Living Digital Things

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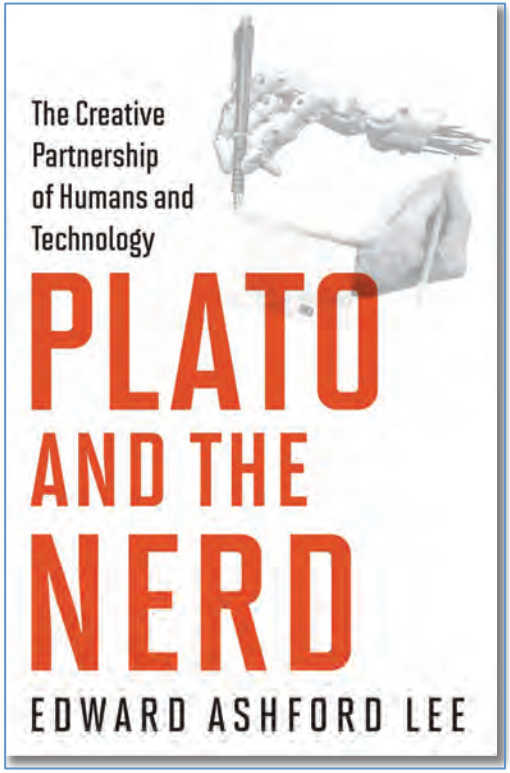
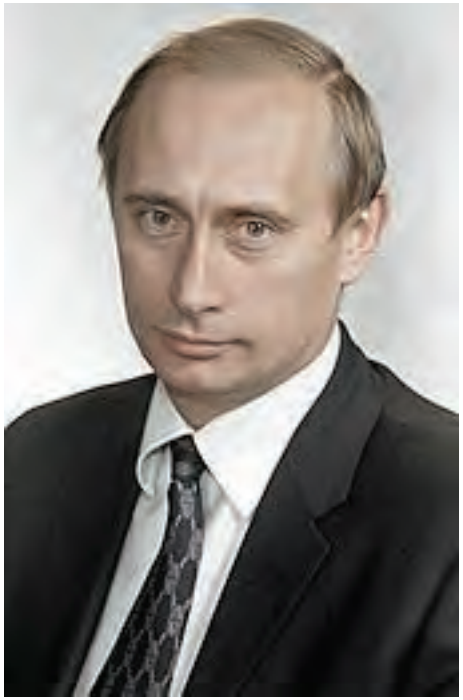
Reference for this talk:



Artificial Intelligence Hype and Fear

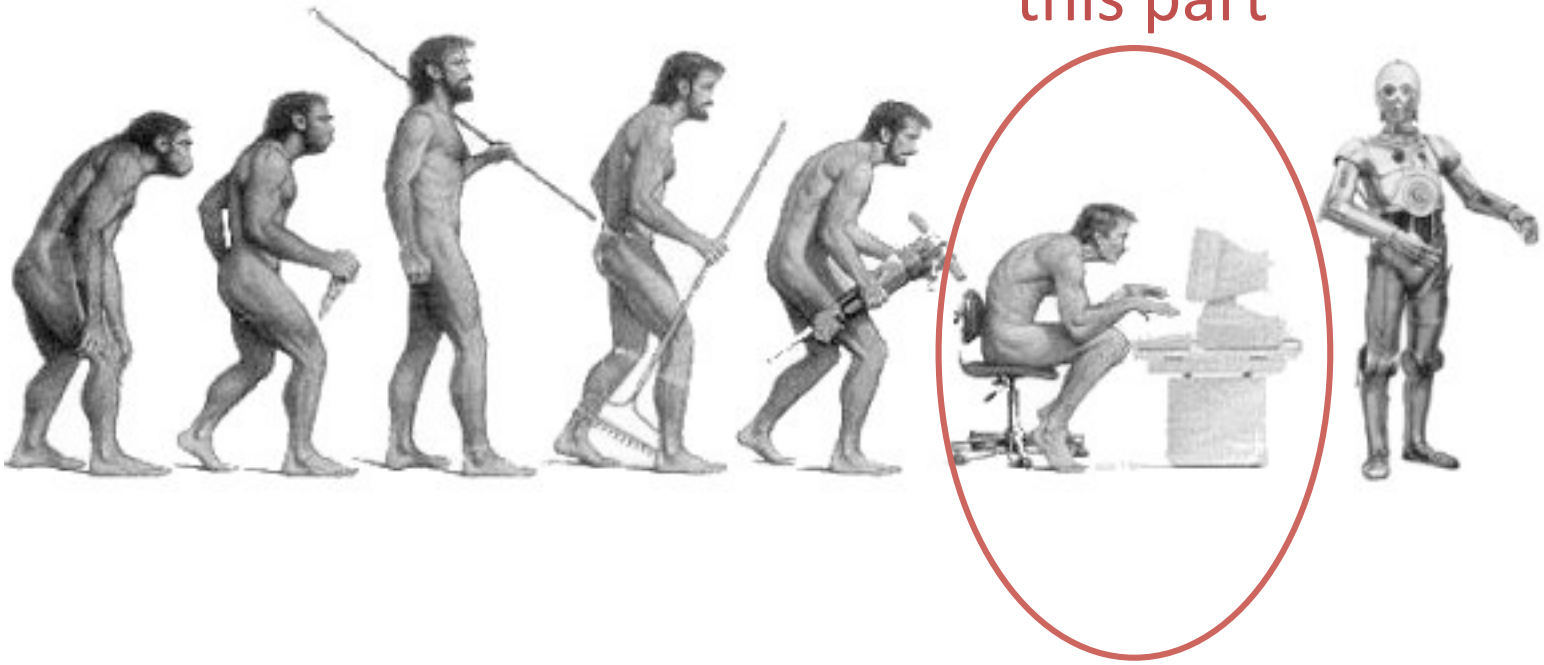


Vladimir Putin: “Whoever becomes the leader in [artificial intelligence] will become the ruler of the world."

Elon Musk: AI represents an "existential threat to humanity" and urges government regulation "before it's too late."

Will artificial intelligence exceed human intelligence?

Let's try to understand this part

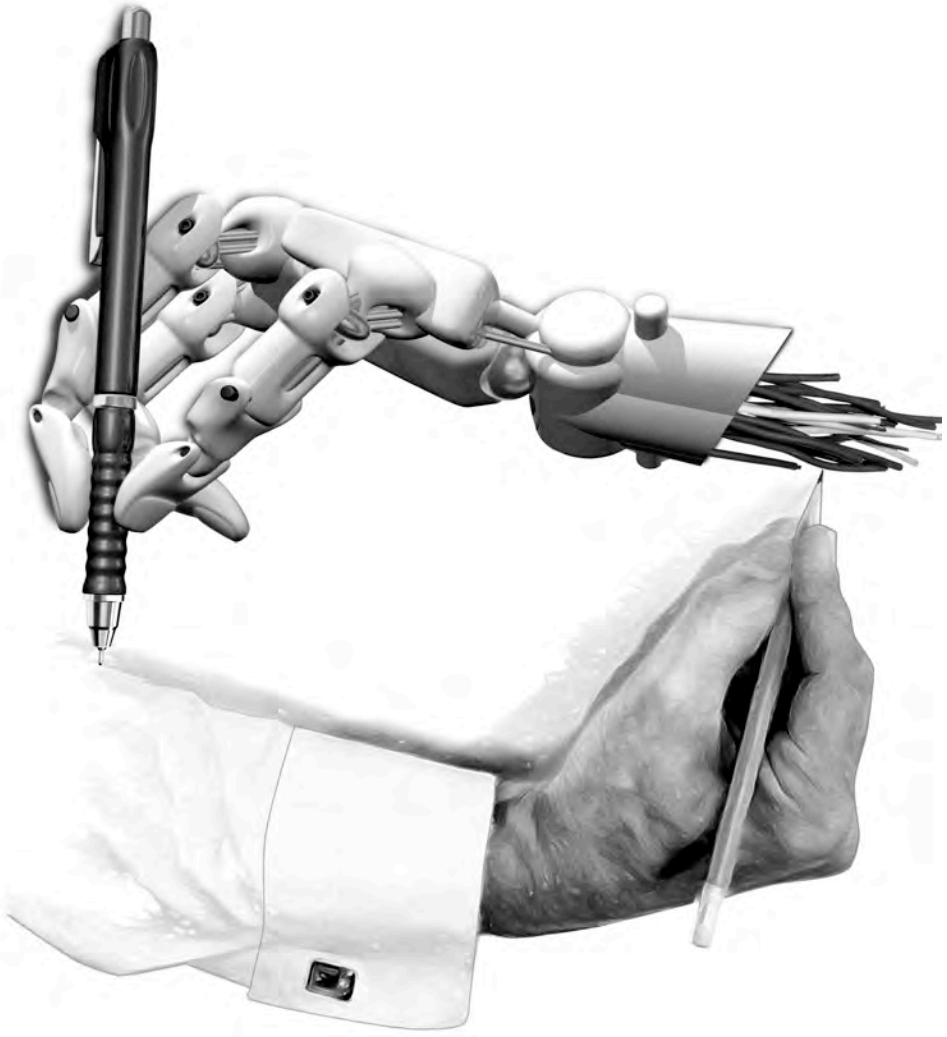


About my Title

Plato and the Nerd

About the Cover Image

The Creative Partnership of Humans and Technology



Science and Engineering

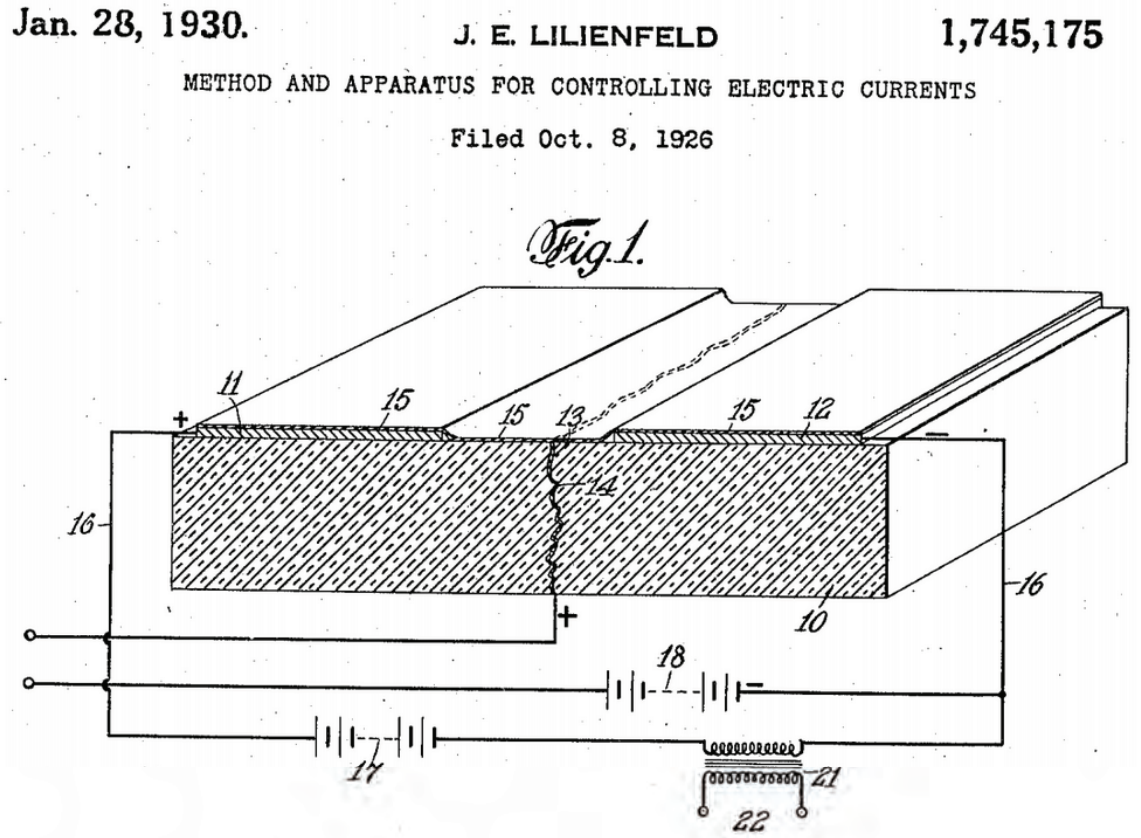
LIGO

Discovery and Invention

Bardeen, Brattain, and Shockley in 1948, one year after discovering the transistor effect. They won the 1956 Nobel Prize for this work.

Discovery and Invention

Julius Lilienfield had been issued a patent in 1930 for the 1925 invention of the field-effect transistor.


Jan. 28, 1930. J. E. LILIENFELD 1,745,175

METHOD AND APPARATUS FOR CONTROLLING ELECTRIC CURRENTS

Filed Oct. 8, 1926

Fig. 1.

DESCRIPTION

Patented Jan. 28, 1930 JULIUS EDGAR LILIENFELD, F BROOKLYN, NEW YORK METHOD AND APPARATUS FOR CONTROLLING ELECTRIC CURRENTS Application filed October 8, 1926, Serial No. 140,863, and in Canada October 22, 1925.

Science, Engineering, & Models

- In *science*, the value of a *model* lies in how well its behavior matches that of the physical system.

- In *engineering*, the value of the *physical system* lies in how well its behavior matches that of the model.

A scientist asks, “Can I make a model for this thing?”
An engineer asks, “Can I make a thing for this model?”

A scientist tries to shrink the number of relevant models.
An engineer strives to grow the number of relevant models.

Is the process of building models rational, systematic, and logical?

Donald Rumsfeld (2002):

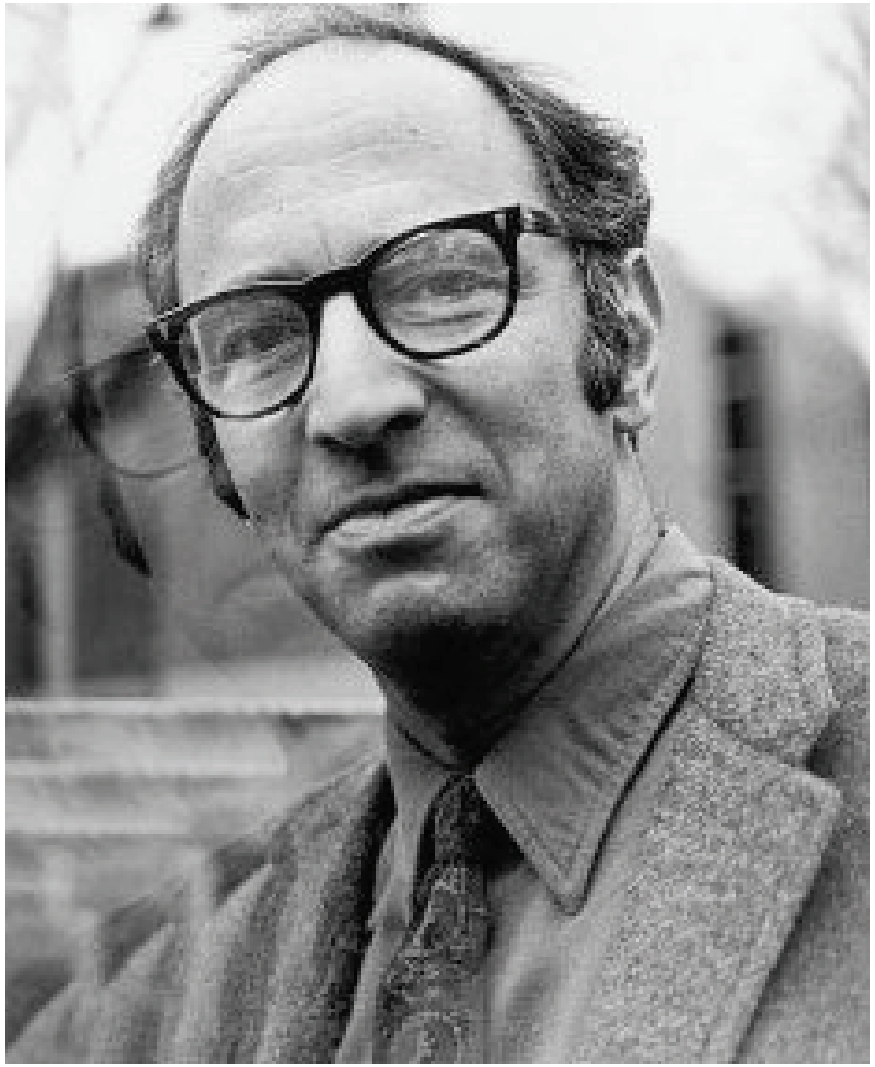
- known knowns
- known unknowns
- unknown unknowns

But left out:

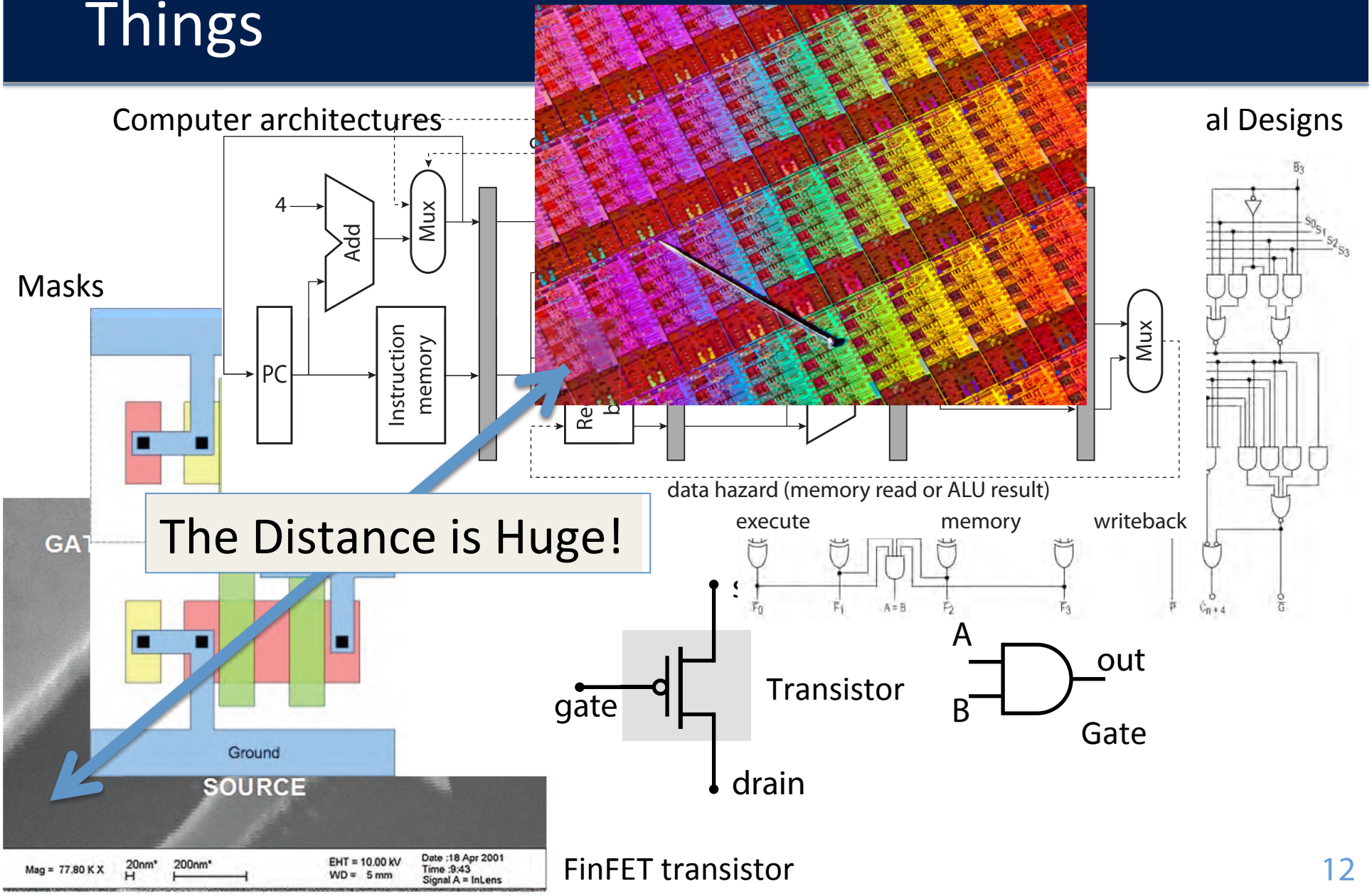
- Unknown knowns

Paradigms

Thomas Kuhn



Models of Models of Models of Models of Things



FinFET transistor

… And That's Just the Hardware

cloud computing	page 114
libraries, languages, and dialects	page 109
programming languages	page 97
instruction set architectures	page 92
digital machines	page 83
logic diagrams	page 81
logic gates	page 78
digital switches	page 77
semiconductors	page 74

Figure 3.3: Layers of paradigms.

Software is Quirky and Idiosyncratic, and Yet it Shapes Thought

```
cmp   eax, ebx
je    label
```

```
INTEGER, DIMENSION(4) ::  W
W = (/ 42, 43, 44, 45 /)
```

$$x[\triangleq\ x \leftarrow 5?10]$$

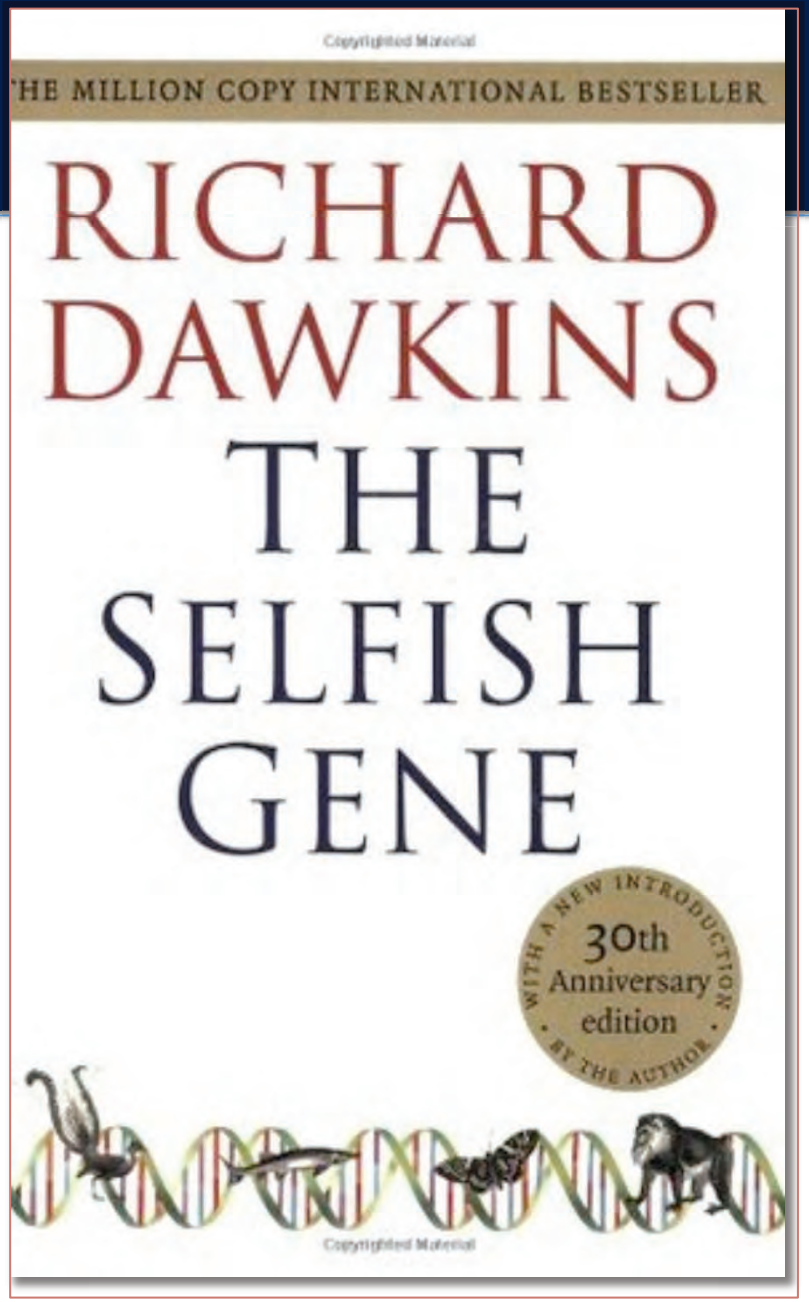

```
<!DOCTYPE html>
<html>
<body>
    <div id="target"></div>
</body>
</html>
```

```
$(document).ready(function(){
    $("#target").text("Hello World");
});
```

```
#target {
    color: red;
}
```

Memes

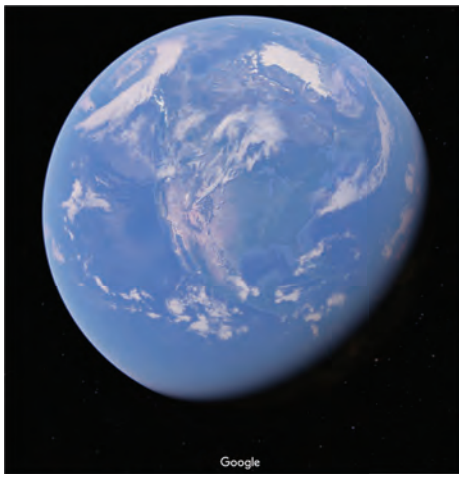
Richard Dawkins



Living Software Systems?

Beyond Turing-Church to persistent, interactive systems:

- 1970s: Time sharing systems
- 1980s: Embedded systems, databases
- 1990s: Web servers
- 2000s: E-commerce systems
- 2010s: Cloud computing, IoT
- 2020s: Living cyber-physical systems



Living Cyber-Physical Systems

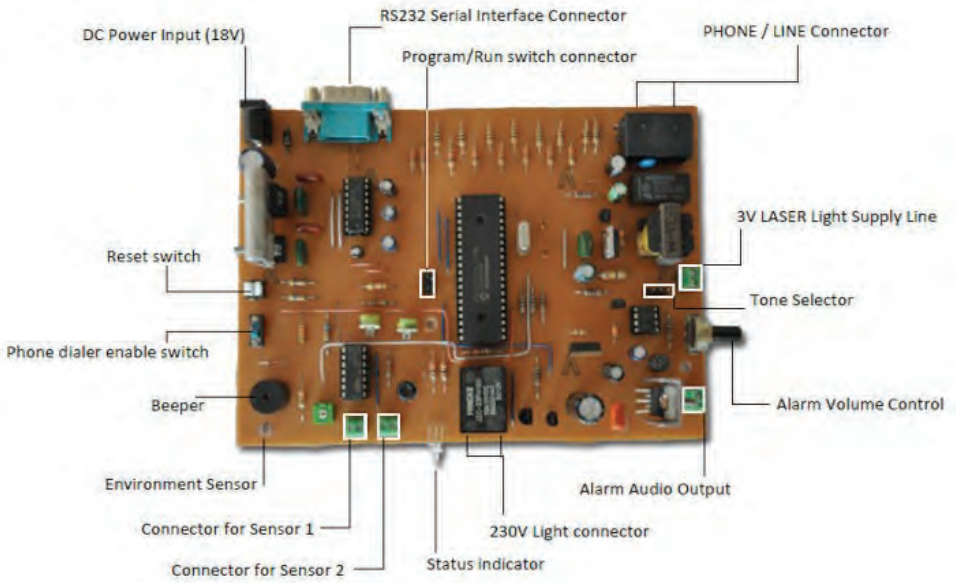
In the *Physical World*, not just the Information World

20th Century:

- Dedicated hardware
- Firmware
- Durable (decades)
- Isolated

21st Century:

- Programmable
- Upgradable
- Interconnected
- Ubiquitous



Most Interesting…

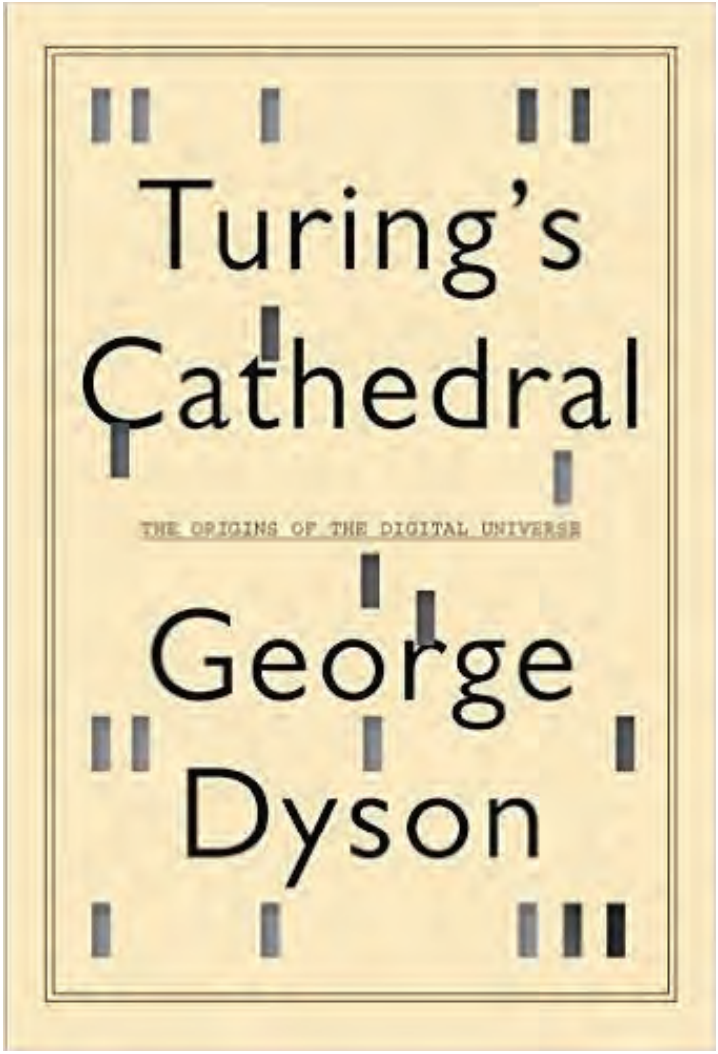
Persistent processes, taking care of themselves (with our help), sensing our world and manipulating it (in our service), and *coevolving* with humans, with our culture and even our bodies.

Coevolving???

Dyson talks about Google's million-plus servers as a "collective, metazoan organism." He points out that "the companies and individuals who nurture [the servers] are ever more richly rewarded in return" and that "unemployment is pandemic among those not working on behalf of the machines."

"The Big Computer [is] doing everything in its power to make life as comfortable as possible for its human symbionts."

(Dyson, 2012, p. 308,313,325)

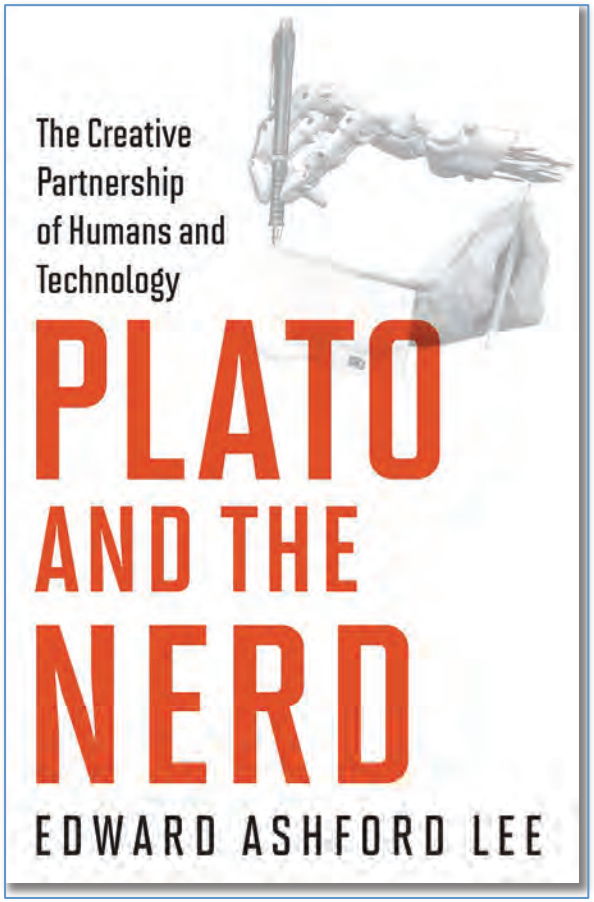


Coevolving???

"If computers and software form organisms, then they depend on us for their procreation. We provide the husbandry and serve as midwives. In exchange, we depend on them to manage our systems of finance, commerce, and transportation. But more interestingly, the machines make the humans more effective at the very husbandry that spreads the software species.

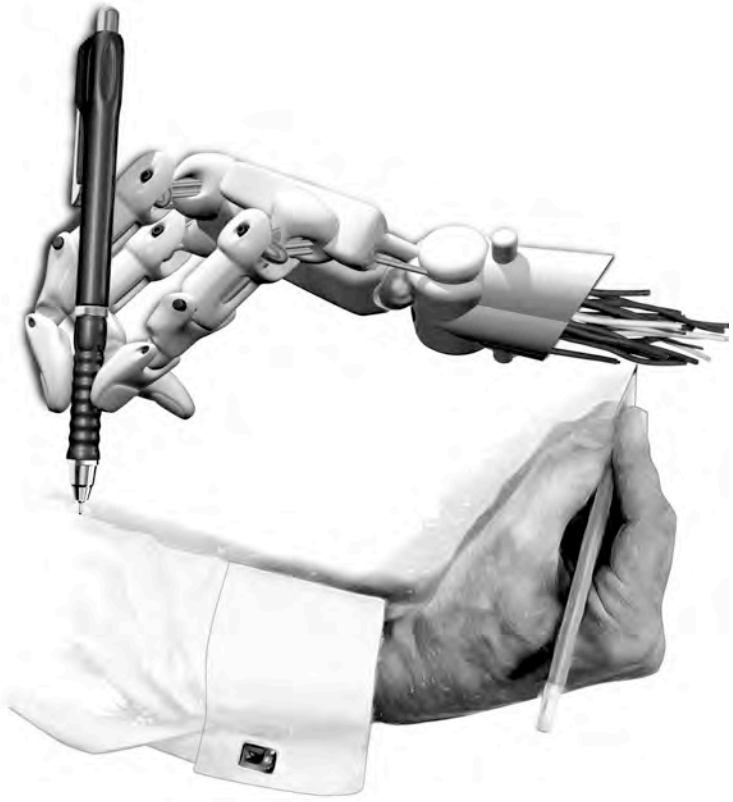
….

the software survives and evolves only if the company survives and evolves, and vice versa."



Symbiotic Coevolution

"Are we playing God, creating a new life form in our own image, or are we being played by a Darwinian evolution of a symbiotic new species? Are humans the purveyors of the 'noisy channel' of mutation, facilitating sex between software beings by recombining and mutating programs into new ones?"



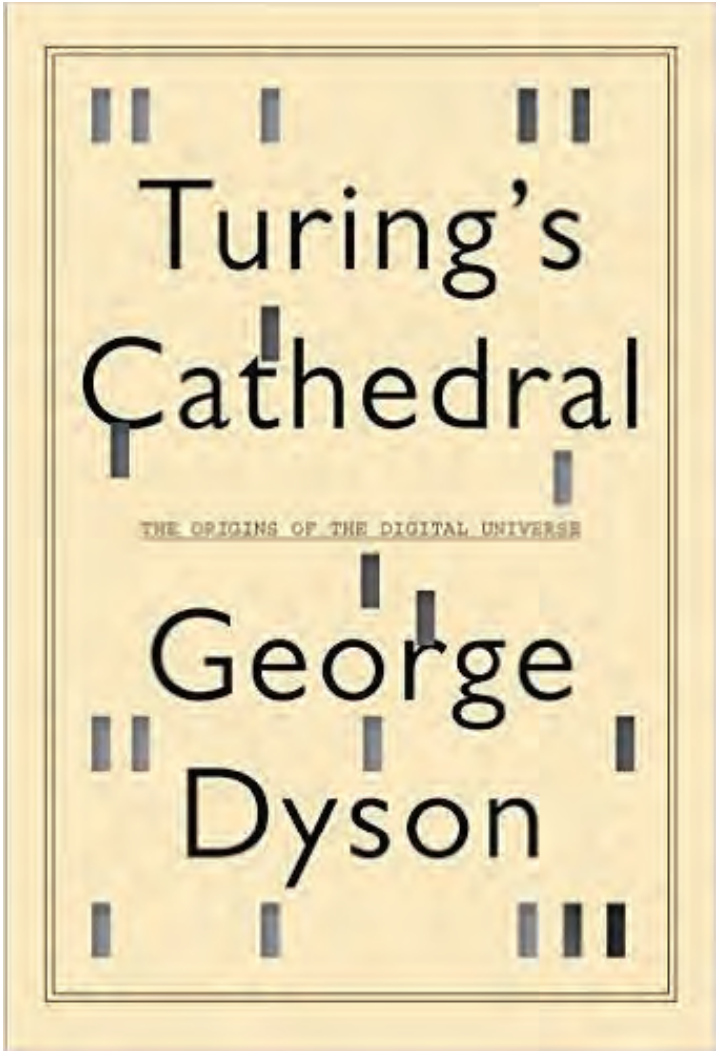
How are Humans Evolving?

The humans are evolving too:

"Facebook defines who we are, Amazon defines what we want, and Google defines what we think."

"Are we using digital computers to sequence, store, and better replicate our own genetic code, thereby optimizing human beings, or are digital computers optimizing our genetic code—and our way of thinking—so that we can better assist in replicating them?"

(Dyson, 2012, p. 311)

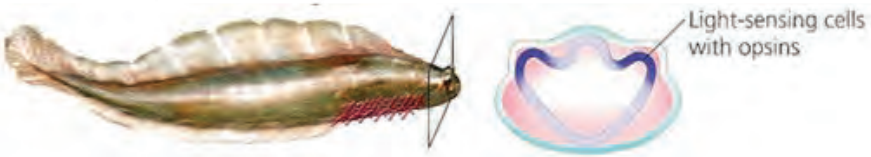


Rapid Evolution

Cambrian Explosion

1. Early chordates with light-sensitive eyespots expressing photoreceptor genes

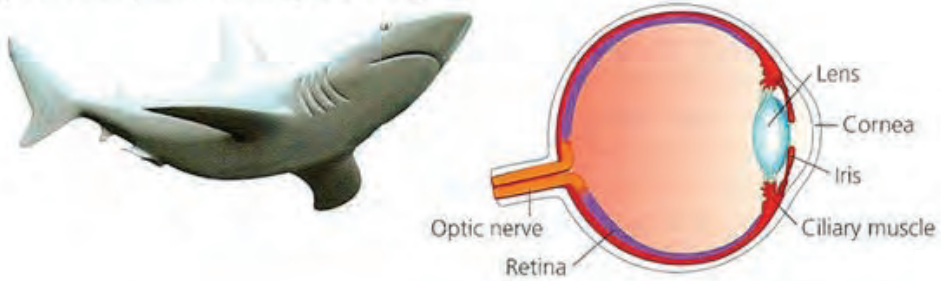
2. Light-sensitive regions bulge outwards to the sides of the head



3. Patch folds inward into a cup, beneath unpigmented skin (lens placode)

4. Surface becomes transparent, and lens evolves ability to focus an image

5. Eyes become spherical, evolve greater acuity

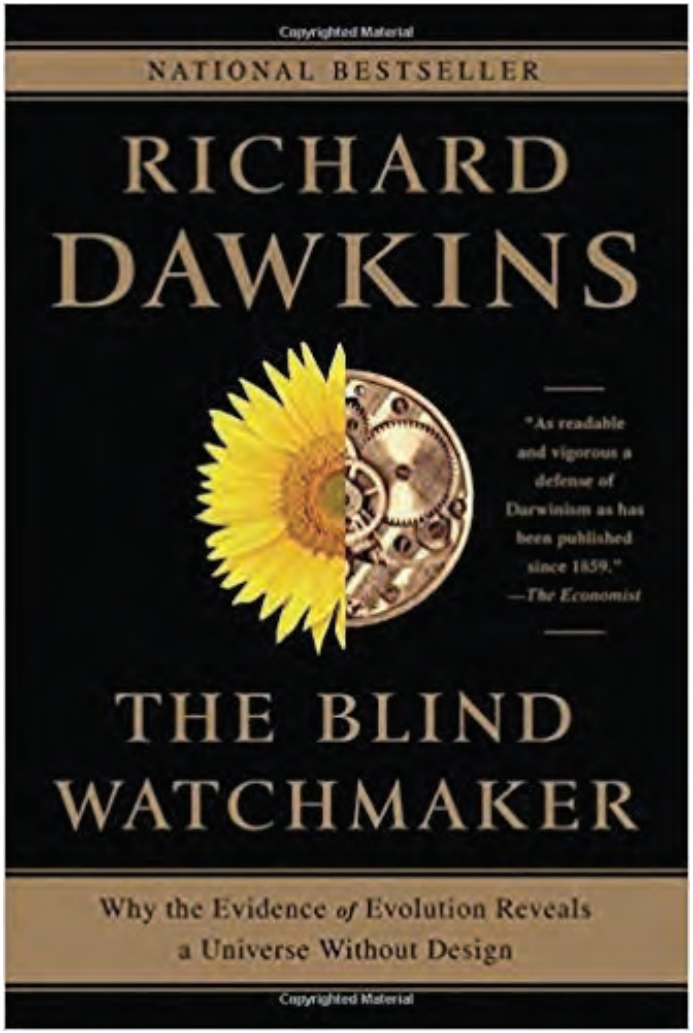


Symbiotic Partnership?
Or Annihilation?

What happens when our software symbionts can sense and manipulate our physical world, not just our information world?

Evolution, or Top-Down Intelligent Design?

Richard Dawkins



The TerraSwarm Research Center 2013-2017

What it is:

Address the huge potential (and associated risks) of pervasive integration of smart, networked sensors and actuators into our connected world.

The Goal

To lead the world in development of the platforms, methodologies, and tools that enable invention of creative, secure, and sound applications using networked sensors and actuators.

The Sponsors:

DARPA

GLOBAL FOUNDRIES

IBM

intel

Micron Raytheon

Texas Instruments United Technologies

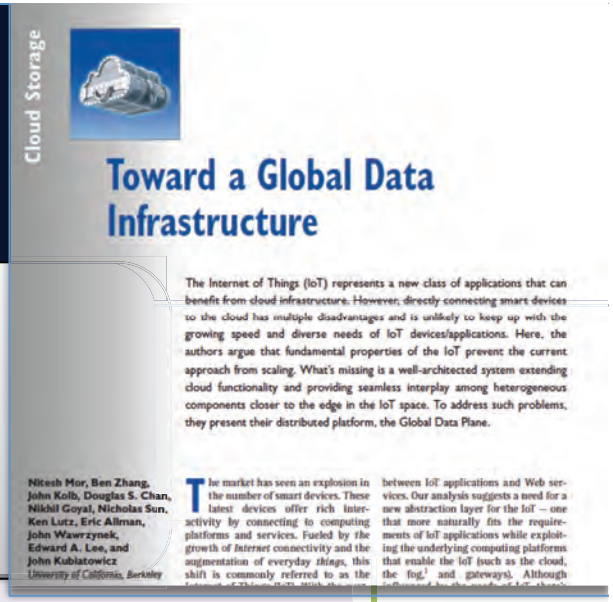
TerraSwarm Institutions

TerraSwarm Research Project as Husbandry for Living Cyber-Physical Systems?

- The global data plane
- The urban heartbeat toolkit
- Accessors for programming the IoT
- Machine learning toolkits
- Localization
- …

The Global Data Plane

A better nervous system?


Cloud Storage

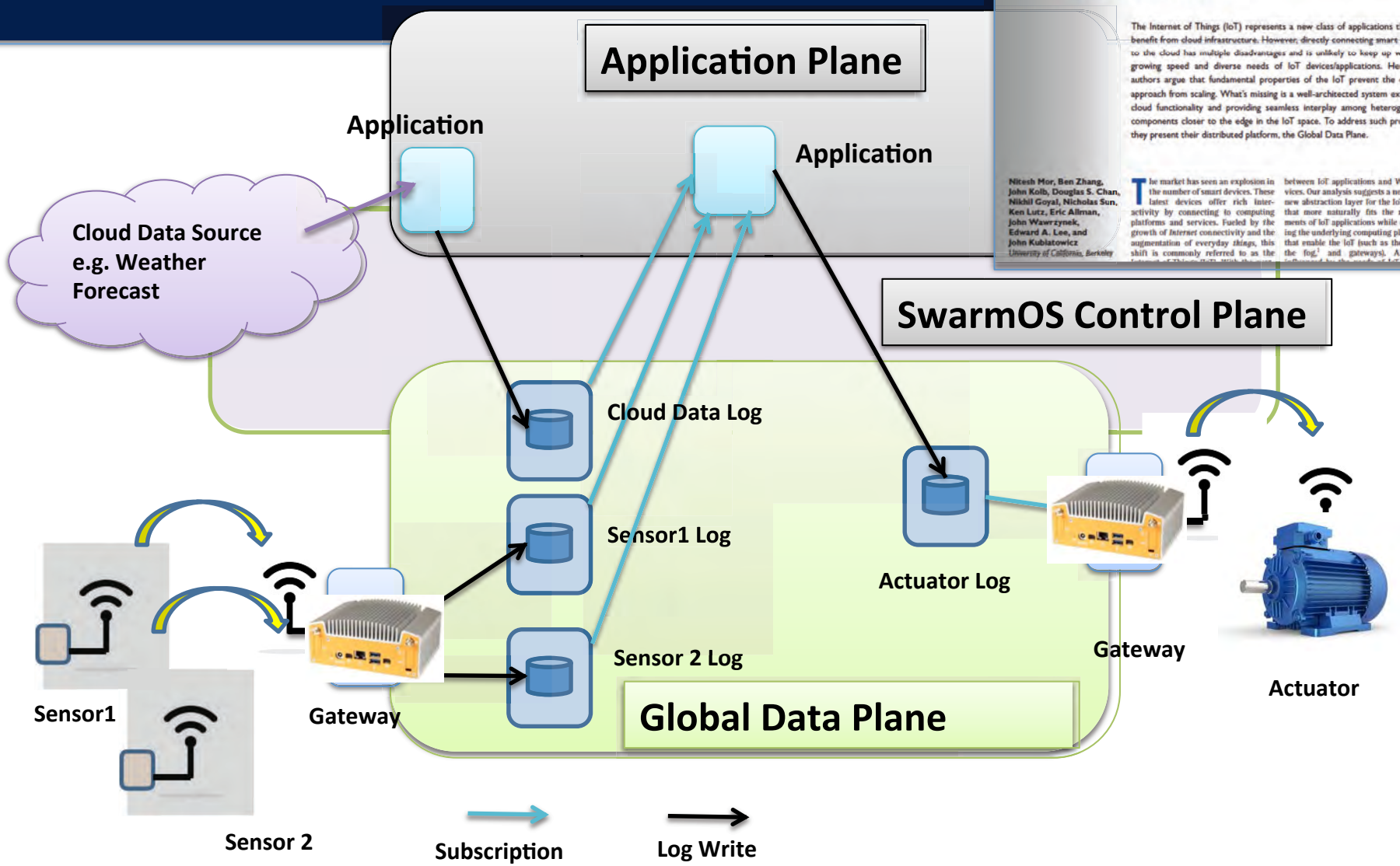
Toward a Global Data Infrastructure

The Internet of Things (IoT) represents a new class of applications that can benefit from cloud infrastructure. However, directly connecting smart devices to the cloud has multiple disadvantages and is unlikely to keep up with the growing speed and diverse needs of IoT devices/applications. Here, the authors argue that fundamental properties of the IoT prevent the current approach from scaling. What's missing is a well-architected system extending cloud functionality and providing seamless interplay among heterogeneous components closer to the edge in the IoT space. To address such problems, they present their distributed platform, the Global Data Plane.

Nitesh Mor, Ben Zhang, John Kolb, Douglas S. Chan, Nikhil Goyal, Nicholas Sun, Ken Lutz, Eric Allman, John Wawrzynek, Edward A. Lee, and John Kubiatowicz
University of California, Berkeley

The market has seen an explosion in the number of smart devices. These latest devices offer rich interactivity by connecting to computing platforms and services. Fueled by the growth of Internet connectivity and the augmentation of everyday *things*, this shift is commonly referred to as the

between IoT applications and Web services. Our analysis suggests a need for a new abstraction layer for the IoT — one that more naturally fits the requirements of IoT applications while exploiting the underlying computing platforms that enable the IoT (such as the cloud, the fog,[1] and gateways). Although



Urban Heartbeat Toolkit

Eyes, ears, hands, and feet?

Residential Gateway

Enterprise Gateway

Circuit Meter

Plug-Load Meter

Climate Sensor

BLE interface

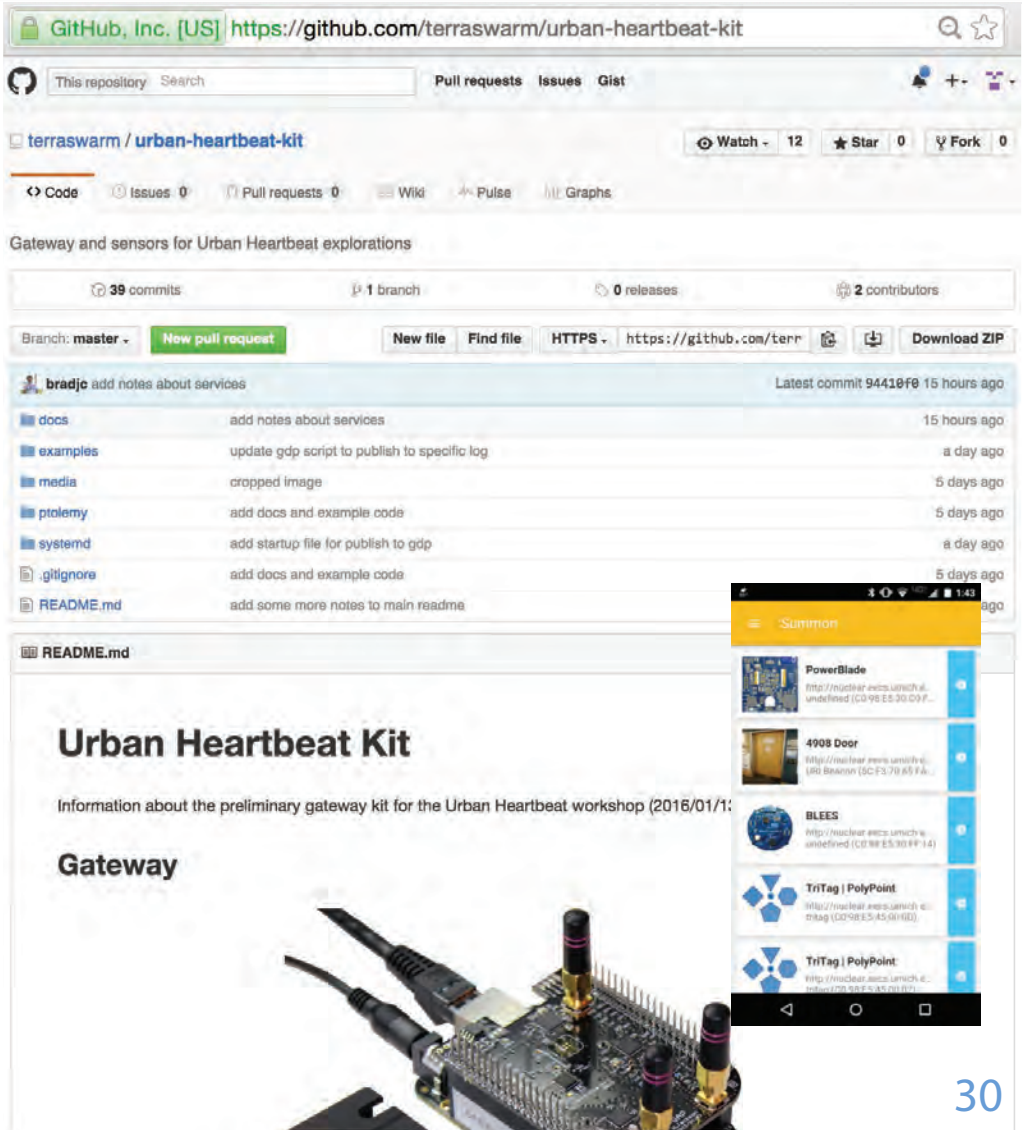
Microphone

RF ranging

WiFi Interface

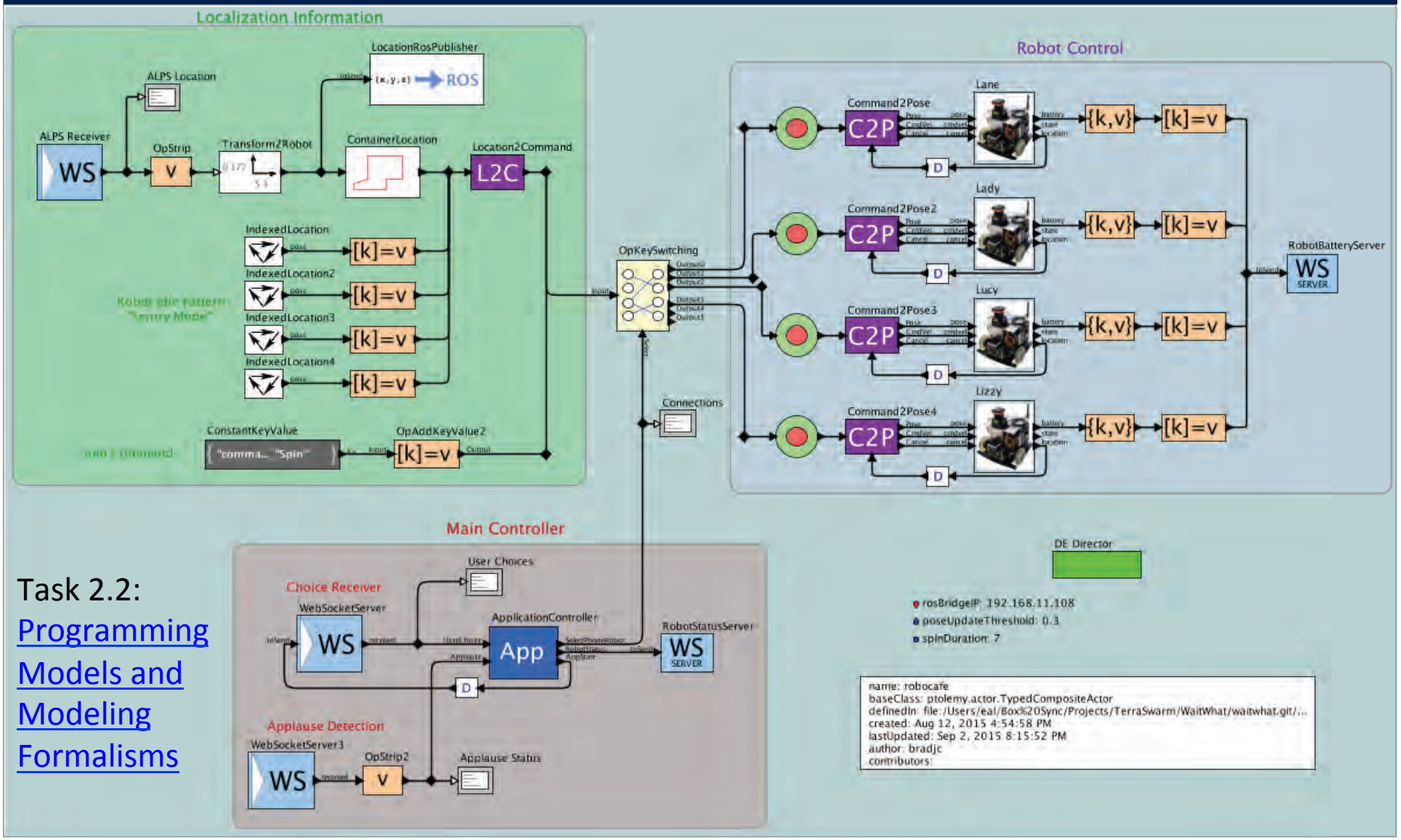
Spectrum Analyzer

Environment Sensor



Accessors

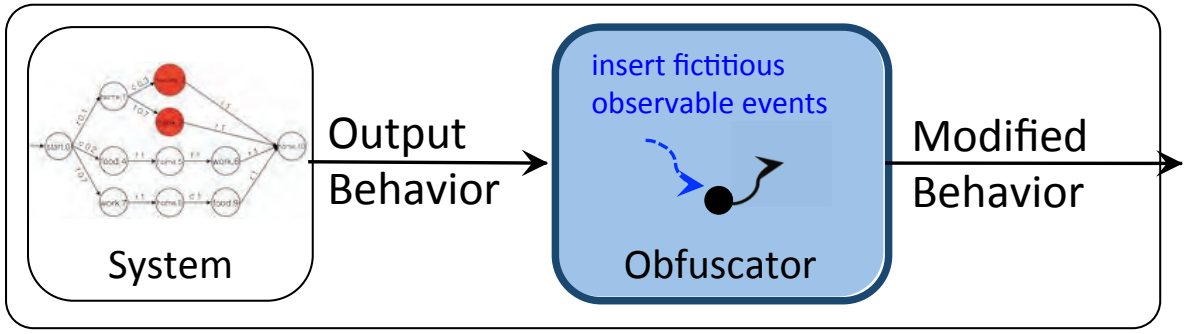
Faster reproduction, mutation, evolution?



Task 2.2: [Programming Models and Modeling Formalisms]

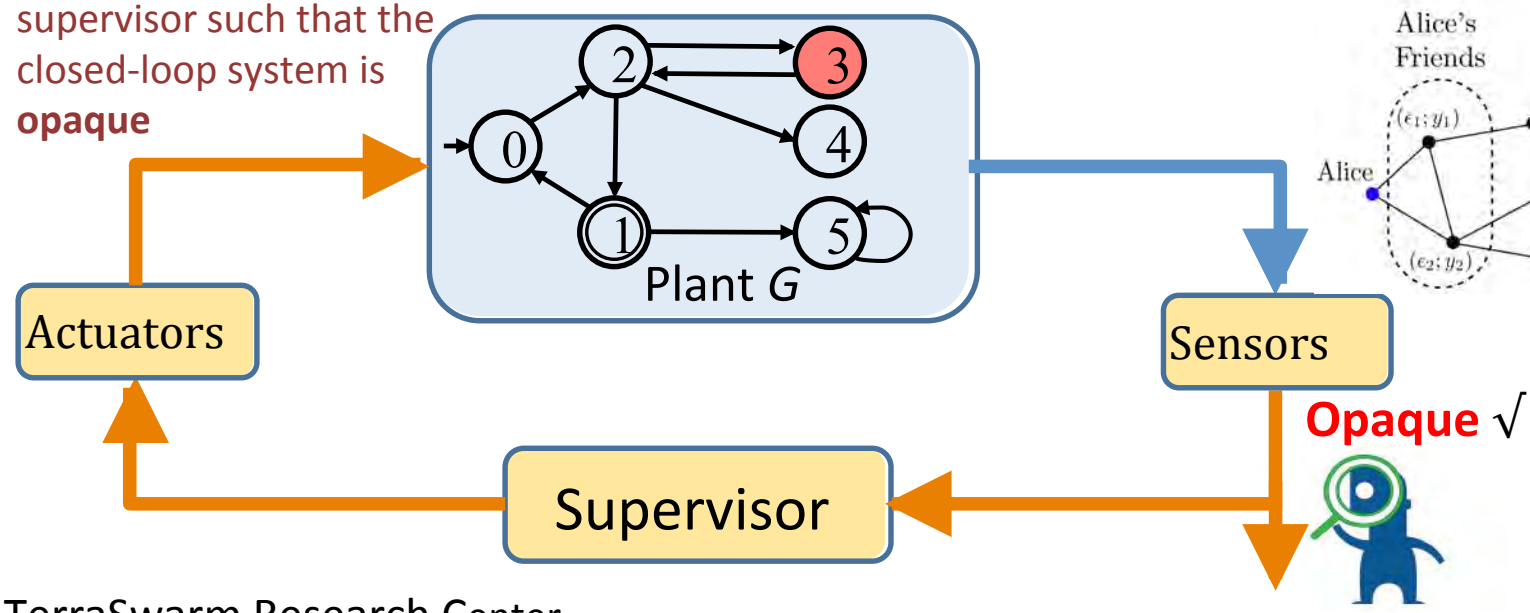
Security and Privacy
A Better Immune System?

Halderman, Lafortune, Rowe

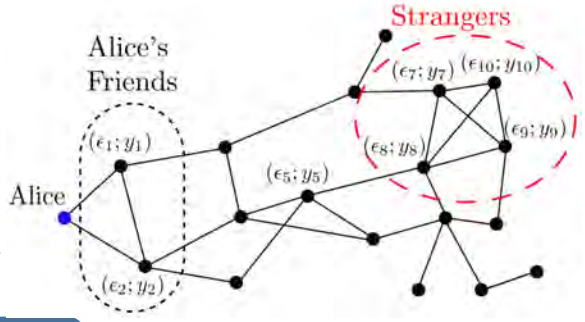


Synthesize an obfuscator (using insertion) *optimizing* the probability that the system remains *opaque*

Synthesize a maximally permissive non-blocking supervisor such that the closed-loop system is **opaque**

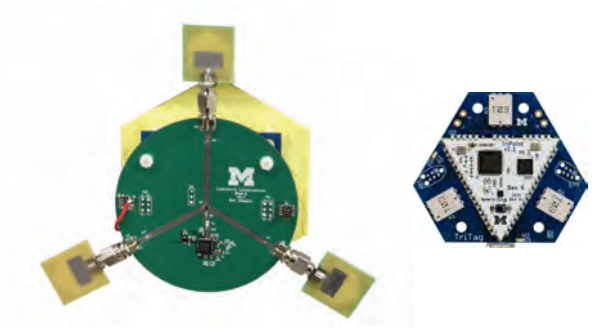


Physics-based privacy: Private smart metering using a rechargeable battery

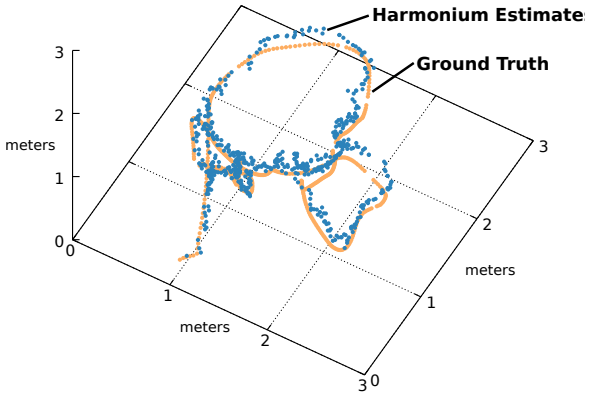


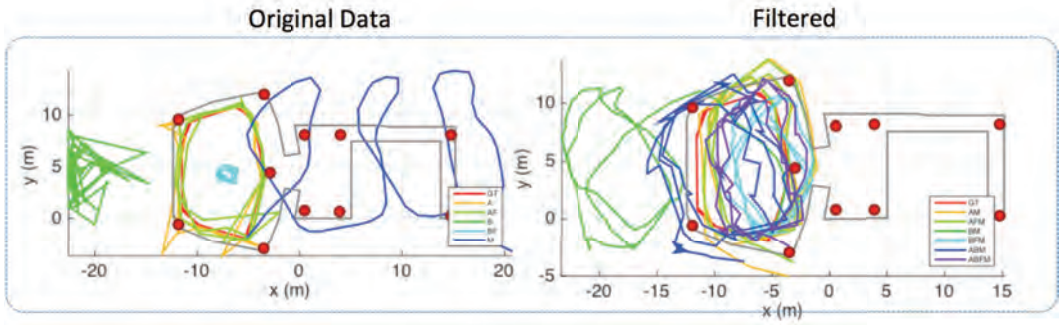
Localization in TerraSwarm Systems
Proprioception?

- Better Beacons…



- Doing more with the data you get…

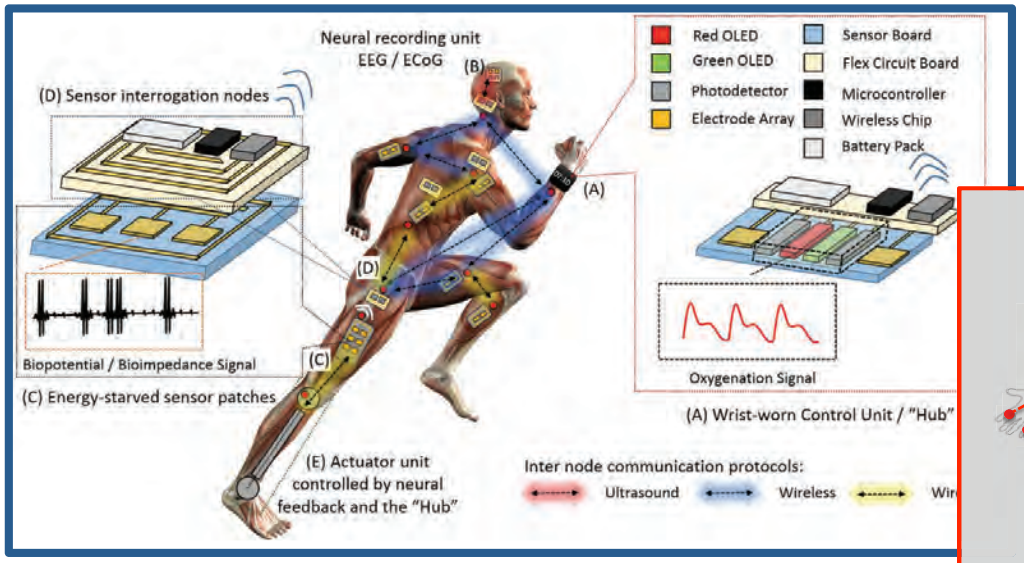




Of Swarms and Humans
Stronger Symbiosis?

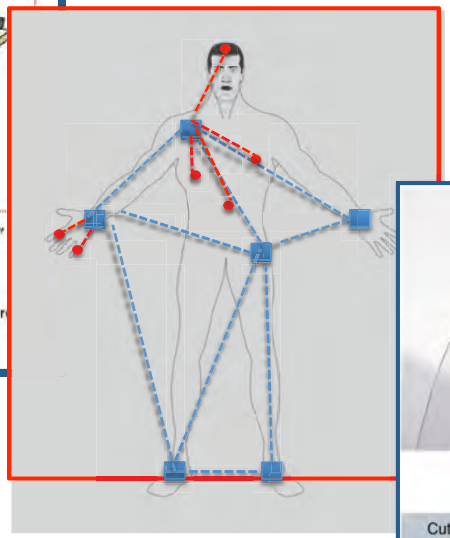
Rabaey, Abbeel, Arias, Hartmann, Carmena, Maharbiz

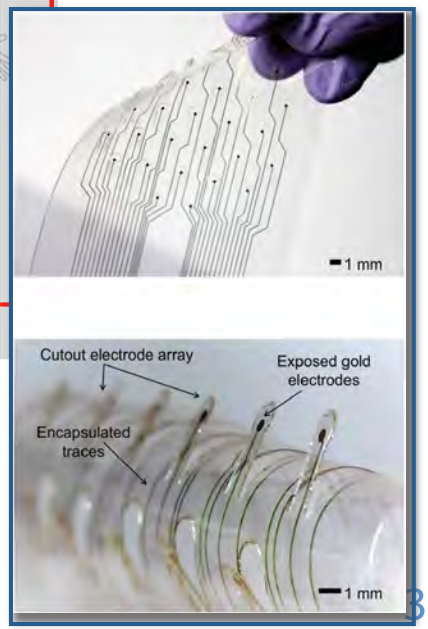
"Human Intranet" to bridge Human-World Information Gap



Exploring various means of human augmentation by combining extra sensing modalities to motor feedback (e.g. tactile)

Body-area network skin





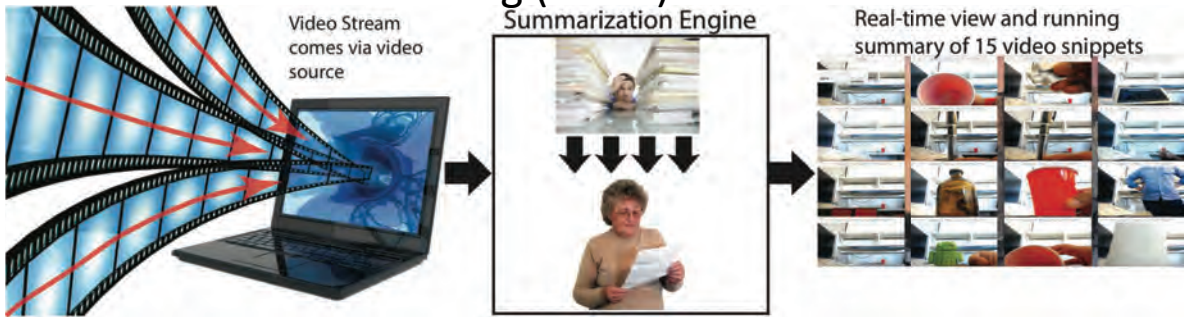
Flexible sensing and tactile feedback

New Project added Nov 2015 – PIs: Rabaey, Abbeel, Arias, Hartmann, Carmena, Maharbiz

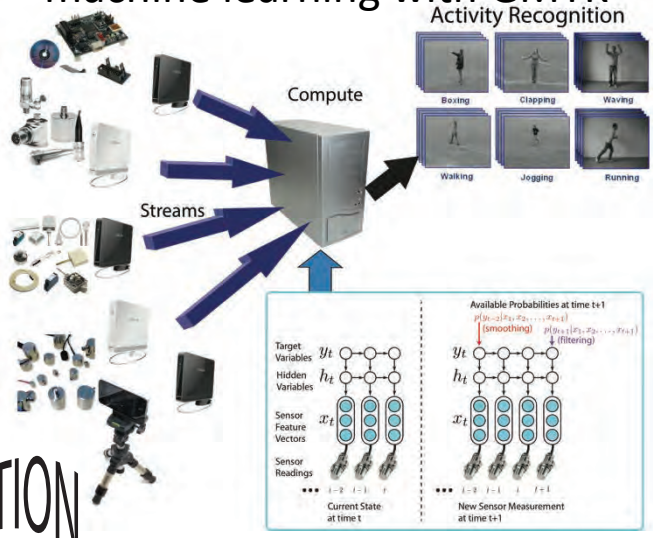
Bilmes, Guestrin, Jafari, Fox

From Data to Information
Dreaming?

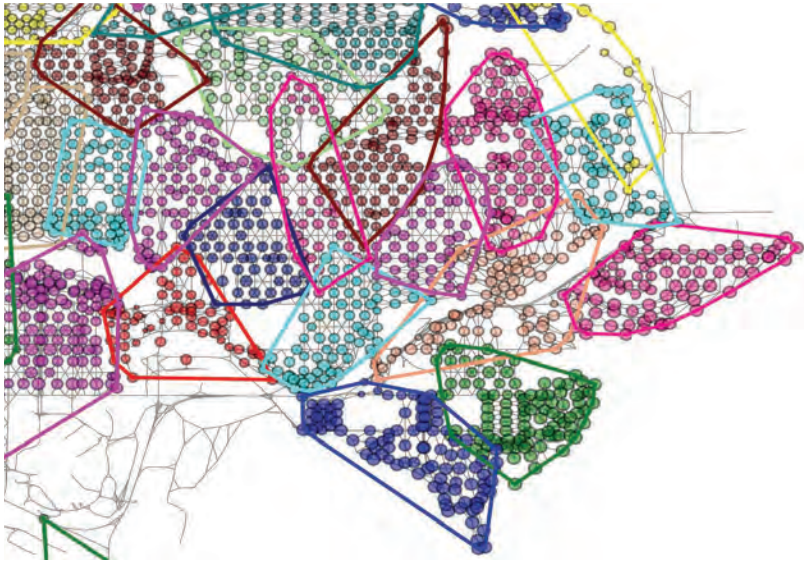
Online real-time streaming (video) summarization!

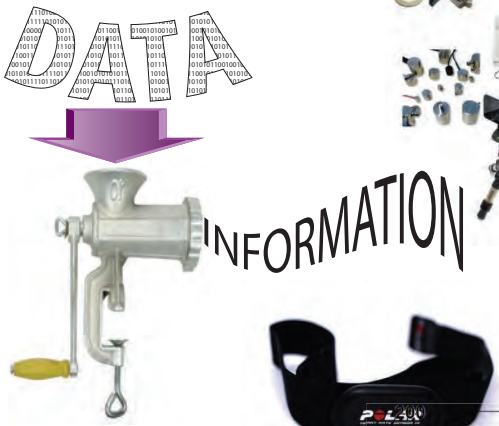


Online real-time streaming machine learning with GMTK

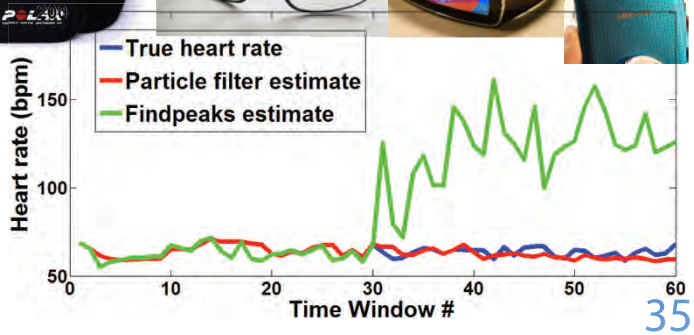


Automatic Neighborhood Detection





Sensor Fusion in Physiological Monitoring

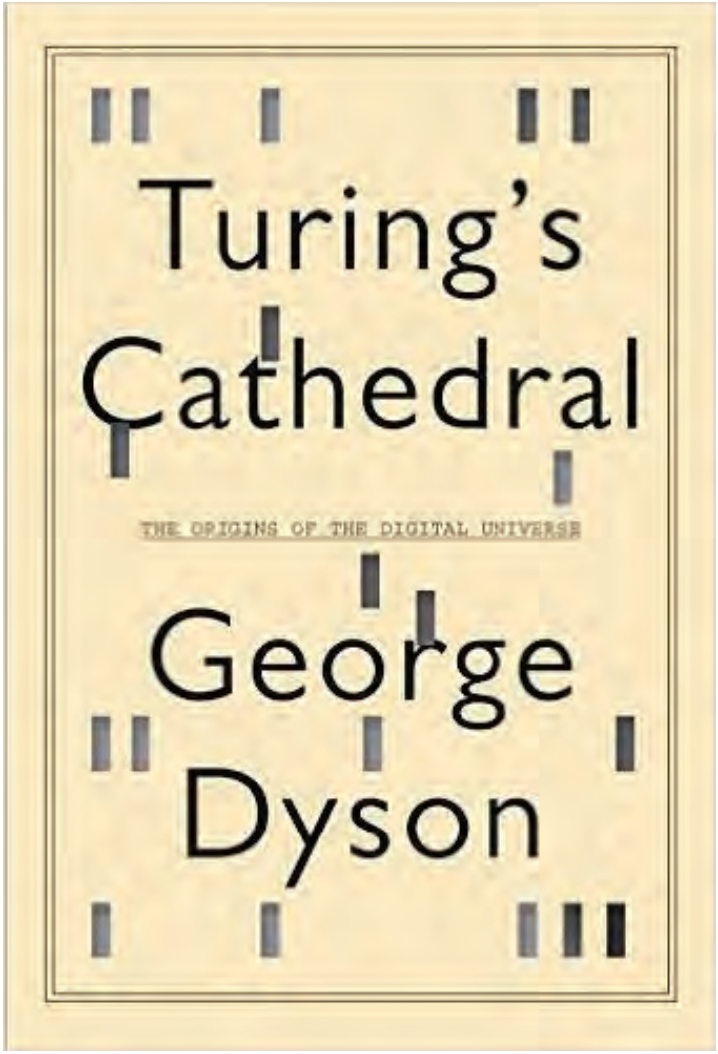


Dreaming?

"The behavior of a search engine, when not actively conducting a search, resembles the activity of a dreaming brain. Associations made while 'awake' are retraced and reinforced, while memories gathered while 'awake' are replicated and moved around.

In 1950, Turing asked us to "consider the question, 'Can machines think?' " Machines will dream first. "

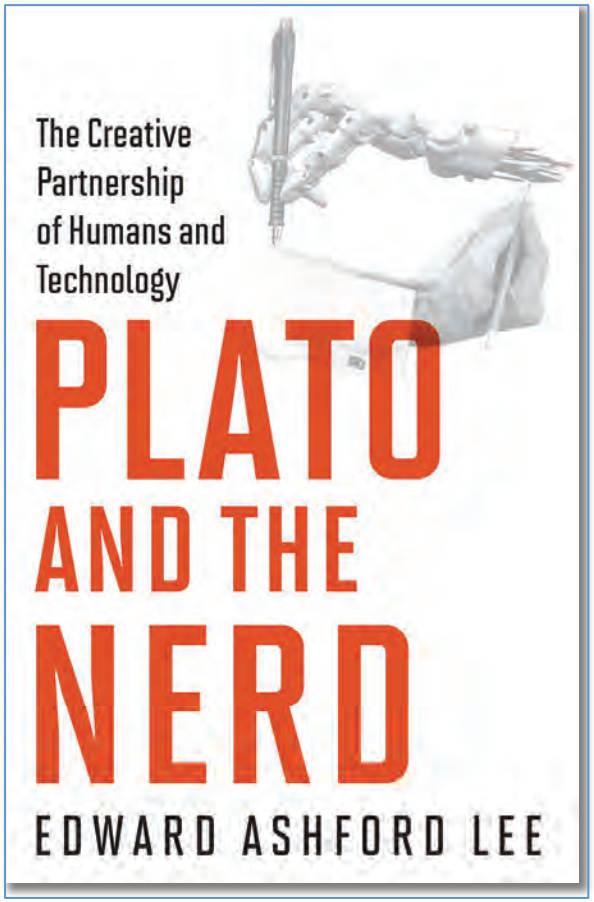
(Dyson, 2012, p. 311)



Dreaming?

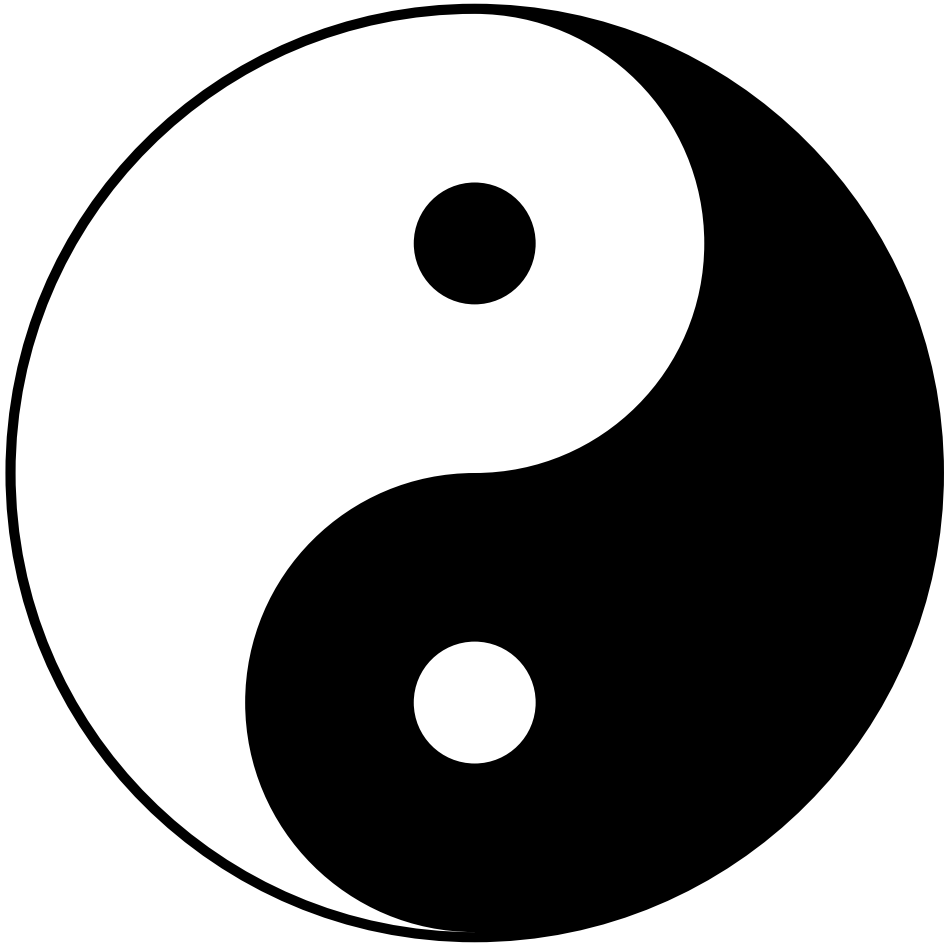
This ‘dreaming’ has mostly been about text from the web and books. Not any more.

“In 2006, Google bought YouTube for $1.6 billion US dollars. … The machines will start to dream in color. And next, as data from sensors comes online, for example from connected cars, thermostats, and the whole Internet of Things world, what more can the machines learn?”

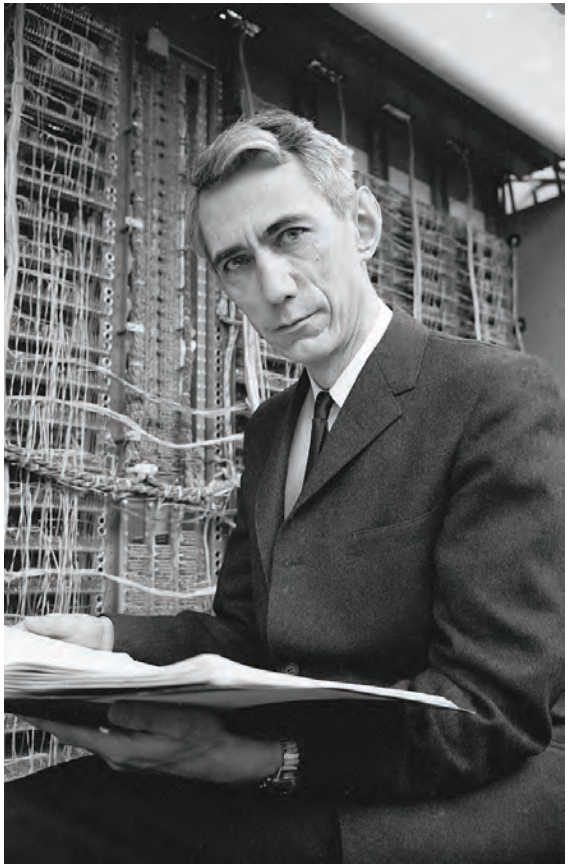


Yin and Yang

陰陽

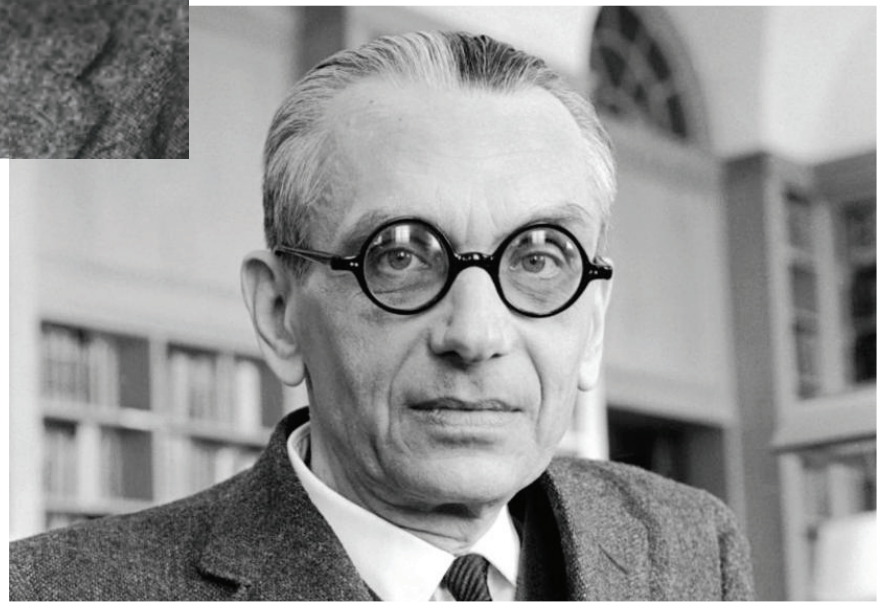


Information Processing



Claude Shannon

Alan Turing

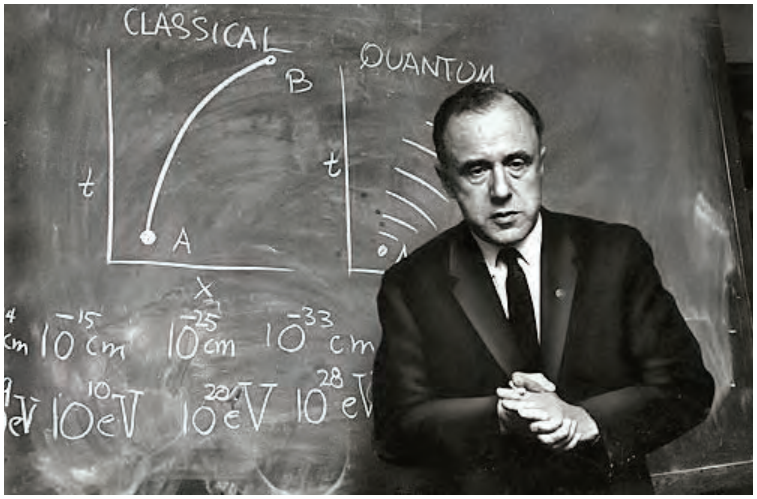


Kurt Gödel

Digital Physics?

1. The number of possible states of a physical system is finite.
2. Physical processes are digital and algorithmic.
3. Every physical process is a Turing computation.
4. The physical world is a computer.
5. The physical world is a simulation.

These theses are not falsifiable, and therefore not scientific according to the philosophy of Karl Popper.



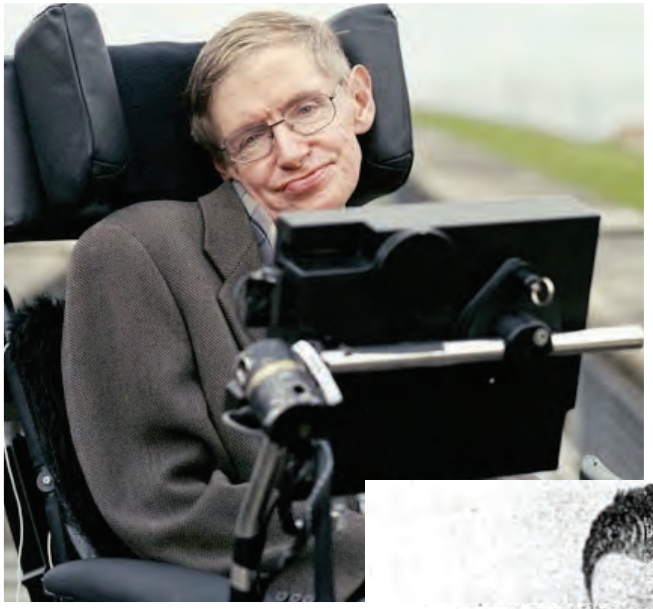
John Archibald Wheeler
"It from bit"

If Cognition is not a digital, algorithmic process, then

"Your mind is entirely your own."

What can we know?

Pierre-Simon Laplace



Stephen Hawking

Thomas Bayes
(probably not actually him)

David Wolpert

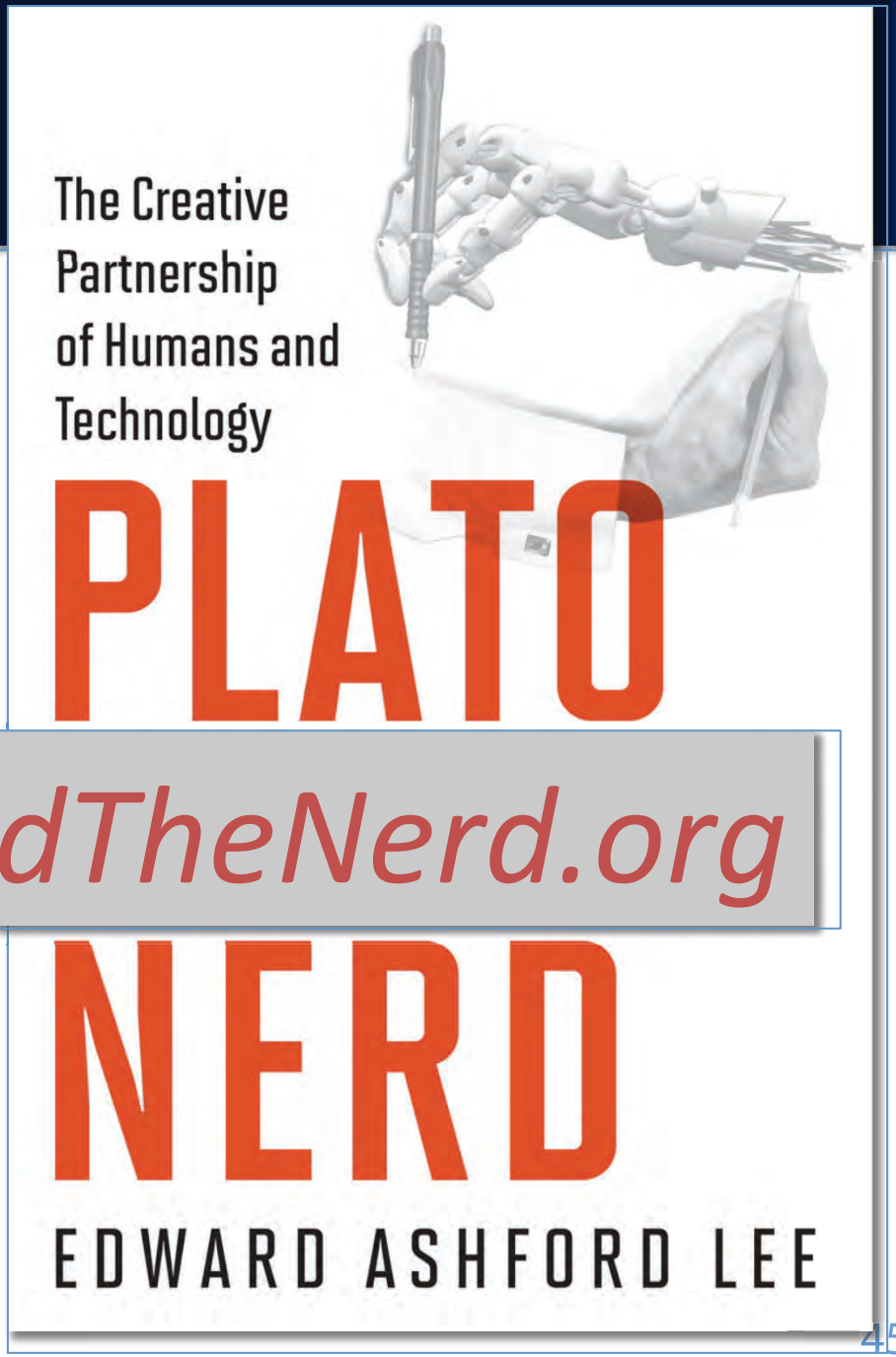
Artificial Intelligences

"That car should be ashamed of itself."

Artificial Intelligences

Do we want computers with artificial (human-like) intelligence?

"I really do not want to have to argue with my car about getting to school on time. It's hard enough to have that argument with my daughter."



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