine. It is a form of "supervised" learning[63] to train artificial neural networks (ANN). After the training, the ANN should do what the trainer expects (the output), for example, recognize a hot dog, from a photo of a hot dog vendor, on the streets of New York City. If the output of ANN fails to recognize the "hot dog" (if the output is *baseball bat*) then the training algorithm, goes *back* and adjusts the "weights" associated with each step, in order to drive the neural net to output "hot dog" as the outcome of supervised learning.

Error correction is a staple and invaluable mathematical tool, in science and engineering. It is of critical importance in many fields. Without error correction codes, information theory[64] may not function. Applications in finance[65] and supply chain[66] predates the buzz of "big data" by at least a quarter century. Hence, error correction routine in backpropagation, in principle, is extremely valuable, and conceptually, is essential.

The discontent about backpropagation stems from the forced fitting of weights to deliver *anticipated learning*. Adjusting weights is a blend of stochastic and heuristic methods. It is not reflective of biomimetic processes in higher organisms and unlikely to represent neural networks in humans. Thus, the call to *"start again"* is both judicious and justified. The application of error correction, in the ***context*** of training neural networks, may be revisited or reviewed by "new" eyes, to deliver new tools, to complement or even replace backpropagation method. However, true AI/ML tools are ***essential*** for our future.

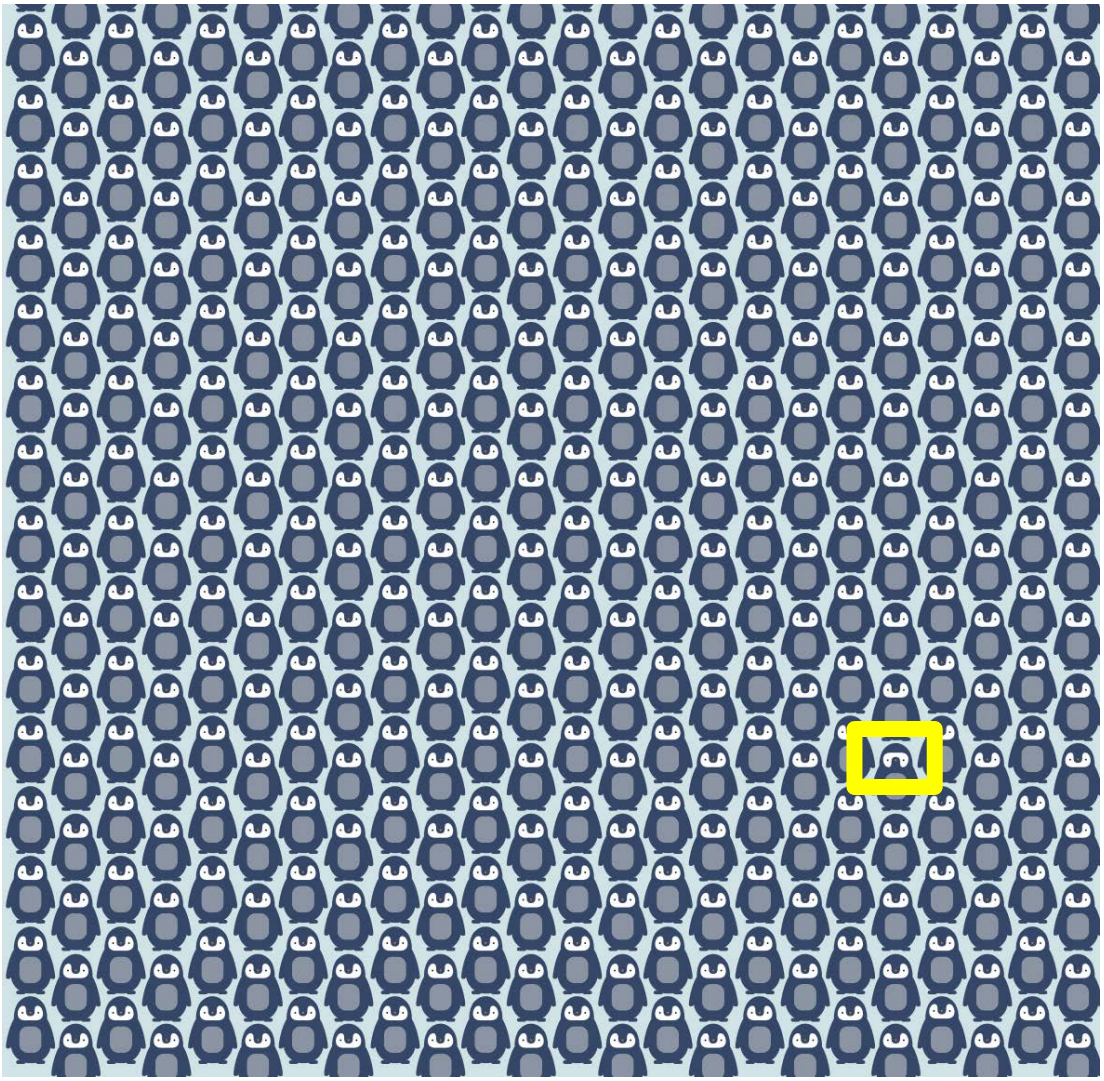


Fig 18: Machine Learning (ML) may be one way to detect anomalies[67] in large data sets. The importance of AI/ML in data analytics will depend on the question and its ***context***.

Moving forward, beyond backpropagation, Geoffrey E Hinton of Google Brain has now, thankfully, re-invented a grand idea that was shining in relative obscurity, for more than half a century. Hinton's "capsule" papers[68] are "the emperor's new clothes" made from Marvin Minsky's "cube-on-cube" (Hinton's "capsule"). Minsky's idea dates back several decades but it was published[69] in a book format in 1985. The illustration from "Society of Mind" is reproduced in Figure 19. In combination with Agent based hierarchical solutions (Agent, Agents, Agency, Agencies), the principles and practice of using ant-based algorithms in multi-agent systems[70] have been around since 1960's.

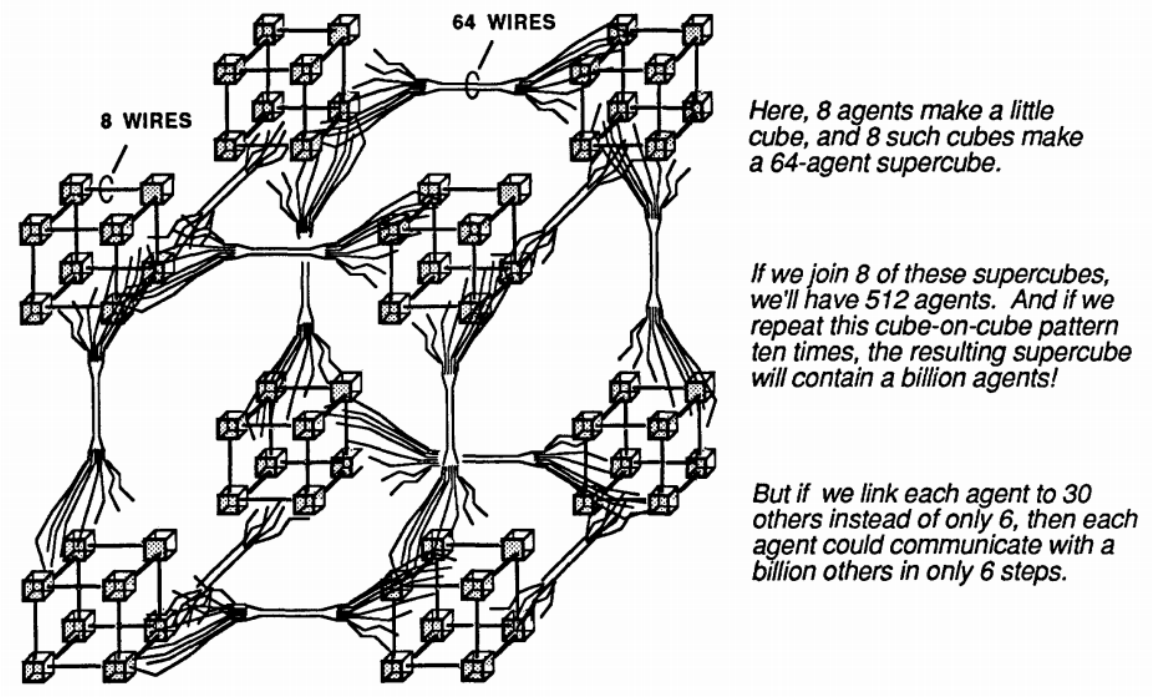


Fig 19: The network concept is obvious in this illustration by Marvin Minsky (ref 69). The abstraction is loosely based on synaptic connections made by neurons (in brains) and may have also inspired Charles Babbage, circa 1850, to lay the foundation of the design (but not build) the difference engine (ref 77). Each unit of data or information or parameter or variable or value (binary) may be captured in ***cubes*** in Marvin Minsky's diagram. It may be extrapolated to the novel ***"capsule"*** concept, suddenly re-invented by Geoffrey E Hinton, of Google Brain, and presented at the 31st Conference on Neural Information Processing Systems (NIPS 2017, Long Beach, California, USA). The power of the "cube-on-cube" concept is evident due to several "re-inventions" of this principle and certain forms of commercial products which may have borrowed its salient features (for example, the "containers" software[71]). Cube-on-cube reappears in several chapters in my book *Haphazard Reality – IoT is a Metaphor*[72] to illustrate various ideas, including the concept of hash tables[73] and blockchain[74] as well as the key essence of connectivity.

ELUSIVE QUEST FOR BIO-INSPIRATION IN DIGITAL TRANSFORMATION

From the dawn of computer design[75] the management of architectural complexity (lower levels of logical circuits to higher levels, nested above one another) has drawn on the biology[76] of neurons, in general, and neuronal scaling, in particular, as a bio-inspired model. The history of artificial intelligence research, and difference engines, proposed by Charles Babbage[77], appear to take cues from neural structures found in worms, animals, mammals and, of course, humans. The human brain is often compared to a computer. It is a gross error, and distortion, of astronomical proportions. The brain is ***not*** a computer.

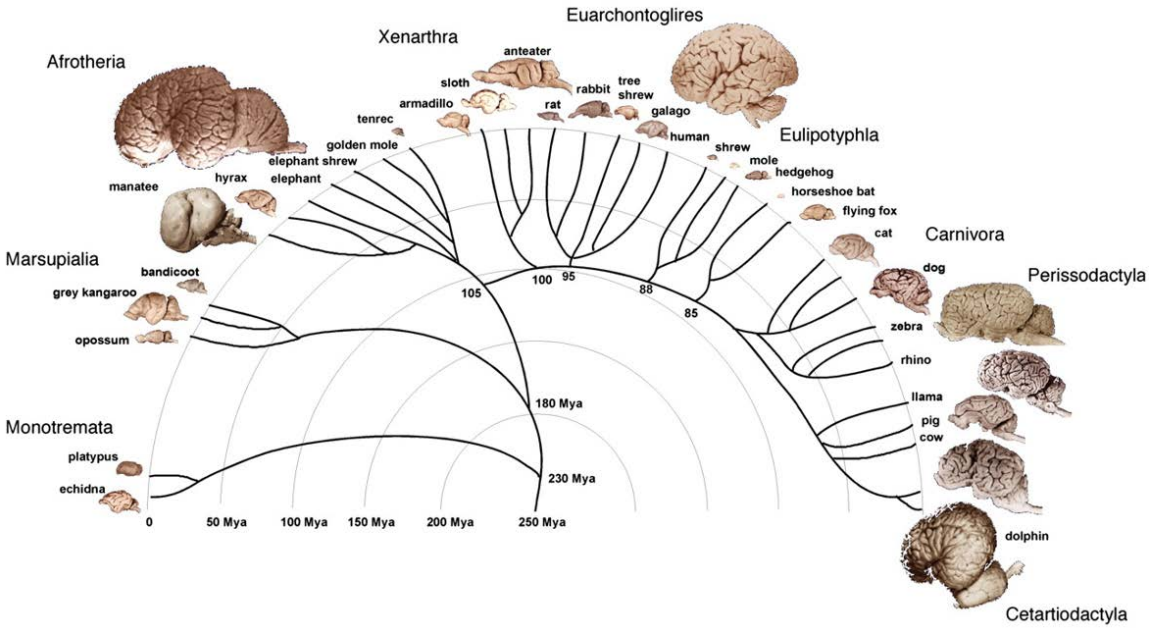


Fig 20: The myth[78] of the human "large" brain. *Homo sapiens* are not special. Large brains appear several times in the mammalian radiation (Mya = Million years ago).

In terms of an analogy, the roughest approximation, if one may dare to simplify, is the notion that the brain may partially perform functions resembling a very advanced systems integration platform. The brain is not a computer but computation may be a part of the platform analogy. The elusive quest for bio-inspired systems is justified because "nature" created structures and functions which successfully survived evolutionary tests.

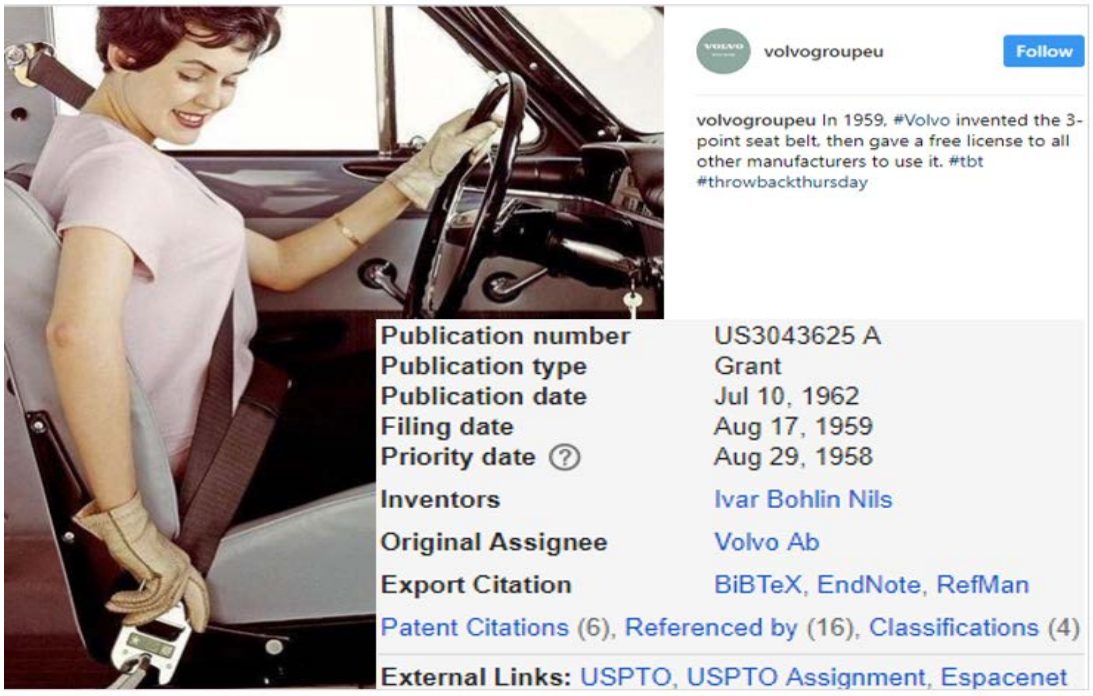
Lessons from bio-mimicry suggests that we should invest heavily on sensors and sensing. Why? Because the epidermis (for example, human skin) is a whole body touch sensor (pressure). Other sensors are located, all around the skull (optical-eyes, auditory-ears, olfactory-nose, gustatory-tongue). Bio communication medium is electrochemical (analogy - telecommunication) and operates in a hub-spoke system. Brain is the hub and the spoke (motor neurons) are muscles. Signal processing[79] happens in the brain, hence, the analogy, brain as a systems integration platform, with a "cloudy" component. Other signal processing (reflex arc[80]) occurs through the spinal cord (analogy to fog or mist computing), for example, the patellar reflex (also, analogous to *in-network* processing).

Digital transformation is bursting at its seams with sensors, but making sense of data, to yield actionable information, is the quagmire of *"haphazard reality"*[81] in IoT.

CRITICAL FOR DIGITAL TRANSFORMATION: CYBERSECURITY

Inviting digital annihilation is inevitable, without cybersecurity. If data and information exchange is desired beyond the closed "stand-alone" paradigm, then security cannot be "layered" as an after-thought.

Implementing security by design, through engineering principles in the backbone, is not only prudent, but may boost profit and brand recognition. The example from the auto industry, illustrated below, is of historic interest, with a message for practitioners, to think first about, and integrate cybersecurity, with digital transformation.



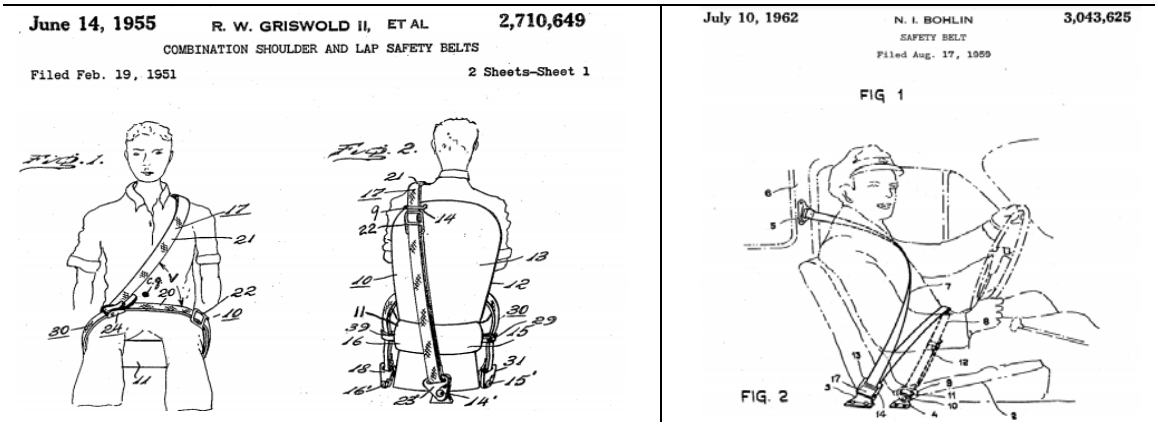


Fig 21: E J Claghorn patented a safety belt[82] in 1885 but medical studies[83] and work from Griswold[84] and Volvo's Bohlin[85] were necessary for widespread adoption. Swedish automobile Saab GT750 (Gran Turismo 750 produced between 1958 and 1960) introduced at the New York International Auto Show, in 1958, featured safety belts, as a standard.

The dramatic cybersecurity story of 2016 came to a quiet conclusion[86] on December 8, 2017, in an Anchorage (Alaska) courtroom, as three young American computer savants pleaded guilty to masterminding the unprecedented Mirai botnet, powered by unsecured internet-of-things devices like security cameras, wireless routers, that unleashed DDoS attack using an internet device on October 21, 2016. The Mirai "packet" strategy (PCAP) targeted IPv4 addresses and related DNS registries (Dyn).

Could IPv6 offer better protection for cybersecurity by engineering design? The economics of the resistance, to move from IPv4 to IPv6, is due to behemoths in the routing business, who have a lot invested in IPv4 and are simply guarding their profits.

DIGITAL TRANSFORMATION X.0

Do you have your compass? We are at the dawn of a new evolution. The road ahead is still under construction, plagued with ambiguity, potholes and gross missteps (Fig 22). Constructive convergence, and synthesis of ideas, may not be so easy.

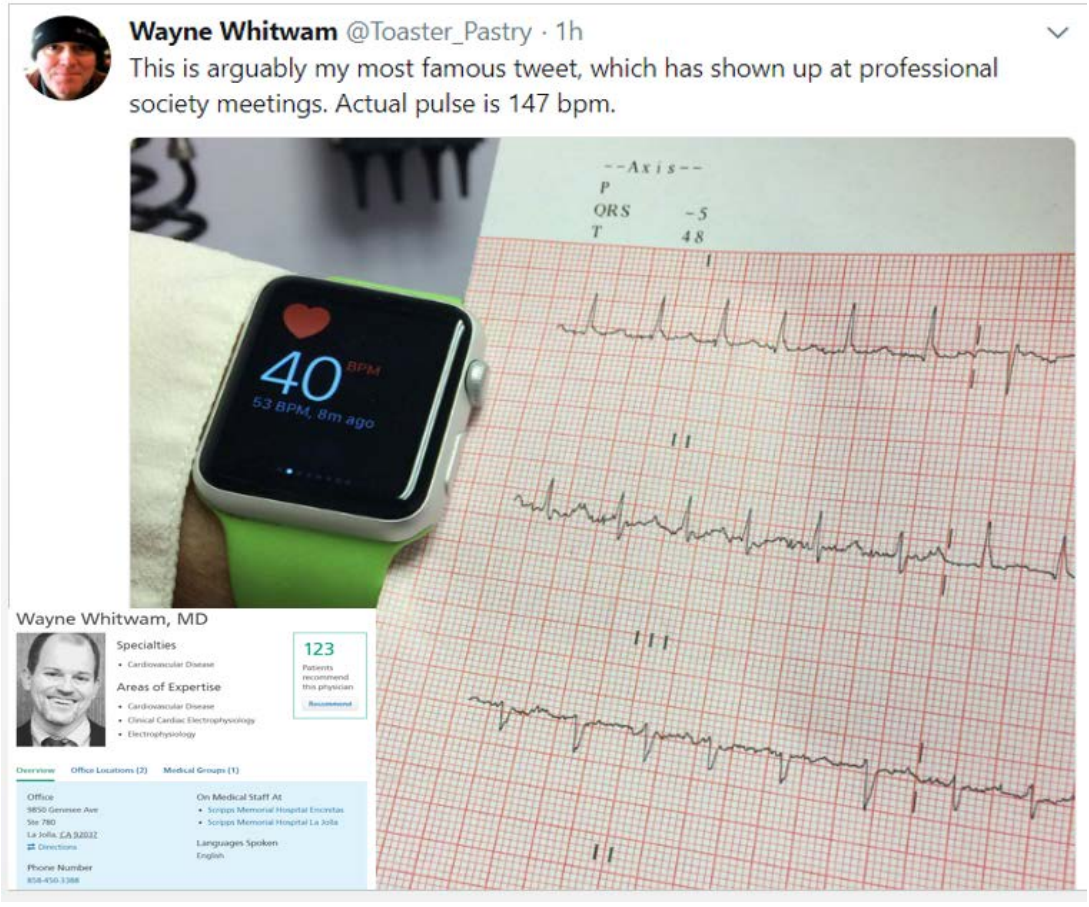


Fig 22: Wearables are a new direction for the consumer internet of things (IoT). It is hyped up to measure vital signs and a tool for remote monitoring. The potential exists but the current practice is deeply flawed. In part, because software technicians are meddling in medicine. The heart monitor on the wrist band displays pulse rate of 40 BPM (beats per minute) but the medically verifiable heart rate recorded by Dr Wayne Whitwam, MD, is 147 BPM. This type of an error may spell the difference between life and death.

In *Darwin's Middle Road* [87] Stephen Jay Gould wrote, "if genius has any common denominator, I would propose breadth of interest and the ability to construct fruitful analogies between fields." This article hints at a lot of different domains and offers clues. I have alluded to diverse domains, which must converge, in order to transform the vision and weave it into the fabric of digital transformation.

The principle of connecting atoms to bits may be pervasive and it may gain ubiquity, in view of increasing computational power and decreasing cost of computation, as well as storage. However, the ideas relevant to internet of things (IoT), industrial IoT (IIoT), data of things (DoT) and network of things (NoT), are only a small part[88] of the connected world. The forthcoming tsunami of changes will be far greater than digital transformation. We need changes to improve quality of life[89] for billions of people.

For readers still willing to explore digital transformation, I may suggest my book "*Haphazard Reality - IoT is a Metaphor"* which is available[90] from the MIT Library.

TEMPORARY CONCLUSION: SIGN POSTS ON THE DIGITAL SILK ROAD[91]

Transformation is not limited to the digital economy. The scope of the economy itself is subject to change, based on other purveyors of civilization, for example, energy, food, water, health and diffusion of education. The cycle of economic evolution may span several generations and cover centuries, before these changes appear striking (Figure 23).

Prediction about the course of these changes are not easy but they are in abundant supply. Careful economic studies are few and far between. It is generally agreed that in the modern world (early 21st Century), we are equally, or more concerned, with access to sustainable and renewable energy, respectful of the ecological and environmental issues.

Hence, breakthrough in energy science and engineering, as well as, healthcare and sanitation[92], can change the future of nations, and as a consequence, the global economy.

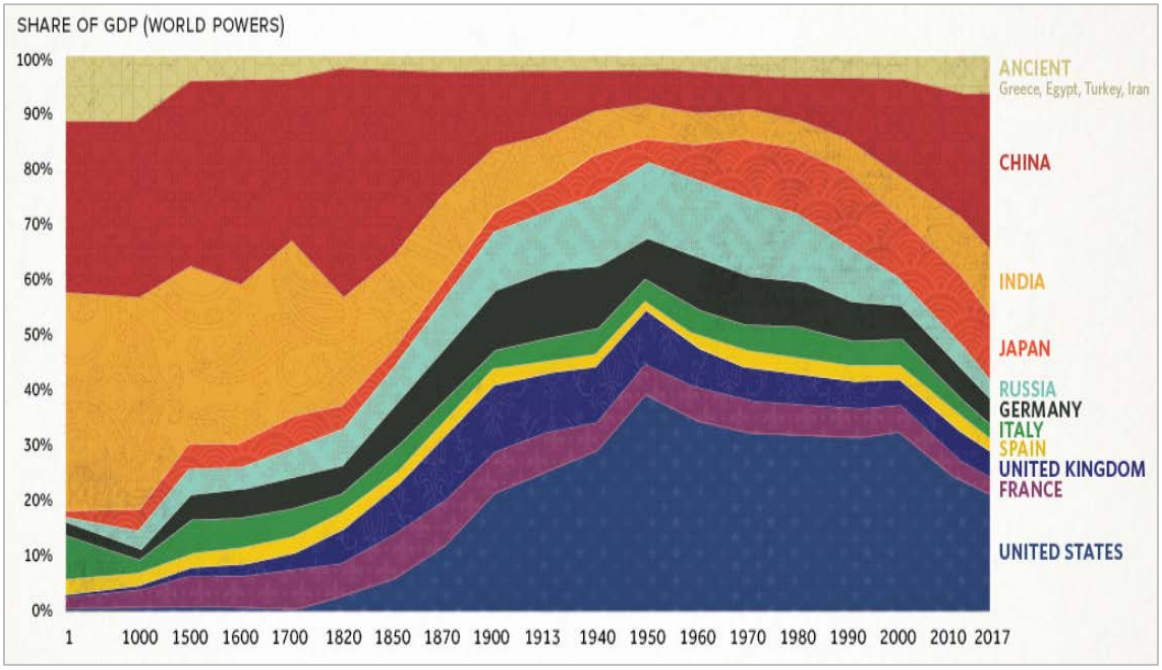


Fig 23: Changes[93] in the share of GDP (gross domestic product) for the past 2,000 years.

Science, engineering, and technological feasibility, will determine whether good ideas from energy research, may find their way to reality of execution, and adoption. To change the economic indicators of the world, the availability of such energy must reach the billions. Paths to adoption are going to be inextricably linked to investment. It may be co-dependent on other forms of infrastructure, for example, communications and roads.

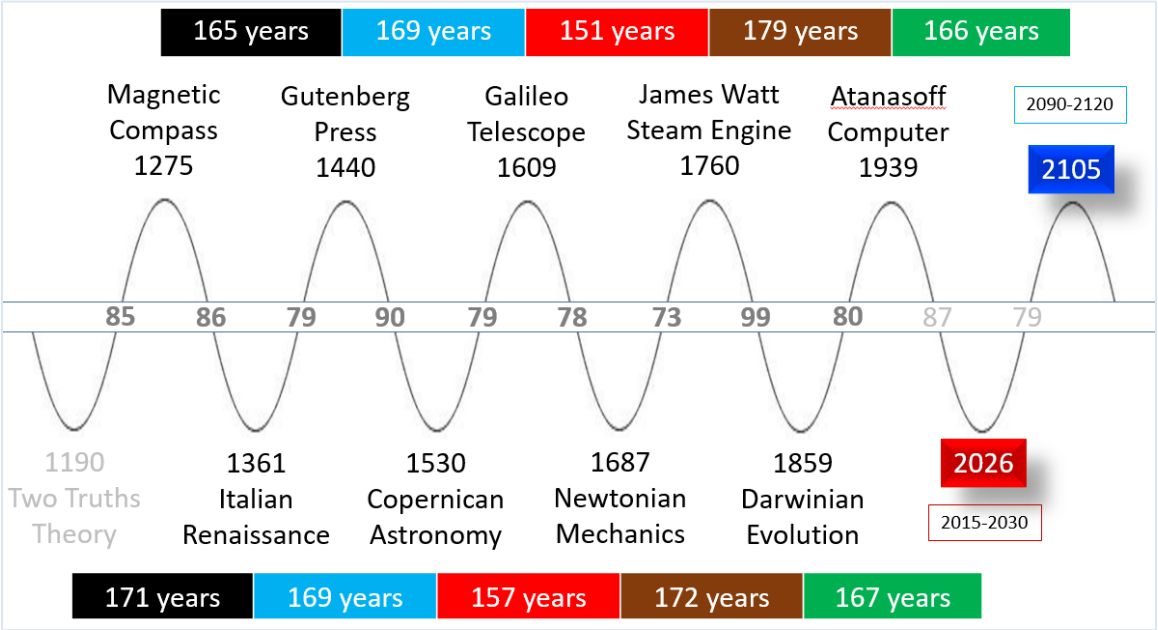


Fig 24: Norman Poire's (ref 10) sinusoidal "march of reason" based on work by several economists including Joseph Alois Schumpeter[94], an Austrian-born political economist, at Harvard University (8 Feb 1883 – 8 Jan 1950) and the original Kondratieff [95] Waves.

Based on the sinusoidal pattern (Fig 24), it appears that the next decade (circa 2026), may witness the emergence of new global direction, followed by transformative technological progress, poised to emerge at the dawn of the 22nd Century.

One may be tempted to predict that the technological breakthrough (circa 2105) may involve energy. The sourcing of energy will revolutionize the global supply chain.

Perhaps the development of hydrogen fuel cells, fashioned as an average sized mobile phone (form factor), or even better, a credit card sized *fuel cell, in every pocket,* may be the then Presidential[96] slogan. The future may increasingly witness FCV (fuel cell vehicles) and a decline in EV (electric vehicles). The form factor of PEM fuel cells may be the size of a credit card or slim iPhone. Will one size fit all? Perhaps not. But, imagine you can insert the credit card (cc) configuration, proton-exchange membrane fuel cell, also known as polymer electrolyte membrane (PEM) fuel cell (PEMFC), in your laptop or smartphone or tablet, to power the devices. Now *re-imagine* the energy supply chain.

The same ccPEMFC may be inserted in the dashboard of your automobile, as its energy source. The "range anxiety" justifiably, will be of concern. How far the car may travel for "one dose" of ccPEMFC? But, before that, *re-imagine* the smart city concept.

Assume a vehicle can travel 10 miles per unit ccPEMFC. You are a taxi in New York where the average distance[97] per trip is 2.6 miles. Have you lost or gained, in the context of the ***massive shift*** from lugging around 700 kg in battery weight (for EVs) or 15-30 gallons of gasoline (ICE) *versus* dash-board ccPEMFC weighing 10-100 grams?

Swap your energy-exhausted ccPEMFC with a fresh ccPEMFC and you have just entered the era of "swappable atoms" where the form factor of portable mobile energy enables you to ***swap atoms***. Carry a 6-pack of ccPEMFC or swap ccPEMFC in a grocery store or convenience store, eg 711. The reality of the 'swap' may be in practice[98] in India.

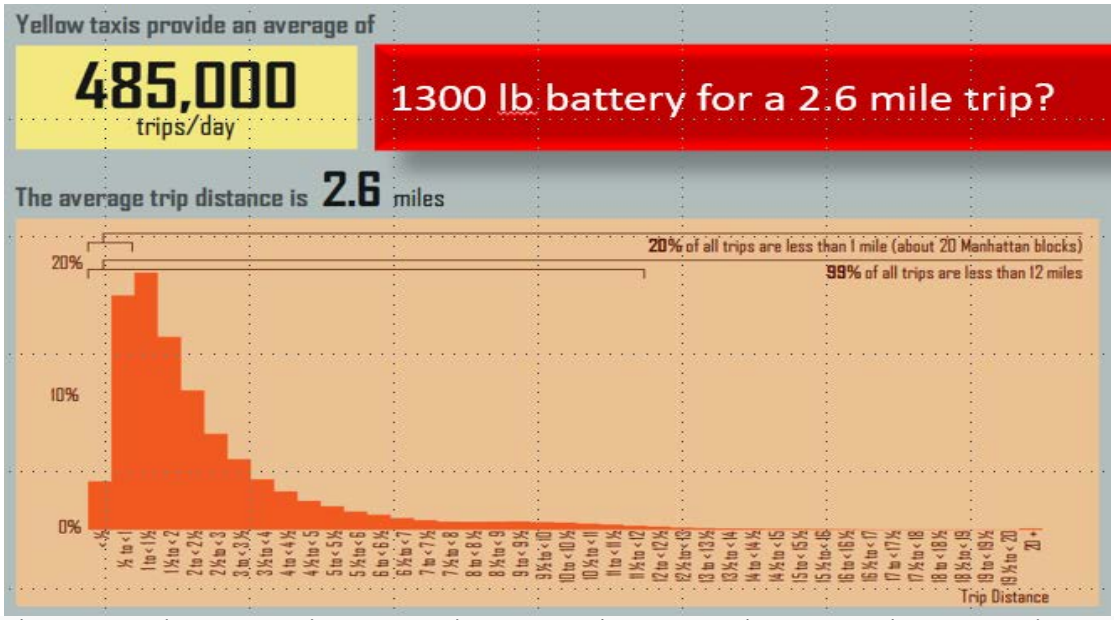


Fig 24: Complementarity between “atoms to bits” & the paradigm of “swappable atoms”

Fuel cell "cards" (ccPEMFC) may fade away in favor of energy in the form of a microUSB flash drive. *Re-imagine* the mobile, grid-free, swappable ccPEMFC but in a new reincarnation: a slim flash-drive inserted into a microUSB-like port.

The energy source may be ***solid*** hydrogen. Contrary to the standard textbooks of chemistry, J. D. Bernal suggested[99] that gaseous substances, under very high pressure, may be transformed into metallic or valence lattices. In 1935, Wigner and Huntington (see reference 99) theoretically calculated the energy of a body-centered lattice of hydrogen as a function of the lattice constant (which corresponds to a density many times higher than that of the ordinary, molecular lattice of solid hydrogen).

I did not read or understand Eugene Wigner’s paper until Glenn Seaborg[100] (element Seaborgium[101] atomic number 106) explained the prediction. The notion of solid hydrogen, in a thimble-sized container, was the basis of a suggestion, I proposed, in a publication[102] in 2005-2006 (published by TEKES, Government of Finland).

At that time (2005), I did not mention solid hydrogen and did not state that one unit of the slim flash-drive-like microUSB device may be sufficient to operate a Boeing 787 or Airbus 380 or the largest container ship, the Hong Kong-registered CSCL Globe, measuring more than 400m (1,312ft) and carrying about 20,000 standard containers.

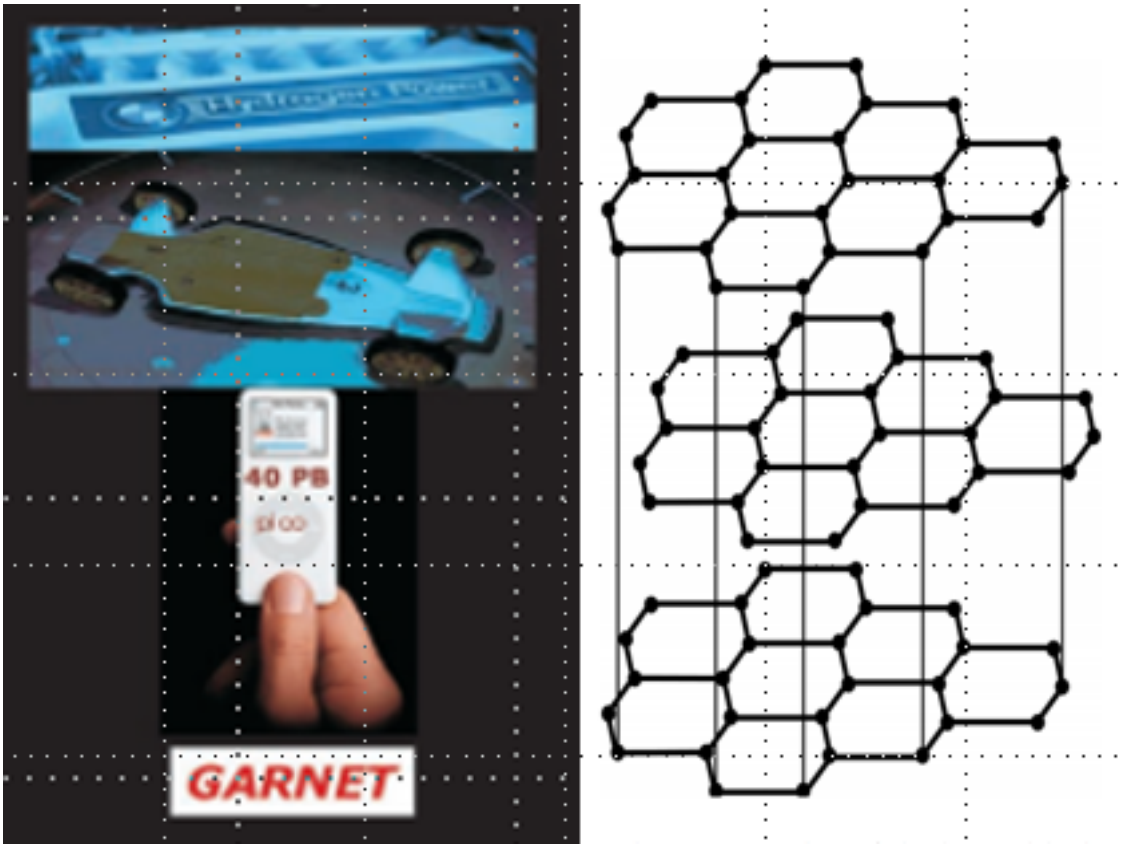


Fig 25: (Left) Energy for a vehicle using a slim credit card sized form factor, proposed in 2005. (Right) Schematic representation of layered lattice of graphite. Metallic hydrogen may assume this type of lattice structure, according to Wigner & Huntington (see ref 99).

In 2017, the impossible was made possible[103] by Ranga Dias, a graduate student at Harvard University, who claimed the formation of metastable (solid) Hydrogen[104] at a pressure of 495 GigaPascals (Fig 26). As with all seminal discoveries, congratulations[105] and greetings poured in from all corners of the globe (Fig 27 quoted from reference 105).

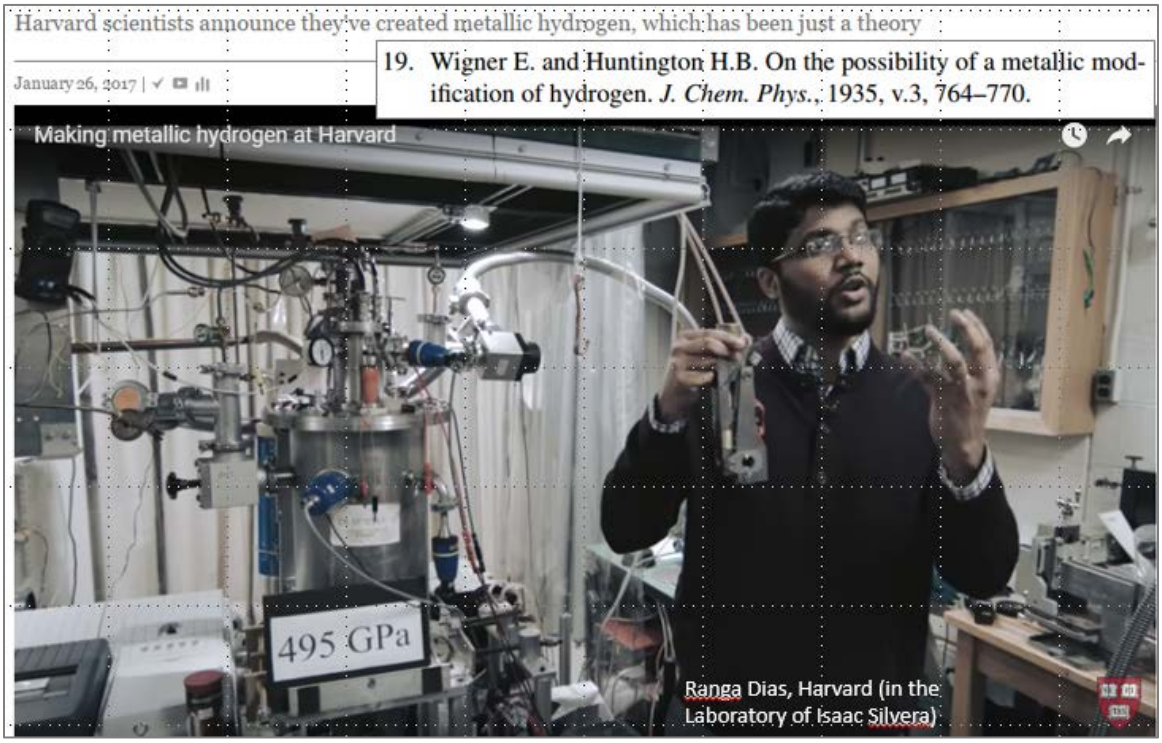


Fig 26: The formation of metallic Hydrogen by Harvard University student Ranga Dias.

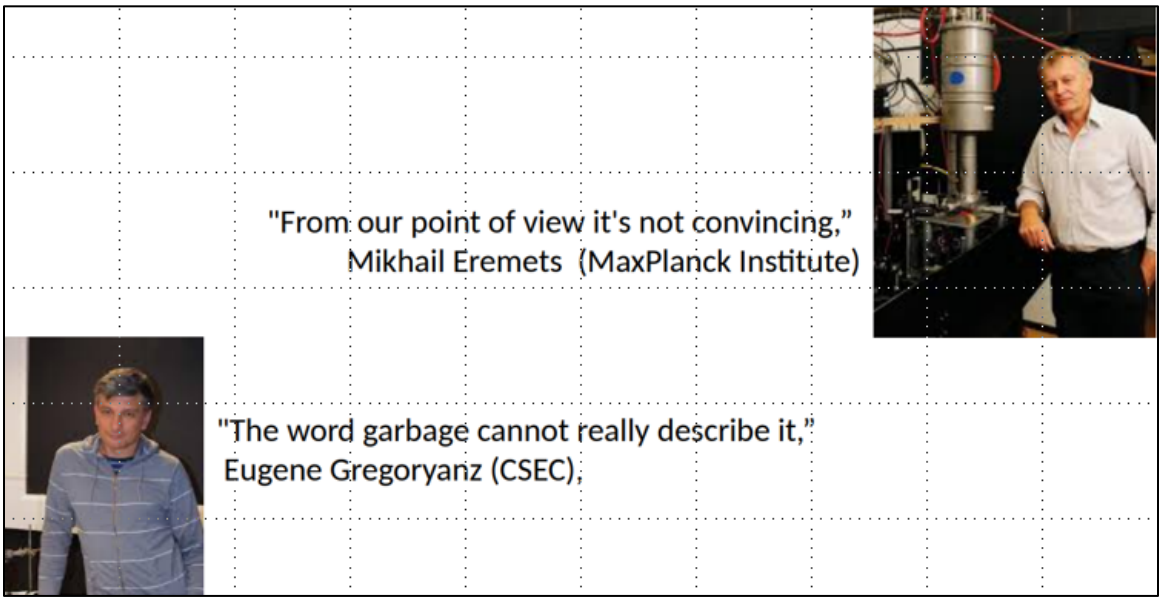


Fig 27: *In Praise of Imperfection* – congratulations poured in from other great scientists.

Packed with metastable hydrogen (solid hydrogen), anything that needs energy ("electricity") may wish to incorporate a standard microUSB port in the design of the device. Insert pH (power Hydrogen) to a phone, laptop, automobile, airplane, building, lawn mower and submarine. Today we may plug in a EV in our homes to charge the vehicle. The fusion-less, grid-less, powerless, struggling economies may change for the better when they can plug-in their homes to the future FCV, to power up their living.

The form factor of portable, mobile, grid-free energy may undergo a radical evolution, which may reach its zenith around 2105-2120 (Figure 24). The metaphor of connecting *atoms to bits* (IoT) may embrace the complementarity which will evolve from *swappable atoms*. The paradigm shift in energy cost, access and distribution, will impact all supply chains. It may catalyze an unstoppable wave of freedom, development and economic growth. *Power to the people* will cease to be merely a political platitude.

A portfolio of inexpensive energy will swing open the final frontier for business and commerce, by further accelerating the creation of markets on the continent of Africa.

The benefits from the energy reshuffle will meet with resistance in the advanced Western nations, due to the dead weight of old technology, linked to the political lobby of the wealthy few. Asia and Africa may leapfrog into the future with solar, hydrogen and fusion, as a part of their renewable, carbon-neutral and sustainable, energy portfolio.

The strength of science behind the chemistry of metastable hydrogen makes it less speculative to suggest that the future of hydrogen-based energy, may be packaged in a micro-USB mini-device, with metallic hydrogen[106] as the fuel. For immobile objects and traditional functions (buildings), the commercialization[107] of fusion energy[108] may be an equally important economic leap for the 22nd Century (see Figure 2). Solar, hydrogen and fusion, may co-exist as pragmatic commercial solutions, globally, in the year 2121.

But what about the expected change in global direction (predicted in Fig 24), in the next decade? It is tempting to speculate that the global forces for good, may begin to tackle gender[109] inequality. Boosting women's opportunities, in the labor market, could add US$12 trillion to the annual global GDP, over the next decade. Gender parity will indeed be a new direction, a transformation which will change the fabric of civilization.

Fig 28: Ubiquitous computing meets ubiquitous energy in the 22nd century.

EPILOGUE

Connecting atoms to bits is an important step for global development and decision systems. Digital transformation is one of many key areas that must march in lockstep, with other facets. The Digital Silk Road[110] promises anything but to be smooth[111] as silk. The forecast about energy, and supply chain, will add turbulence to anticipated changes. The journey will be mired in false promises, snake-oil sales and rabid sensationalism.

No one may escape the travails of time, especially those inflated with hubris. The cyclical rise and fall of General Electric[112] is one example. On August 28, 2000, GE was at its prime with a stock price of $34.55 (Fig 29). More recently, on 20 December 2016, shares of GE[113] were $32.25 per share. By 29 December 2017, GE's share price was nearly halved to $17.45 per share. In a recent[114] analysis, from six CEO regimes at GE (Wilson, Cordiner, Borch, Jones, Welch and Immelt), the megalomania of Jack Welch may have disproportionately sowed the seeds of GE's decline[115] but Jeff Immelt[116] is not without blame. Transforming GE to an energy company, or to a software company, are good slogans, for on-stage glitz and glamour, for *"Minds and Machines"* showmanship.

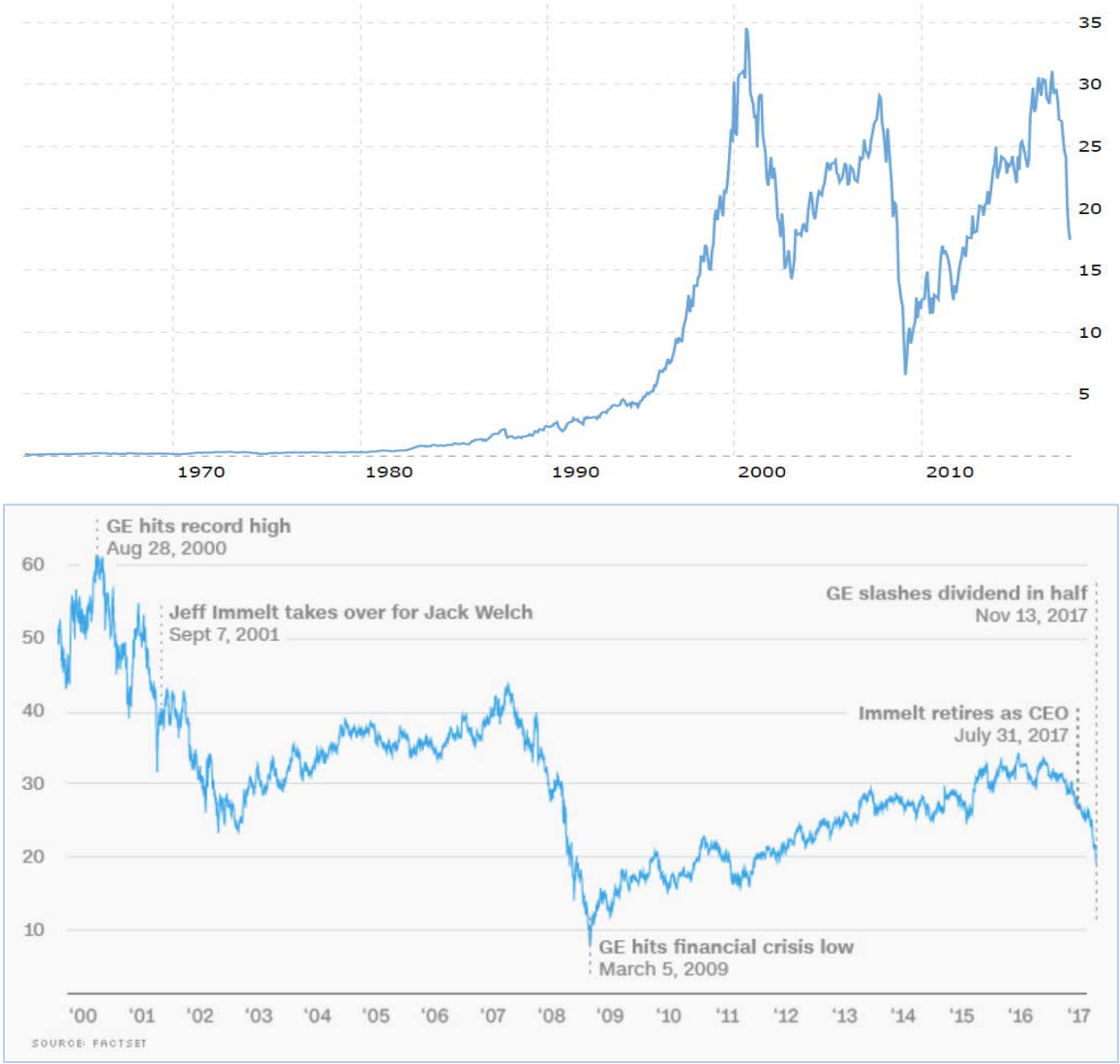


Fig 29: GE share prices[117] from 1962-2017 (top) vs changes in GE leadership (bottom).

The economic disequilibrium[118] due to technological chasm may be tearing apart[119] the fabric of society, according to one[120] report. The undue emphasis on digital transformation in this and other articles, is, therefore, an alarming example of bias. GE is an example of what happens when leaders lead by hubris or fall for hype[121] and act as marketing agents rather than visionaries. Quick and dirty may win, but, for how long?

Based on my very limited knowledge and multiple other inadequacies, it may be an act of stupidity, on my part, to suggest what domains are equally (or more) important.

Feeding the world tops the list, not only because of its short term need (daily hunger) but its long term impact on the evolution of the brain[122]. In parallel, reasonable elimination of sugar[123] in our diet, and in processed foods, may be crucial for nutrition.

The bitter politics of sugar[124] and its collusion with big pharma, may be sowing the seeds of an epidemic, called diabetes. Hence, to empower people, self-monitoring of blood glucose[125] is quintessential, in order to prevent excess sugar in their daily diet.

Fig 30: Over the course of a 15-year study[126] on added sugar and heart disease, participants who took in 25% or more of their daily calories as sugar were more than

twice as likely to die from heart disease as those whose diets included less than 10% added sugar.

Inexpensive clean energy may be a key economic performance indicator, which will influence industry, commerce, workforce, financial arbitrage and globalization. The path to inexpensive energy may still run through political minefields (see Figure 1).

It is of general opinion that the trio of sanitation, water and health, as well as healthcare, are critical[127] necessities for billions, mostly ignored by the affluent world.

Emergency management, telecommunication and roads (infrastructure) are the bread and butter of the connected world. 5G is icing on the cake, not an immediate staple.

Advancing any domain for human progress is rooted in science and engineering. The tools for public goods, for example, nanotech and graphene for solar photovoltaic cells, as well as, desalination, and purification, of water, are fruits of academic ***research***.

It is ironic that GE's strength is in energy and healthcare. It is still taking the company on a downward trajectory. One reason may be its extreme affinity for the Western idea of business profitability. GE aims to serve its shareholders and maximize profit. If a business, such as GE, were to serve the community and, then, rake in the micro-payments from billions of users, it may generate trillions in revenue, *over time*.

The Western business school ethos of more and more profit is the yardstick of capitalism. In part, it fuels the lifestyle and luxuries we take for granted in the West. We are not without blame for the greed[128] that may decimate families due to medical bills. Yet, we are too timid and cautious[129] to raise our voices or act with purpose. The cost of prescription medicine in the US (Table 1), by law, cannot be subjected to price control.

Glybera $1,000,000	Elaprase $375,000 pa	Myozyme $300,000
Luxturna $850,000	Naglazyme $365,000 pa	Arcalyst $250,000 pa
Spinraza $750,000	Folotyn $360,000 pa	Cerezyme $200,000 pa
Soliris/Ionis $750,000	Cinryze $350,000 pa	Fabrazyme $200,000 pa
Kymriah $475,000	ACTH $300,000	Aldurazyme $200,000

Table 1: The adulation[130] for cure for blindness at a cost of $425,000 per eye per dose far outweighs the muted outcry[131] about the outrageous acts by US and EU pharmaceuticals.

A *pillar* of Western business is optimizing "shareholder value" which may be archaic to some but still peddled by the Jack Welch[132] school. It is clear from demand of "executive education" courses from elite US universities that the emergent economies are keen to emulate the Western practices, based more on pillars and less on building bridges.

The Chinese and Indian business schools are preaching personal wealth creation and how to catalyze ROI. But, what worked for the affluent Western society (US and EU) may not be reproducible in the East, with billions of hungry people who can neither afford healthcare nor education. The Eastern penchant for Western business practices is a form of myopia that neither Joshua Silver[133] nor his mission[134] or his vision[135] can cure.

Globally, there is a lack of understanding. Tools and technologies, by themselves, are impotent for sustained improvements, hence, are incapable of generating long term

profitability and wealth of nations. When tools and technologies are a part of a *system*, in the *systems approach* to a solution, *then*, the outcome may favor long term profitability.

Use of *ad hoc* tools are often mired by initial failures. The use of RFID, as an identification tool for tracking and tracing goods in the supply chain, is still a grand idea. In 2000, retailers expected ***that*** productivity, instantly, simply by slapping on a RFID tag. It was catalyzed by hype and the stampede for a new source of *billable hours* from a variety of consultants and consulting firms, oblivious of the *systems* approach.

The lessons[136] of *productivity* are steeped in *complementarity*. You cannot have one without the other. Complementarity is about *systems* where multiple tools and many technologies[137], both new and old, may *converge* to produce an impact, greater than the sum of the parts. Elegantly illustrated by the history[138] of electrification, similar lessons apply to most tools (RFID, sensors, AI, ML, blockchain, 3D printing, digital foundry).

Taken together, what does it mean for global transformation and its subset, the digital transformation? Unfortunately we shall witness catastrophic clashes, especially with respect to the ongoing parade of expectations from AI[139] and its apparently super-natural powers. Even more troubling is the observation that once-admired companies, mammoth consulting firms and so-called "captains" of industries are marketing untruths.

Having said all of this, we must hasten to return to reality, to face the brutal facts in Figure 31, about the global gaps which continues the morbidity. It is not enough to blame the policies and politics of unethical humans in the loop, pre-occupied with treachery, lechery and debauchery, rather than helping to catalyze science to serve society, deliver human values and dignity.

Each one of us has a role to play, no matter how small. Our existence is based on compassion and knowledge. Compassion without knowledge is ineffective. Knowledge without compassion is inhuman[140]. In our pursuit of ideas, we must strive to think about the correct[141] questions. Wrong questions will generate wrong answers[142]. Humanity needs compassionate dreamers[143], an ethical sense of higher purpose, and humility.

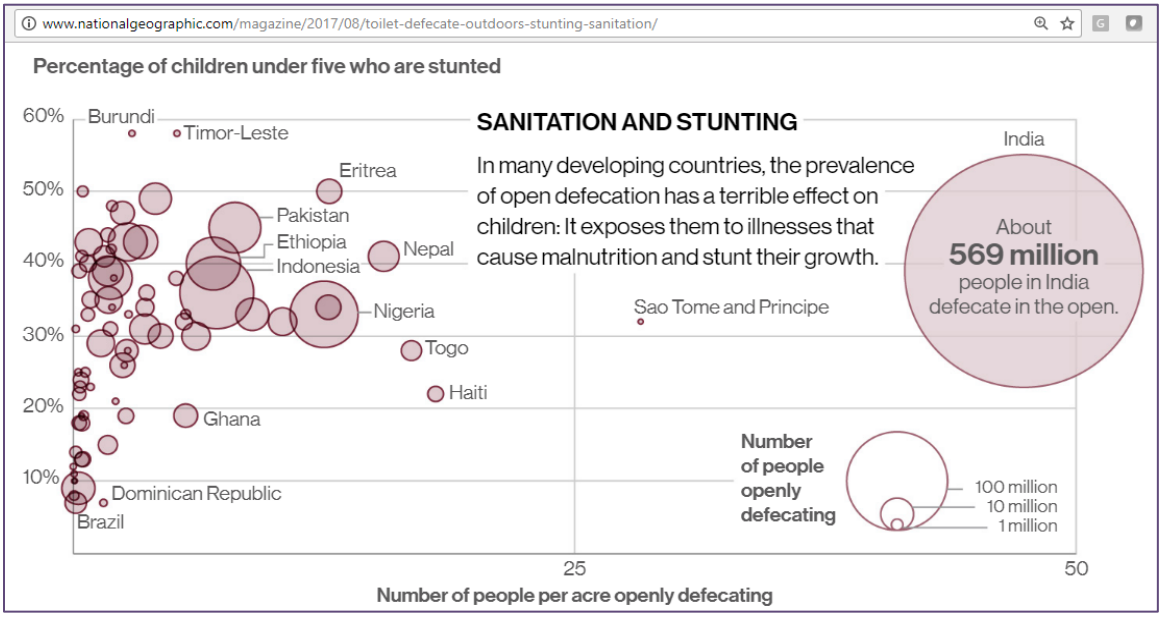


Fig 31: Remediable injustice? How lack of adequate sanitation may be robbing billions of children in the world, from a healthy childhood (ref 92). Can science help society?

Notes

[1]https://en.wikipedia.org/wiki/Sally_(short_story)
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[7]https://mitpress.mit.edu/books/inversion-factor
[8]Le vrai point d'honneur [d'un scientifique] n'est pas d'être toujours dans le vrai. Il est d'oser, de proposer des idées neuves, et ensuite de les vérifier. *La Science des Rêves*, Science et Vie Junior, 214, (18 May 2007), page 13
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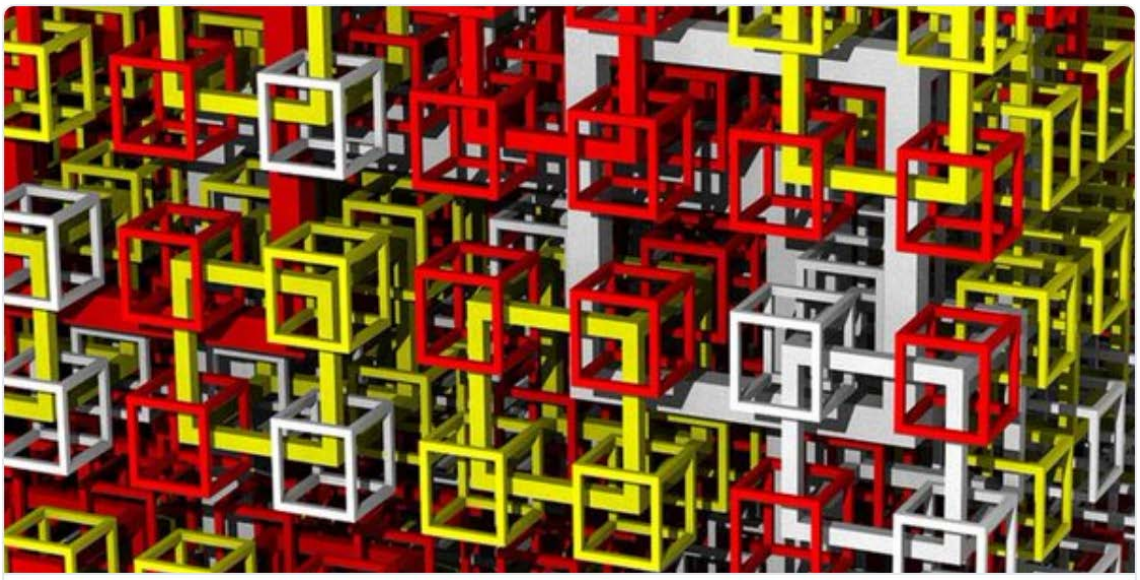
[142]http://www.bmj.com/content/bmj/360/bmj.j5808.full.pdf
[143]https://www.iupac.org/publications/ci/2011/3301/jan11.pdf



Shoumen - I finally had some time to complete a thorough reading of your recent paper, "Adapting Decisions, Optimizing Facts and Predicting Figures." It was certainly thought-provoking. As you know, we have been thinking about some of these ideas, but it is nice to see them woven together more completely than I have before. I think the trick for industry will be to fearlessly use these ideas instead of rejecting them out of ignorance, cynicism, or short-sightedness.

JAW

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17 June 2004

Jeffrey A. Wilke

Jeffrey A. Wilke
CEO
AMAZON

Jeff Wilke (JAW) has served as CEO Worldwide Consumer since April 2016. From February 2012 to April 2016, Jeff served as Senior Vice President, Consumer Business, from January 2007 until February 2012, he served as Senior Vice President, North American Retail, and from January 2002 until December 2006, he was Senior Vice President, Worldwide Operations. Jeff joined Amazon.com as Vice President and General Manager, Operations in September 1999. He left AlliedSignal (Honeywell) where he was Vice-President and General Manager, Pharmaceutical Fine Chemicals. Jeff spent the preceding six years in a variety of operations and general management assignments in the chemical, polymer, and electronics industries. Jeff did his graduate work (MBA and MS in Chemical Engineering) at MIT's Leaders for Global Operations (formerly Leaders for Manufacturing) program where he focused on Total Quality and Process Improvement techniques. He began his working career writing software and leading software development at Andersen Consulting (now Accenture). Jeff also holds a BSE degree in Chemical Engineering (*summa cum laude*) from Princeton University, NJ.