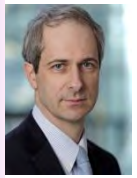

Yves Caseau
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National Academy of Technologies of France

Big Data, Behavioral Change and IOT Architecture

Euro-CASE Annual Conference 2016
BIG DATA - SMARTER PRODUCTS, BETTER SOCIETIES

ATV – Danish Academy of Technical Sciences
DTU – Technical University of Denmark
November 14th, 2016

Version 0.5

Outline

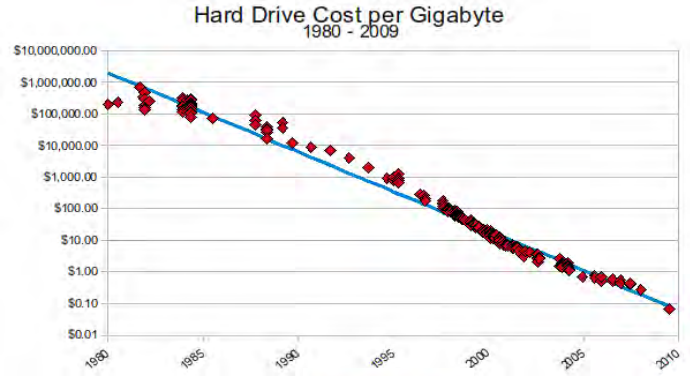
1. **Big Data : A Multiple Paradigm Shift**
   Our NATF 2015 report on the disruptive nature of Big Data

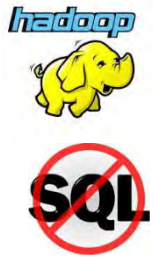
2. **Facilitate Learning New Behaviors Through Games**
   Exponential rate of change yield adaptation stress : the value of games for learning

3. **Internet Of Things Architecture**
   From Event-Driven Architecture towards A Society of Minds

The NATF 2014 Mandate on Big Data

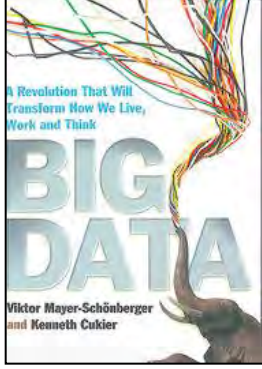
- Big Data is a natural evolution of software technology in an exponentially changing world
  - Wealth of data sources thanks to sensors and digital transformation
    - Spectacular decline of storage cost
      1To: 1 M$ in 1995, less than 40$ in 2013
  - New challenges (3V : Volume, Variety, Velocity) have spawn new technologies
    - Massively distributed data
      avoid data transfer with petabytes ☺
    - Massively parallel processing
      Flow computing, Event processing
    - Unstructured data



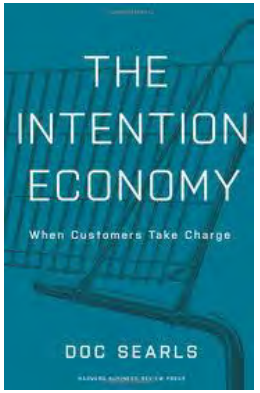


- Should we see Big Data as an evolution or a revolution ?

Big Data – A Revolution That Will Transform How We Live



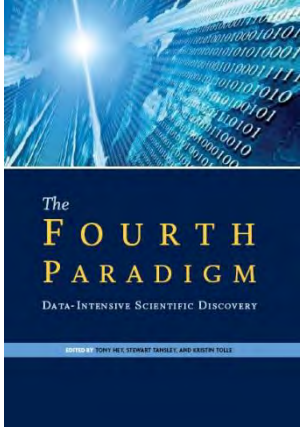
- Intension economy and synchronized marketing
  Retargeting (Criteo) and Recommendation (Amazon / Netflix)



- Predictive Learning has shown its relevance
  Target example / de-anonymization

- Big Data and connected objects
  to enrich service through memory and analysis

Continuous Feedback Loop as a Data Mining Paradigm



- Break away from causal analysis
  « The data deluge makes the scientific method obsolete »

- A systemic approach that is closer from computer sciences than from statistics
  A real-time learning loop that is evaluated on its operational results

- Simple methods that are tuned on extremely large data sets over perform sophisticated algorithms tuned on regular data sets

Google

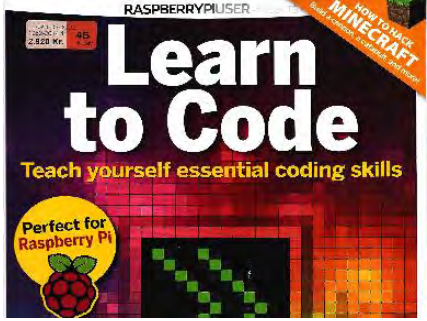
Data Ecosystems and Data Privacy

- Data taxonomy: anonymized / aggregates, profiles, usage and scores (computed)
  Big Data undercuts anonymization

- Debate around data processing finality ?
  - External audit (CNIL), non-transferable
  - Need for OPT-IN &
    shared **domain finality** constraint
    (basis for consent)

- Who owns the data ?
  - Profile : customer; usage : co-ownership,
  - Computed scores belong to companies (within a domain finality)

A New Way to Write Code



- « Data is the new code »
  Algorithms may be reconstructed from data

- Massively parallel, distributed, open-source
  Thomas Hoffman:
  « *Big Data is getting at the core of computer science* »

- Algorithms are synthesized through Machine Learning + sub-linear techniques

facebook

- Tools and techniques from Big Data enable the reinvention of traditional IT business systems

Part II

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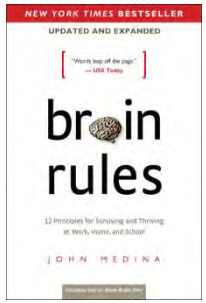
The Promises of a World of Sensors and Data Science

- An era of abundant scientific information about the impact of behavior on health and well being
  - Example : Brain oxygenation on IQ
  - Big data techniques allows for more detailed & in-depth studies
  - Impressive rate of expansion of studies & scientific literature



- IOT & e-Health: exponential growth of sensors adds to this trend
  - Example : **Withings** Body Cardio scale with *Pulse Wave Velocity*
  - Smartphones will become part of our healthcare journeys
  - Connected wearables generates longitudinal traces (individualized)

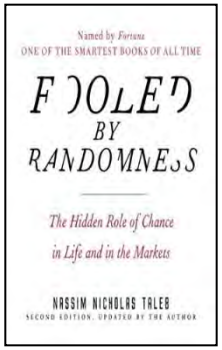
- Empowering users to better control their health and wellbeing
  - More information (personalized, accessible at any time)
  - Better feedback (real time, insights, …) through wearables

Tracking Without Sense : User-Centric Design

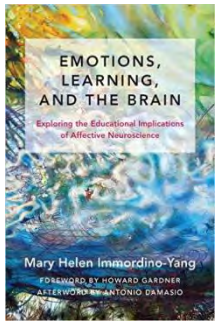
- Users do not want dashboards
  - They become bored quickly (cf. wearable quick and sad fate)
  - Tracking without sense (not everyone is a data scientist)
  - True in home automation
    (remote control and monitoring is not enough)

- Connected devices must come with a story and a coach
  - We are moved (and we remember) stories,
    not data sets (N. Taleb)
  - To react on an sustained time horizon,
    we need positive feedback loops

AXA Health Gateway



- Behavioral change is hard
  - Cf. temporal cycles of engagement
  - Need to leverage emotions, hence the popularity of games
  - Biorhythms are important :
    find the right moment and the right state of mind



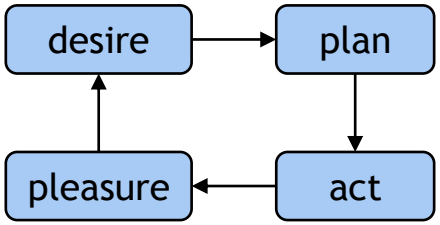
Adaptive Stress Due to Technology Change Rate

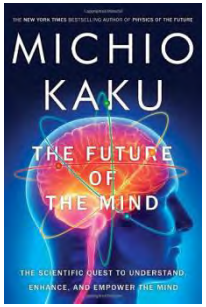
- Summary
  - Adoption of ICT is fast & widespread but worries are being expressed
  - Adaptation stress : Technology > usage > understanding « a world of accelerated permanent change »
  - A fear of not being in charge (mastery), especially temporally
  - Physical experiences are still preferred to virtual ones, additive logic versus substitution

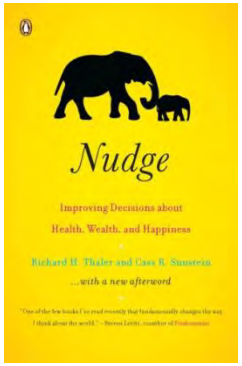
- Recommendations
  1. Reduce stress though training / learning / explanations
  2. Invite « real back into virtual » : leverage mirror neurons ☺
  3. Life hygiene and detox : promote temporal and spatial rest zones
  4. Leverage emotions

To Build a Successful Digital Experience Means "*To Include a Fun Learning Journey*"

- Learning without a User Manual
  - Use Analytics : measure discovery and appropriation
  - Continuous feedback with IOT
- Leveraging Pleasure through Games
  - Play with simple emotions (badges/rewards) but also surprise/ …
  - Cf Mikio Kaku (emotion: evolutionary mechanism of learning)
- Leveraging Communities of Learning
  - Social digital experience « Virality is the product »
  - Learn by imitation (e.g. video tutorial with other users)
- Learn by Doing (Montessori heritage ☺)
  - Kinetics memory
- Leverage Cognitive Biases
  - *Dan Ariely*
  - *Richard Thaler*
  - *Daniel Kahneman*

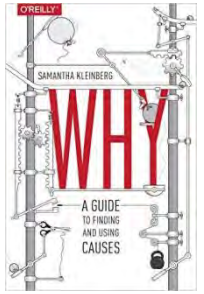




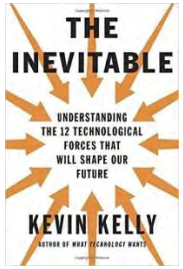


Internet of Things and Life Coaching

- The best tool for behavior change is a “game to learn about yourself”
  - Sensors to monitor yourself and your environment
  - Digital tools to tell a story
  - Data science to generate insights (without the burden of causality)



- Learn by doing : “Yourself as a system” => insights discovery
  (i.e. discover what makes you gain weight versus loosing weight)
  - This is natural for regular “quantified self” user
  - Bringing this experience to everyone is a challenge
  - Leverage behavioral science into digital sciences (e.g., notification cycles)



- This is as much about “small data” as “big data”
  - Personalized healthcare (we are all different)
    cf. Health 4P: Personalized, Preventive, Participative, Predictive
  - Data privacy is a true and rising concerns (privacy by design)

snips

Part III

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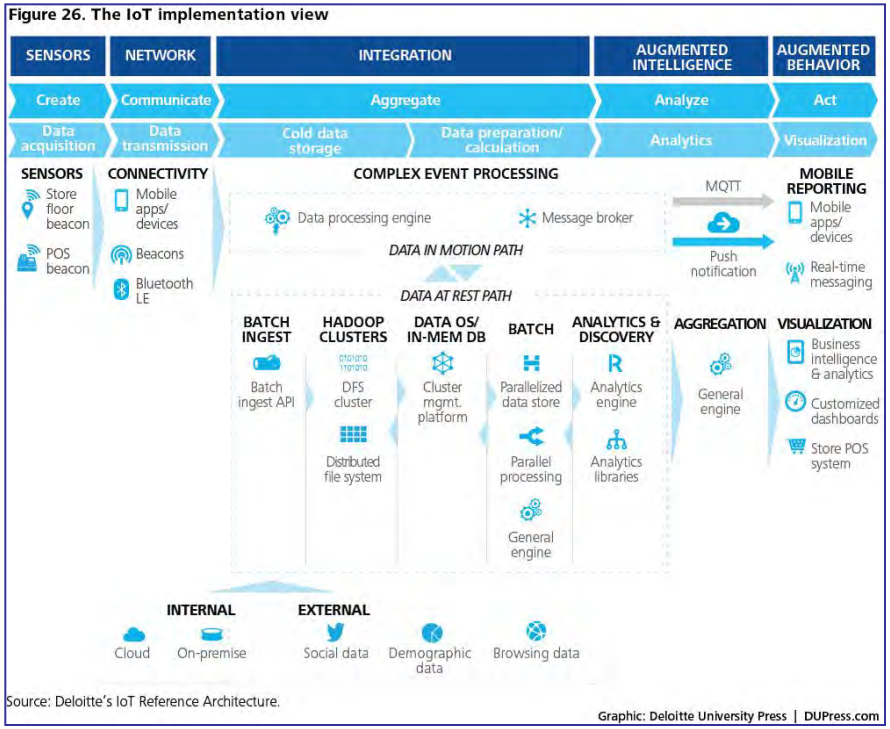
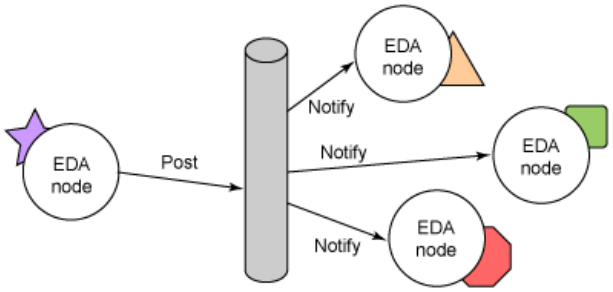
Internet of Things Architecture is Grown, not Designed

- IoT is foremost a B2B topic, where traditional top-down system engineering approaches make sense … However the B2C world is governed by customer usage, hence “chaotic” (in a complex systems sense)
- Most IOT reference architectures are too hierarchical, too “Telco-oriented” ☺
- One of the best reference is, from my point of view, *Deloitte’s “implementation view”*
- Still this is too:
  - structured,
  - holistic ….
- … I advocate for emergent patterns:
  - Systems of Systems
  - Grown from usage (biomimicry)



Event-Driven Architecture



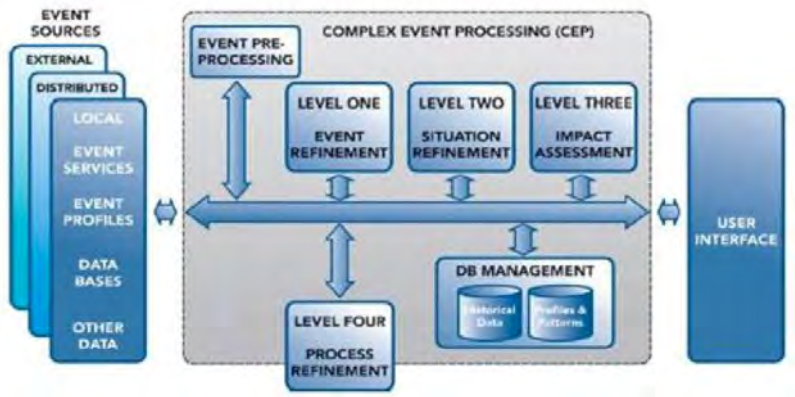
- Event-Driven Architecture is well suited for smart objects systems
  - Scalable, open, distributed
  - Cf. IFTT : open API-based, event-driven architecture

myfox

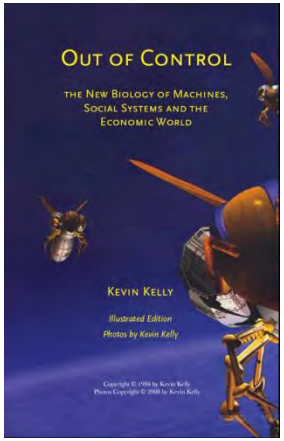
- To adapt continuously to its environment, the preferred architecture is to distribute control and analytics
  - Avoid SPOF, better fault-tolerance
  - Biomimicry for smart home : multiple layers of controls corresponding layers of abstraction since complexity yields fragility
- Redundant and distributed storage
  - Not every piece of data should be moved …
- Smart systems operate on a multiplicity of time scales
  - cf. lambda-architecture : hot/cold analytics
  - Event-driven learning at multiple time horizons

Emergent EDA Systems : « *Engineering as Parenting* »

- Smart Systems are hierarchical → hierarchies of events
- Complex Event processing → move between abstraction levels



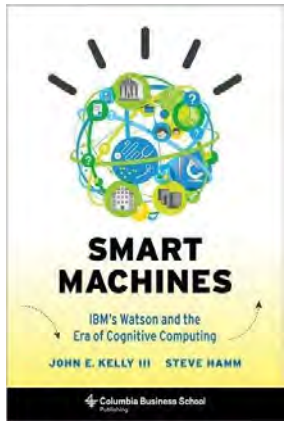
- "Human in the loop" => emergent design
  - Design "conversations" with users
- Common goals must be reified (and distributed)
  - complex systems (teleonomy)
  - Cf SlapOS, OAI, …
- Biomimetics : "*grow what works*"
  - E.g., muscle growth
  - Smart Home example : Adhoco

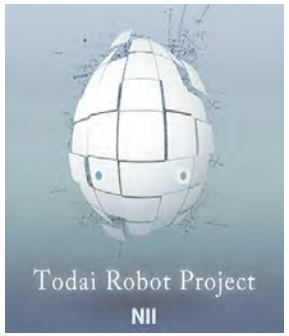


adhoco
adaptive building control

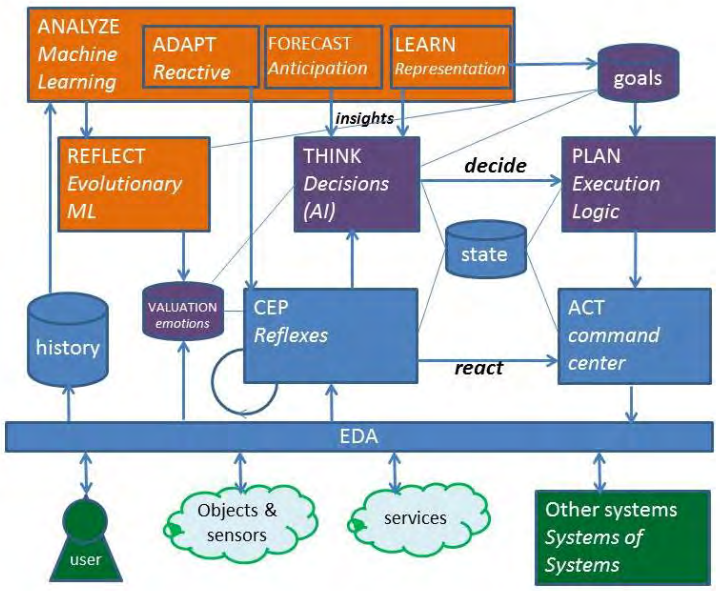
Cognitive EDA Systems

- "*The era of cognitive computing*"
  - Systems "*grown by machine learning, not programmatic design*"
  - "*Society of minds*" - Cf. Todai Robot – University of Tokyo





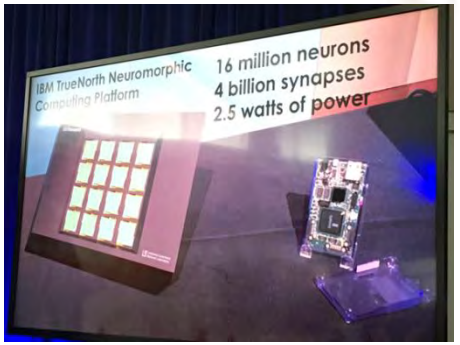
- "*Biomimicry as a design principle for cognitive engineering*"



A short overview:

- Reflexes
- Inductive Thinking (ML)
- Deductive Thinking (Rules & Planning)
- "Emotions" (evolutionary / meta-heuristics control)

Systems of Systems : Fractal IOT Architecture



- Smart / learning systems are coming
  - Cf. feedback from CES 2016
  - Cf. feedback from Singularity University
  - Ability to integrate cognitive systems into small silicon footprint is growing exponentially ☺
- They are embedded into “Systems of Systems”
  - Learning/ data / analytics is distributed & multi-scale
  - Learn from sensors, as close to the data as possible
- It is easier to build really smart smaller objects than large systems, thus they will appear first and “intelligence” will come locally before it comes globally
- Role of meta-learning loops and meta-narrative (coaching)
  - Critical role for SoS (global perspective)

Conclusion

- **Big Data represents a set of paradigm shifts**
  - Data as code, designing emergent systems though ML
  - The opportunity for disruption is larger than new services and new usages
- **Smart data empowers a new generation of smart systems, but they must be designed for human needs**
  - IoT does not have to power to change human behavior by itself
  - Educate the user though games because she is the most important part of the smart system
- **Event-driven, adaptive and cognitive Internet of Things architecture**
  - IoT architecture is derived and built from consumer usage
  - Cognitive large-scale systems will emerge bottom-up since it is easier to derive closed-loop learning systems on a smaller scope