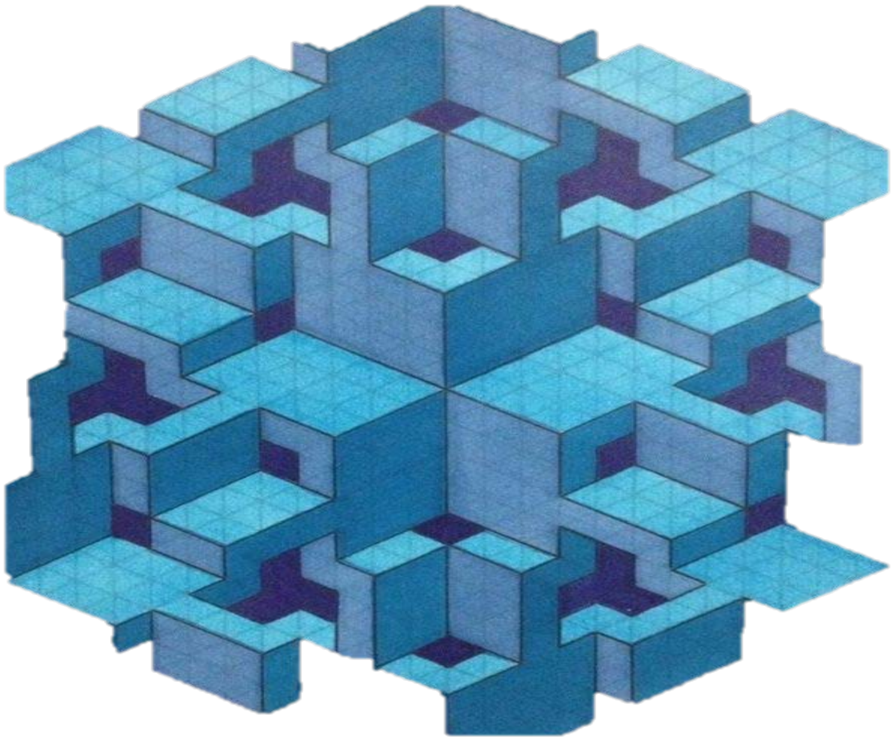

Digital Enterprise X.0

A blog about building blocks

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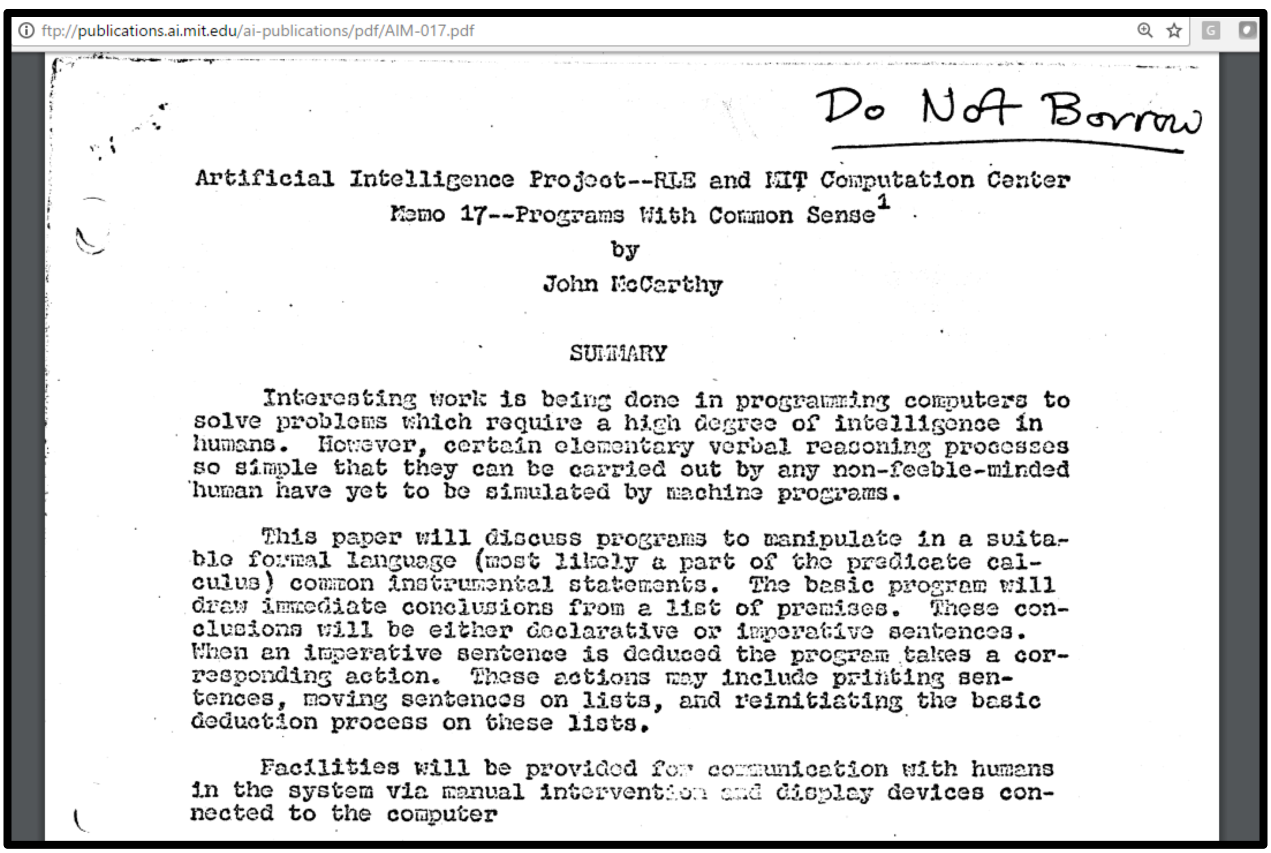

ftp://publications.ai.mit.edu/ai-publications/pdf/AIM-017.pdf

Do Not Borrow

Artificial Intelligence Project--RLE and MIT Computation Center
Memo 17--Programs With Common Sense[1]
by
John McCarthy

SUMMARY

Interesting work is being done in programming computers to solve problems which require a high degree of intelligence in humans. However, certain elementary verbal reasoning processes so simple that they can be carried out by any non-feeble-minded human have yet to be simulated by machine programs.

This paper will discuss programs to manipulate in a suitable formal language (most likely a part of the predicate calculus) common instrumental statements. The basic program will draw immediate conclusions from a list of premises. These conclusions will be either declarative or imperative sentences. When an imperative sentence is deduced the program takes a corresponding action. These actions may include printing sentences, moving sentences on lists, and reinitiating the basic deduction process on these lists.

Facilities will be provided for communication with humans in the system via manual intervention and display devices connected to the computer

Fig 0: The fact that a program can find a solution in principle does not mean that the program contains any of the mechanisms needed to find it in practice. (1956 ● MIT AI Lab Memo # 17 by John McCarthy)

Digital Enterprise X.0

A blog about building blocks by Shoumen Datta

PREFACE

Experts and non-experts have already commented that this blog is shoddy and second grade in style and content. It lacks several seminal issues indicative of the author's lack of knowledge, depth and business experience. I concur. Therefore, please proceed with caution. The intent (please see appendix) was to offer suggestions about paths that may be different or diverges from conventional wisdom or what is in vogue. The disjointed digressions are an attempt to connect the "dots" and that process may be chaotic. This is not an instruction manual, recipe or a roadmap. It is a compass. It points in so many directions because of what may be possible, the yet unseen tangled networks and the looming digital quagmire.

Aren't we are all apprentices in a craft where no one ever becomes a master? from Ernest Hemingway

ABSTRACT

The approaching wave of digitalization may dwarf the immense economic consequences of what could have happened if we were to flood the Sahara Desert. In this essay, we may not even scratch the surface of convergence which is the quintessential foundation of the imminent transformational tsunami. Flooding the Sahara [1] is a metaphor. We present vast opportunities for business solutions in terms of development and sales of services under the banner of Digital Enterprise X.0 (DEX) and its potential for global diffusion. Modular services may offer delayed differentiation using "lego bricks" or building blocks aggregated to form platforms, which can rapidly configure trillions of outcomes for billions of customer choices, using variant configuration and dynamic composition. The combinatorial efficiency may be optimized by a "menu" to select choices triggered by customer preferences. Sense-aware bots may "drag and drop" or "plug and play" Agent-based entities at mobile edge devices (or interact in a mist or fog). It may execute functions (data analytics - predictive, prescriptive, diagnostic) at the edge or in the cloud, linked to objects, processes, decisions, patterns or things connected to the internet [2]. Hence, a convergence, of enterprise systems, with IoT, a conceptual digital design metaphor. Synthesis of each element, in sequence, offers a micro-revenue harvesting potential for each creator, developer, provider of each function in each micro-service. The trans-disciplinary convergence and systems integration, necessary to arrive at the outcome, is rewarded when the end customer pays, after the value of the service is realized or the outcome is delivered. Revenue collection "at the end of the tunnel" may require a channel master, brand integrity, security and interoperability between platforms (local and global, private and public, open and proprietary). Monetization demands tools and technologies to document every event in an irrefutable digital ledger. The latter is essential for billing purposes, if the partners in the ecosystem may wish to claim their fraction of nano-earnings from each micro-payment.

BACKGROUND

Digital transformation is still embryonic and evolving. The process is punctuated by islands of hype and hyperbole [3] which makes it difficult to synthesize the fabric, in order to capture the convergence and continuum, characteristic of most enterprises. The alternative approach is to discuss discrete events, such as, tools, technologies and applications, that is, business as usual in terms of products or services. Compartmentalization of business solutions further fragments the collective use of data and diminishes the potential for profitability which may ensue from data analytics, if the interdependencies between silos, were analyzed. Static data storage may not be beneficial in this age of data driven decisions.

We are drowning in data yet suffering from poverty of information and knowledge. The classical chasm between information technology (IT) and operational technology (OT) is a reminder that the enterprise was not designed to interface or analyze external/internal data to boost efficiency, reduce waste and take advantage of risk pooling. Systems integration to promote collective "intelligence" by dissolving the archaic IT/OT boundary is not a core competency for most enterprise. Thus, supporting businesses are still creating discrete products and pushing independent domain specific business services touting their use and efficacy in a manner which resembles a hammer looking for a nail. Not every product or service is a solution and certainly one solution may not fit all. In some cases, the solution may not be a solution at all [4] but a public relations gimmick to impress the uninformed through game shows or board games and marketing chutzpah. The elusive quest for wisdom about "disruptive" [5] digital transformation from dubious management gurus [6] with a widely known predilection for self-promotion [7] is tantamount to dissemination of dead ideas [8] from live people [9].

WHAT IS THE EXPECTED OUTCOME ?

Pulling the digital thread through the eye of the needle relies on the assumption that every needle has an eye. Once threaded, we must be able to display a measurable outcome, that is, the needle must move, hopefully, in a manner which may be sustainable and supports an ethos of ethical profitability.

Neither the hand-waving about the prospects for digital transformation nor the glib PR of estimated economic growth due to digitalization [10] may be realized, even partially, unless we focus on building the foundation, at the systems level. We have to make sure that there *are* "new eyes" in every system, if the process of digital threading is expected to succeed. Convergence of digital threads are quintessential to the systems integration process, which in turn, is key to linking the systems of systems, at the heart of the enterprise, both analog and digital. Solutions are likely to incorporate elements, we have seen, or what already may exist. Innovation germinates from imagination, and thinking, what no one else has thought [11], by visualizing creative juxtaposition of blocks or bricks, to create new designs or patterns, and to implement them for systemic improvements. A catalyst for entrepreneurial economic growth is not so much to obtain novel facts or delve into research, but to uncover unique ways of thinking about existing facts, data, tools and technologies, percolating them in "various speeds" in a matrix of unusual or imaginative combinations. Frequent departures from conventional wisdom, creative destruction of existing rules and application of the principle of non-obvious relationship [12] are vitamins for progress.

Fig 1: Partial view of one of the floors of a NY Times printing facility (1 NY Times Plz, Flushing, NY 11354)

Imagine standing in front of a machine on the floor of a New York Times printing facility (Figure 1). You take out your smartphone and click on the app marked DEX. What you expect is the software avatar of the hardware, ie, machine, in front of you (aisle 8A in Figure 1). You see a blinking icon in a network diagram displaying other connected machines (8A, 8B, 7A in Figure 1). You tap the blinking icon to focus on the digital duplicate of 8A, that is, the Digital Twin [13] of the paper-cutting and sorting machine (8A in Figure 1). You tap on the parts icon to drill down to the details, for example, performance (blade speed), wear and tear (MTBF of blade), lubrication of the hydraulic cutting arm (oil pressure), temperature inside the press which holds down the paper stack (to optimize performance of the blade) and conveyor belt surface aberrations (data from mounted camera under the belt analyzed using optical recognition).

This scenario is part of an expected **outcome** relevant to, for example, **efficiency**. We need **metrics** to measure the **value** of key performance indicators (**KPI**), for example, down-time, based on the **data** (outlined in above paragraph as blade speed, MTBF of blade, oil pressure, temperature, belt health) and data **analytics,** to understand the **meaning** of the data, in terms of **information,** related to efficiency.

The data thus converted into information can update and inform the status of the machine (8A in Fig 1). Individual machine data, when combined, can further inform the KPIs for the entire machine floor or the entire operational system. Instead of one machine, we can acquire data and analytics from a **swarm** of machines and rather than understanding the status of one machine, we optimize the entire **operation.**

The **transaction cost** [14] to obtain each piece of data can be **aggregated** and the monetary value of the information is deduced. To perform comparisons, we model and run "what if" **simulations** to compare the operation with and without data, with respect to the sequence of events in the cascade or the final outcome (may be affected) of this operation, due to an unplanned failure of a machine (preventable).

If two machines shut-down due to over-heating without an alert (absence of temperature sensor data) what will be the impact on the operation? Will decreasing the output affect distribution or logistics or the supply chain? Can it impact quality of service for delivery and customer satisfaction? Will it damage brand image? Will the ripple effect influence the ecosystem of partners? Can it reduce EVA (economic value added) parameters? Each event in this multi-pronged process may have a value or can be assigned a weight in addition to transaction cost (positive or negative). Comparing the simulated transaction cost between [a] acquisition of data/information to inform and alert vs [b] operation running without these tools, may provide the rationale and justification to invest in digital transformation or not.

HOW TO PREPARE TO ACHIEVE THE EXPECTED OUTCOME ?

This discussion must begin by reiterating the obvious - no one solution or architecture or strategy may suffice to address the needs of Digital Enterprise X.0 (DEX). Complete disregard for archaic or monolithic approaches (for example, IBM DB2, SAP R3) may be a bit unwise. Salivating for new tools (for example, Google Spanner, IBM Watson) may be replete with copious shortcomings.

The disturbing efforts by some behemoths claiming "brain in a box" by 2020 [15] can only amplify hype through yellow journalism. AI apocalypse is a marketing [16] attempt devoid of scientific foundation. For example, engine wants to reduce NOx emissions [17] without increasing carbon dioxide. The outcome depends on a plethora of parameters which must be optimized, such as, controlling multiple points of injection of the fuel, how to determine efficiency by balancing fuel composition, temperature, humidity data from hygrometer, etc. It is difficult for humans to monitor, adapt and regulate NOx emissions to the lowest level because the optimization requires too many experts to learn, observe, agree and predict the thresholds and the range, before each equation can be solved and the results applied to the process. A portfolio of algorithms and solvers using the principles of machine learning (ML) may be used. Is this AI or artificial intelligence at work? This is ML at work using contextual higher order reasoning (CHOR) in real-time. Publicists call it AI. This is the crux of the discontent, over-selling of what is intelligence [19].

A portfolio of solvers [18] is not equivalent to intelligence. What is intelligence [19] if we are discussing actions at the level of a worm or an ant? Solvers rely on data but forced fitting data to models is fitting noise. Processed data may be denuded of its informational content just as processed food can lose its nutritional value. Just because the data was smoothed does not mean that the data is smooth. Hence, curation of data through a data "forge" and then harvesting the data based on feature engineering [20] is a prelude to composing betters models. But, models *per se* are fraught with problems. Most models are incapacitated in the face of dynamic change in data or fails to be useful if the rules or patterns in the data may change, indicating the need for feature engineering re-design [21].

Automatic code generation based on models [22] continues to be an useful tool for equation based models (EBM) but may lack the dynamic attributes increasingly important due to the volatility of digital transformation. Modularity, dynamic composition and mathematical models to drive the best outcome in face of uncertainty are the general principles of rational Agents and multi-Agent systems. The latter is essential for enterprise architecture as a key component of AI and will enable us to profit from use of AI.

Hence, we propose introducing Agent based models (ABM) with EBM. Meta-modeling principles from model driven engineering [23] could be useful in digital transformation if the meta approach may be better tuned to accommodate dynamic changes expected in the future. Knowledge representation and symbolics, for example, in feature engineering for data analytics, will be avoided in this blog. Rather we shall focus on interoperability and connectivity between platforms and applications. Convergence of various cyberphysical systems (CPS) or CPS SoS (system of systems) with time sensitive networking will present even more complex challenges [24] where interoperability between platforms may solicit more attention. However, tuning the engine vs polishing the chrome, may continue to haunt us. It is difficult to find the balance, coalesce teams, adapt and/or adopt with respect to state, context and dynamic composability needs, at present and in the future. Examples of progress may be found in GE Predix, Siemens MindSphere, Hitachi Lumada and IBM Bluemix, in addition to other less known IoT platforms.

BUILDING BLOCKS OF THE DIGITAL ENTERPRISE X.0 (DEX) – A BRICK BY BRICK ACCOUNT OF DEX

The preparation necessary to substantiate the introductory level of Digital Enterprise X.0 (DEX) outlined under "expected outcome" in the preceding section, offers the grand potential for new lines of business.

The evidence from GE's Predix suggests that GE may use this platform for its own business units and sell the platform as a service. This is the new business. The scope and reach may be far greater than what appears to be on offer from any vendor, at this time.

This solutions space is analogous to fractals [25] or Minsky's cube-on-cube paradigm [26] rather than point or line. It will evolve and change as the semantic context of DEX adapts to diverse domains, from manufacturing to medicine to mobility, serving different needs in Memphis, Maputo and Mumbai.

The vision, investment and determination necessary to create this new line of business may be uncommon. Few companies possess a portfolio of operations where DEX systems may be developed, evaluated and implemented. The customer and supplier base of these companies may be the first users. Hence, expect a network boost from creating the business of DEX.

Not all components of DEX may be created *de novo*. DEX needs to tap into applications (start-ups) and potential advances (academia). Commodity tools (sensors) and services (cloud, storage) are likely to be procured. Foresight is crucial to converge and orchestrate near-term needs, profitability and long-term sustainability of the vision.

If the expression "low hanging fruit" creeps in early discussions, that is an ominous sign and the plight of DEX may be compromised. It is abundantly clear that incremental gains must be a part of this journey but such gains may not be "low hanging" from the onset of this process.

Slapping a sensor on a machine to harvest vibration signals from a pump is not indicative of digital transformation. Similar mistakes [27] were made at the dawn of the 20th century with electrification [28]. It was repeated [29] two decades ago when retailers thought affixing a RFID tag offered transparency and the digital supply chain was a *fait accompli*.

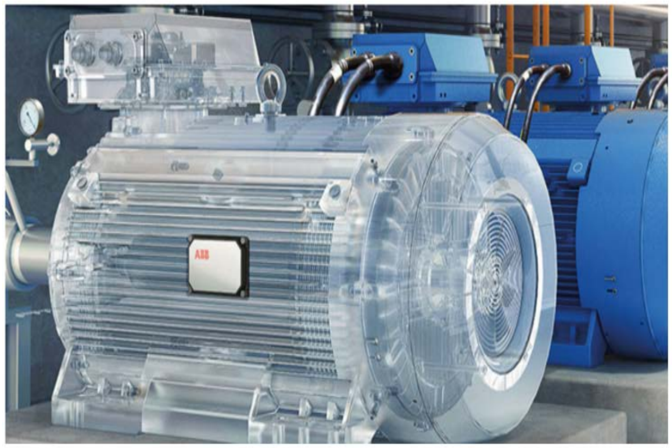


Fig 2: Digital Twin of a pump showing virtual (VR) sensor. The context of a pump within the operation (water purification, air recirculation, oil flow) is key to the value of data vs information. Including sensors to identify pump metrics is perhaps an incomplete approach, incongruent with the convergent vision of operational efficiency in the context of the customer (pump is one asset in the operation of the plant).

Convergence of the need for data with acquisition tools to harvest data (for example, from RFID, sensor) is step one in a systems approach. Subjecting the data to appropriate analytical tools may help to make "sense" of the data in step two. Extracting actionable information or knowledge makes the data valuable (sense and response) to the supply chain network or partners. The architecture and systems engineering principles must converge with the business process and the context of the data, with respect to the operation, where the information may be actionable.

Latent in the "preparation" is the need for organizational vision which must sufficiently percolate within senior leadership. They must be imbued with the spirit to grasp beyond their reach and embrace innovation uncertainty with a pledge to proceed beyond proof of concept to large scale implementation. The rationale for the latter is based on the principle in Young's double slit experiment conducted by Akira Tonomura [[30]] in HCRL, Kokubunji [[31]]. There must be a consensus to move mountains and remain cognizant of the fact that there are *mountains beyond mountains* [[32]]. The action plan may commence by acknowledging **convergence** is as important as **connectivity** between digital threads.

How to connect the entities to drive the "outcome" is a key question. This is a convergence issue which manifests as systems integration, has many moveable parts which may rapidly change. Components may become relics within the time span of implementation due to short half-lives. Functions often may not scale and non-linearity is the norm. Response or lag time in proof of concept (PoC) may not extrapolate in large scale implementations due to non-deterministic real-world variabilities which one may not capture in deterministic models used for PoC. These known unknowns behaves poorly at the systems level (Figure 3). Early attempts to create systems to generate tangible outcomes [[33]] resulted in the "Store of the Future" in 2002 [[34]]. The PoC may be best described as a successful failure.

The complexity of the components, which are systems within systems, and integration with data and analytics, remains challenging. It may have inspired Amazon GO, the no-checkout convenience store of 2017. GO is wobbly, incomplete and still a PoC, on steroids. But, Amazon's "Store of the Future" is still not yet good to go [35].

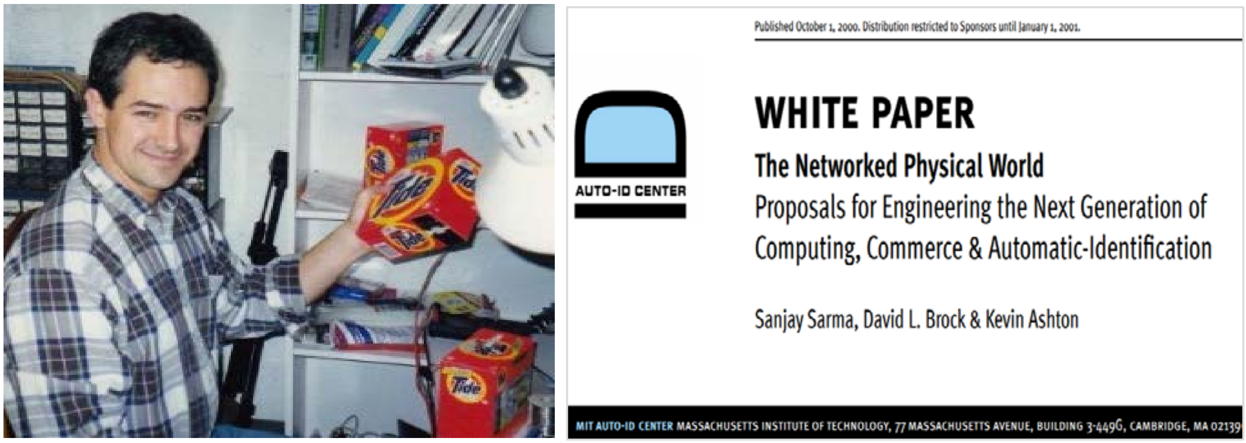


Fig 3: Dr David Brock attaches RFID tags to objects (1999), at the MIT Auto ID Center, which created part of the vision (*The Networked Physical World*) and further catalyzed digital transformation and DEX [36].

WHICH STRUCTURAL ELEMENTS AND COMPONENTS ARE CRUCIAL FOR CONNECTIVITY ?

Over the past half century we have made progress in connecting various software modules with a host of different interfaces. In a simplistic form, we would like to connect processes and data in a manner that it can use the outcome (decisions) to inform and improve the process (classic feedback loop). Process and data must stay decoupled but encapsulating process and data in software "wrappers" may generate myriad of different forms. Perhaps the most useful are functional modular representations or "lego" blocks, which can be used for complex combinatorial creations, to develop layers of successively higher order functions, subject to rapid assembly, dis-assembly and dynamic re-assembly, if necessary.

The Agent Network Architecture proposed by Patti Maes [37] was based on a 1989 proposal [38]. Some of the ideas [39] are still germinating at the hands of Google, Apple, Microsoft and others [40]. The potential revolution cryptic within the vision of Agent Network Architecture (ANA) was recognized by experts [41] and gained academic momentum [42]. However, its use in industry [43] may be still sluggish [44], at best.

Agents based architecture provides the tools critical for interface components. These tools are key to facilitate connectivity and interoperability between the blocks or modules or units of Agents. Thirty years later, Agents are still struggling to cross the bridge to the business world. There weren't any "low hanging fruits" then and there may not be any "low hanging fruits" now. The myopia prevalent in the business world leads to the stampede for "low hanging fruits" but without the understanding that "low hanging fruits" require low level skills. The rational Agent based approach is the underpinning of AI.

Development, deployment and diffusion of ANA and other Agent architectures are pregnant with solutions [45]. Skills necessary to design, evaluate and implement these architectures are neither trivial nor automated. The “winter” of AI [46], the resurgence of AI hype [47] and the lack of CS graduates [48] are hampering the arduous tasks which must be undertaken if the so-called fourth industrial revolution, characterized by ubiquitous connectivity, is expected to yield actual profit. It appears that these discussions are increasingly part of corporate marketing budgets rather than R&D or education investments. All things digital, IoT and AI, in particular, is prime tabloid fodder and electrifies cocktail banter at the gatherings of glitterati in a highly secure winter chalet, feeding the frenzy of paparazzi [49]. AI is rather useful if we may think less of human level intelligence and more of higher order reasoning.

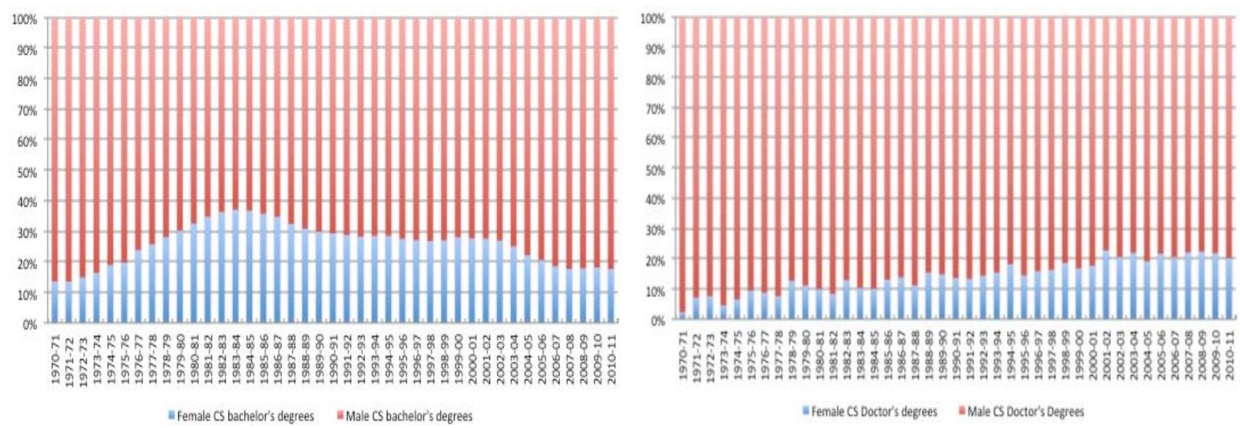


Fig 4: BS (L) & PhD (R) degrees in CS (computer science) from US universities [50]. Too few in numbers to supply the workforce necessary to catalyze convergence (IoT, AI, ML, Agents, Robotics, Data, AR, VR).

Connectivity by powerpoint (Fig 5, left) is witnessing exponential growth [51]. But dissecting these “boxes” and reducing each to its basal functional granularity may reveal multiple layers in each “box” and each with its own multi-dimensional matrix (but not always) representing complex interactions, dependencies and potential for interactions between building blocks and function modules (Fig 5, right).

In Agent based architecture, each function is encapsulated as an Agent with interfaces which can connect to other Agents encapsulating other functions (process, decision, location, data feed, sensors, analytical engine, edge parameter, cloud store). Each unit or block or box may comprise of multiple Agents in accordance with the “layers” of functions that each represents. Each Agent or a collection of Agents (referred to as an *Agency*) within a “box” may serve as a module capable of executing one function. It can be used independently (1 Agent) or as a collection of function-specific Agents (Agency).

Thus, Agents and Agencies (representing these “boxes” at the level of desired granularity) can be mixed and matched without the need to re-tool or re-structure or re-program the entire function or operation. In equation based models (EBM), the interrelationships and dependencies are refractory to dynamic adaptability because they are hard-coded. Hence, addition or deletion of functions (boxes) alters the equation and renders it useless or incompatible unless re-programmed or re-structured or re-designed.

In contrast, in Agent based models (ABM), dynamic composability is normal since each Agent or Agency can interact with any other Agent or Agency as long as the Agent interface enables the communication. The Agent interface can control the connectivity, because it can be configured by design to regulate the nature of data sharing process, by differentiating between sharing data vs information. The Agent acts as a "wrapper" within which the decoupled modules of process definition (feature) and data co-exists in separate sub-modules. They can function as 1 entity for data/information sharing or differentially parsed based on business or security logic. If a bot pings your location, your PSA (personal security agent) may trigger *selective permeability* (Figure 8). The Agent shares information "not in the office" but protects your actual GPS location data because of your *selective* privacy settings in the Agent interface layer [52].

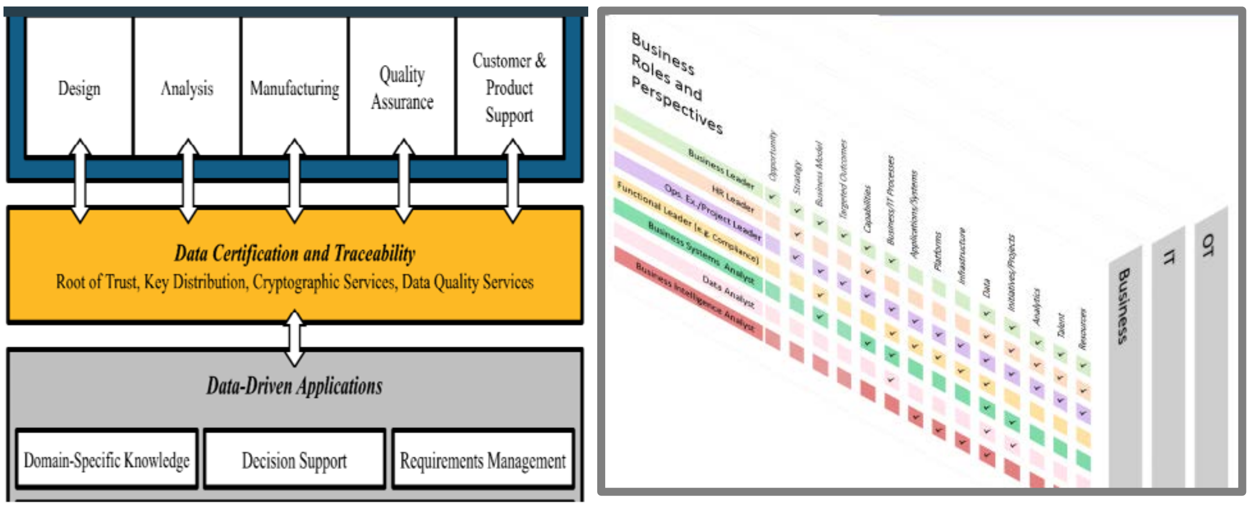


Fig 5: Connectivity by design require architectural modularity and interoperability between the modules. Elements are available from object-oriented analysis and design principles [53] and related advances [54]

Is this *modus operandi* applicable to all enterprise architectures in order to align businesses with DEX? Unlikely. As previously stated, digital transformation must be a value-driven process guided by metrics including transaction cost analysis. But, most businesses lack granular transaction cost information. The economy, as a whole, still considers Agent based models [55] as an academic [56] storm in a tea cup [57].

In preparing to augment connectivity, businesses must undertake an analysis of the structural elements in their existing software architecture, especially the interfaces (API), which influences system behavior and collaboration between elements (within the existing architecture framework).

Enterprise architecture [58] was not created for digital transformation or DEX. It is critical to understand which structural elements can be or should be changed to Agent based architecture (ABM) to augment connectivity between elements. Which elements are likely to provide the alignment necessary to adapt between static, dynamic and real-time events in the age of 5G, GIS, AI, ML, M2M, IoT and industrial IoT?

This is a powerful analysis and should be documented as a template for business process engineering or re-design (BPR). The template may be a key learning and form a part of the service provided through the new line of DEX business, as a part of the business solutions arm of the corporation (how GE created the new business of GE Digital as a part of the GE conglomerate). DEX will offer new services to move the rest of the business world (SME) on the road to digital transformation through DEX implementations.

Interfaces to and from data sources and sinks, as well as analytics at the core and the edge, are increasingly commonplace in domains as diverse as finance and fashion. Interoperability between elements and interfaces (both internal and external) shall determine system behavior and interaction between ecosystems or platforms. Assigning a priority and value to interfaces, with respect to stability and security, may reduce or balance the risk of innovation. Risk is implicit and may be omnipresent in transformation from a product-based ERP state of mind to a service driven economy, which is "always-on" and mobile, digital and connected, fragmented yet linked to a plethora of partners, regulators, influencers, customers and constantly bombarded by digital environments and ecosystems (Figure 6).

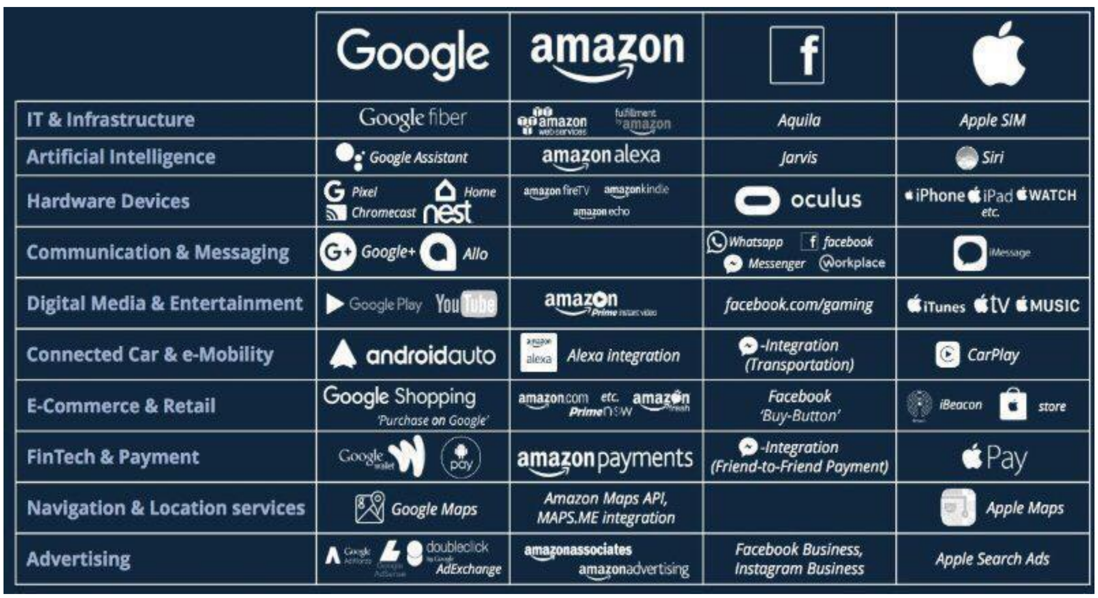


Fig 6: The global digital environment is faced with and reacts to these captivating influencers. Can B2B and B2C interactions adapt to and adopt the *de facto* standards of communication and connectivity?

Preparing to transform the architecture to enable DEX is just one part of progress. It may be useful to use a "bill of materials" (BOM) approach in evaluating key expected outcomes relevant to the operation (for example, manufacturing, water purification, retail, commodities) or business services (logistics, supply chain, finance, business solutions). What do you wish to change or improve or make more efficient or reduce waste or increase productivity? Which nodes, if improved, may lead to decreased uncertainty, better margins, less waste, higher quality of service and will aid greater brand recognition?

Once these targets are identified, that is, each outcome you expect to influence profitability, the task begins to create process maps of dependencies and network of layers which may have an impact on the outcome. For each dependency and/or sub-layer and/or sub-node, it is vital to map its data/analytics flows/engines and the metrics associated with the input/output of data/decisions to measure and determine the performance of that dependency/sub-layer/sub-node with respect to a part or the entire operation, that is, the network of layers/dependencies/nodes, each in its appropriate semantic context.

This approach may benefit from principles of business dynamics using structured analysis in terms of systems engineering thinking and convergence with system dynamics [59]. Software tools (SyntheSim, iThink, Powersim) may help in creating models [60] and may make the tasks less onerous. Classical SD (system dynamics) may still be relevant in the age of DEX. But, the practitioner must be creative and innovative in applying SD to model development for DEX purposes. Blind use of SD as a recipe may be incongruous in view of the EBM infrastructure of classical SD versus the need to move to a digital by design strategy. The latter is volatile by nature and data drivers are often subject to network effects.

In addition, models must be able to simulate adaptability to dynamic situations which oscillate between closed-loop/open-loop with variable feedback control loops, if any, and may be subjected to networks of inter-dependent/inter-related, asynchronous, non-linear and decentralized dynamics. Perhaps we need to determine [1] which nodes, sub-nodes, instances, can perform as modular structural elements in Agents based models (ABM), [2] the interface with legacy systems and [3] dynamic co-existence between ERP/EBM systems versus ABM.

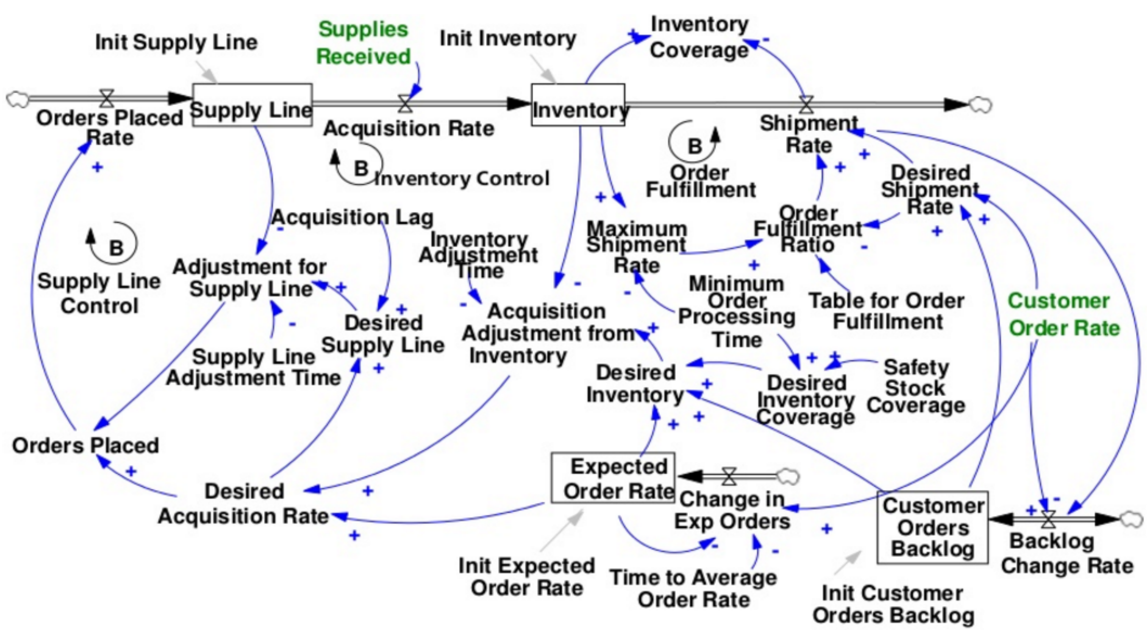


Fig 7: Use of SD (system dynamics) modeling [58] to understand dependencies and networks which may influence outcomes. SD is in need of creativity to adapt to DEX, the digital enterprise, by including, for example, data flow, information streams, analytical engines, dynamic composition, risk and security.

Connectivity between structural elements in the architecture of business solutions will continue to pose challenges due to multiplicity of legacy systems built on different principles. Continuation of mainframe servers may serve as an example and reminder of the dead weight of old technology that still co-exists. How has the processing of payroll changed due to the digital onslaught? Externally, the change is the medium of delivery - paper checks vs electronic transfers. The processes for payroll including payment cycles and deductions may not have changed significantly since the first GE data processor in 1959 [[61]].

Connectivity between structural elements, old and new, must be able to respond to and interface with the network. Connectivity between layers, domains and external systems becomes more crucial in the age of DEX. The drum roll about connectivity has reached a fever pitch in the context of IoT and IIoT. The tools and connectivity between tools and interfaces between software and hardware must continue to evolve and are subjected to rapid replacement/substitution/upgrade based on customer demand. If the customer wants to know the price of gasoline in 3 different zip codes, the app or service provider must connect the data streams, design the visualization appropriately and work within the telecom standards, protocols and latency boundaries to deliver the user experience capable of capturing a critical mass of repeat customers. The important principle here is interoperability between systems.

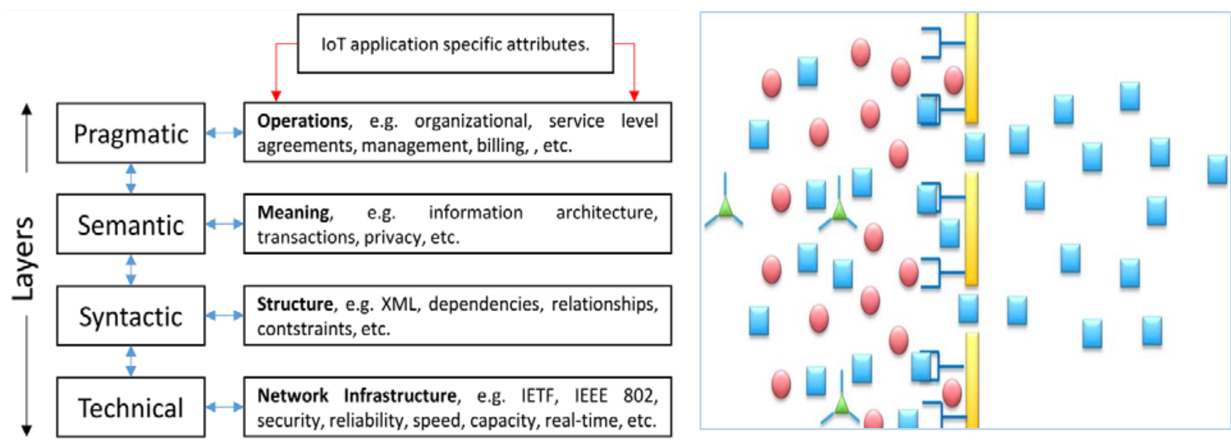


Fig 8: Architectural components must evolve and serve syntactic, semantic and pragmatic demands [[62]]. Selective permeability (cartoon, right) may be necessary for data security and privacy between layers.

The nature and reach of connectivity, and its interactions with the ecosystem, is so crucial for the final customer-facing outcome that the new line of business solutions and DEX leaders cannot be constrained by lack of interoperability, between domains, including third party API and systems on-demand. Evolving open platforms or platforms that are partially open (for example, GE's Predix) are indicative of a future trend. Interoperability between platforms and systems are driven by interfaces (API). Agent based interfaces are interoperable by design and may be selectively permeable for security. EBM products using specific software languages or closed data dictionaries or specifically designed to restrict semantic interoperability (for example, Epic electronic health record systems) are road blocks on the path to global DEX. The digital tsunami may annihilate closed approaches, especially in the emerging markets.

Connectivity between the (hardware) physical machine in aisle 8A (Figure 1) and its digital (software) representation is a part of the "liquid" interface of DEX as outlined in "expected outcome" segment of this article. If every piece of hardware - that is, every machine manufactured by a different equipment factory - were to use proprietary interfaces for its data port (for example, data from sensors) then interfaces for data analysis may be incompatible. Software and hardware are likely to be poles apart in aligning their product interfaces for data communications unless they belong to the same club [[63]].

An Agent model of the machine (hardware) may be interoperable with a number of Agent-based software data and analysis tools. The Agent model of the machine is not one Agent but an Agency made up of many Agents representing each discrete component in the machine (parts, sensors, belts, ball bearings, gears). The software representation (this Agent model) of the hardware is the Digital Twin concept [[13]]. Digital Twins are not restricted to machines but can represent humans. For example, a human may be uniquely identified on the smartphone screen, of a RN or MD in a hospital who can view and monitor real time data about the patient's heart rate, oxygen saturation, end tidal carbon dioxide and blood glucose level from sensor data or diagnostic devices [[64]].

Without the type of connectivity and interoperability described above, the "expected outcome" with reference to Figure 1 may be difficult to achieve. The modularity of the Agent infrastructure - bricks and blocks - can be combined to create components in manufacturing plants, bridges, turbines, airplanes, automobiles, EKG machines, pulse oximeters, mammography, sensors, oil pipelines, water pumps, satellites, violins and agricultural machinery. Access to digital object repositories [[65]] may enable a "drag and drop" tool to create any machine or object or tool as a duplicate or Digital Twin [[13]]. Activating the software to connect the data from the object or machine with the Digital Twin or avatar calls for a plethora of other interfaces and telco components which must "discover" [[66]] the hardware (machine), "discover" the sensor data stream from that specific machine (in a shop floor of thousands of machines) and connect it to the specific software model on the smartphone or tablet of the user. The pivotal role of "discovery" and the tools for automatic identification and secure communication of data must converge to fuel the digital convergence, in order to accomplish the "expected outcome" for DEX.

The hype about trillions of objects connected to the internet (in IoT and industrial IoT) is oblivious of the fundamentals [1] that a connection to the internet is not equivalent to a function and [2] that IoT is not a solution or a tool or technology but rather a design metaphor. Functional value of connected objects depends on **discovery** [[67]] of the appropriate objects in context of the operation and relation to the data streams. Taken together, it may create an *ad hoc* dynamic composition of objects which offer value when constituted as a function and the ensuing network of things [[68]] provides an outcome. An analogy is the *ad hoc* creation of a mesh network [[69]] which also highlights the role of standards and interfaces. Connectivity of objects offers limited value unless the connectivity is in the context of an operation. For example, the efficiency of pumps is important to the manufacturer but the customer who buys the pump to execute an operation prefers information on the whole operation in terms of all the key performance indicators, not just the motors or the pumps [[70]]. The outcome economy is less interested in tools and more interested in the final outcome. DEX is also interested in performance and outcome.

Components of connectivity have been discussed *ad nauseam* in millions of technical and business publications but a few other issues deserves to be mentioned.

Telecommunication standards are immensely critical in bridging domains. It must be flexible to switch between protocols as IP applications (software) move from closed to open to hostile environments (PLC in boiler room of a plant) and interacts with multitude of objects, data and processes using diverse modes of communication. It is the central theme of application dependent networks which posits that applications will trigger how the network will respond because the application is the focus or the master (it is the monetization node) while the telecom network is a medium (slave) for delivery. The network must respond to the needs of the application, by switching to appropriate fixed or wireless or hybrid technologies, for example, multi-protocol label switching (MPLS) network.

It may be obvious that the application running on the Digital Twin of the machine in aisle 8A (Figure 1) will be deemed inefficient if the sensor data from the machine failed to populate the Digital Twin sensor database with the pressure or temperature data. One reason for such inefficiency may be the nature of the telecommunication signal on a shop floor densely packed with machines spewing exabytes of data. If the communication link suffers from interference (WiFi or Bluetooth or VPN or controller area network, LPWA) or transmits null data signals (occurs with RF data in a dense data environment or if reflected by metal in the infrastructure) then the Digital Twin application fails to provide the desired outcome.

Connectivity in the age of DEX, therefore, requires new thinking in design, construction and utilization of telecommunications networks to prioritize network applications and service demands. DEX expects significant application-efficiency gains for networks to ensure robust connectivity adhering to the QoS with respect to latency, bandwidth and data rates.

To respond to these targets, over the past few years application triggered systems (for example, ACI from Cisco, ADN from Huawei) are trying to meet future application demands, especially for 5G, for example, by decoupling the services plane. Applications do not need to know the underlying network complexity, which must be navigated, in order to deliver the service – the application.

Not everything is about high data volume, broadband and zero latency. There are a growing group of functions in the IoT/IIoT domain where proprietary low-power wide-area (LPWA) networks are providing services for very low bandwidth, very low data, very low power and very low cost devices.

In preparing for the digital transformation tsunami, it goes without saying that reliability of connectivity will be paramount in a DEX environment because we are increasingly reliant on data driven decision support systems. The medium of telecommunications is the principal conduit for acquisition of data. If this medium shows “cracks” and the data falls through these “cracks” then the analytical engines will view data streams or data flows with missing data sets. The analysis by the analytical engines will be based on data presented to the algorithms. The outcome or prediction will be flawed to the extent of the significance and context of the missing data (machine shop vs pediatric cardiology ICU in a hospital).

If the flawed data is for a MTBF (mean time between failures) value then the outcome may be an unanticipated machine downtime due to fractured blade or rotor or spindle. The flaw in data acquisition may be due to network traffic congestion, inconsistencies or interference from other signals or time [71] spoofing (systems security breach). If the missing data pockets were for heart rate from a pediatric patient in the ICU, with cardiac arrhythmia, then the outcome may be fatal and a funeral, bit too soon.

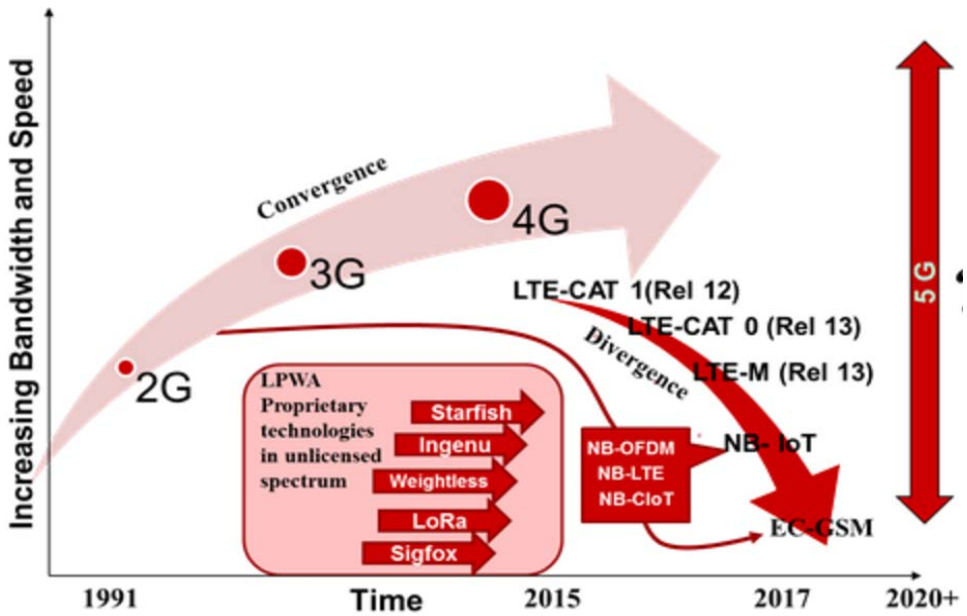


Fig 9: Niche IoT applications use low-power wide-area (LPWA) networks using proprietary products [72]

The complexity and variety of network evolution follows the new uses of networks for different types of applications which may be created in remote corners of the world and/or crowd sourced. Traditional voice communication relied on hierarchical network architecture and follows a Poisson distribution model because phone calls are likely to remain at a constant frequency and duration, over time. But internet (IP) communications follow power-law distribution model [73] where most users connect via central nodes. Machine-to-machine (M2M) communication, which may be in progress in the scenario depicted in Figure 1, may be comprised of many different cases, each with a different need.

For example, autonomous vehicles and robotic surgery both demand near-zero latency, extreme bandwidth and ultra-high reliability. The environment for a vehicle rapidly changes as it moves on a crowded street lined with tall buildings or inside a tunnel or a bridge or climbs the Twin Peaks. The environment for robotic surgery may be an urban hospital from where the surgeon is "performing" a laparoscopic cholecystectomy (gall bladder surgery) on a patient in Petit Bois Island, Mississippi.

These scenarios emphasize that connectivity demands are very diverse. To meet these demands we must be able to slice, dice and splice dynamic programmable network-agnostic networks on top of fiber, copper, wireless, LTE and future 5G, using open source platforms and protocols, for example, software defined networking (SDN) and network function virtualization (NFV). Network flexibility is vital. It is enhanced by dividing the network and using open source software, as far as appropriate, to manage the decoupled data plane (traffic forwarding), control plane (devices) and services plane (applications). If a connected vehicle needs software download or must upload sensor data, the customer expects the outcome to be download/upload. In the outcome economy, the customer will not care if it is a wired or wireless connection, SDN or NFV. Implementation must offer complete connectivity for the customer.

For the telecommunication industry the concept of monetizing the "pipe" is increasingly irrelevant because the revenue is realized only when billions of end customers access or use the services. It is hard to differentiate "pipes" which must adhere to standards and protocols that are globally accepted. The value-added portfolio for telco may be in real-time data analytics, which is not their core competency. Hence, it is important for progressive telecoms and OEMs [[74]] to create partnerships across a diverse cross-section [[75]] of other component providers [[76]] in order to multiply their sources of partial revenue (micro-payment, nano pay-per-use). The service will only earn revenue when delivered to the end user.

Sharing fractional micro-payments may require new tools for micro-event billing segmented by micro-sequences which may include micro-services [[77]] and require seamless convergence to deliver the end service (outcome). The modularity of micro-services and use of software-oriented architecture [[78]] may be better suited to Agent based architectures. SOA may enable harmonious co-existence of Agent-based models (ABM) and equation-based models (EBM) to optimize dynamic composition when serving the on-demand service request (application triggered). Services in each layer may have a different provider. Each provider in the ecosystem will claim a fraction of the end-revenue which is earned only when the service is delivered at a satisfactory quality of service level. A potential scheme for this approach was suggested [[79]] and if analyzed, it resembles, at least, in principle, a digital ledger or blockchain [[80]].

Fig 10: Who will build the blocks? New lines of businesses may emerge in the domain of DEX blocks which are not limited to enterprise architecture could include cybersecurity [[81]] and Digital Twins [[13]]. Both instances are influenced by AI and the rational Agent approach may the common building block.

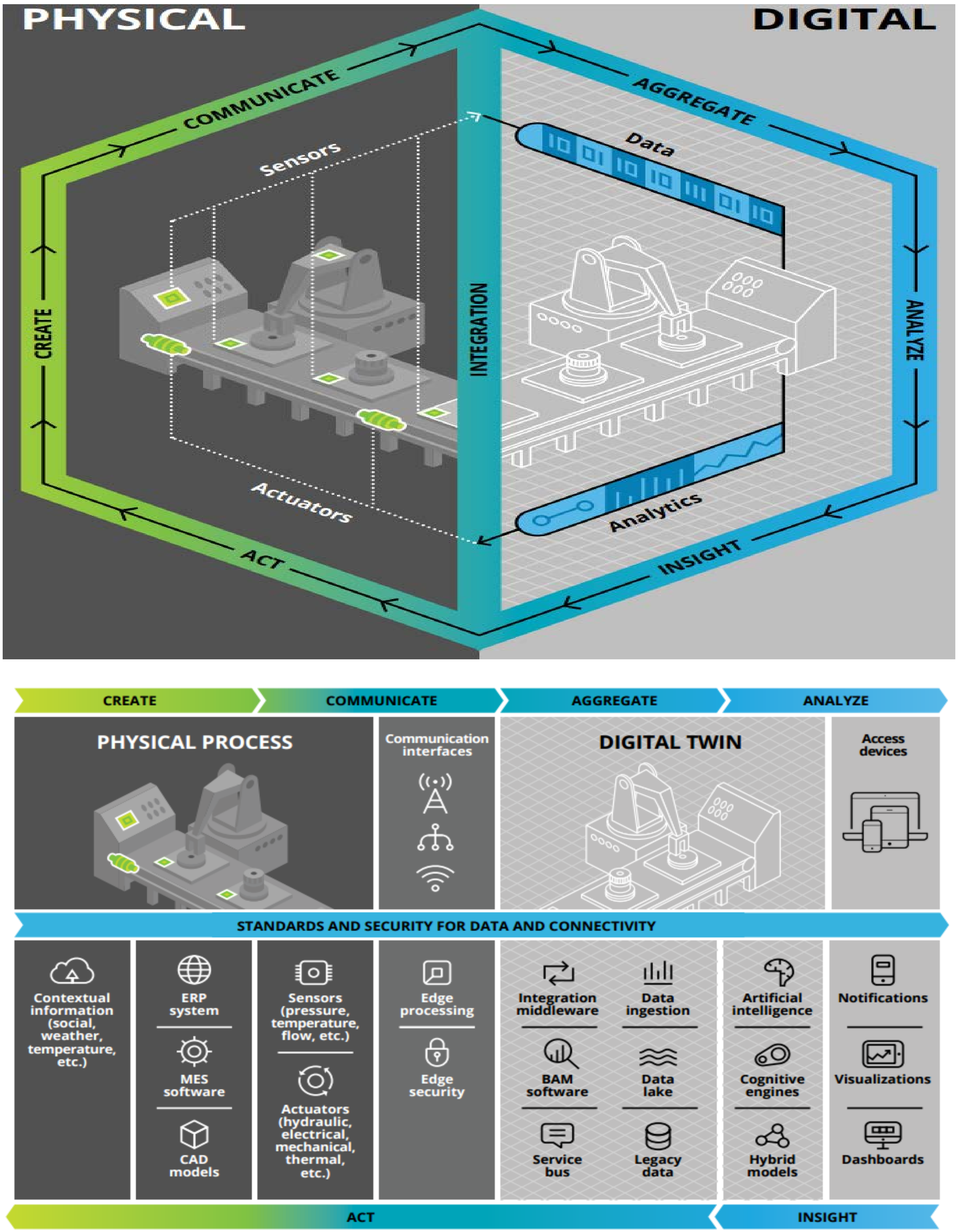


Fig 11: Digital Twins are within our reach? Cartoon from article by Aaron Parrott and Lane Warshaw, Deloitte [82]

WHY INTEROPERABILITY BETWEEN PLATFORMS IS SYNONYMOUS WITH PERFORMANCE AND PROFIT ?

A challenge for open platforms providers is that open is synonymous with free in the digital economy. A quandary for open platform providers is the lack of monetization systems integration, that is, seamless convergence between micro-billing tools, digital ledger of micro-service delivery confirmation and time guarantees for time sensitive networks or real-time events. The ecosystem is strained when seamless functionality is compromised due to lack of interoperability between services or platform (assuming that connectivity is not punctured and the data flow is agnostic of the protocols and the telecom networks).

The sketch (Figure 12) outlines the diverse domains that must interact through the mobile platform to provide the service you demand (the expected outcome). The plethora of service providers include hardware and software vendors, telecom, security systems, asset owners (airline, car, garage, hotel, restaurant, wearables) and other public/private agencies (map, traffic, news, weather). Each provider wants a share of the revenue. The customer only pays when the end-to-end connectivity offers value.

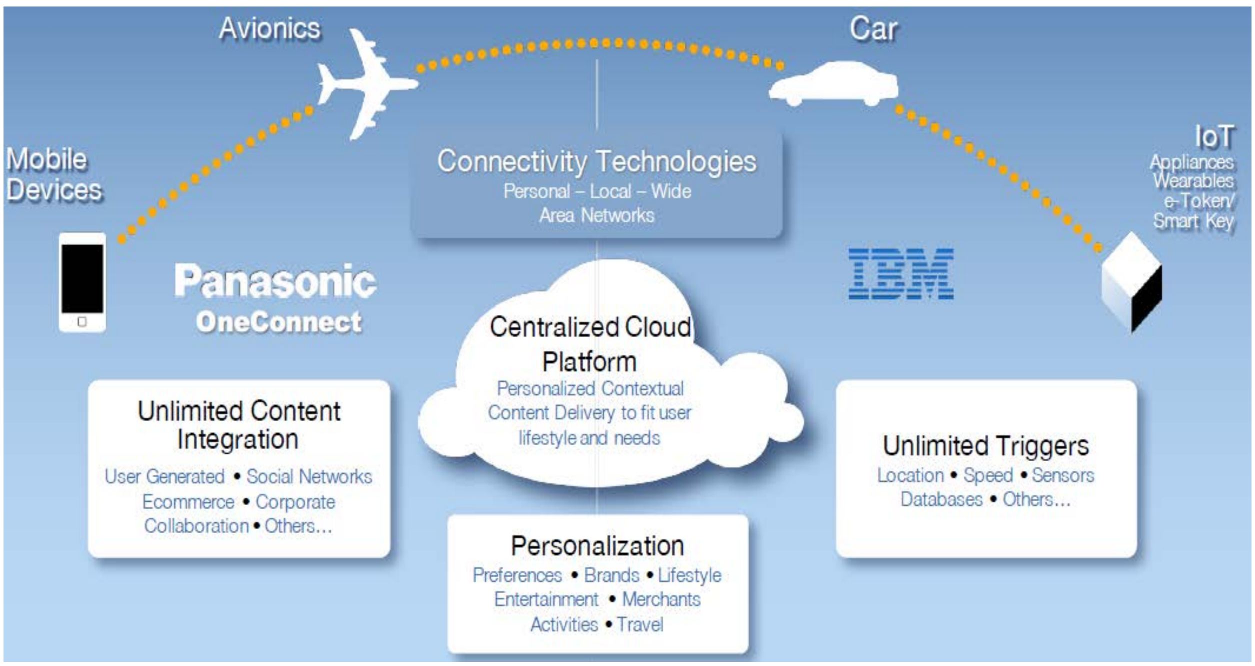


Fig 12: Your mobile device [1] receives update from your calendar [2] flight/terminal arrival/departure data from the airlines [3] informs your car rental agency that your flight is delayed [4] confirms that your checked-in bag is arriving soon on the conveyor belt [5] unlocks the car door [6] displays the map to the destination [7] cautions about excess traffic on Memorial Drive [8] informs the mobile device of the person you are meeting about your estimated time of arrival [9] guides you to the parking garage space [10] offers you choices for dinner reservations [11] confirms the dinner reservation [12] checks you in at the Le Meridien at Cambridge [13] unlocks your hotel room door [14] calls your lovely wife at 9pm EDT [15] merges your OneNote [16] syncs the FitBit [17] sets the wake-up call [18] checks the weather.

The consumer centric IoT-esque illustration in Figure 12 contains the essential structural elements also common in B2B or intra-enterprise scenarios. Convergence of Agents-based micro-services, ABM, EBM, data, connectivity, analytical engines and decision support "sense & response" systems augmented with security and higher order reasoning tools (ML, DL, AI) are at the core of Digital Enterprise X.0 [[83]].

Modular units encapsulating core functions, processes or data holders, which can be sourced from a common services (SaaS) repository (across multiple verticals or business units) may offer benefits in terms of risk pooling, reducing waste and re-use or recycling of software components. Once identified, the units may be connected through interoperable, configurable and adaptable interfaces. The resultant architecture can be recombined with other units to increase the combinatorial potential which may be essential to capture and map the process cascade, in terms of functional outcome. These units must be capable of "discovery" and amenable to be "discovered" when interacting with and between platforms.

How the modular units/blocks will be combined, to create the higher order structures, which maps to the process or the platform, is a rate limiting factor. The compilation (drag and drop) may be slow if humans are necessary to create these units per process maps or events/data flow. Automating this process and creating a "supervisory" Agent to guide the process, when triggered, is an option. The ability to use natural language descriptions as a trigger will facilitate the process and empower non-technical users to create appropriate outcomes (Figure 13) by selecting and stitching the components using verbal commands and logic operators (using set operators to specify epistemic constraints).

For example, a non-technical TSA employee encounters an individual and wants to know if that person was in pre-recorded photo bank. To set up the search parameters, the program requires defining what algorithm based facial recognition application may be used. To select the algorithm based app, one must understand the parameters that makes the algorithm useful. The TSA employee is unable to perform this task and sends the request to the technical desk to search for a match with the person the TSA employee encountered. The delay in arriving at the outcome was sufficiently long. In the interim, the person of interest had ample time to board the aircraft and depart.

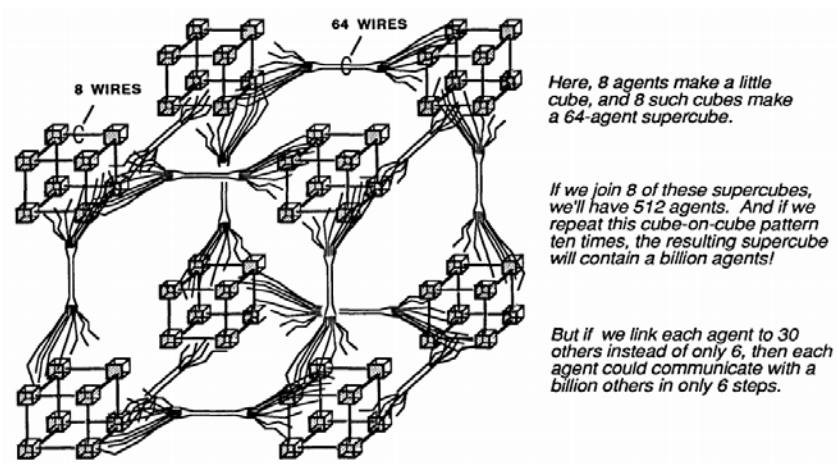


Fig 13: Connectivity between cubes [[82]] or modular units (blocks, bricks, Agents) can contain functions with multiple variables and create higher order Multi-Agent networks which can converge on platforms.

One solution is programming abstraction [84]. If the program understands (semantics) natural language descriptions, then, it concludes from the natural language query that the TSA agent wants to find a match of the person within the pre-recorded material. The program solves for the required algorithm parameters, processes the request and provides an output, which may be instrumental for airport security. Software automation by implementing programming abstractions may be useful to configure dynamic architectures on demand. Interoperability between programming interfaces will catalyze seamless connectivity between cubes [85]. The hype about AI bots in automation [86] is just that - hype. Programming abstraction is a tool defined by the rigors of computer science and software engineering.

Platforms may be viewed as higher level structures to aggregate, converge and synthesize digital building blocks. Modular units shuffle and re-shuffle within dynamic transformation processes where decoupling and recoupling may design, re-design and optimize the structural elements that can deliver the expected outcome. This layer is closer to the customer's expectation of the digital experience at the edge. The interaction at the edge favors, and often demands, pay-per-use models rather than stoic contracts. Connecting to the platform is the bridge the customer chooses. If the customer selects to cross the bridge then the possibility of monetization increases. The transaction cost to access, use and re-visit the platform (if satisfied) will drive and define service diffusion [87], create markets, predict market penetration and may be indicative of the potential for sustainable ethical profitability [88].

Digital transformation is hard at work to convert products to services. For example, Rolls Royce may no longer sell jet engines but "uptime" services which offers engine performance as the outcome [89]. The pay per performance metric eliminates the multi-million dollar price tag for the engines. By lowering the barrier to entry, Rolls Royce engines can serve low cost airlines. Reducing barriers to entry in emerging markets requires different strategic perspectives. US management gurus often insist on chanting the same mantras from an analog world, burdened with the dead weight of old technology, and affordable to less than 10% of the world's population. Digital tools may help us leapfrog the old world inhibitions.

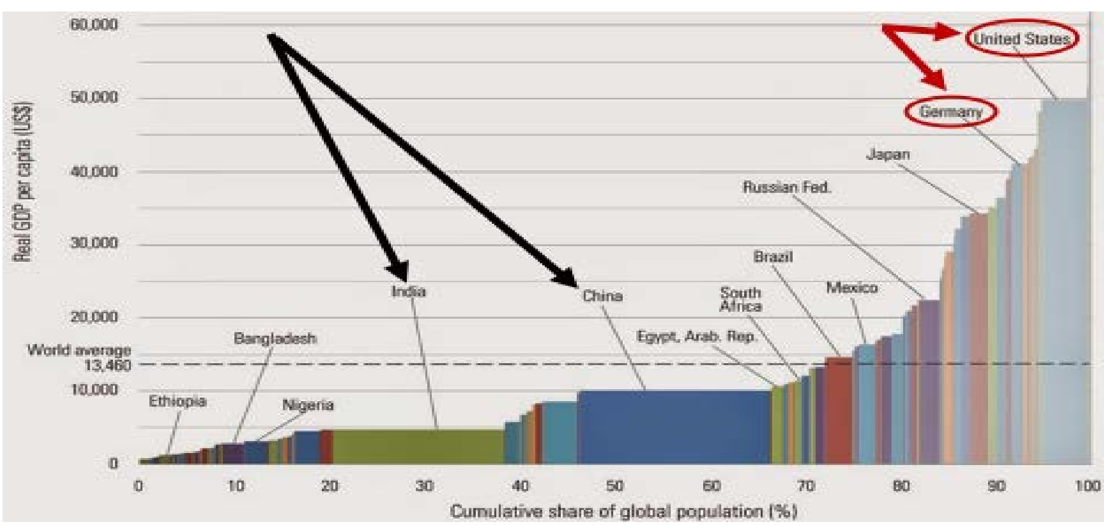


Fig 14: Strategy and management ideas used in US and EU unlikely to help the emerging economies.

The platform principle enables service aggregation from any person or behemoth or small or medium enterprises, if the services and tools are designed to interface with one or more open templates. For example, assume the pump manufacturer Grundfos is still living in an analog world of products but anticipates charting a digital transformation path to embrace DEX. Pumps are one component in a plant where the outcome may be purified drinking water. Creating a digital twin of the plant with its share of pumps and various other equipment is one way to create a new line of business. Analytics may predict which equipment may need service or replacement. Predictive analytics coupled with supply chain improves efficiency and reduces downtime. The outcome is a steady supply of clean drinking water. In the analog model, the pumps and data from pumps may be the sole focus of the pump manufacturer. In the digital paradigm, the contribution of Grundfos to create the digital twin of the plant and monitor its pump for optimum efficiency may lift many boats. It will earn the customer's trust. The customer can rely on "Grundfos Digital" to monitor the entire plant operation using Digital Twins. Isn't that a new source of revenue? Will Grundfos still continue the old world *modus operandi* of charging for pumps and maintenance? Can Grundfos think different and envision the global challenge of the digital tsunami? Can it transform its revenue model to reflect micro-earnings based on service/performance related to the outcome? Why not make the product "free" but charge a penny per gallon of clean water leaving the plant? Is this a new idea? Not at all. Please ask the telecommunications and the telephone industry.

Thinking different is applicable to existing platforms which must change if the platform wishes to serve the masses. Nano-satellites [90] are using different tools and technologies [91] which are clashing with the multi-million dollar satellite industry by lowering unit costs (to thousands of dollars) for satellite service. Innovation in education, using credibility as a platform to build technical services, is the hallmark of edX, developed by MIT [92] and Harvard. Massive open online courses (MOOC) are evolving [93] and often are disastrous [94]. But, it discovers students determined to benefit from available academic wealth [95]. By lowering the barrier to entry, MIT is accelerating the diffusion of excellence, usually at no cost to the student. For example, the microMasters program in Supply Chain Management [96] is free unless you want a credential. It costs $1,350 for the entire program. Successful candidates who may earn the credential can apply to MIT for a Masters in Engineering (M. Eng) degree in Supply Chain Management (SCM). Credit from the online program makes it possible to complete M. Eng in SCM in one term at MIT at half the cost [97]. The full-time residential program lasts for 10 months or two full terms at MIT.

The edX platform running the MITx microMasters program [98] is capable of harvesting the crème de la crème students who may further bolster the credibility, reputation and prestige of the program and the institution. In the recently completed SCM microMasters, around 200,000 students registered and 2,000 sought a credential ($2.7 million in tuition fees). In the absence of the SCM online program, the capacity for accepting students into the residential program at MIT is about 40. Student tuition is $71,000 for the full 10-month residential program (M. Eng in SCM). If 40 paying students attended MIT then they would pay $2.84 million to MIT. By reducing the barrier to entry from $71,000 (full time) to $1,350 (credential), the program earned $2.7 million. Was it a financial loss? Perhaps. But, the edX microMaster's strategy identified the best of the best brains. Later, during Fall 2017, about 40 students from the 2,000 cohort will join MIT and complete M. Eng in SCM at half the cost of residential tuition (plus living expenses).

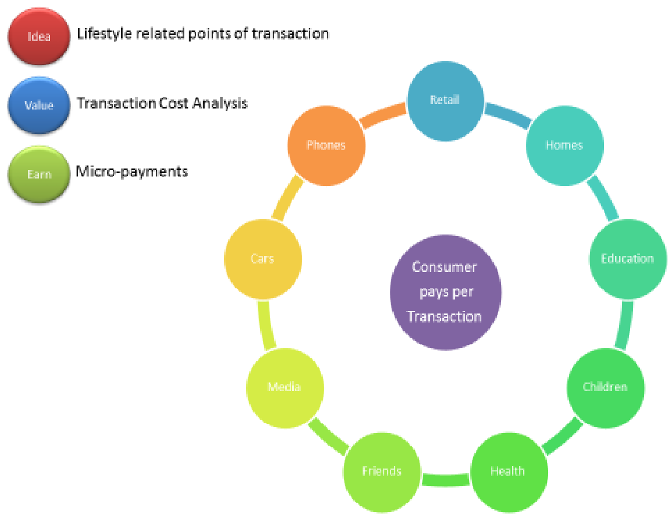


Fig 15: Pay-per-use micro-revenue model is digital by design. It touches every facet of an user everyday in a manner that is distributed over time without making time to access create a barrier to entry. For example, if an educational course is distributed in unit packages and if the charging tool operates are per unit (each unit may be 5 minutes in duration) then even full-time employees can complete a course in many steps by accessing and learning a few units, between breaks or when they have some spare time. Instead of an upfront payment of $100 for an online course of 1000 units, the user pays $0.10 per unit. Using a pay-as-you-go self-paced system converts almost all individuals to potential students if they have access to mobile device, telecom infrastructure and an incentive leading to economic growth.

Perhaps counter-intuitive but profitability of platform providers may be directly proportional to the open source strength of the platform. In other words, if platform vendor(s) offer "almost free" access to the platform then the potential for profit increases dramatically and sustained over the long term. The logic behind this apparently illogical statement is firmly rooted in the principle of micro-payments. If tier two and tier three providers can create touch points to the platform without high licensing costs then the ecosystem of function providers and app creators, from all over the world, will exponentially flock to associate with the "channel masters" platform. Consider Amazon's network of other vendors who use Amazon's brand to market their products (especially the category of used/new book sellers). The global diffusion of the platform and its connectivity with providers from all around the world also unleashes the creation of new markets all around the world, naturally. The more end users and customers use the services and touch the platform, the greater is the market penetration, hence, more trips to the bank.

If each pay per transaction is affordable and within reach of 80% of the population, both in terms of cost and services they actually need and use, (health, insurance, security, education but not flamboyance, ie, wardrobe matching, luxury cruise, LVMH), then every point of contact is a potential point of sale, hence, a point of revenue, even if it is only a penny per transaction. This is a profitable idea [[99]]. Micro-earners include PayPal, PayTM, Amazon Pay, Apple Pay, Google Pay, Samsung Pay, Ali Pay, Citi Pay and others. It goes without saying that DEX platforms and access must be essentially global and truly mobile [[100]].

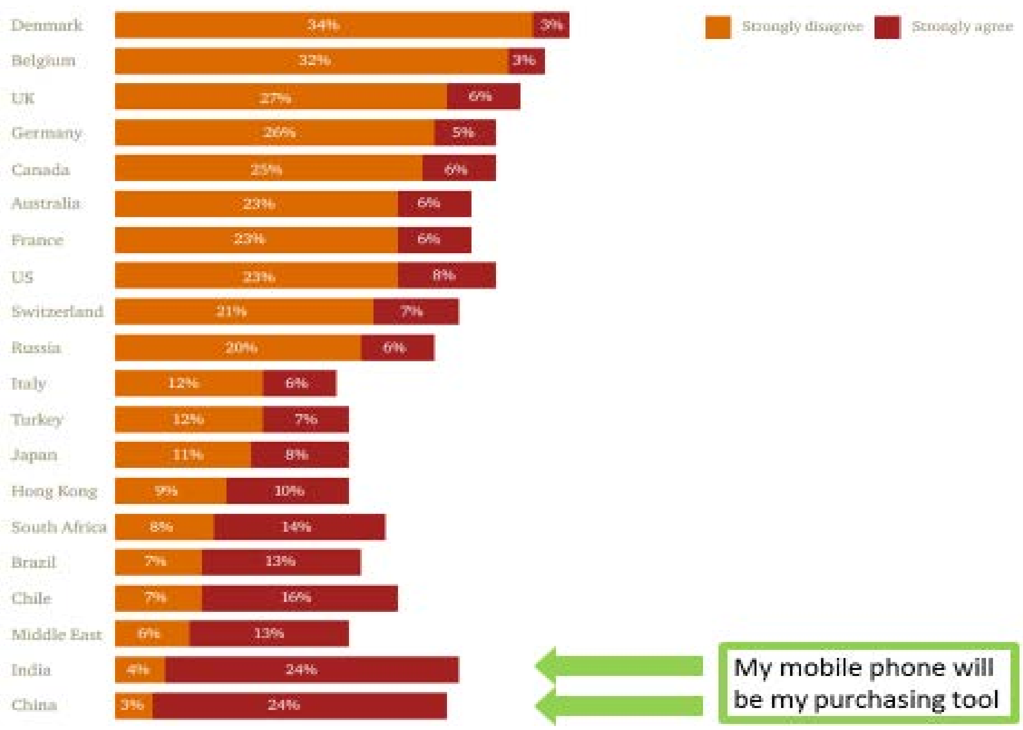


Fig 16: Pay-per-use micro-revenue model is mobile by design. Emerging economies are the markets [97]

Fig 17: Rationale for "Miss Moneypenny" paradigm: Pay-per-use micro-revenue model at a penny per transaction may be an ethical profitability model. It may work due to volume of transactions [101] which may continue to increase [102] and already proven to be quite lucrative for the financial sector [103].

HEALTHCARE PLATFORMS

The corner of the world referred to as South-east Asia, stretches from Pakistan to Philippines. It is home to about 80% of the world's population and enjoys a certain market envy. It may be the testing ground for the Miss Moneypenny paradigm (Figure 17). If businesses can use platforms as service delivery tools or engagement points and if pricing per access is limited to one or two pennies per transaction, it is likely to become feasible. The South-east Asian market of 5.5 billion is poor in several pockets and many still earn around $1.90 per day [104]. Two pennies per day is more than 2% of their daily earnings. This is a context that is front and center of businesses in India, China and Africa. This is why it is necessary to abandon the strategies developed and disseminated in US and EU (Figure 14) as paths to profitability.

Providing health and healthcare access using pay-penny-per-use platforms will test the art of the possible. Healthcare does not discriminate between the wealthy, poor or the impoverished [105]. It is the access to healthcare by the poor and from impoverished nations that is limited. 10 million children die annually due to preventable causes [106] and 3 million neonatal deaths are due to pre-term births [107].

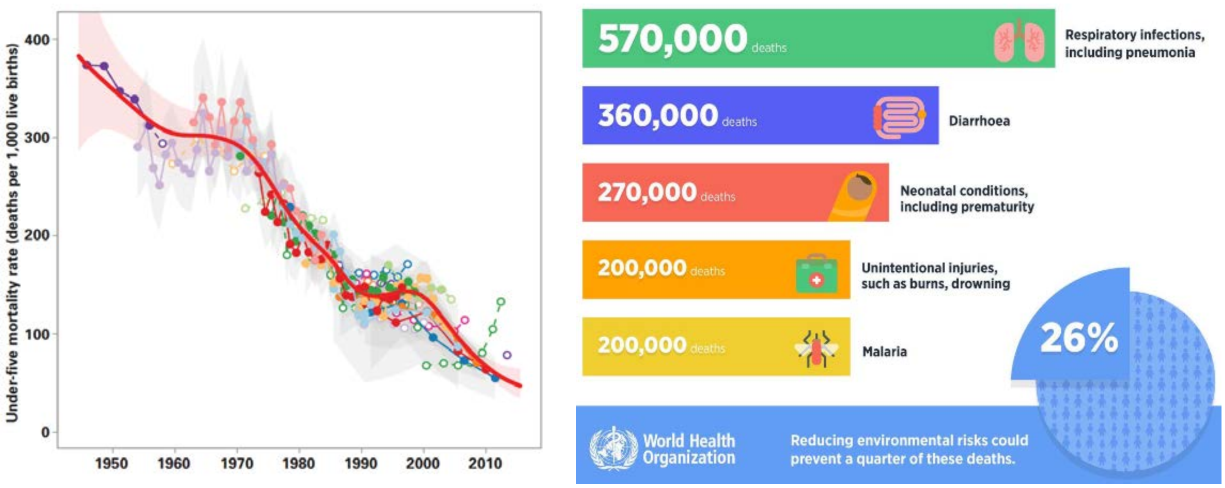


Fig 18: Good downward trend for child mortality [108] but overall access to healthcare is still infinitesimal.

Healthcare is in need of solutions where technology can help to keep platforms open yet find routes to ethical profitability for the vendors via value added services. The deep complexity of security [109] and privacy infrastructure in healthcare creates quagmire. It discourages technology innovators. But, health workers are unlikely to disrupt this impasse. Innovation is expected from the technology leaders, but in convergence with people and processes that must be compliant with the ethics and ethos of healthcare.

Platform as an aggregator is the lowest common denominator in this discussion. The vast landscape of healthcare makes any discussion abysmally incomplete. Preventive medicine may serve as a simplistic use case where low cost sensors or gateways may be used in combination with mass produced low cost non-invasive devices to monitor certain vital signs, ***if*** they have access to the devices and mobile phones, perhaps with hot swappable bio-nano-sensor arrays on "sticks" connected via micro-USB interfaces [110].

Indicators such as heart rate [111], blood glucose [112], hemoglobin [113] and urine analysis [114] may be useful. Data uploaded to a common platform, when analyzed, may create a molecular metabolomics profile, which may be instrumental in molecular diagnostics, if necessary [115]. Pattern changes in these data sets may be indicative of physiological malfunction. Depending on the sensitivity of the sensor data [116] and analytical precision, early detection, diagnosis and intervention may reduce morbidity and mortality. It may reduce acuity and hence the cost of healthcare from emergencies and hospitalization.

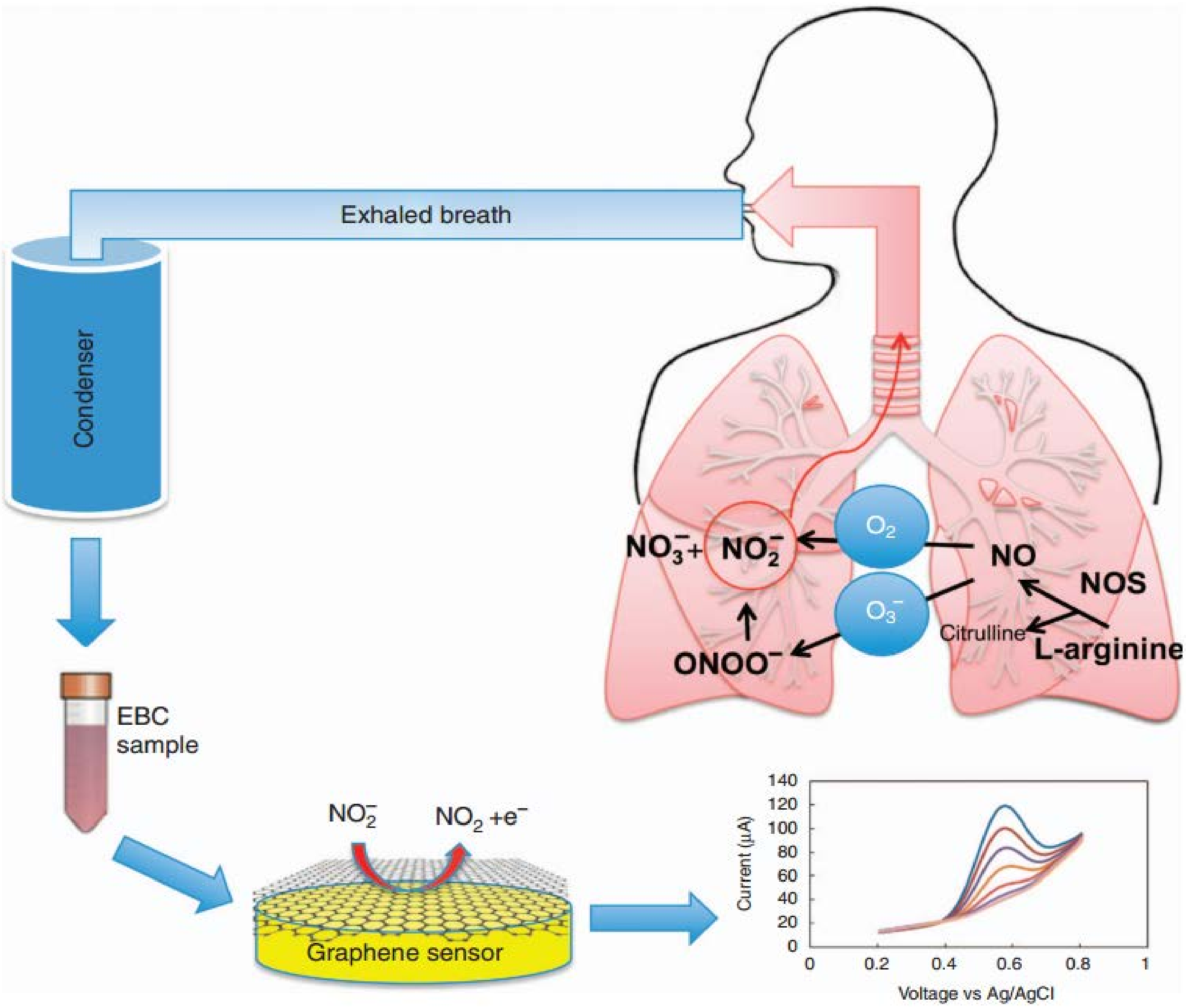


Fig 19: Exhaled breath condensate (EBC) is collected. Nitrite content is measured electrochemically using graphene oxide sensor. Increased levels of nitrogen oxides (NO) are associated with inflammatory disease states such as asthma, chronic obstructive pulmonary disease (COPD) and cystic fibrosis (CF). The increased level of exhaled NO in asthma may be due to an increased expression of inducible NO synthase (iNOS) in bronchial epithelium. Given the relative stability of nitrite in EBC, it is a promising biomarker of chronic respiratory inflammation. The nano-sensitivity of probe-free/label-free sensor for the detection of nitrite in EBC enables early detection and reduces cost of hospitalization [117].

The transition from classical sensors [118] to nanowire and graphene [114] sensors [119] may increase sensitivity for sensing changes [120] in disease [121], microbiomes [122], and water [123]. The latter is a medium of transmission for many pathogens. Some of these tools and technologies are nearly two decades old. What is lacking in healthcare is an informed vision and the convergence of technical tools on platforms. The leadership for systems integration is suffering from paralysis by analysis. The situation may be similar to use of RFID in retail stores which lacked ignition [124] circa 2002 vs the 2017 "back to the future" attempt to re-invent the past through Amazon GO, the new no-checkout grocery store [125].

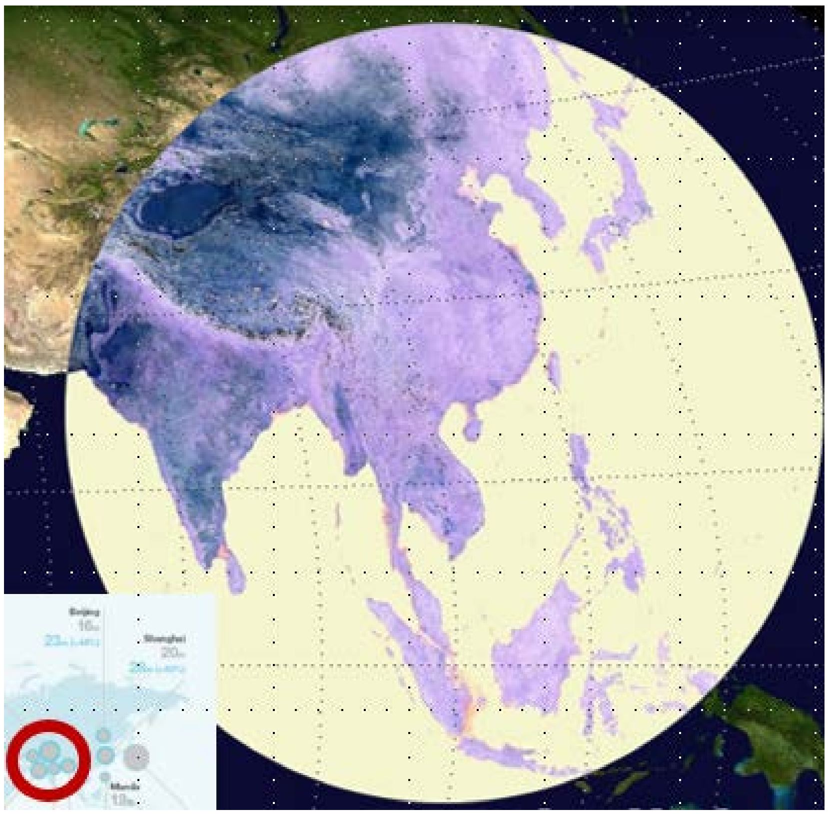


Fig 20: More people (about 5+ billion) live inside this circle than anywhere else in the world. Five cities (small red circle) represents a market of 100 million (Dhaka, Calcutta, Mumbai, New Delhi, Karachi).

If convergence of healthcare platforms were a reality, the long-term profitability seems to be immense. Consider New Delhi, with an estimated population of 40 million by 2030. Assume 10% of the population subscribes to health platforms. The platform vendor earns $0.01 per day as a micro-payment from the customer to access/upload data/analytics through the platform. That translates to an annual revenue of US$14.6 million for *one point of contact on the platform from one city*. If 1% of the 5.5 billion people in SE Asia paid $0.10 per event per day then the platform revenue soars to US$2 billion per year. This is not a "low hanging fruit" and seeks an astute visionary with a penchant to make a difference to create the convergence for healthcare, for the underserved. Hence, the "Amazon" of healthcare is still out there.

Convergence in healthcare requires thinking of healthcare as a fabric rather than as a visit to the doctor. Healthcare vendors start the thinking with billing codes. Hence, it is hard to realize that a 30 minute hospital visit, after a patient survives a myocardial infarction (heart attack), leaves the patient at risk for 99.999% of the time. Where is the system to monitor the patient? We have tools but not the systems because the businesses in the business of systems integration know precious little about health. The healthcare industry still cannot find the "billing code" for remote monitoring of a cardiac patient in order to prevent future emergencies or reduce re-hospitalization. Emergency visits [126], hospital stay, diagnostic procedures [127] and unnecessary routines [128] are profit centers for US healthcare industry.

Healthcare platform innovation may not germinate from Accenture (systems integrator) or CVS Health or McKesson. Electronic health/medical record (EHR/EMR database) providers are not promoting global platforms but poster perfect for epic greed [129], skilled in information blocking [130] by developing closed systems and preventing semantic interoperability, deliberately, by design. For healthcare information technology (HIT), the inability to access EHR/EMR information is often fatal [131] but continues unabated.

Perhaps it is hard to change systems from inside. Tesla and Google changed the auto industry rather than GM or Toyota. YouTube and Facebook re-invented media, not ABC, NBC or BBC. Space exploration entered a new era with SpaceX and Virgin Galactic, not through Boeing or Airbus. Retail giant Wal-Mart is struggling to catch-up with innovator Amazon. Hence, the elusive quest continues, for a leader to rise and implement micro-payment based systems innovation for healthcare as a service, for the rest of us. Is it going to address all healthcare woes? No, but, it may be helpful to billions. The near complete lack of such tools and lack of EHR/EMR in most of SE Asia makes it a fertile ground for "open" platforms. The immense scale of implementation may be unsettling to providers who may think in terms of US and EU.

The ecosystem of device manufacturers and their convergence with platform providers through mobile infrastructure to acquire, deliver and distribute data, in a manner that is safe and secure, is a tall order. The open source movement is generally focused on access to data. Lack of data or inability to combine data to extract information is one reason why medical errors are a leading cause of death in the US [132].

Enabling access to data from devices is an anathema for manufacturers. It results in interoperability issues [133] and asphyxiates open source approaches [134] vital for healthcare. Lack of medical device interoperability issues are more pronounced in the affluent nations (US and EU). The inability of emerging economies to afford US-based EHR/EMR systems (Epic, Cerner) is a blessing and a catalyst for open source integrated clinical environments [135] to improve healthcare and safety.

Justifiably, monetization of the open source model deserves attention. Data acquisition from devices, the data model and interfaces, are some of the essential "open" elements. Safety, security and privacy must be demonstrated in the open model. Authorized access to raw data must be kept open and almost free for patients, hospitals, healthcare workers and anybody else who may be legally permitted to use.

A simplistic analogy is a person calling a bank or checking the online statement to find out what is the balance in the checking account. This data (balance in the account) cannot be "closed" to the account holder. If the account holder asks how to optimize her rate of interest or investment, ie, seeking advice (analysis), then the bank can charge a consulting fee for an appointment to discuss individual needs. For access to data in terms of bank balance, the bank can charge 10 cents each time a customer calls or a nano-payment of 1 cent each time the customer wishes to query the balance through the online portal.

In the open source healthcare platform model, the vendor may not restrict the data but may impose a micro-payment for accessing the platform to access the data. Customers may understand that there is a cost to develop, implement, maintain and secure the infrastructure which enables these transactions.

It may be a quantum leap forward if the healthcare industry is able to obtain raw data from devices and use an open platform model as a tool for convergence. If it is your data, then, you should be able to access your health data, anytime, anywhere. But, perhaps, there will be pay-per-access nano-payment.

If the person observes that the blood glucose level is 139mg/dl and wishes to know what it means, then it triggers a different application, which may require the services of an analytical engine to process the data and respond to the query. This analytical engine may be provided by the platform vendor or may be sourced from a third party, similar to Apple/Google app stores. Access to this app is not free and the query may cost the customer 10 cents each time. If 1% of the world's population (~7.5 billion people) asked one question each month then it could generate $90 million in annual revenue from 1 question.

The monetization model distributes fractional micro-payments to the app creator, platform host, telecom provider and other micro-service vendors. If the system required thirty different vendors to converge for the systems integration to answer that question then each vendor may receive 1/30th of the $90 million revenue or $3 million per annum (if revenue was shared equally among the partners).

Dynamic pricing of queries may be based on the complexity of the question. Dynamic composition of micro-services, analytical tools, algorithm engines or portfolio of solvers must be sourced, aggregated, activated and executed in order to respond. It may not be difficult to understand why the structural elements of this architecture must be modular, blocks to be "discovered" if necessary, interoperable, agile, compatible, perhaps capable of natural language processing and preferably Agent based tools.

Platform analytics will evolve as a key tool for monetization for open platforms and medical internet of things (MIoT). Security [[136]], privacy and data de-identification may play pivotal roles. The question of "intelligence" in analytics and how the platform will address ***context*** of input data remains a challenge. Reasoning (erroneously referred to as AI) must occur in a specific context for specific goal(s). Medical expert systems accepting list of symptoms as input and generating output (most likely diagnosis) ignores the basic tenets of medicine: hypothesis-directed gathering of information, complex task of interpreting sensory data (obtain uncertain indicators of symptoms) and the goal of curing the patient. The latter may involve treating less likely but potentially dangerous condition rather than likely but harmless ones.

AI AND ANALYTICS – THE BREAD AND BUTTER WITH JAM FOR FUTURES, NEAR AND FAR

Artificial intelligence (AI) is a potent tool but may be an unfortunate yet ***very*** attractive choice of words to capture the public imagination. Reference to intelligence in AI is due to its use of the phenotype of neural networks, with input and output (I/O), as a core [82] feature of artificial neural networks (ANN). The lack of erudition in AI was mimicked when an AI program was requested to name colors (Figure 21). However, the world has embraced AI and etched it in its psyche. AI appears to possess that Midas touch. All things AI sells faster than hot scones with clotted cream. For a few, witnessing the transmutation of tabloid fodder from speculation to truth may be deeply troubling because there is no "intelligence" in AI [137] with respect to human intelligence. It was never there, may not be there now, or in the near future.

Yet, the tools of AI are critical in the connected global economy to catalyze growth, reduce inefficiencies, make sense of data. Collectively AI presents immense potential to increase profitability for practitioners.

Fig 21: I gave the neural network a list of about 7700 paint colors along with their RGB values. (RGB = red, green, blue). Could the neural network learn to invent new paint colors and give them attractive names? The invention of paint by numbers may not be bad [138] but the names are less desirable.

Yet it is an egregious error of judgement when venerable corporations manipulate the media [139] in the name of AI. IBM spun a story how IBM's AI flagship Watson could improve cancer treatment [140]. It was unsuccessful yet PricewaterhouseCoopers walked away with $23 million for the project, which, despite contractual stipulations, was not implemented at the M D Anderson Cancer Center, University of Texas.

If we can look beyond the name and the fake publicity, the tools (Figure 22) collectively referred to as AI, are indeed extremely useful. Higher order reasoning is indeed necessary for digital transformation and is an important monetization tool for analytics in DEX, the digital enterprise, made up of rational Agents.

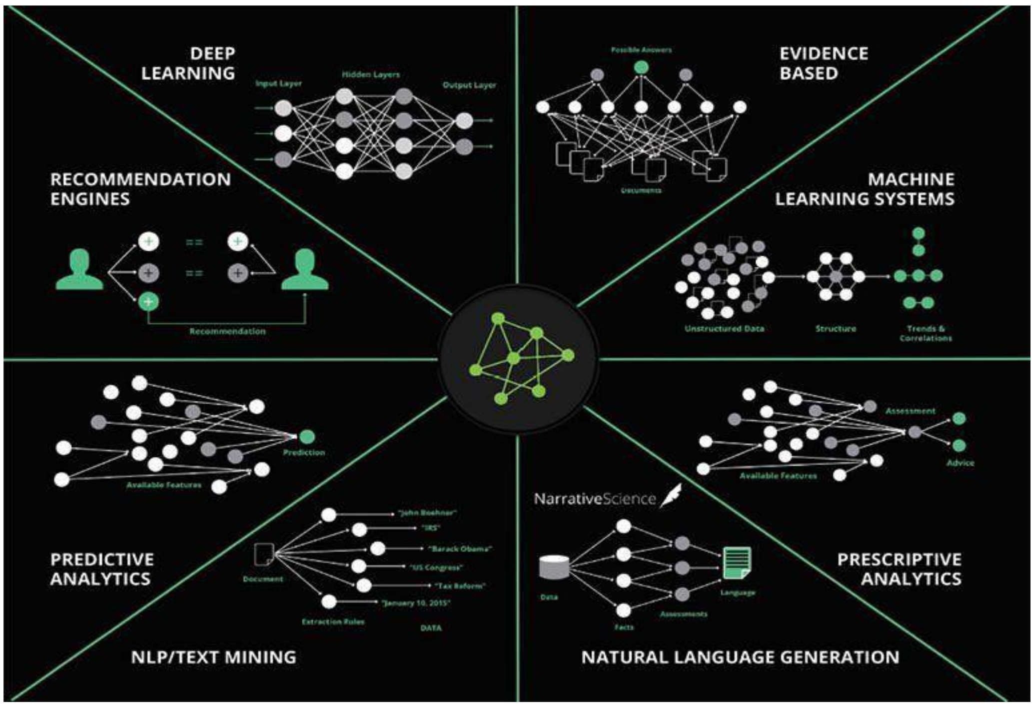


Fig 22: The combination of tools which are collectively referred to as AI by the media and businesses.

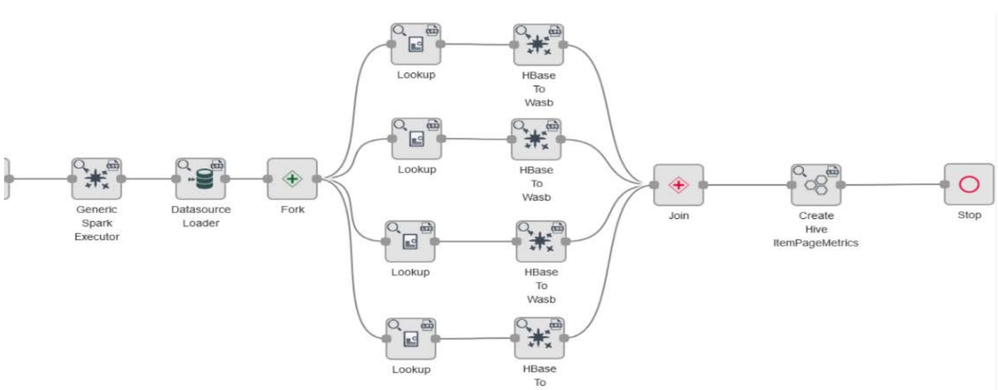


Fig 23: So called augmented intelligence [AI] in this diagram is rather pedestrian quality workflow [141]. Converting "work packages" (box) to multi-Agent systems may enable us to profit from principles of AI.

The scholastic effort in this field over the past half century or more has resulted in breakthroughs that makes it possible for systems and computers to process speech and recognize photographs, among other advances. The field has progressed from rule based expert systems [142] to pattern recognition systems which uses artificial neural networks [143] and/or statistical methods [144]. Unfortunately, the exaggerated views verging on narcissistic stupidity [145] appears to be more fashionable (Figure 25).

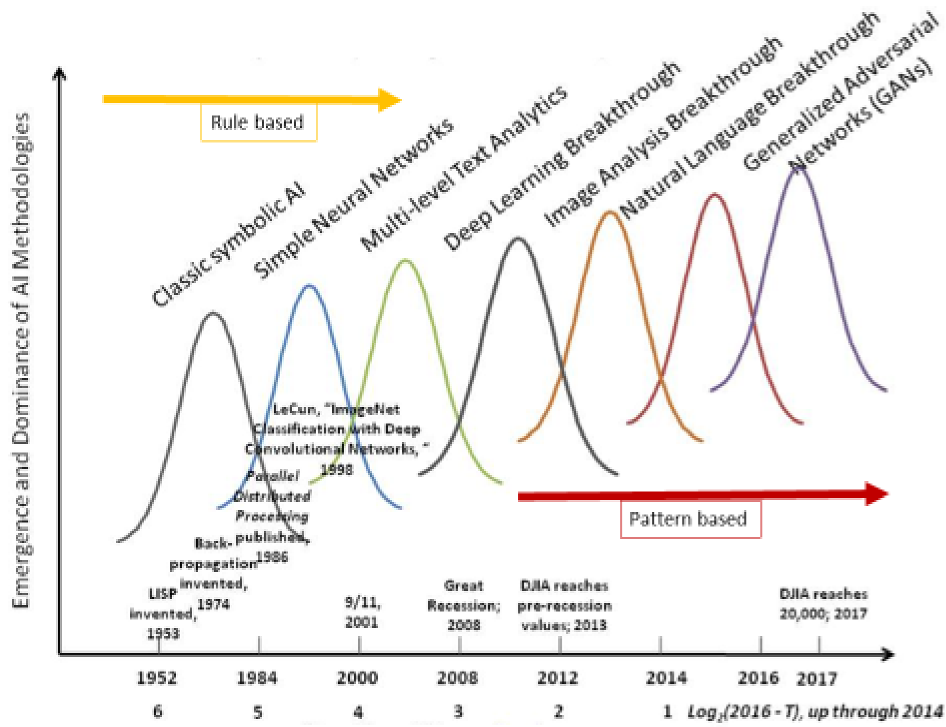


Fig 24: Brief History of AI – The evolution of rule based systems and pattern recognition [146] by ANN

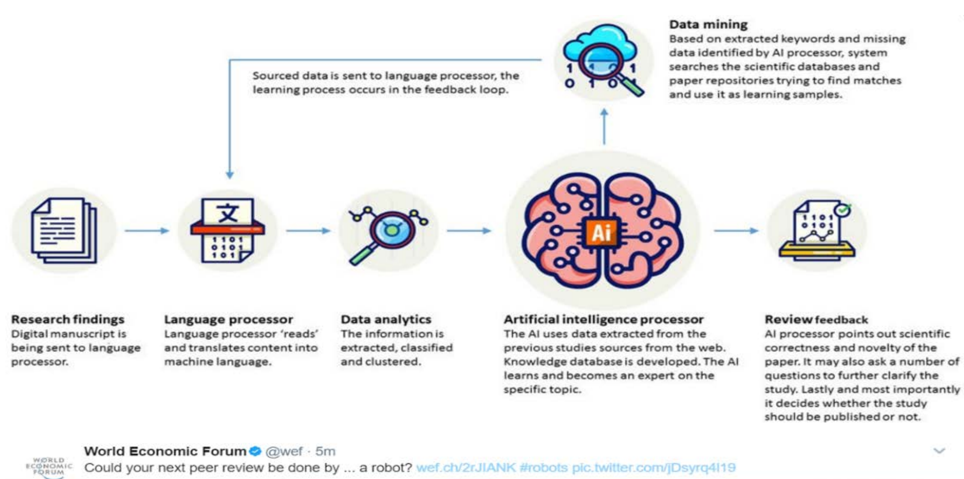


Fig 25: Sensationalism is a hard habit to resist for marketing, even if it is a form of misrepresentation.

Perhaps we can use this AI awareness that has gripped the global imagination. It seems that almost everything in the business world strives to be laced with AI or shrewdly insert AI in the folds (Figure 26). We have moved from hot dog eating contests as spectator sports to watching numbers creep up on AI acquisition charts (Figure 27). Perhaps there is a silver lining. May be school students dreaming about six figure starting salaries will be inclined to take a deeper look at Khan Academy [147] or edX or MOOCs [148] to understand that mathematics, computer science, linguistics, epistemology, neurology, engineering and basic science are indeed salient to understanding the foundation of AI and learn how to apply AI.

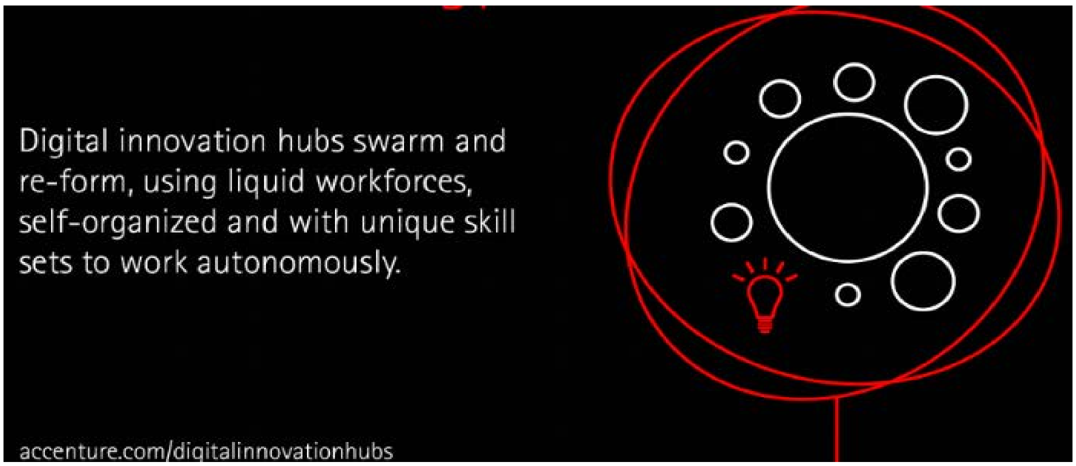


Fig 26: Why is AI missing in this ad? Not really. It is carefully concealed to stir the viewer's imagination.

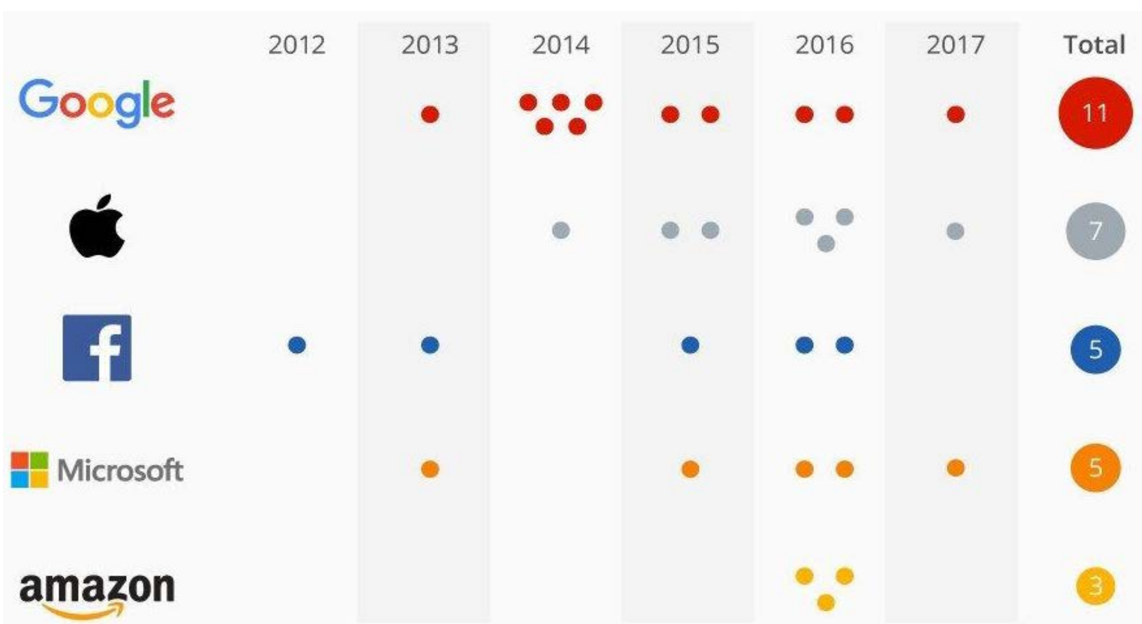


Fig 27: Number of AI start-ups acquired [149]. Like watching balls jump up the tube in a lottery drawing.

Contextual higher order reasoning (CHOR) sounds insipid compared to the magnetism of AI and unlikely to become a household name. Artificial neural network (ANN) tools, including convolutional neural networks (CNN) and recursive neural networks (RNN), in combination with predictive analytical tools (ANN and statistical techniques) drives machine learning (ML) analytics. Speech, NLP and vision are components necessary for many industries and image analysis is integral to medical diagnostics.

These tools are expected to be part of analytical engines or apps [150] associated with the open data platform for healthcare (for example, openICE [131], the integrated clinical environment). These tools may or may not be created by the platform lead but sourced from contributors including crowdsourcing. Verification and validation [151] of these solvers and apps may be performed for the channel master (platform lead) before they are uploaded. Who will choose the correct solvers or apps? If the consumer does not know how to choose, the importance of programming abstraction (page 22) increases. NLP can guide these choices by extracting information from user's speech, if the platform is quite sophisticated.

Monetization of apps [152] and sharing micro-dividends from micro-payments, harvested by app stores or app creators for crowdsourced apps, will present financial challenges that must be addressed. Apps with "security badges" "pre-validation" "five star reviews" are likely to be "preferred" and will rise to claim profitability, if the monetization model of the ecosystem is approved and online. At a systems level, nano-payments for micro-services is a horizontal need for Digital Enterprise X.0, or any version of digital transformation, in an economy where the exponential clamor for blockchain may be justified.

Platforms for remote monitoring, telemedicine and in-hospital care, are in need of open source tools to aggregate data, structure and function. Without decision support and predictive analytics, healthcare platforms may be impotent to serve as the conduit for contextual connectivity and convergence.

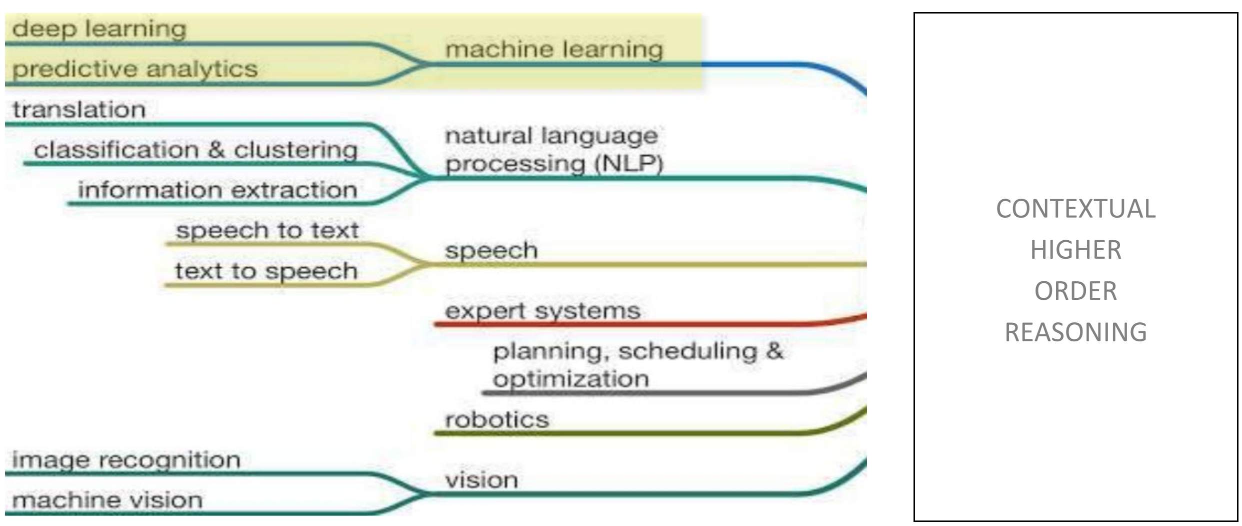


Fig 28: Contextual Higher Order Reasoning (CHOR) as another name for Artificial Intelligence (AI) may never see the light of the day. Decades ago, knowledge representation was introduced (it is pivotal for enterprise architecture) and the term "intelligent reasoning" [153]. Is CHOR akin to *intelligent reasoning*?

LOOKING FORWARD

The illustration below is "Rue Future" (Future Street) from Eugene Alfred Henard's (1849-1923) article, "The Cities of the Future" (1911). Henard (architect of Paris and from 1880 a life-long employee and advocate of public works in Paris) looks into the future and sees movement towards underground (or enclosed) vehicular traffic, "smart" buildings, pneumatic tubing for vacuum cleaners ("almost sure to come into general use"), an improvement in the system for water delivery and removal, replacing coal with natural gas. His ideas, if implemented in Paris, would cost $420 million, then, $15 billion, today [154].

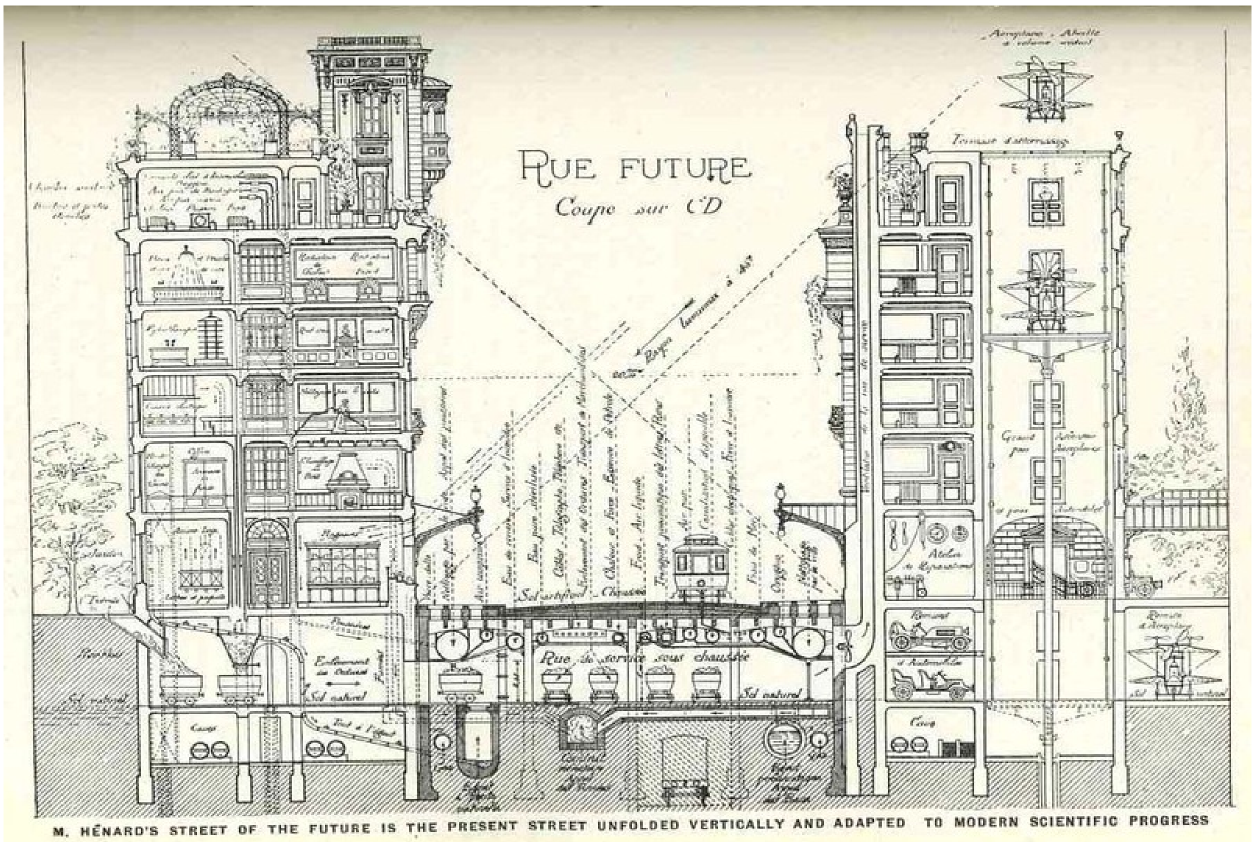


Fig 29: Size, scale and vision of "Rue Future" is comparable to the Digital Enterprise X.0 (DEX) proposal.

DEX is comparable to the foresight in Rue Future. Hence, it is difficult to conclude any discussion of DEX and its building blocks because we haven't even started the journey, in earnest. Digital transformation must be viewed in the context of demand, demographics, markets, economic trends in the context of the socio-cultural milieu. Digital enterprises must embrace digital twins, optimize security and mobility. The challenges of DEX may not be solved by yesterday's thinking or today's solutions. Opportunities for the diffusion of DEX may arise from unexpected quarters, unchartered waters and may even unleash untapped potential.

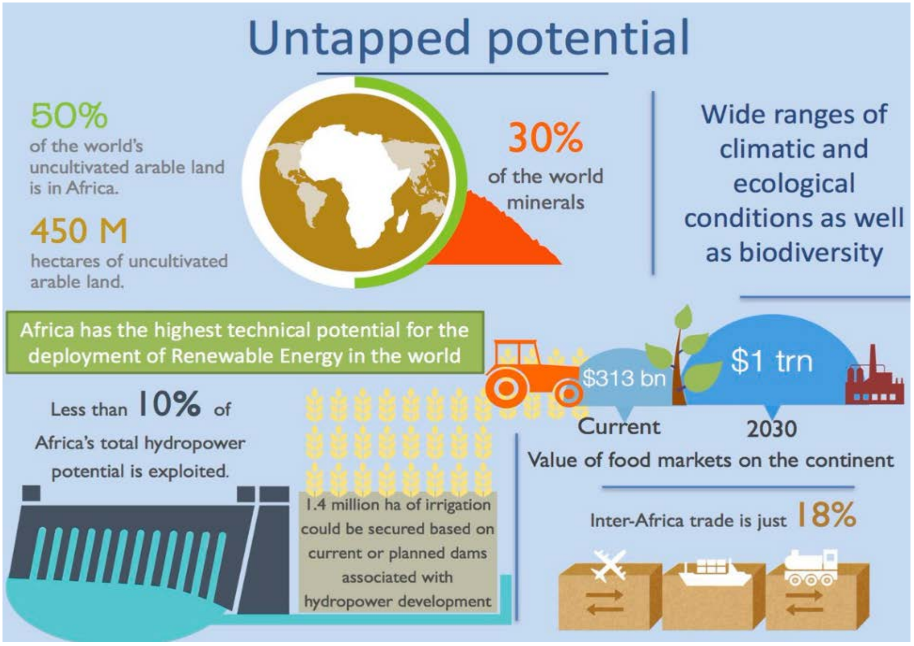


Fig 30: Flooding the Sahara Desert could have changed Africa. Technology should serve humanity.

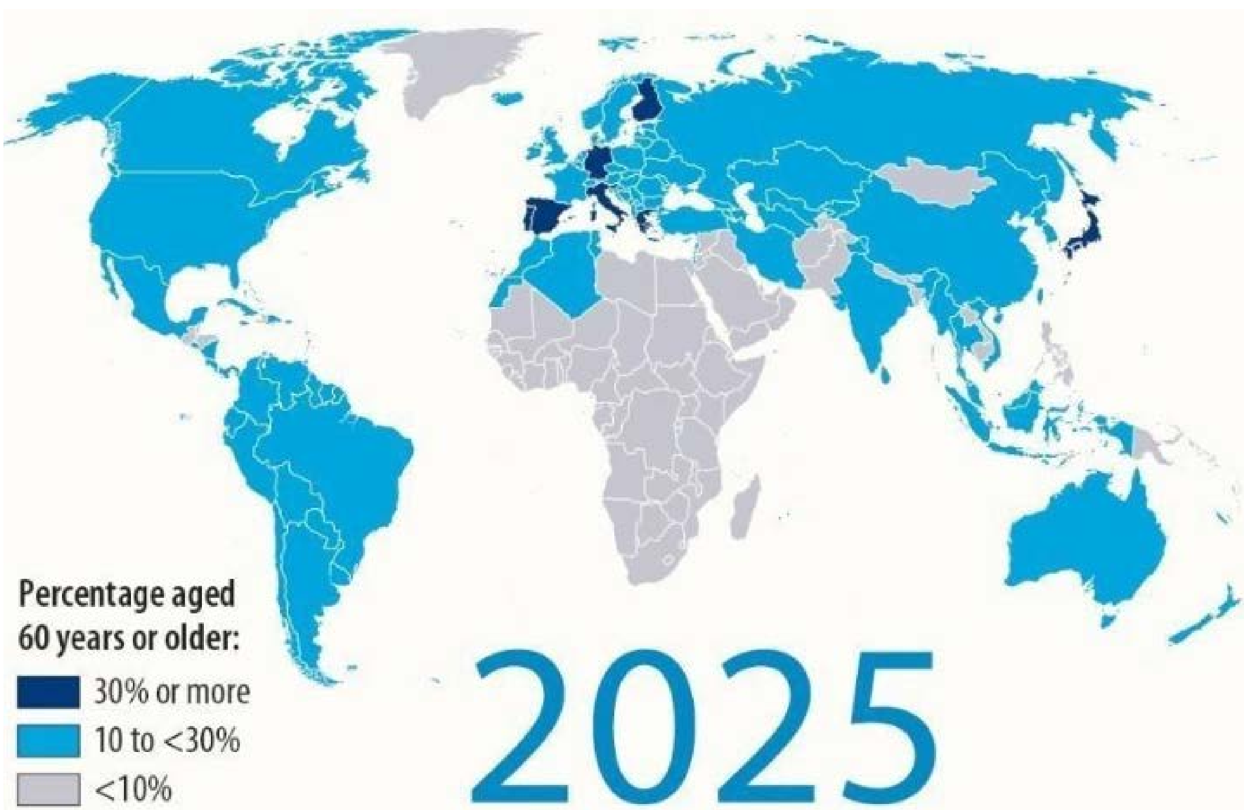


Fig 31: Testament of Youth [155]

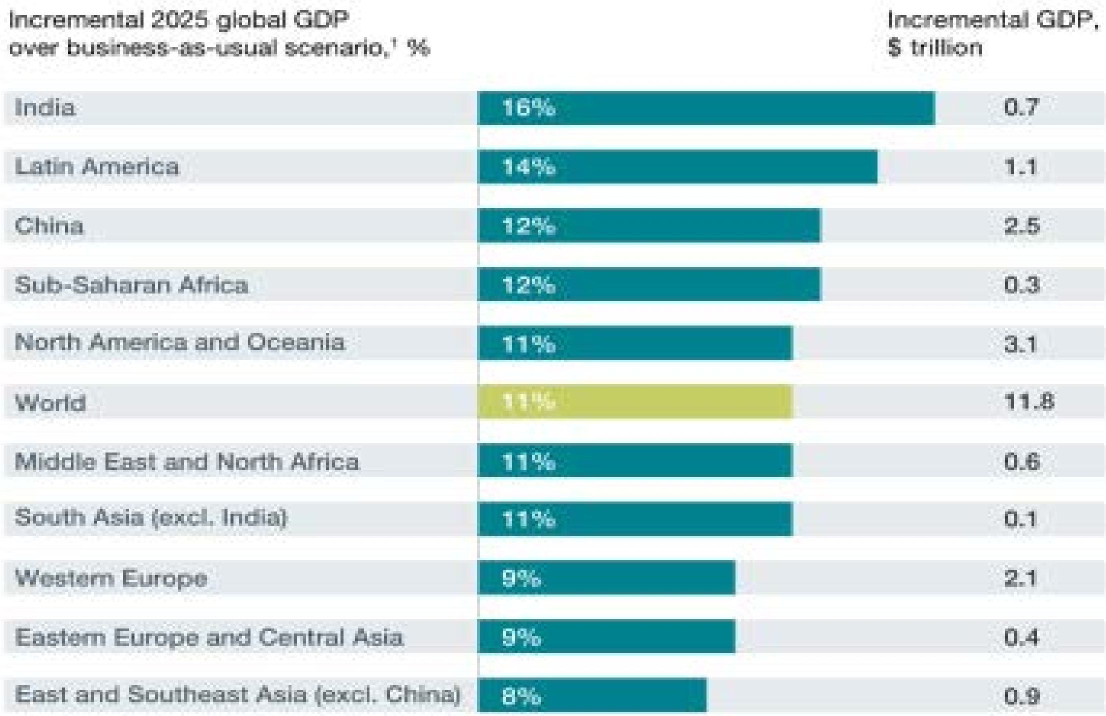
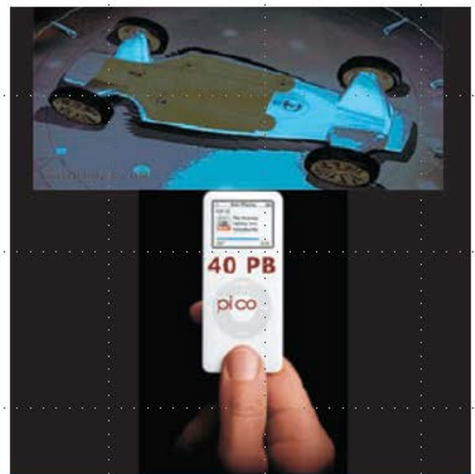


Fig 32: Money left on the table? Gender parity may increase GDP up to $12 trillion in 2025 [[156]]. The education of women and gender parity at the workplace is an economic no-brainer to increase profit.

Fig 33: In 1920, Goddard outlined how a rocket might reach the moon. NY Times wrote he "lacked knowledge ladled out daily in high schools" and argued thrust was not possible in a vacuum [[157]].

paper). The uncanny innovator in Mr Jobs has extracted the service model through iTunes and may be poised to compete with the likes of Nokia or NTT DoCoMo. Skype-like features in an IPv6 enabled iPod will come with built-in 802.11g, 802.15.4 and 802.16 features (WiFi, Zigbee, WiMax) but aesthetically engineered to expose the crème de la crème of human-machine interface that is central to Apple's innovation. Wave your iPod.femto at a Marks & Spencer store to compare the price of the "collezione" charcoal grey pure cashmere scarf that you saw at Tie Rack, buy petrol and pay for groceries at Tesco or pause "Sleepless in Seattle" if Mum is Skype-in mode to you.

(see figure 26) when the iPod evolves as your secure-car operation platform.



Excerpt from an article in 2005 (iPhone 2007)
https://dspace.mit.edu/handle/1721.1/56251

Fig 34: Apple employees Jeff Robbin and Bill Kincaid developed iTunes in the 1990's but left Apple to market it as SoundJam (1998). Apple bought SoundJam and re-introduced it as iTunes in 2000. In 2001, the debut of iPod in the US catapulted the concept of micro-payment based crowd-sourced apps on a platform. Combining the concept of iPod and the almost parallel release of i-mode (2001) platform by NTT DoCoMo in Japan, it wasn't hard for the public to predict that the iPod may also serve as a mobile device and phone, as suggested in a 2005 article reproduced above [[158]]. The control of objects using a mobile device was a concept introduced around 1999 in the form of IoT by the MIT Auto-ID Center. The concept of IoT with that of a mobile device linked to telecom was one rationale for the suggestion (cartoon above) that in future we will control automobiles with a phone. The figure shows the potential of "plugging in" or inserting a "stick" in the automobile. This concept was not elaborated in the 2005 article because it was too far out as science fiction, at that time. The concept of inserting a "stick" to control the automobile was based on ideas surrounding metastable hydrogen which proposed the potential of hydrogen to behave as a metal [[159]] and hence "packaged" as a source of energy for hydrogen powered objects, for example, the hydrogen powered automobile model showed in the cartoon (above). The disclosure of this idea at this time is appropriate because the presence of metastable hydrogen hypothesized by Eugene Wigner in 1935 has been confirmed to exist [[160]]. It is a first step by graduate student Ranga Dias at Harvard University [[161]] on the road to driving an automobile or flying an airplane using a highly compact USB thumb drive type "stick" as shown in the cartoon from 2005 using the iPod form factor. The future stick may be no larger than a thimble or perhaps similar to a credit card sized pack of energy. This form factor may change the automobile industry which will no longer need solar fuel cells or batteries which weigh thousands of kilograms and reduces range. Taxicabs and auto-rickshaws can use credit card size energy packs and swap the energy cards in retail stores or convenience stores when depleted [[162]]. Mobility of atoms and its connection with bits (data, information) is a catalyst for the untethered but networked physical world - a digital by design metaphor suggested by Sanjay Sarma [[163]] and others, as a conceptual basis for diffusion of IoT.

In our excitement to engage with the explosion of emerging advances, tools, ideas, IoT, and applications, we have devoted less attention to the foundation of semantic interoperability [164] necessary to make sense of the data. Meaning of the data drives its value and extracting actionable information is the Holy Grail. At the heart of this process is the convergence of data, which is essential for relevant analysis, but that cannot happen unless we optimize connectivity between data holders (streams, lakes, fog, cloud), which must understand (cognitive tools?) the context of the data, in order to select, channel or curate the data, before subjecting it to associations, algorithms and analytics. Cross-pollination and information arbitrage depends on semantic interoperability between modules, building blocks, systems, ecosystems and end-user facing applications (where the *rubber meets the road* in terms of revenue, profit and loss).

We will be handicapped if we fail to "look forward" in addressing the ontological basis of semantic interoperability between entities. Agent based architectures are one approach. A global discussion between standards bodies, ontologists, linguists, business user groups, developers and enterprise architects are essential to improve systems interoperability, if and where Agents may fear to tread [165].

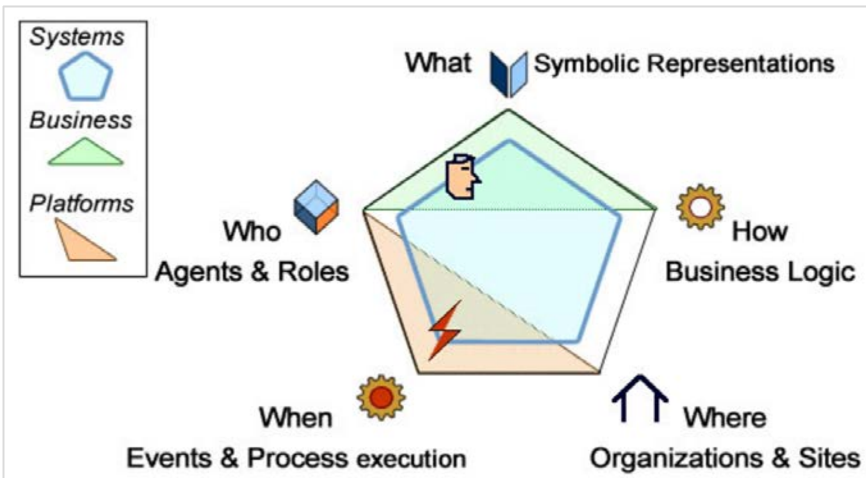


Fig 35: In 1987 John A. Zachman, an IBM researcher, proposed the Zachman Framework, a concept of what is involved in information system architecture [166]. Organizations may not have one architecture, but a range of diagrams/documents representing different aspects or views and/at different stages [167].

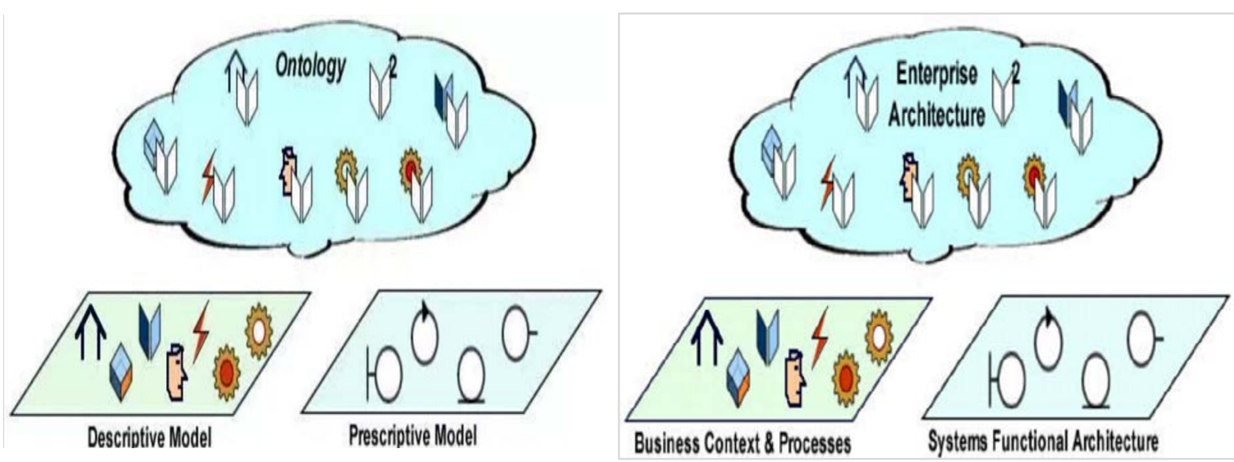


Fig 36: Models sub-layers to ontologies. Enterprise architecture as an ontology of symbolic systems [168].

CONCLUSION

It is possible the transformational tsunami will wipe out the need or significance of DEX. The discussion about forward looking thoughts may be wishful thinking. Quest for open source [169] may be stunted. The academic discussion what constitutes intelligence may be obliterated by the market forces driving AI. The financial muscle behind market driven AI (Figure 37) can crush dissent and defund dissenters.

However, it is reassuring that AI leaders in some of the corporations are exceptionally brilliant engineers (for example, Peter Norvig, Andrew Ng) who are aware of the deep shortcomings of intelligence in AI and they pay attention to neuro-scientists (Tomaso Poggio). Yet, the marketing machines keep churning out chest-thumping tabloid fodder, as if it were the truth. In the middle-ages "artificial flight" attempted to mimic birds. The Wright brothers turned to wind tunnels and aerodynamics, which removed "artificial flight" from our vernacular and gave birth to the aviation industry. AI will generate deep reasoning (DR) and profitable analytics but not intelligence. But, truth always lags behind, limping on the arm of Time (Baltasar Gracián y Morales). Is the truth in AI for a few? Is this discussion about AI a storm in tea cup? Will it suffice if the market acknowledges this is not intelligence or AI but DR or deep reasoning?

Why AI is devoid of intelligence may be unintelligible to individuals without knowledge of neurology or the desire to understand what does it mean to sense or taste or hear. The various aspects of neurology essential to grasp the concept of intelligence, even in its rudimentary form, may include anatomy and physiology of the nervous system and a comparative perspective of neural systems (octopus vs worms). As discussed elsewhere [47], the physical representation of neurons in our brain is not representative of the ***functional*** outcome. This is the single most crucial factor in this debate. Just because computational systems can create neuro-morphic structures, does not mean it can re-create the function or pass the Turing Test. Cryptic and deep in the functional context are states of intelligence, intuition, perception and characteristics that makes us, humans, intelligent. Harnessing the amorphous attributes are beyond engineering systems because the biology still remains undiscovered and our elusive quest continues.

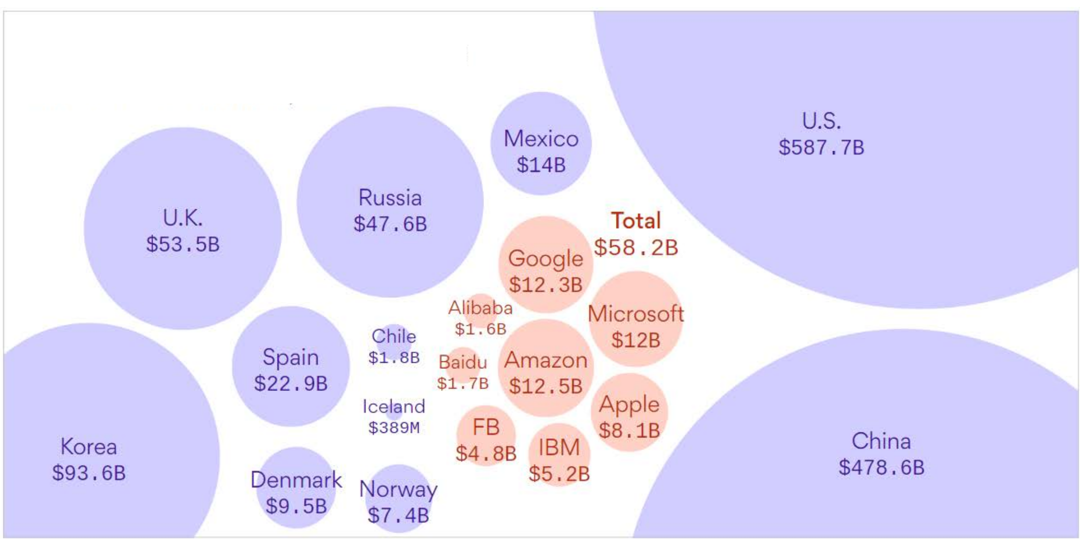
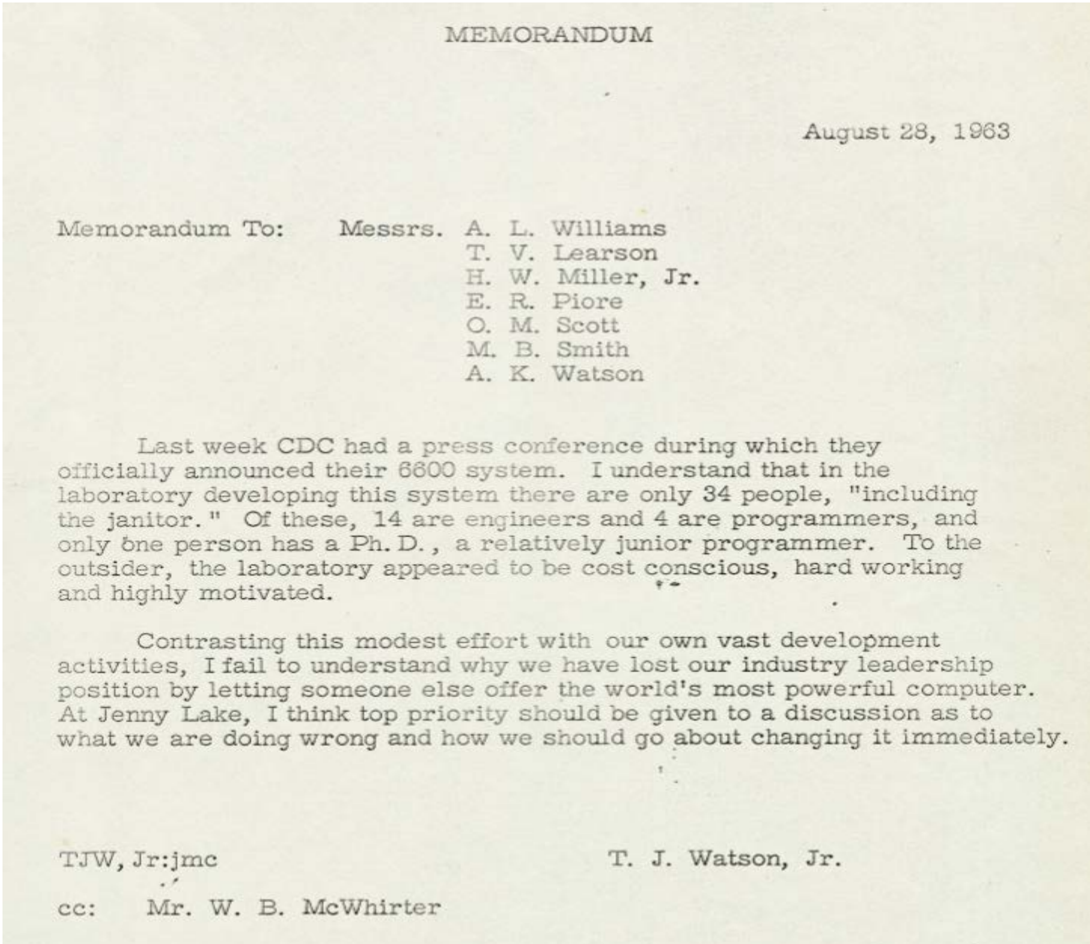


Fig 37: R&D budgets of AI-intensive firms and select countries (OECD, 2015). Bubbles brewing trouble?



MEMORANDUM

August 28, 1963

Memorandum To: Messrs. A. L. Williams
T. V. Learson
H. W. Miller, Jr.
E. R. Piore
O. M. Scott
M. B. Smith
A. K. Watson

Last week CDC had a press conference during which they officially announced their 6600 system. I understand that in the laboratory developing this system there are only 34 people, "including the janitor." Of these, 14 are engineers and 4 are programmers, and only one person has a Ph. D., a relatively junior programmer. To the outsider, the laboratory appeared to be cost conscious, hard working and highly motivated.

Contrasting this modest effort with our own vast development activities, I fail to understand why we have lost our industry leadership position by letting someone else offer the world's most powerful computer. At Jenny Lake, I think top priority should be given to a discussion as to what we are doing wrong and how we should go about changing it immediately.

TJW, Jr:jmc T. J. Watson, Jr.

cc: Mr. W. B. McWhirter

Fig 38: Innovation abhors conventional wisdom and driven by vision reflecting confluence of ideas

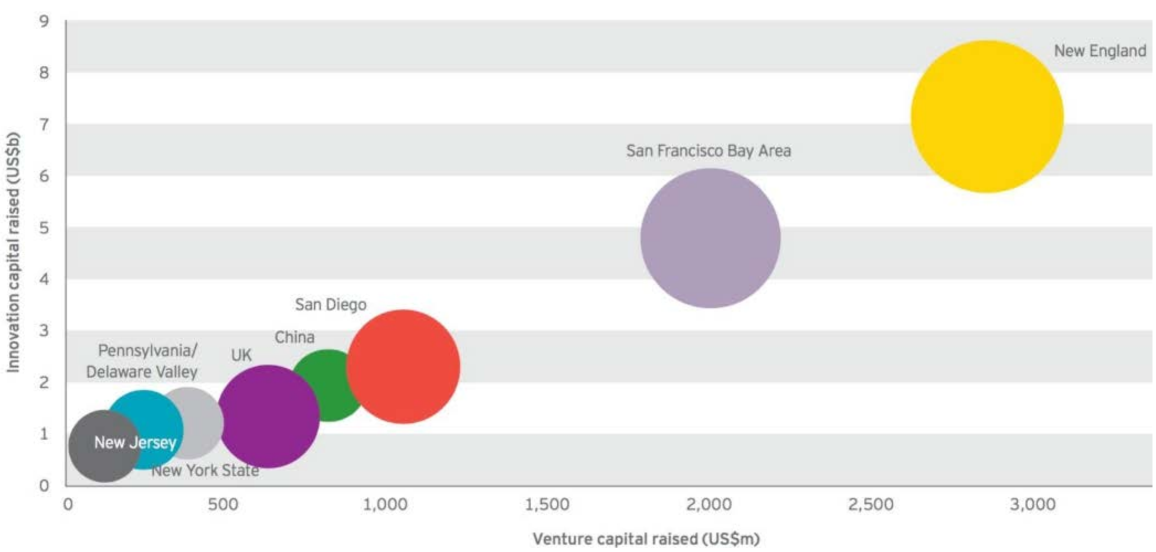


Fig 39: Geography of biotech innovation (Ernst & Young, 2016) proportional to research and education?

Quantum leaps are integral to progress of science (Galileo Galilei) and society (Leo Varadkar). The revelation "what is intelligence" may be breaking news, tomorrow on BBC, from Corina Logan. Hence, paradoxes may be converted into paradigms. What is heresy today may be in harmony, tomorrow. We must view the past (Fig 38) with the present (Fig 39) and accept change (Fig 40) in our future (Fig 41). But, it is encouraging to observe the diffusion of change, even if they are only in illustrations (Fig 42). Things that we may not wish to change are our norms of respect, égalité, and a sense of dignity [170].

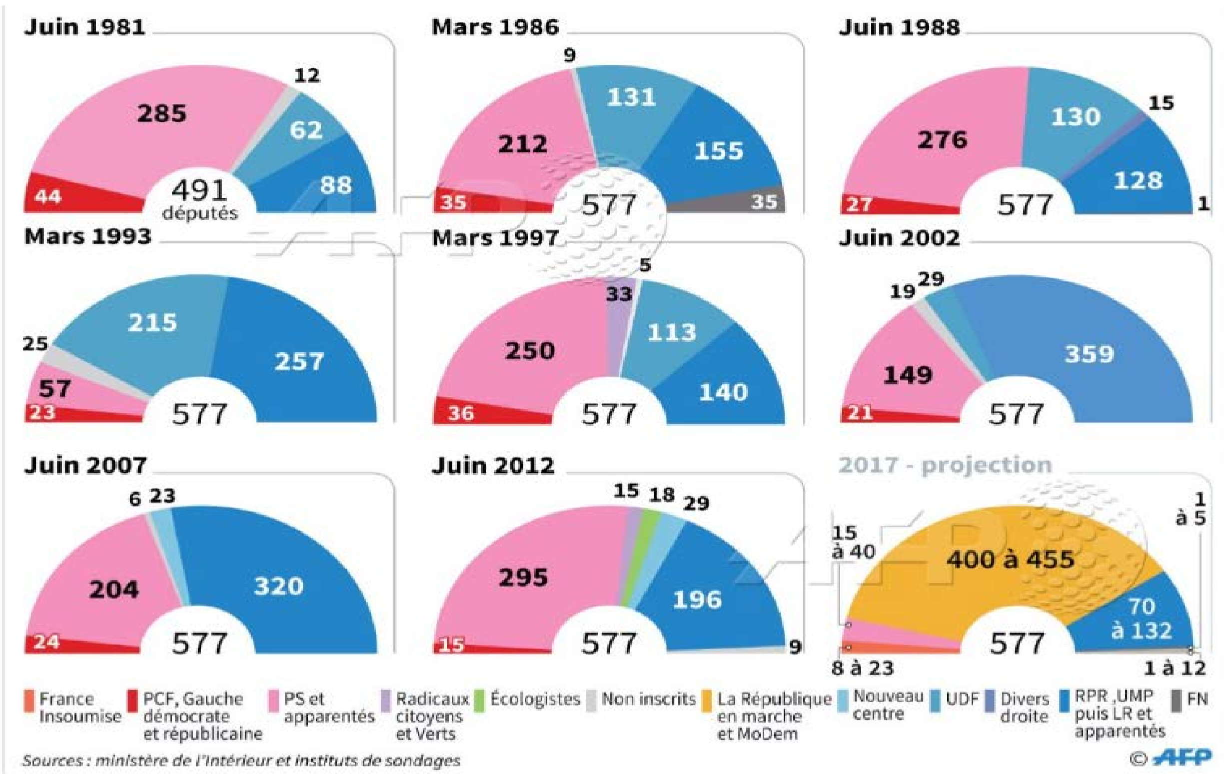


Fig 40: French Revolution 2.0 (La deuxième partie débute environ deux cents ans plus tard).

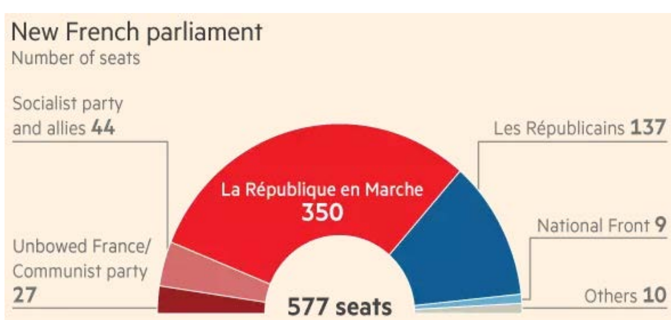


Fig 41: Le parti naissant du président français Emmanuel Macron La République en Marche et son modéle d'allié centenaire sécurisent 350 des 577 sièges à l'Assemblée nationale. Macron réfute Voltaire? En 1741, Voltaire [171] écrivit "sans la voix de la le Maure, & le canard de Vaucanson vous n'auriez rien qui fit ressouvenir de la gloire de la France." Macron voudrait différer. N'est-ce pas?

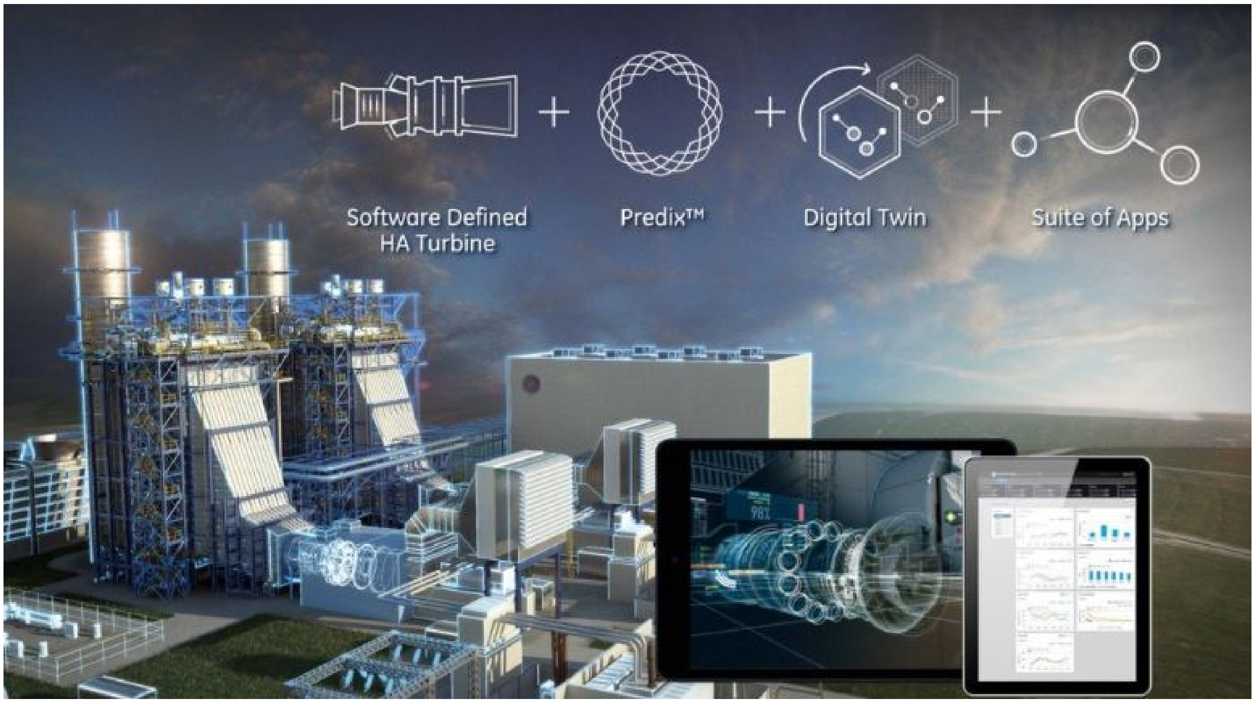


Fig 42: The manufacturing enterprise illustrated by Deepesh Nanda suggests convergence of digital threads in DEX.

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APPENDIX

The Great Wave at Kanagawa, 1829 by Katsushika Hokusai (modified)

Digital Tsunami

The objective of this blog is to suggest tools and structures that businesses may use or develop in order to benefit from the tsunami of digital transformation, create new lines of business and venture into new global markets. The task is immense and as a consequence any cohesive synthesis is vastly imperfect, as indicated in the “preface” on page 2. Despite its critical shortcomings, the appendix (this section) will try to provide a context for individuals who may be less acquainted with the current wave of digitalization.

Imagine a well-built grand highway.

Now, re-imagine a well-built grand highway but in the middle of nowhere!

Consider that within a few miles from this highway there are people living in the area. You are here to sell Tesla Model 3. By now you have grasped the conundrum. Haven't you? Your potential customers near the highway are strongly suggesting that if you wish to sell cars, please help them to build roads.

But that is a different task, the job of building roads. Other potential customers are taking you (on their horses) to show some of dirt roads and even stretches of ill-maintained paved roads which are peppered with pot holes. Can you help them repair pot holes or can you sell them faster horses, instead of Tesla?

In the analogy to digital transformation, imagine the highway to represent the digital platform of convergence. The car is your application or transaction or enterprise, on that platform, which enables you to connect to the ecosystem, using the platform (that is, you travel from A to B to C and may engage in commerce, if the highway was connected to the people and businesses via roads, lanes and bridges).

The job of building roads and repairing pot holes, dampens the thrill of driving the Tesla down the highway. Digital transformation projects are failing or pilots are struggling to break away from small scale implementations because we are interested in the exciting aspects of the digital revolution, IoT and AR/VR. We are less interested to help bridge the gap from legacy, devices and monolithic systems.

This blog suggests that decomposition of the enterprise into modular blocks and enabling connectivity between the building blocks to synthesize the customer facing outcome may be a multi-step and tedious process, but one that is mandatory, if we expect to profit from the vast potential of digital enterprise.

To profit, the customer facing outcome must be the reverse of what is mentioned in the last paragraph. Customers are seeking solutions to their problems not just "patches" or information about the problem when unpacked and reduced to tractable sub-problems. Dissection is quintessential but the customer will reward (pay) the value provider who can synthesize a "systemic" solution not just install a tool or technology as a contribution to the "whole" solution. Hence, "tool" providers (Intel, Cisco, Microsoft, Oracle, SAP, IBM) are all consulting companies. Tools are not produced in the context of the enterprise but externally with guidance from knowledge experts. The demand from system integrators (Accenture, Deloitte, KPMG, Wipro, Infosys, TCS) is to "stitch" the "patches" from "tool" providers and expect a harmonious and functional "quilt" to serve as a solution. Exception to this model are conglomerates like GE, Siemens and Hitachi. They are evolving from manufacturing and finance to systems companies recognizing the underpinning of data, information and knowledge which is at the core of profitability in a connected world. The creation of GE Digital and its software evolution through Predix, is one example. It reflects a thinking about systemic solutions approach to problems rather than depend on vendors or system integrators. Both are essential in the ecosystem but business solutions from businesses may offer a different flavor because they view the whole "elephant" rather than look at it in parts.

The Blind Men and the Elephant ● John Godfrey Saxe (1816-1887)

In systems thinking a common analogy is that of six blind men from Indostan (India) touching various parts of an elephant and claiming that "elephant is a tree" (man who touched the leg), "it is like a rope" said the blind man who touched the tail. "Like a snake" (man who touched the trunk). "It is like a big hand fan" (man who touched the ear). "Like a huge wall" said the man who touched the belly of the elephant. "Like a spear" said the blind man who touched the tusk. They were misguided in describing the part they touched and as a consequence their interpretation is incorrect about the whole animal.

The illusion of expertise peddled by vendors and integrators are true in the context of their "part" of the solution. The latter was not unsuitable for an analog world where the company had no idea of what happened to the product once it left the manufacturing plant. In the service paradigm, connectivity is the bread and butter. Customer experience is king. The ubiquity of digital transformation has the potential to constant communicate and harvest outcomes from each user layer or machine or device. The inability of the system to use that data or extract the information is directly proportional to its profitability or lack of it.

Hence, the "illusion of expertise" which was once suitable and sufficient for discrete analog enterprises, is now a chronic recurring challenge which handcuffs systemic innovation. The vast complexity of business evolution in its always connected digital transformation *modus operandi* is an entirely new playing field. There is plenty of room for conglomerates to profit from unleashing ***intrapreneurs*** and supporting unconventional entrepreneurial innovation to splice with conventional wisdom. Leaders must recognize the illusions (and delusions) in traditional business as usual and help to remove those roadblocks to spur real transformation, that is, the whole "elephant" is your customer.

The whole "elephant" is the customer. An "analog" approach to "parts" may be insufficient to increase profitability when continuous connectivity of service, and "intelligent" decision support systems in near real-time, are desired outcomes and key performance indicators (KPI) expected from digital enterprises. The metaphor of building blocks in this blog now must help build the metaphorical elephant which is a connected system, a biological enterprise. One cannot use the mouse as a model to build an elephant.