Dreams, Lies, and the Autonomous Web

Mike Amundsen
CA Technologies
@mamund

Introduction


Ctrl
PgUp
Mike Amundsen
@mamund

12:00

My Profile

Profile Photo

Full Name Mike Amundsen

WeChat ID mike_amundsen

My QR Code

Gender

Region

What's Up Not Set

LinkedIn Account Not Set

11:56

My QR Code

Mike Amundsen

Scan the QR Code to add me on WeChat

API ACADEMY

SERVICES EVENTS

RETURN TO HOMEPAGE

API ACADEMY SERVICES

The API Academy team consists of industry experts who have been brought together by CA Technologies to provide expert consulting services for organizations that want to take their API programs to the next level.

Contact us to find out more about how we can help you understand the API economy, plan a program strategy, architect effective interfaces, build a secure, manageable API infrastructure and empower your developers to create truly valuable client apps.

Email: apiacademy@ca.com

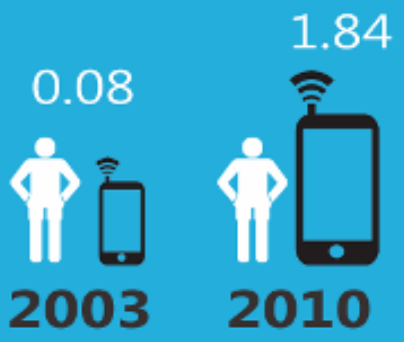
We are at a crossroads…

0.08

2003

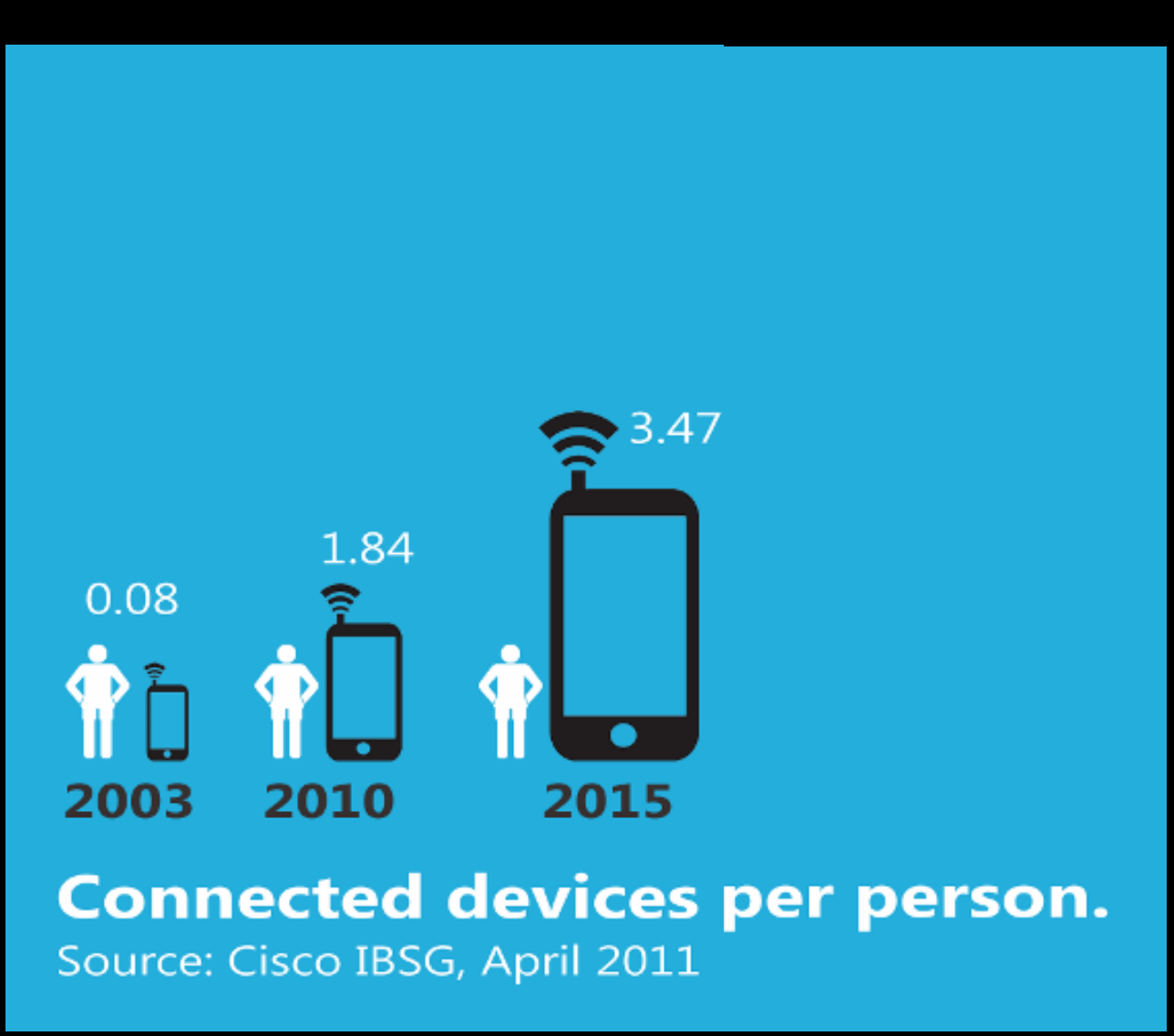
Connected devices per person.

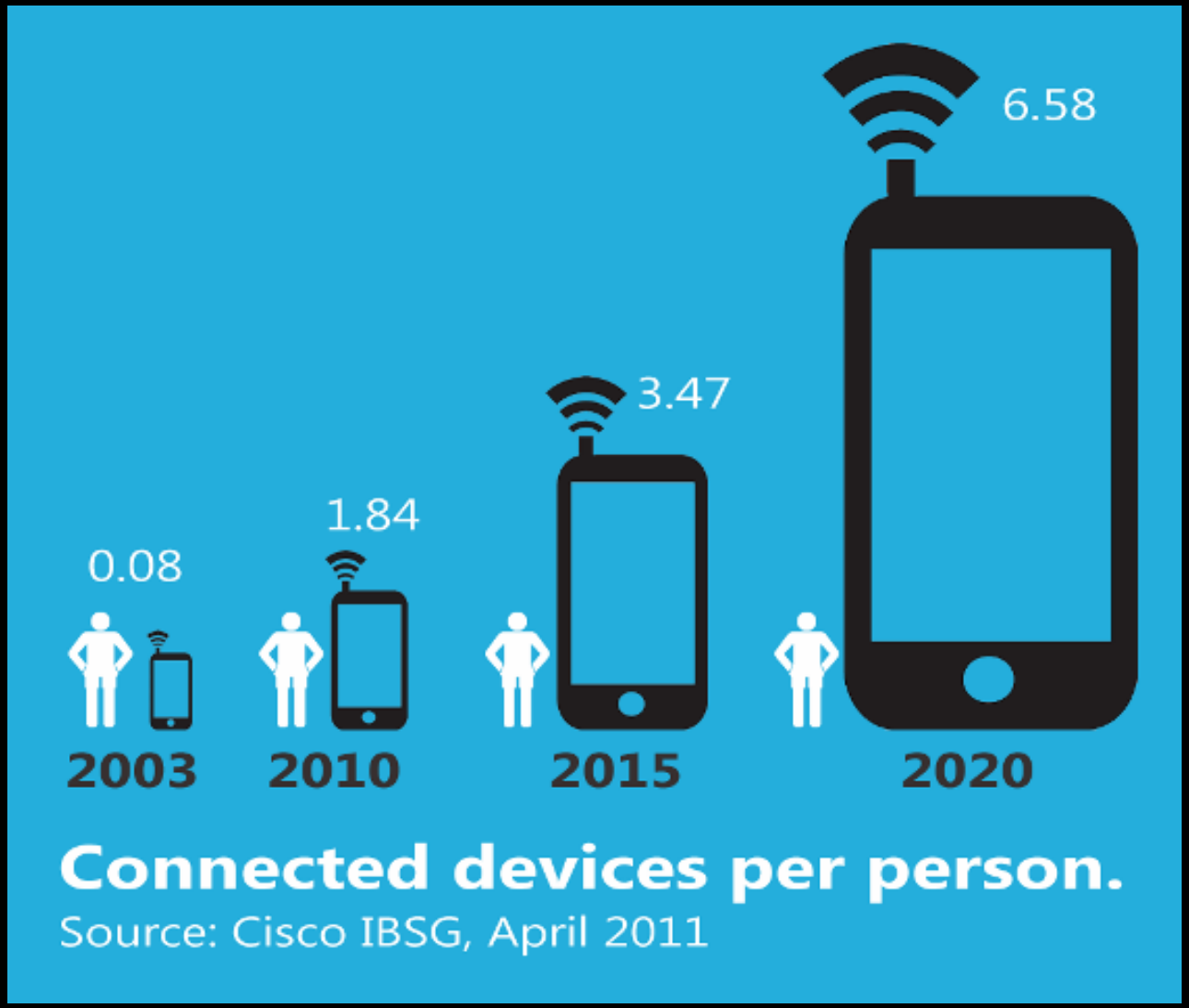
Source: Cisco IBSG, April 2011



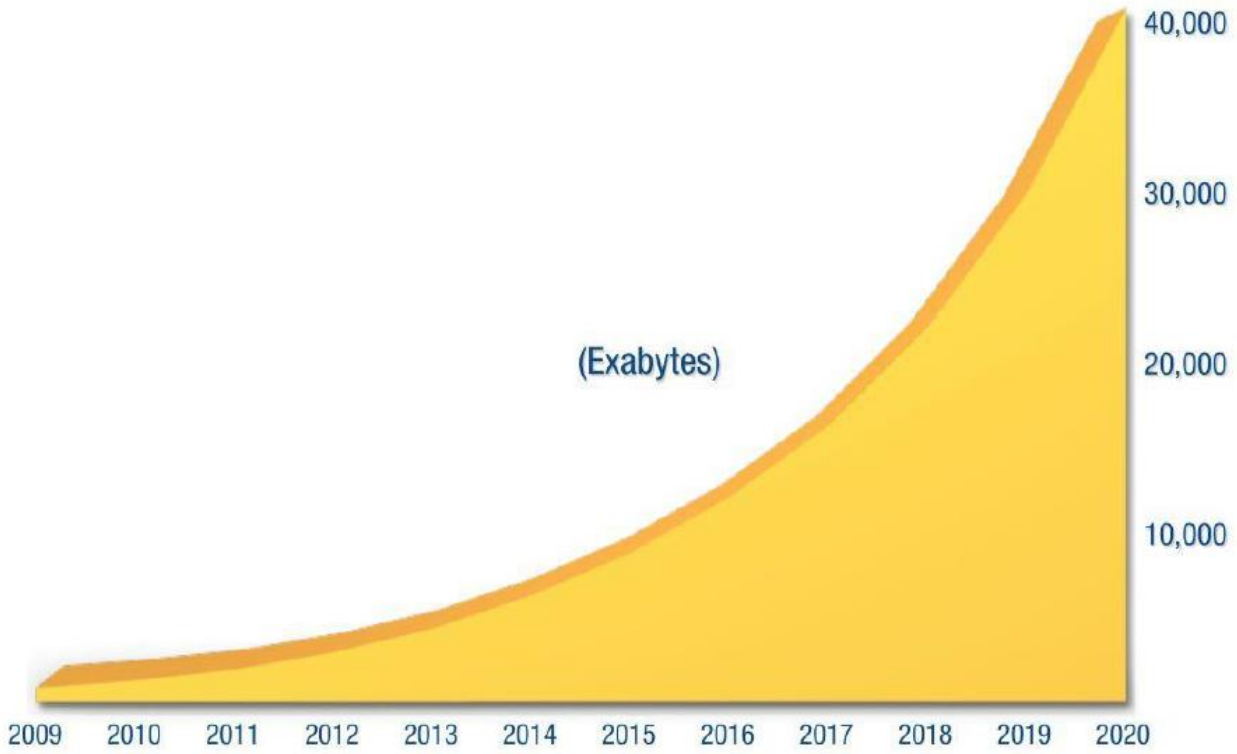
Connected devices per person.

Source: Cisco IBSG, April 2011


0.08
1.84
3.47
2003
2010
2015
Connected devices per person.
Source: Cisco IBSG, April 2011


0.08
1.84
3.47
6.58
2003
2010
2015
2020
Connected devices per person.
Source: Cisco IBSG, April 2011

The Digital Universe: 50-fold Growth from the Beginning of 2010 to the End of 2020



This IDC graph predicts exponential growth of data from around 3 zettabytes in 2013 to approximately 40 zettabytes by 2020. An exabyte equals 1,000,000,000,000,000,000 bytes and 1,000 exabytes equals one zettabyte. Source: IDC's Digital Universe Study, December 2012, http://www.emc.com/collateral/analyst-reports/idc-the-digital-universe-in-2020.pdf.

Mother Tongues

Tracing the roots of computer languages through the ages

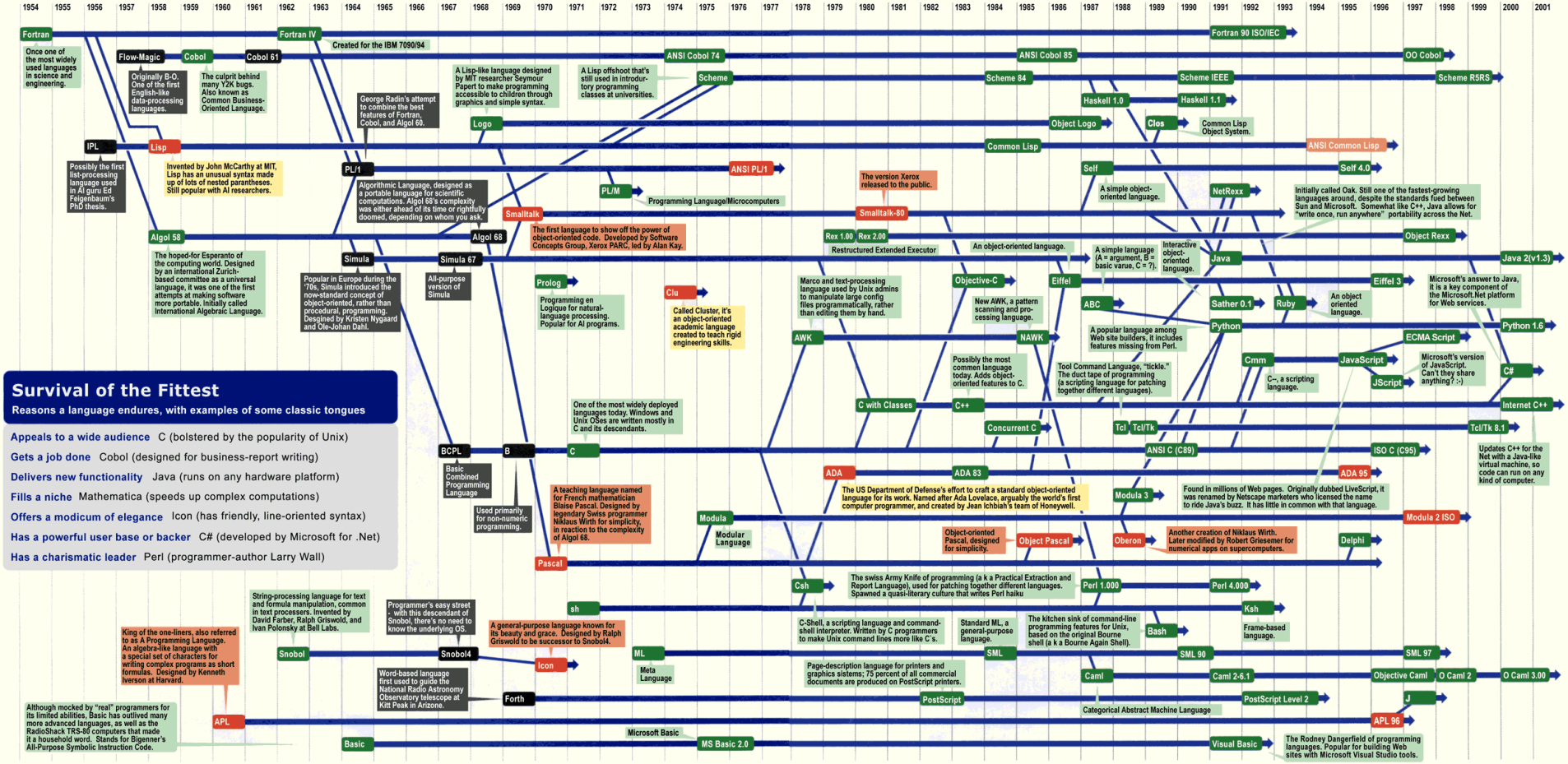
Just like half of the world's spoken tongues, most of the 2,300-plus computer programming languages are either endangered or extinct. As powerhouses C/C++, Visual Basic, Cobol, Java and other modern source codes dominate our systems, hundreds of older languages are running out of life.

An ad hoc collection of engineers-electronic lexicographers, if you will-aim to save, or at least document the lingo of classic software. They're combing the globe's 9 million developers in search of coders still fluent in these nearly forgotten lingua frangas. Among the most endangered are Ada, APL, B (the predecessor of C), Lsp, Oberon, Smalltalk, and Simula.

Code-raker Grady Booch, Rational Software's chief scientist, is working with the Computer History Musuem in Silicon Valley to record and, in some cases, maintain languages by writing new compilers so our ever-changing hardware can grok the code. Why bother? "They tell us about the state of software practice, the minds of their inventors, and the technical, social, and economic forces that shaped history at the time," Booch explains. "They'll provide the raw material for software archaeologists, historians, and developers to learn what worked, what was brilliant, and what was an utter failure." Here's a peek at the strongest branches of programming's family tree. For a nearly exhaustive rundown, check out the Language List at *HTTP://www.informatik.uni-freiburg.de/Java/misc/lang_list.html.* - Michael Mendeno

Key

- 1954 Year Introduced
- **Active:** thousands of users
- **Protected:** taught at universities; compilers available
- **Endangered:** usage dropping off
- **Extinct:** no known active users or up-to-date compilers
- **Lineage continues**



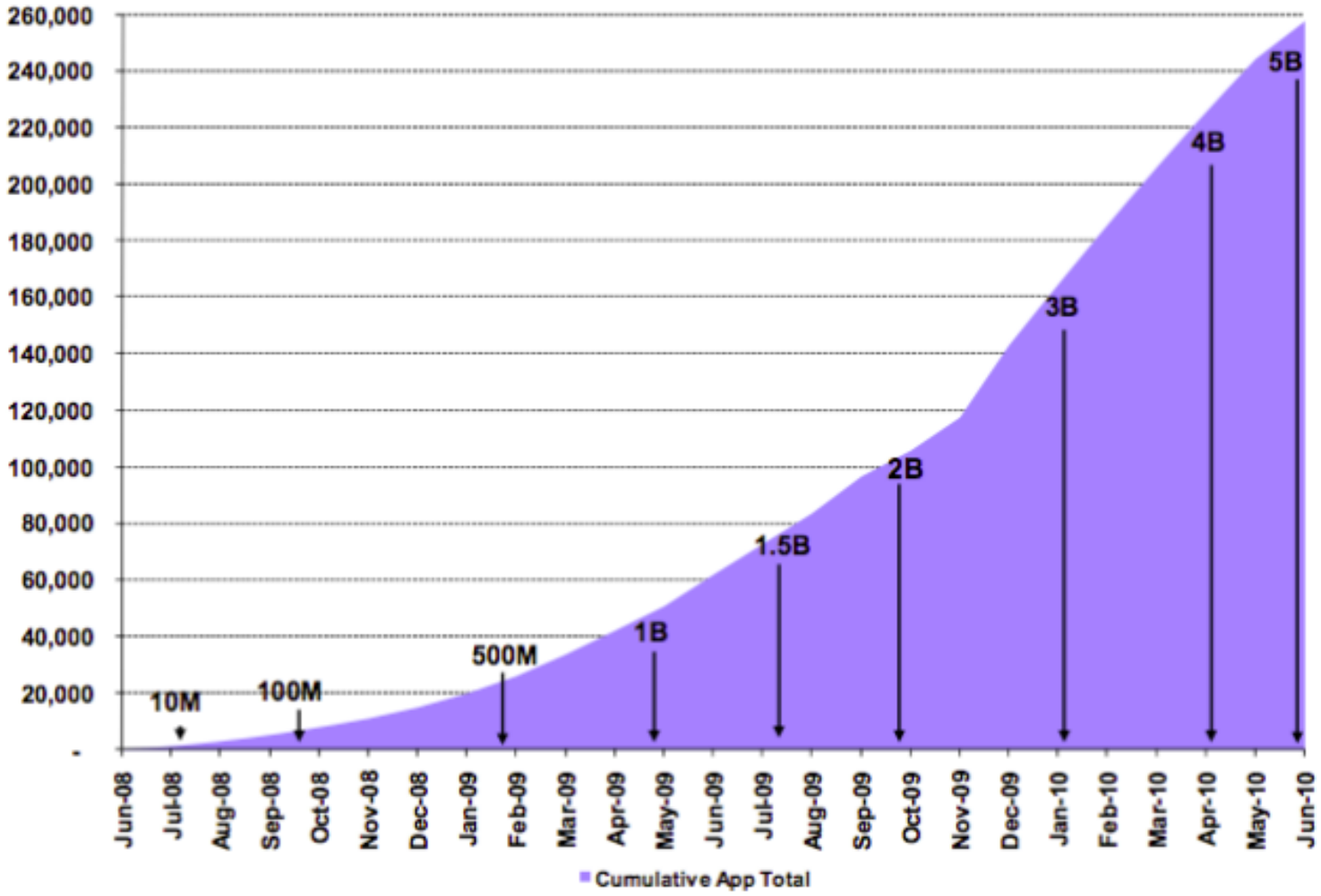
Survival of the Fittest

Reasons a language endures, with examples of some classic tongues

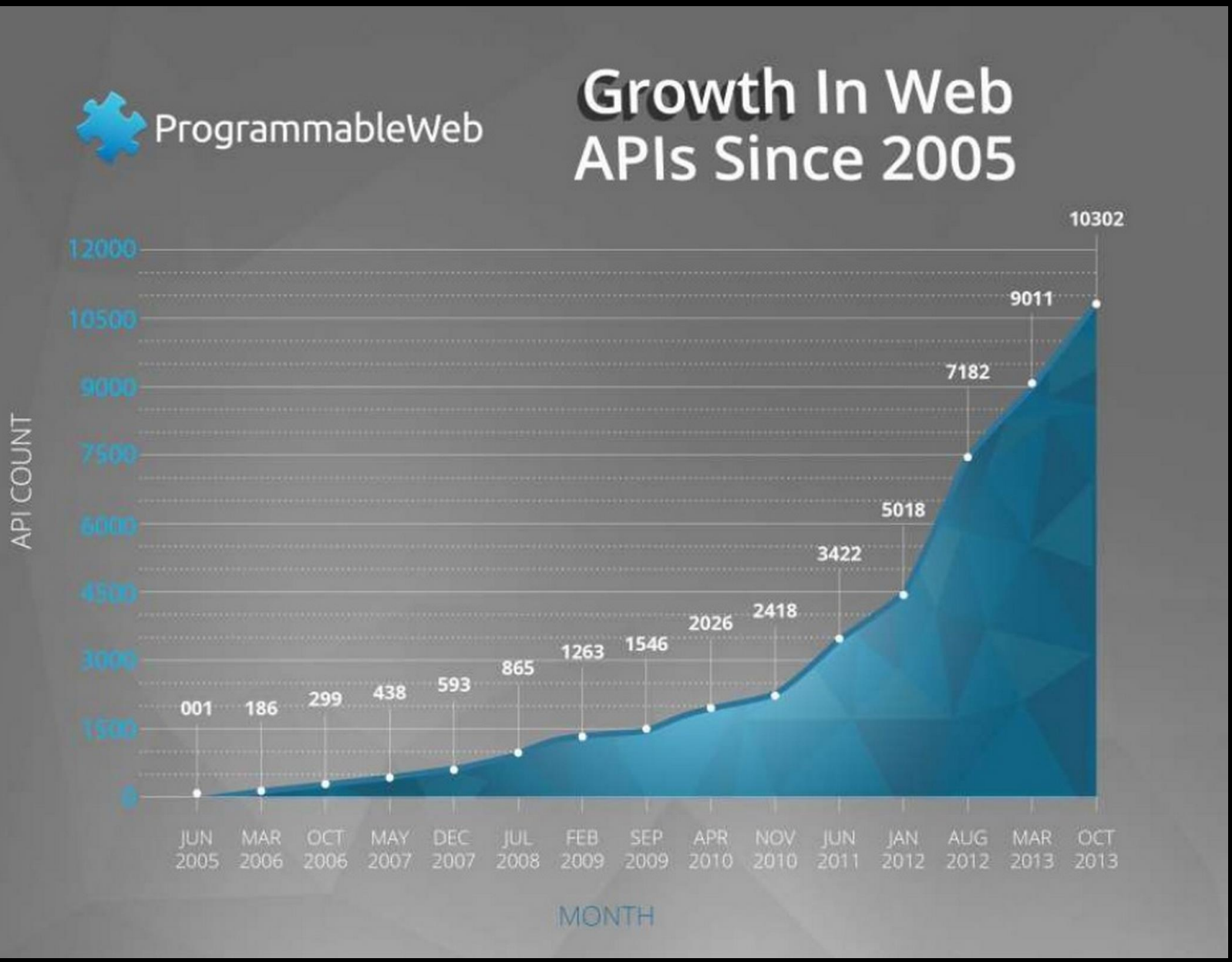
- **Appeals to a wide audience** C (bolstered by the popularity of Unix)
- **Gets a job done** Cobol (designed for business-report writing)
- **Delivers new functionality** Java (runs on any hardware platform)
- **Fills a niche** Mathematica (speeds up complex computations)
- **Offers a modicum of elegance** Icon (has friendly, line-oriented syntax)
- **Has a powerful user base or backer** C# (developed by Microsoft for .Net)
- **Has a charismatic leader** Perl (programmer-author Larry Wall)

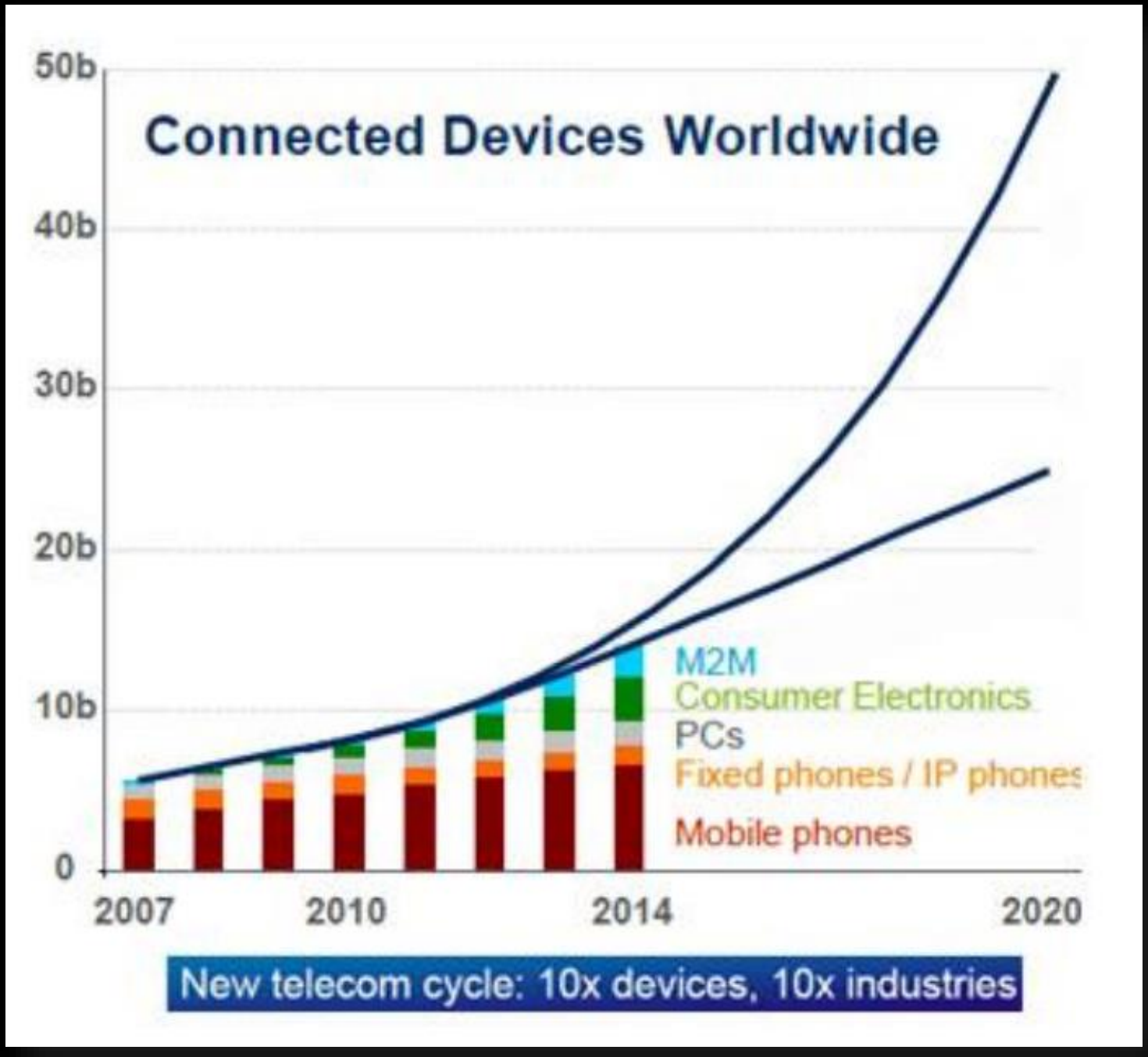
Sources: Paul Boutin; Brent Hailpern, associate director of computer science at IBM Research; The Retrocomputing Museum; Todd Proebsting, senior researcher at Microsoft; Gio Wiederhold, computer scientist, Stanford University

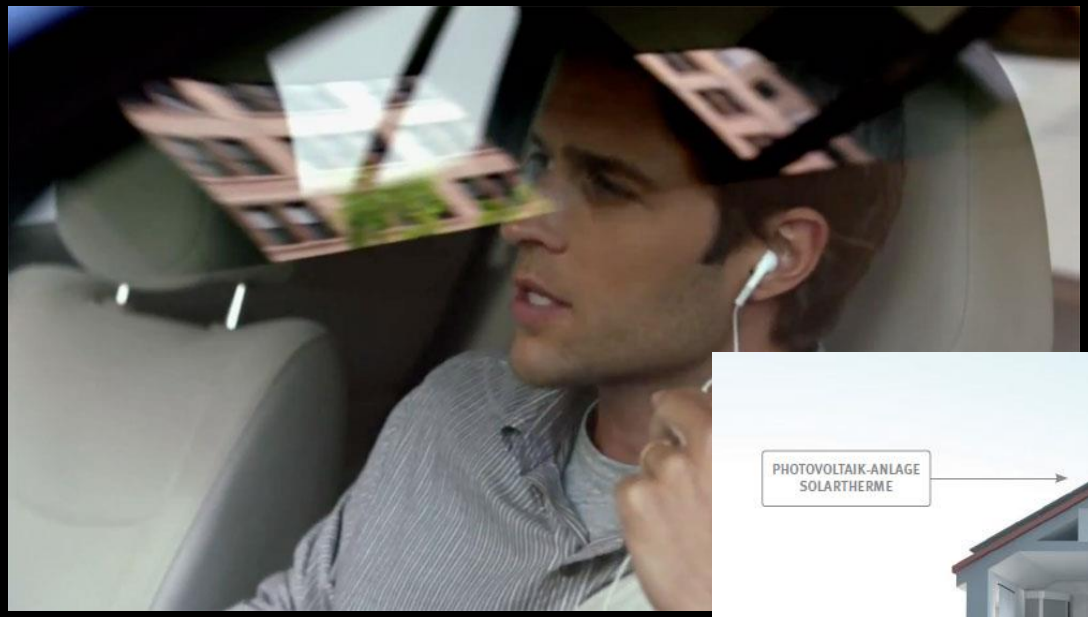
Figure 4: Cumulative apps and downloads

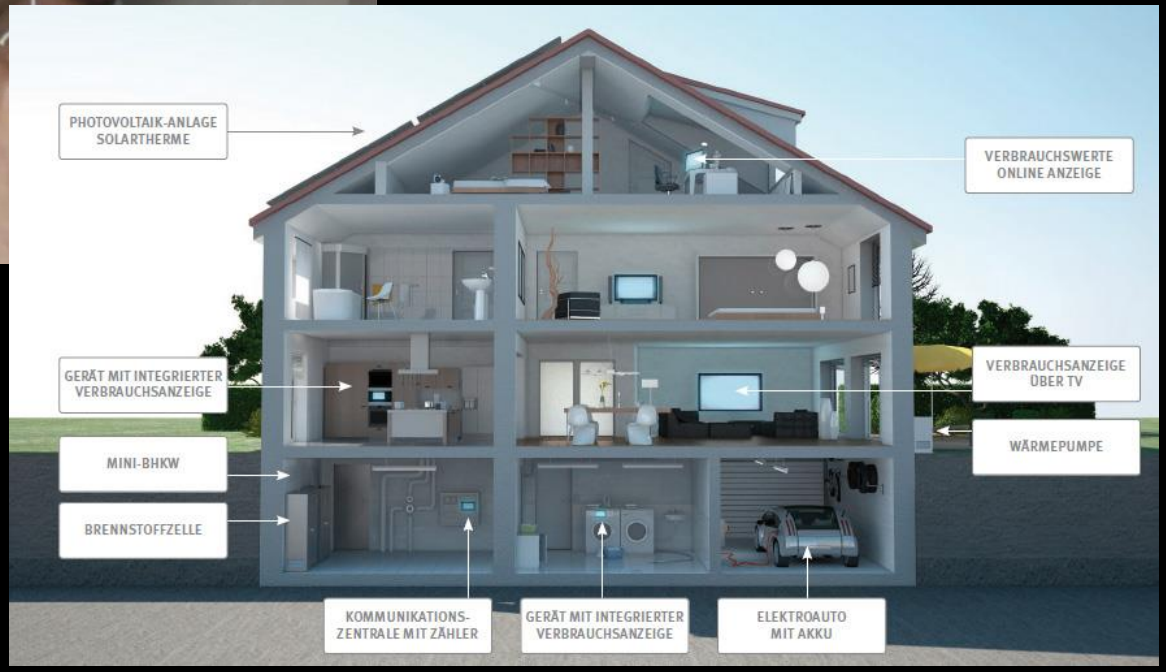


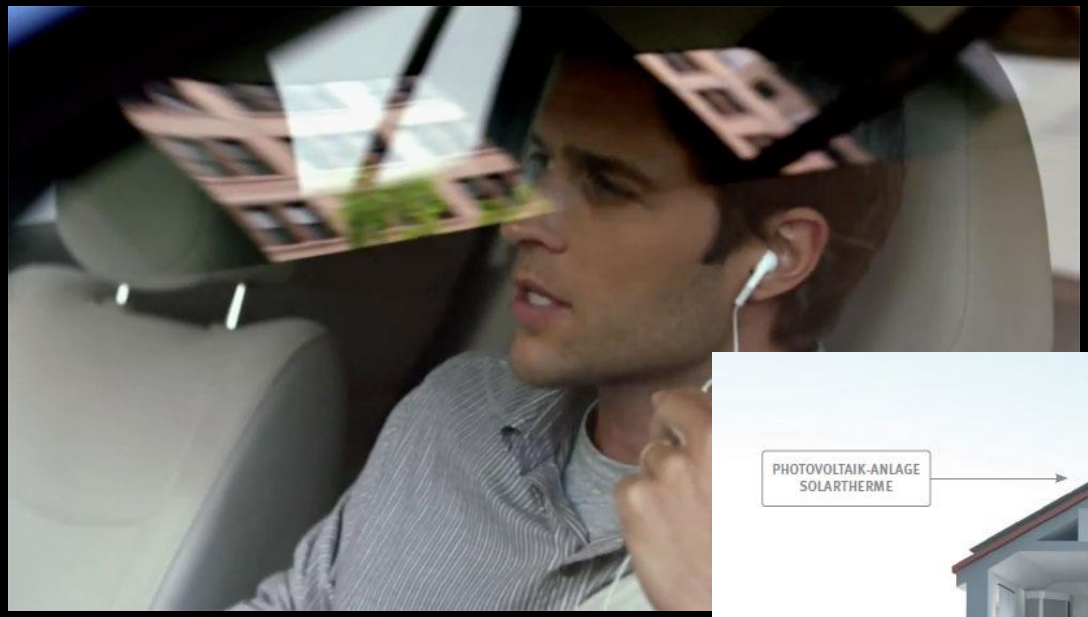
Source: Deutsche Bank and Apple data


ProgrammableWeb
Growth In Web APIs Since 2005
API COUNT
12000
10500
9000
7500
6000
4500
3000
1500
0
001
186
299
438
593
865
1263
1546
2026
2418
3422
5018
7182
9011
10302
JUN 2005
MAR 2006
OCT 2006
MAY 2007
DEC 2007
JUL 2008
FEB 2009
SEP 2009
APR 2010
NOV 2010
JUN 2011
JAN 2012
AUG 2012
MAR 2013
OCT 2013
MONTH

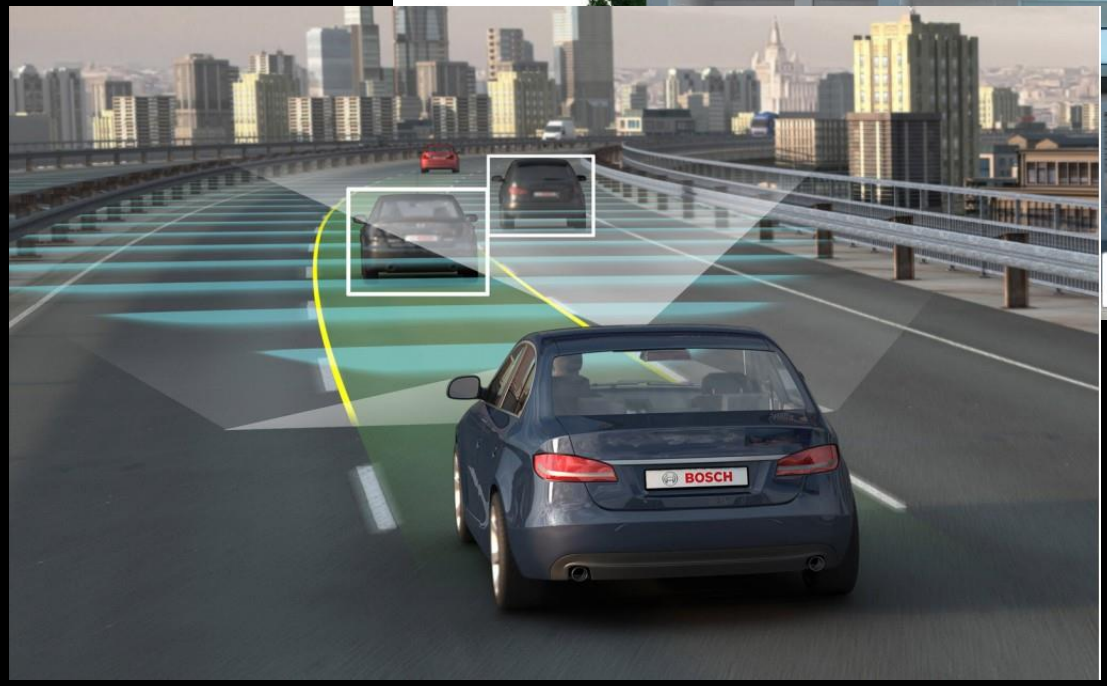

Connected Devices Worldwide
50b
40b
30b
20b
10b
0
2007
2010
2014
2020
M2M
Consumer Electronics
PCs
Fixed phones / IP phones
Mobile phones
New telecom cycle: 10x devices, 10x industries




PHOTOVOLTAIK-ANLAGE
SOLARTHERME
VERBRAUCHSWERTE
ONLINE ANZEIGE
GERÄT MIT INTEGRIERTER
VERBRAUCHSANZEIGE
VERBRAUCHSANZEIGE
ÜBER TV
WÄRMEPUMPE
MINI-BHKW
BRENNSTOFFZELLE
KOMMUNIKATIONS-
ZENTRALE MIT ZÄHLER
GERÄT MIT INTEGRIERTER
VERBRAUCHSANZEIGE
ELEKTROAUTO
MIT AKKU



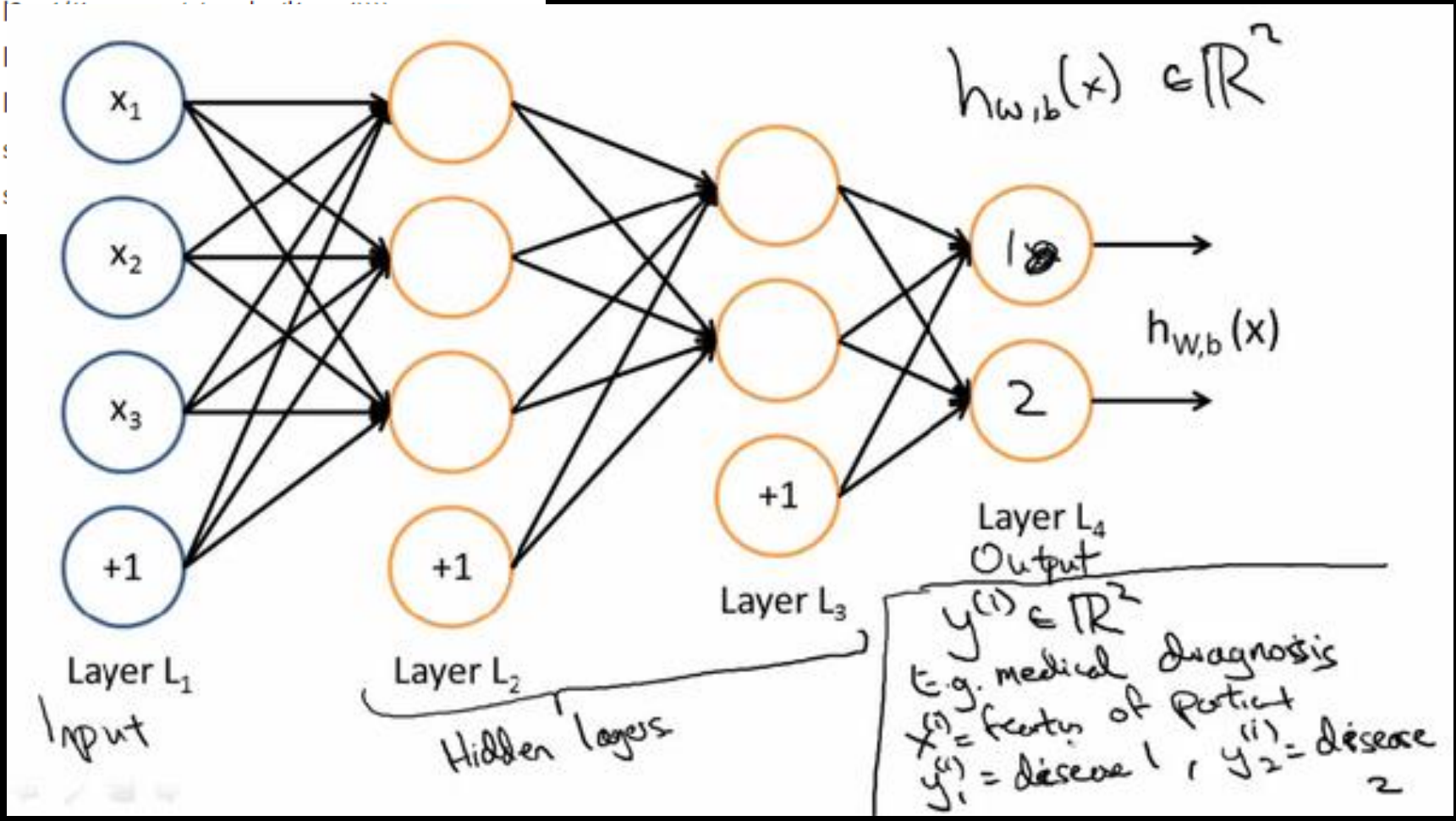

PHOTOVOLTAIK-ANLAGE
SOLARTHERME
VERBRAUCHSWERTE
ONLINE ANZEIGE
VERBRAUCHSANZEIGE
ÜBER TV
WÄRMEPUMPE
ELEKTROAUTO
MIT AKKU

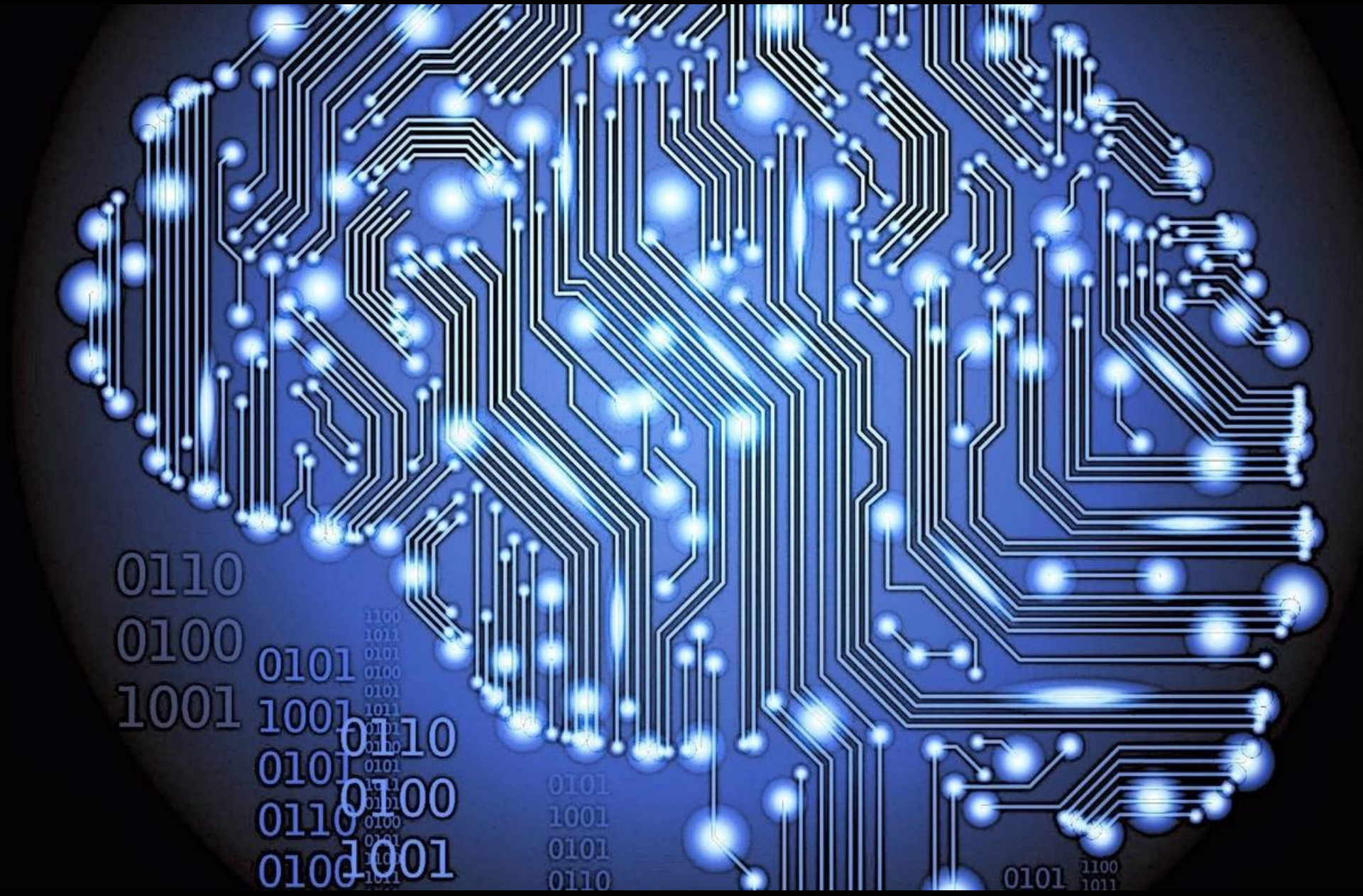

BOSCH


STOP


BIG
DATA
USE
ONE
SOFTWARE
USING
WORKING
GARTNER
MASSIVELY
BIOLOGICAL
HUNDREDS
PERFORMANCE
ALSO
DISK
SHARED
TIME
RELATIONAL
GENOMICS
TOOLS
SET
WITHIN
PROCESS
DEFINITION
SEARCH
INCLUDE
SYSTEMS
NETWORKS
INFORMATION
RECORDS
COST
CONTINUES
CITATION
COMPLEX
TERABYTES
MPP
RESEARCH
DATABASES
STORAGE
DIFFICULTY
TARGET
ABILITY
SETS
EXAMPLES
APPLIED
SENSOR
ARCHIVES
ELAPSED
CURRENT
EVERY
LARGER
CASE
SOCIAL
LARGE
MAY
MANAGEMENT
DISTRIBUTED
CAPTURE
MANAGE
GROW
STORE
ANALYTICS
SAN
PARALLEL
TOLERABLE
SIZE
NEEDED
PETABYTES
INTERNET
TECHNOLOGIES
PROCESSING
LOGS
BUSINESS
MOVING
TENS
CAPACITY
PRACTITIONERS

```
X = np.array([ [0,0,1],[0,1,1],[1,0,1],[1,1,1] ])
y = np.array([[0,1,1,0]]).T
syn0 = 2*np.random.random((3,4)) - 1
syn1 = 2*np.random.random((4,1)) - 1
for j in xrange(60000):
    l1 = 1/(1+np.exp(-(np.dot(X,syn0))))
```




0110
0100
1001
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1001
0110
0101
0100
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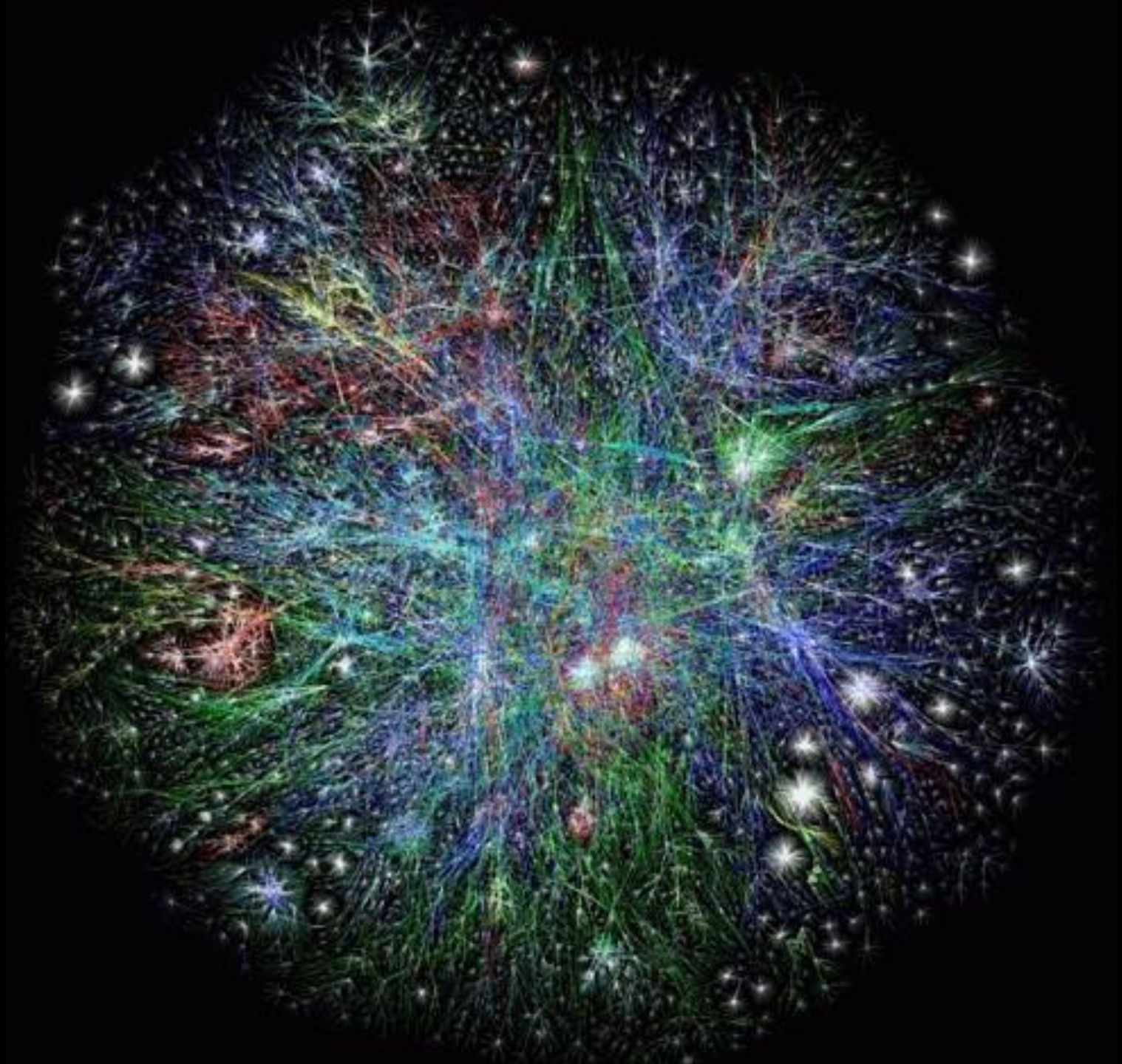
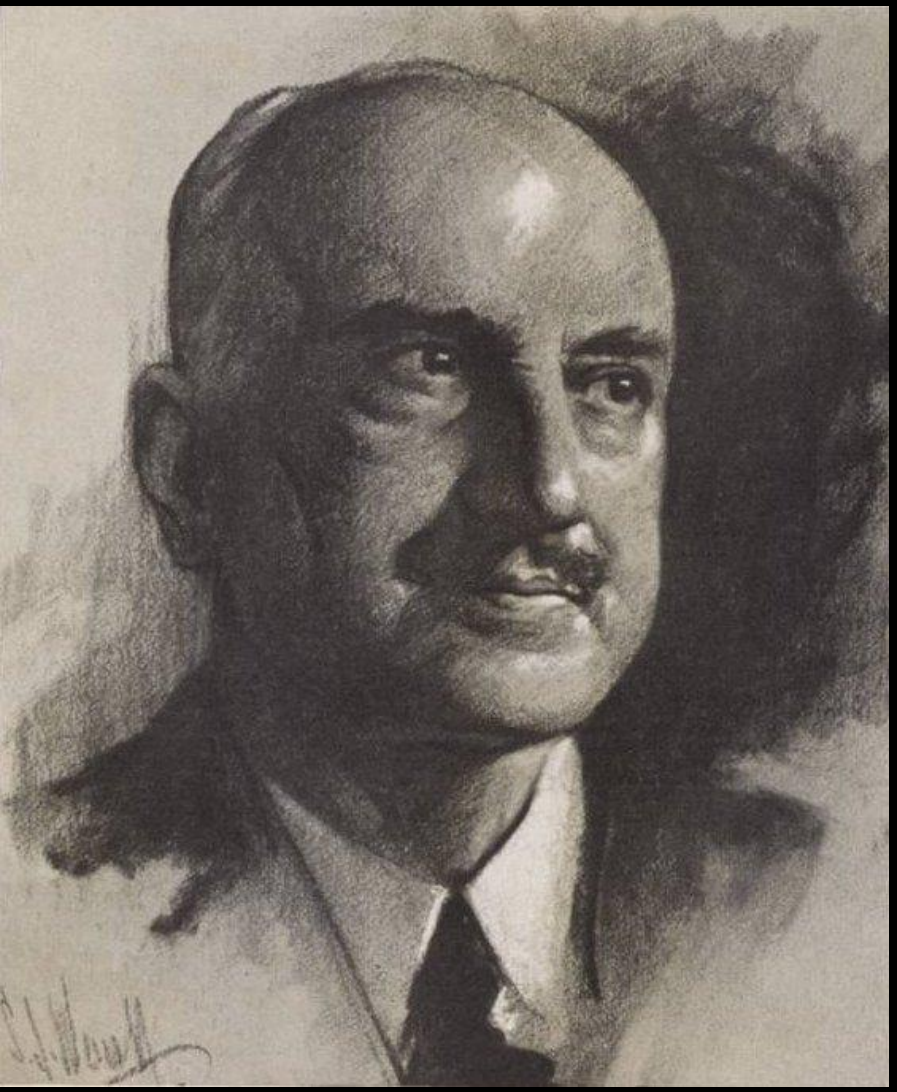
1001
0101
1001
0101
0110
0101
1100
1011


IBM
IBM
IBM
IBM



Program the Network



“Those who cannot remember the past are condemned to repeat it.”

George Santayana, 1905

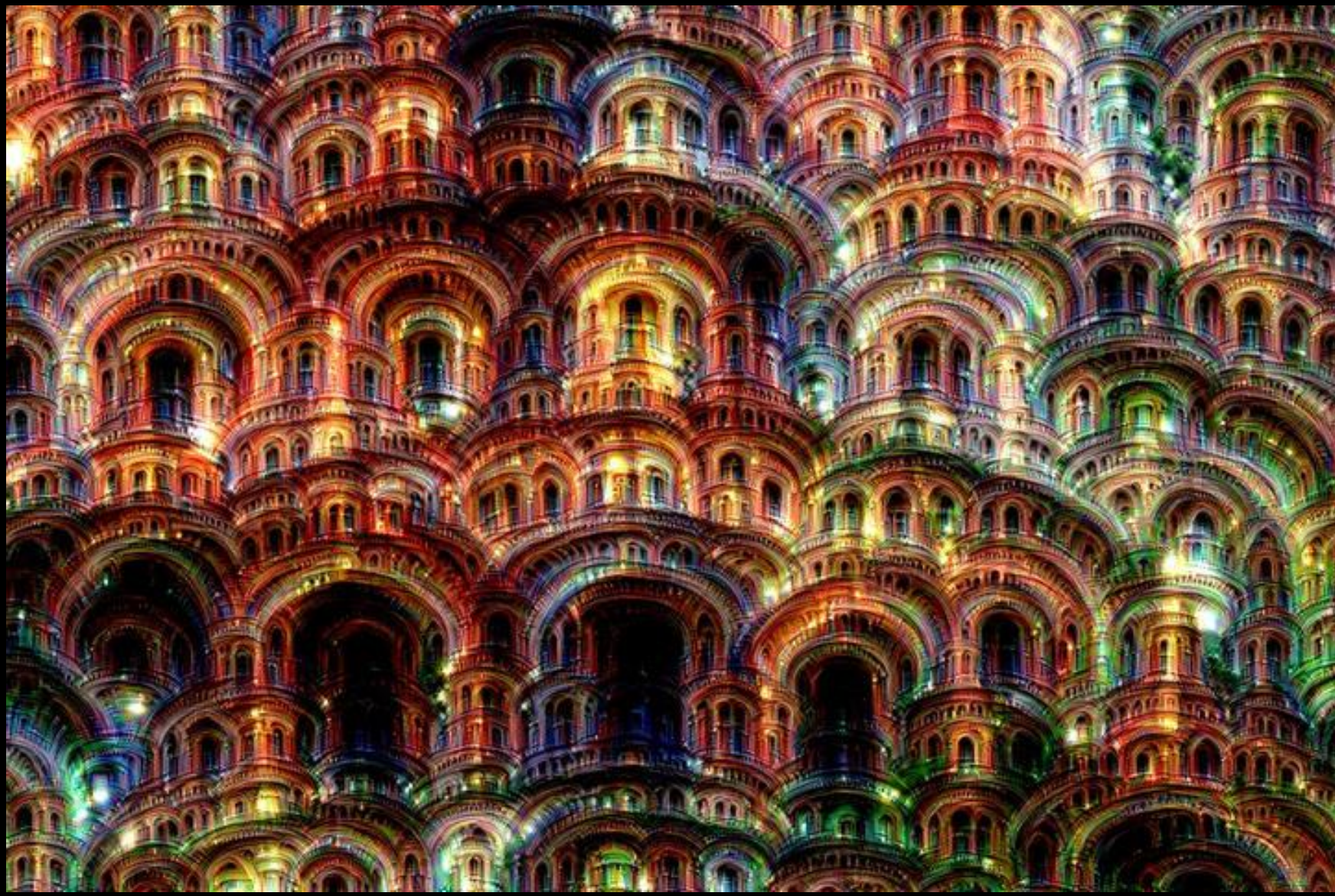
“Those who ignore the mistakes of the future are bound to make them.”

Joseph D. Miller, 2006

"One does not discover new lands without consenting to lose sight of the shore for a very long time“

- André Gide (1869-1951)

Dreams



Google’s DeepDream creates strange images


"Admiral Dog!"
"The Pig-Snail"
"The Camel-Bird"
"The Dog-Fish"

Google’s DeepDream creates strange images

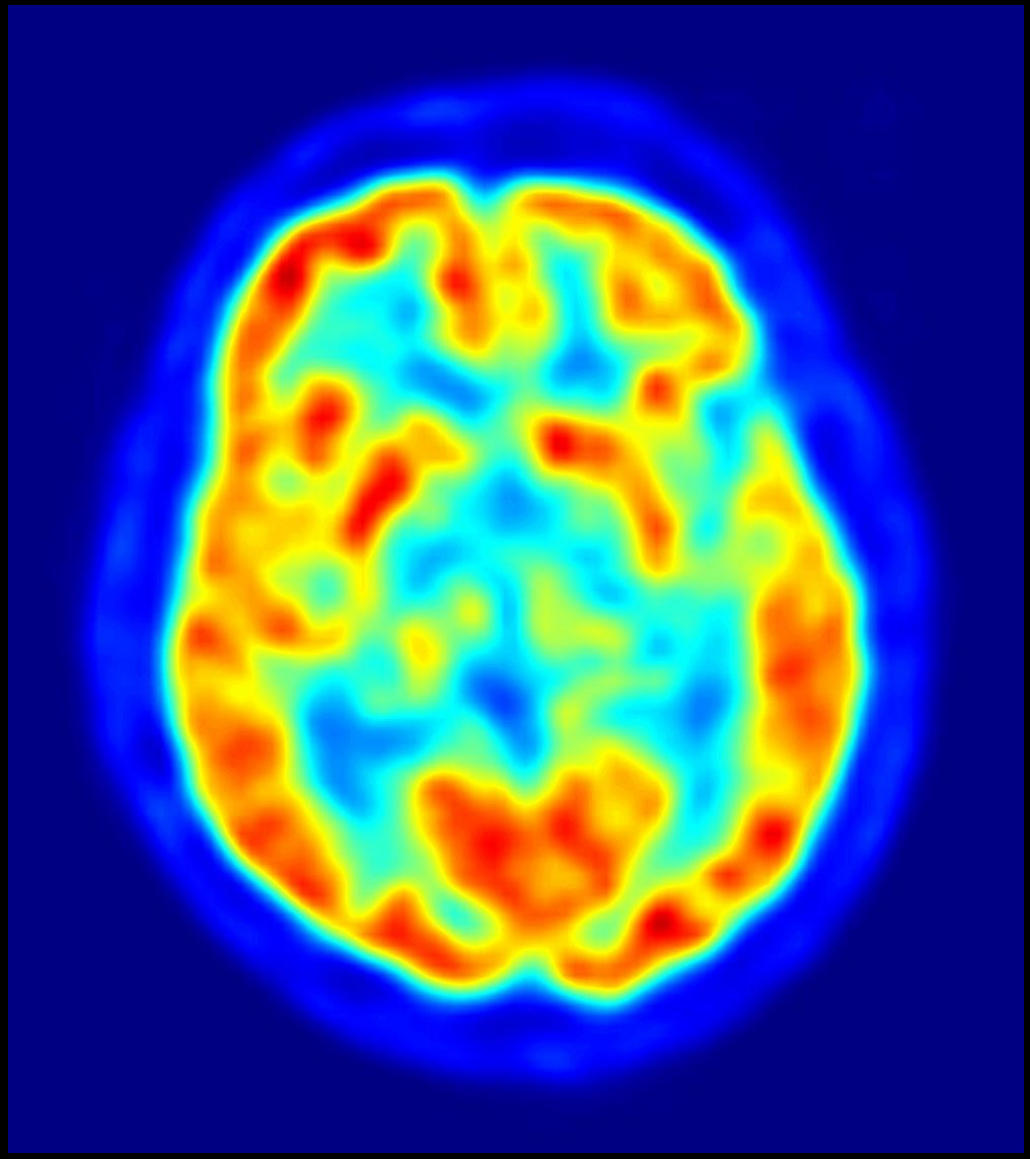
imaginations

Google’s DeepDream creates strange images

archtypes

Google’s DeepDream creates strange images

to learn about the brain



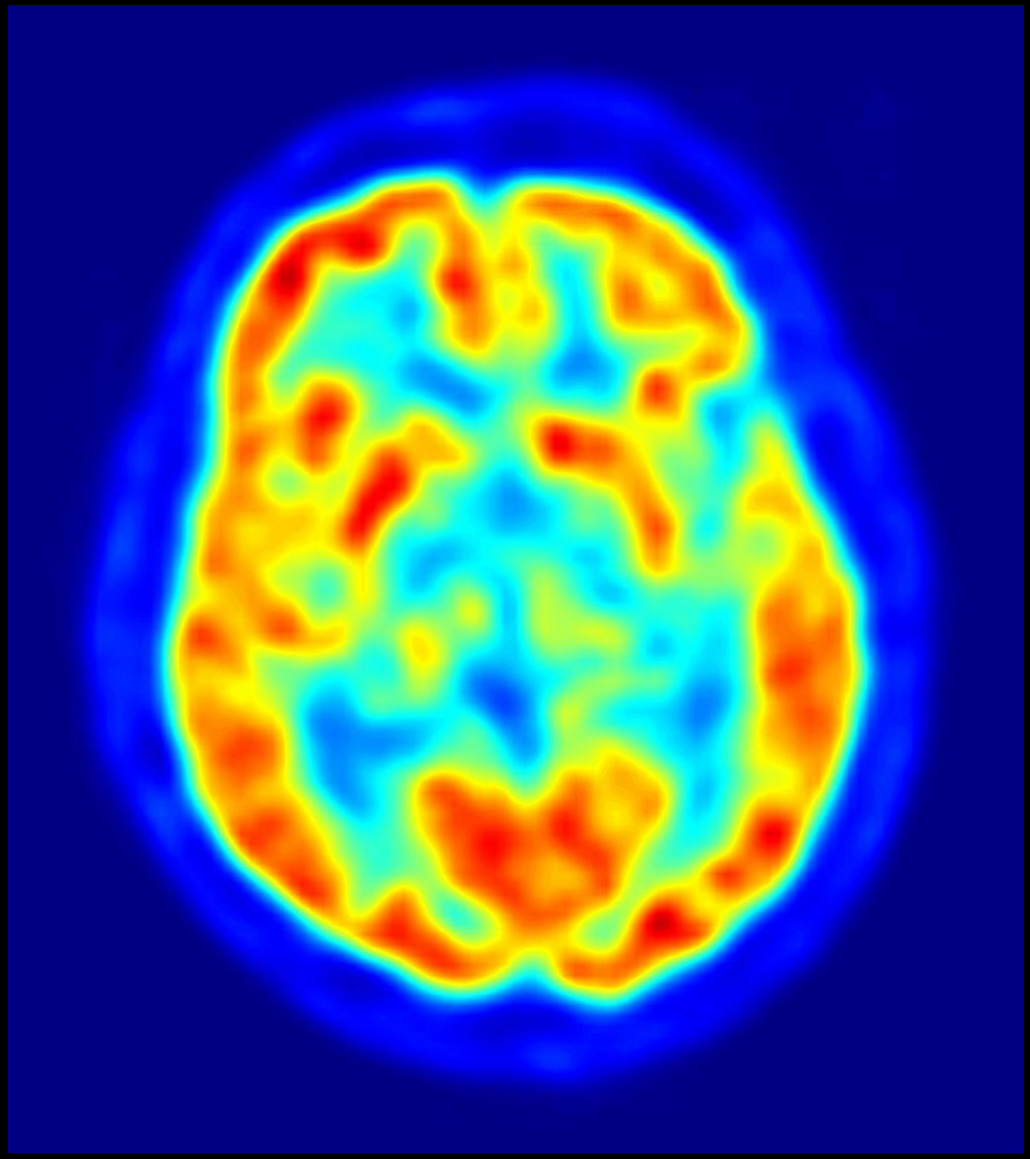
Dreams are the way our brains *hallucinate*

Dreams are the way our brains *practice*

Dreams are the way our brains *learn*

What about Big Data?

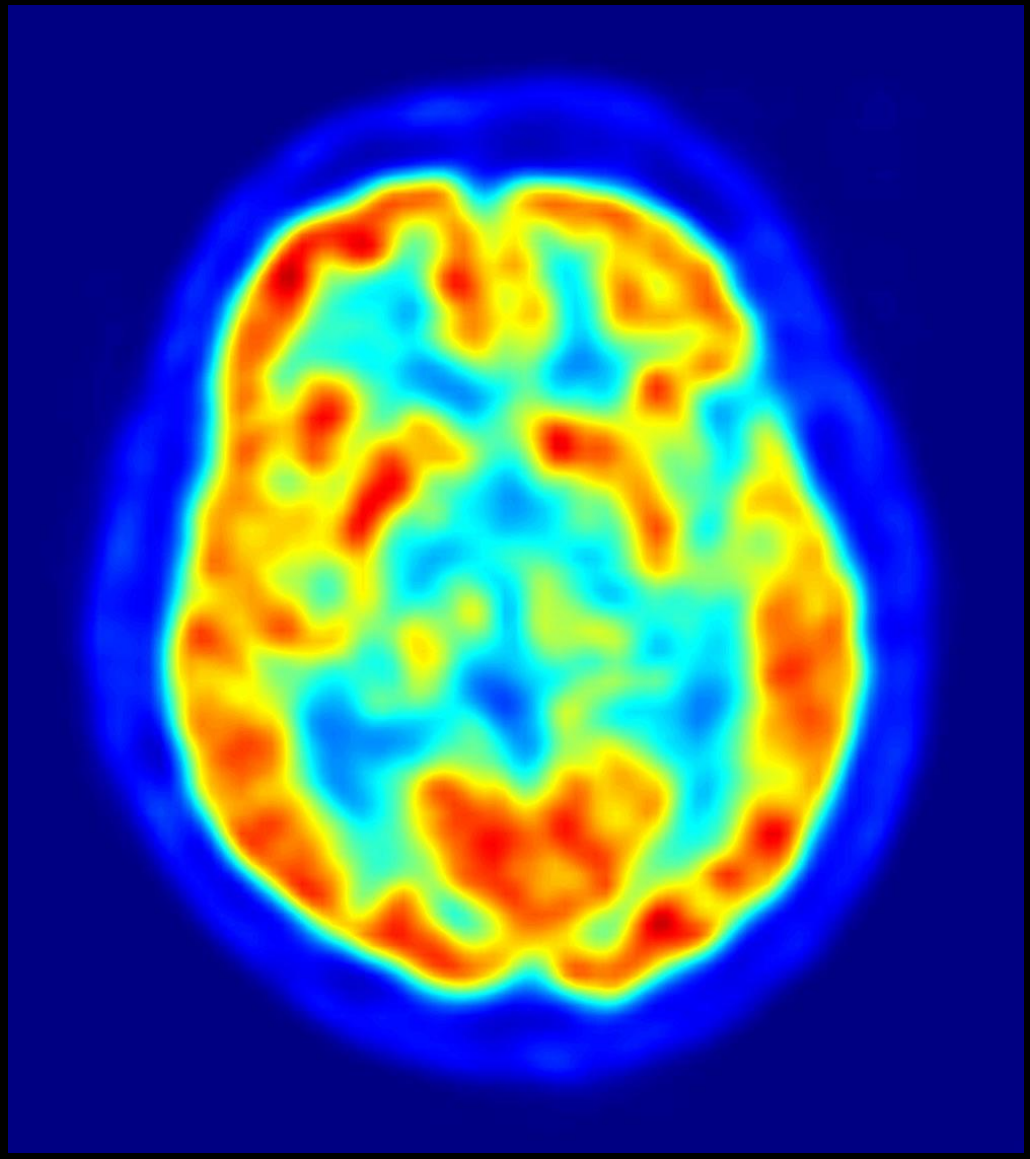
1 Yottabyte of Storage



100 Terabytes

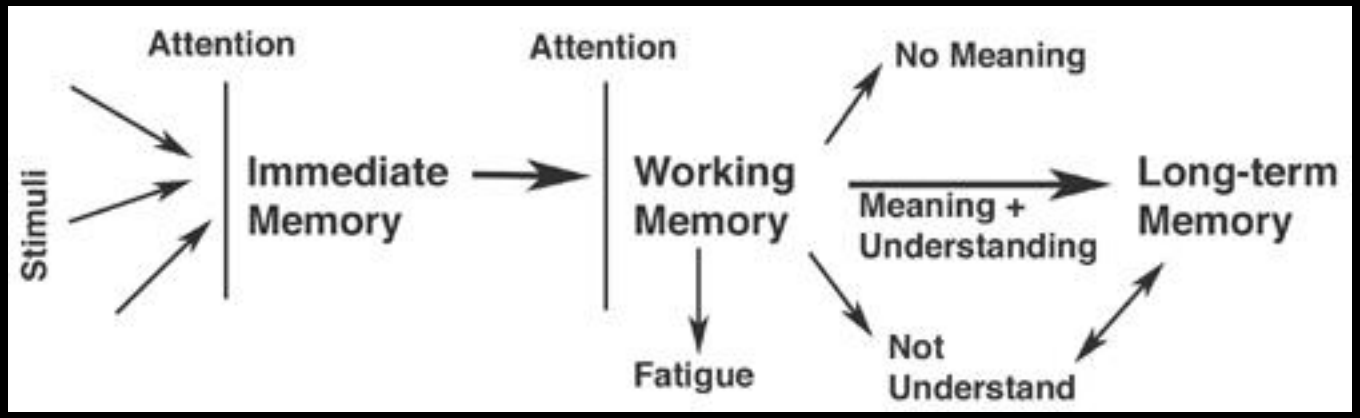
100 Terabytes
100,000 Gigabytes

100 Terabytes
100,000 Gigabytes
250+ years of storage per person

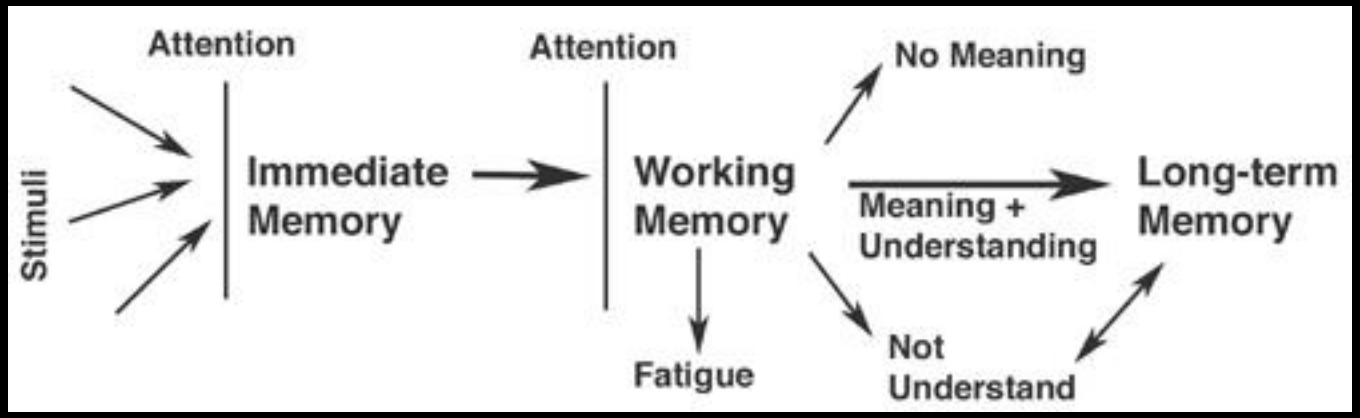


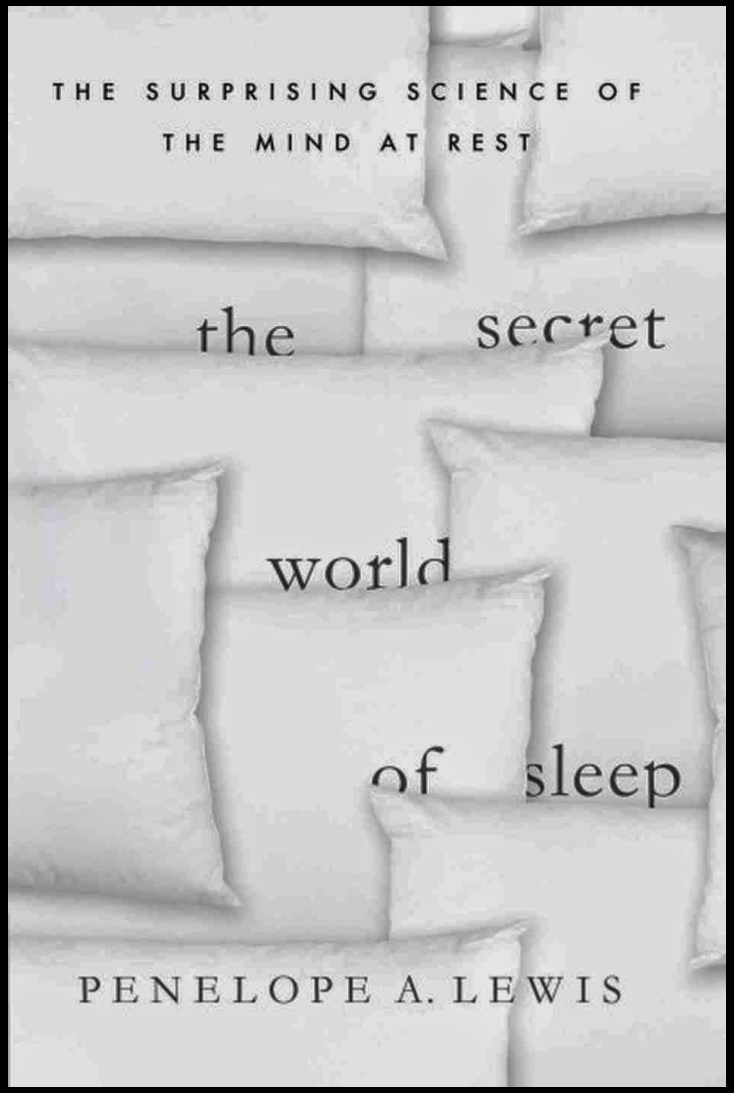
Does the brain retain all
100 Terabytes
of data, experience, memory?

NO


Attention
Attention
No Meaning
Stimuli
Immediate Memory
Working Memory
Meaning + Understanding
Long-term Memory
Fatigue
Not Understand

Pruning data into long-term memory




THE SURPRISING SCIENCE OF
THE MIND AT REST
the secret
world
of sleep
PENELOPE A. LEWIS

“Forgetting makes our brains more efficient.”

Forgetting is important…

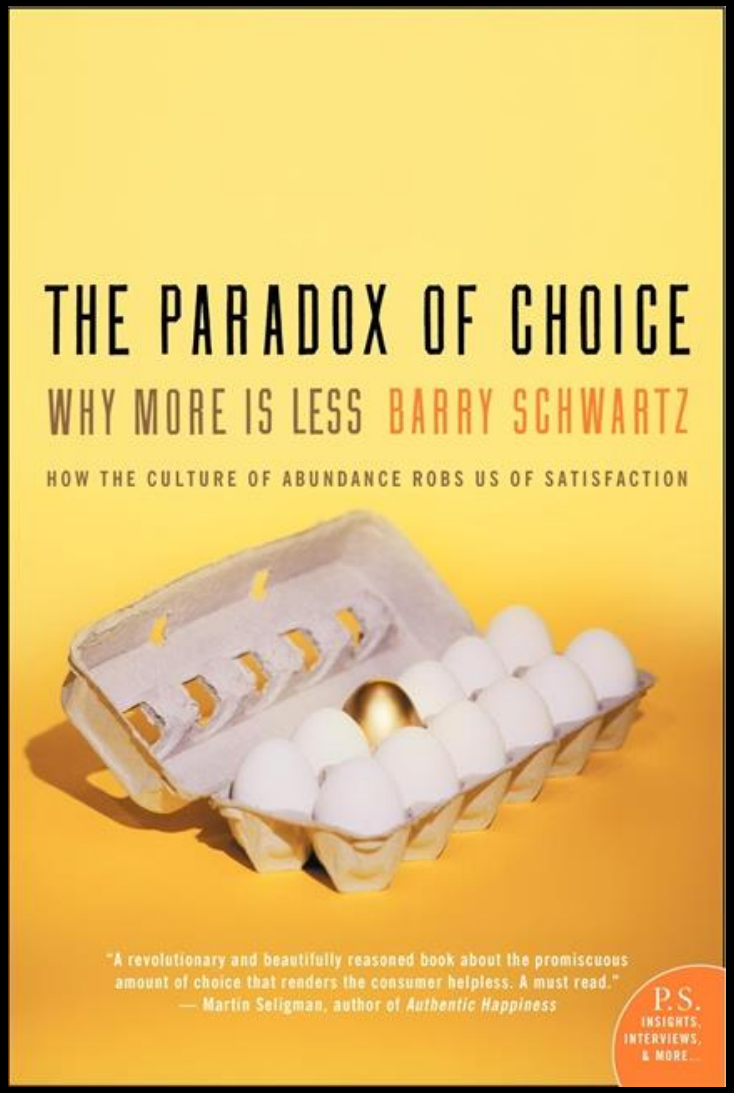
Forgetting is important…
So is CHOOSING

Learning to choose is hard.

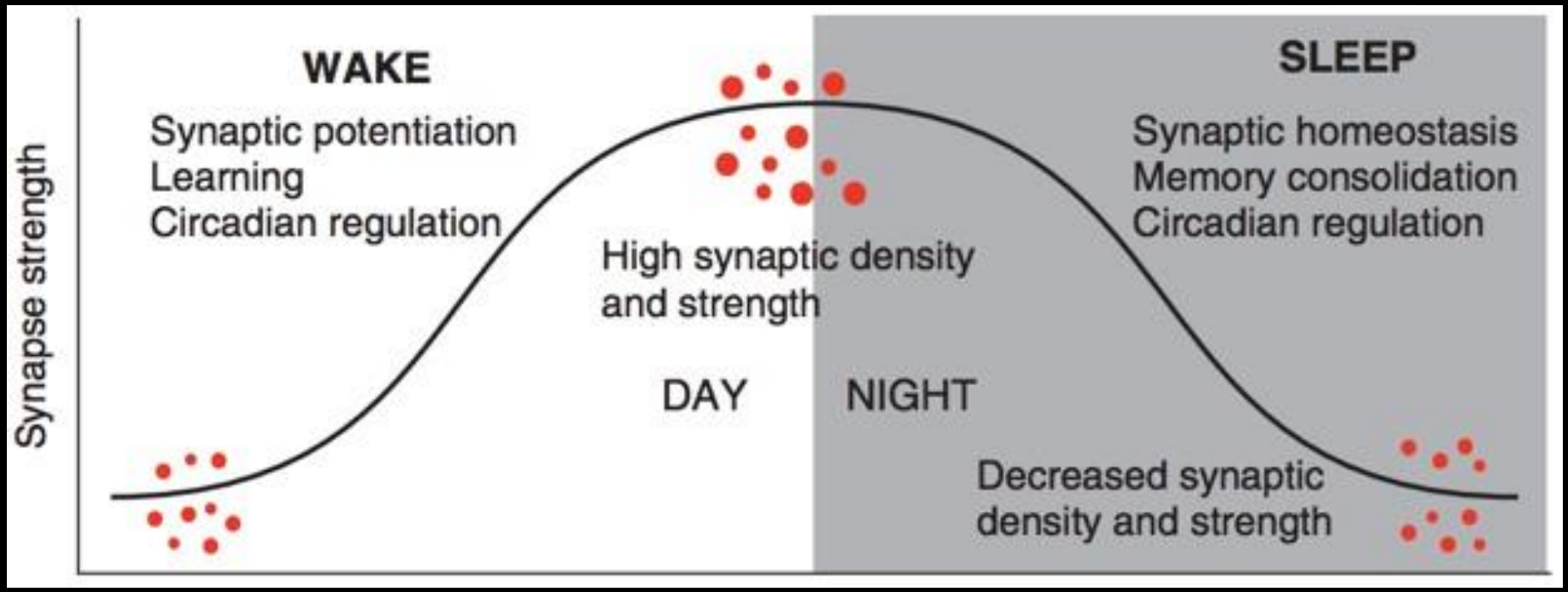
Learning to choose is hard.
Learning to choose well is harder.

“Learning to choose well in a world of unlimited possibilities is, perhaps, too hard.”

Barry Schwartz, 2004


THE PARADOX OF CHOICE
WHY MORE IS LESS
BARRY SCHWARTZ
HOW THE CULTURE OF ABUNDANCE ROBS US OF SATISFACTION
"A revolutionary and beautifully reasoned book about the promiscuous amount of choice that renders the consumer helpless. A must read."
— Martin Seligman, author of Authentic Happiness
P.S.
INSIGHTS, INTERVIEWS, & MORE...

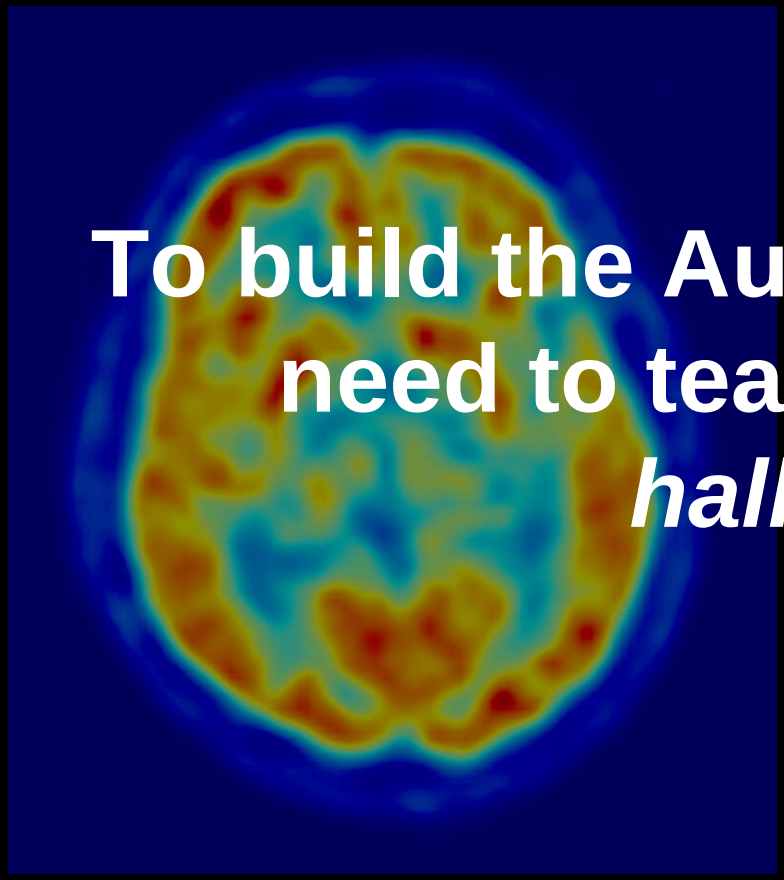

Scoop Away
Fresh Step
Deli Cat


WAKE
Synaptic potentiation
Learning
Circadian regulation
SLEEP
Synaptic homeostasis
Memory consolidation
Circadian regulation
High synaptic density
and strength
DAY
NIGHT
Decreased synaptic
density and strength
Synapse strength

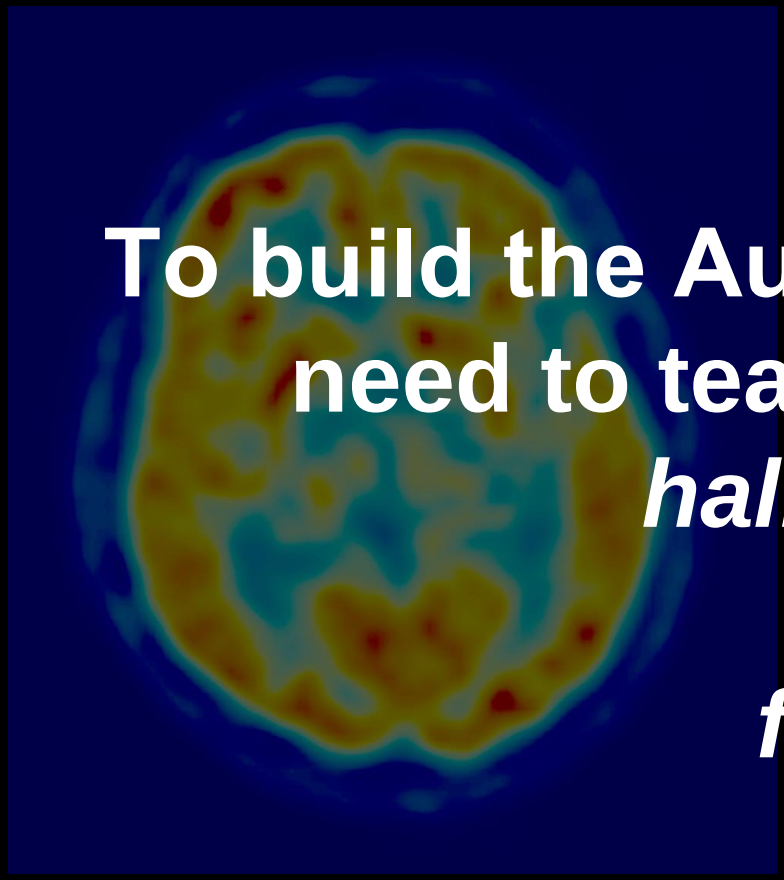
“If you torture big data long enough, it will tell you what you want to know.”

- Edward Tufte

To build the Autonomous Web we'll need to teach machines to



To build the Autonomous Web we'll need to teach machines to *hallucinate*



To build the Autonomous Web we'll need to teach machines to

hallucinate

and

forget

Lies


Video camera on windscreen detects traffic lights and moving traffic
Rotating sensor on roof generates 3D map of surroundings
Radar sensors - three at the front and one at the back - help determine position
Two people in car - driver to take over in an emergency, and engineer to monitor software
GOOGLE IMAGE

“A key is simple.
A car is complicated.
Driving a car in traffic
is complex.”

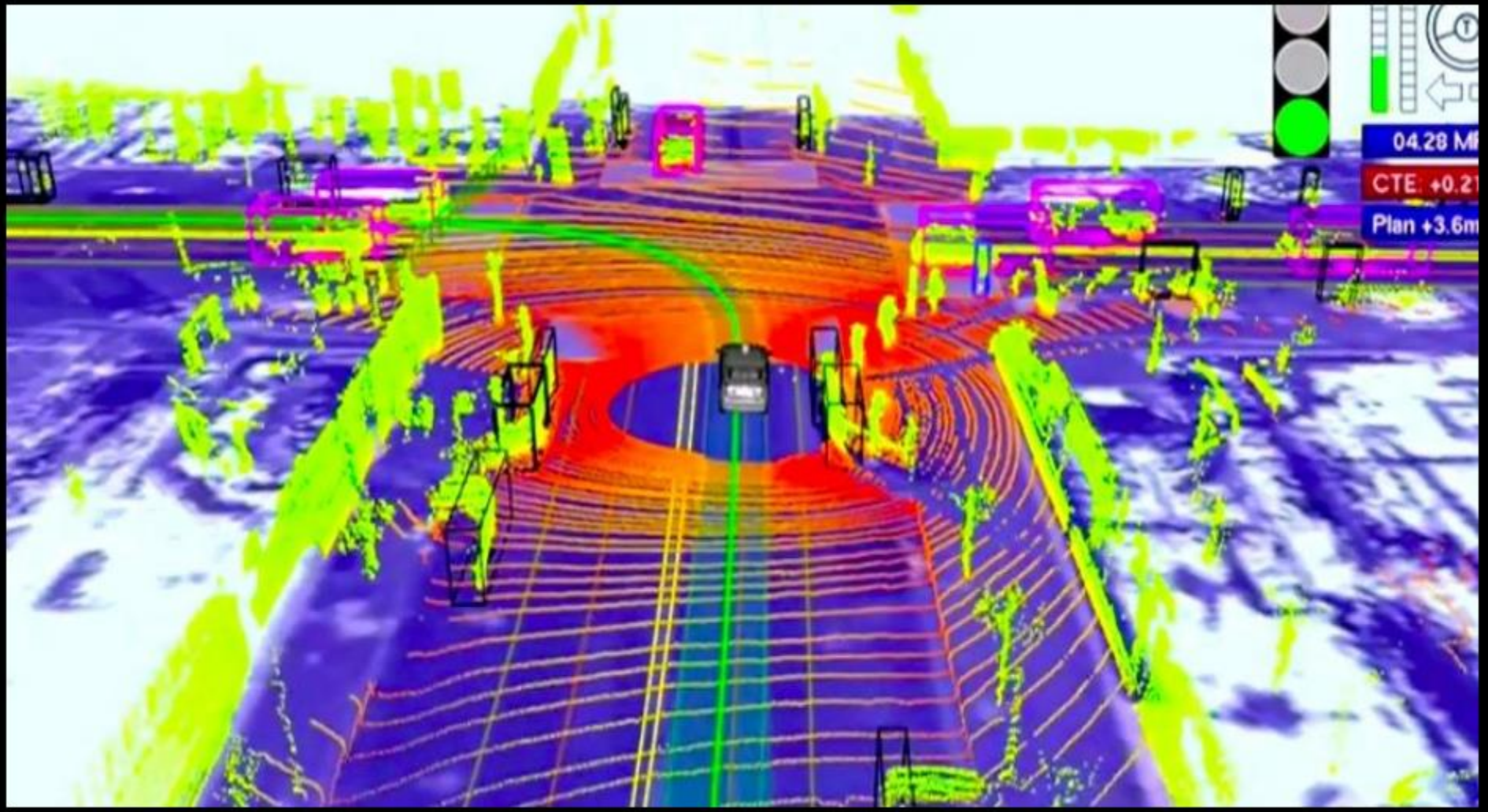
- Michael Lewis

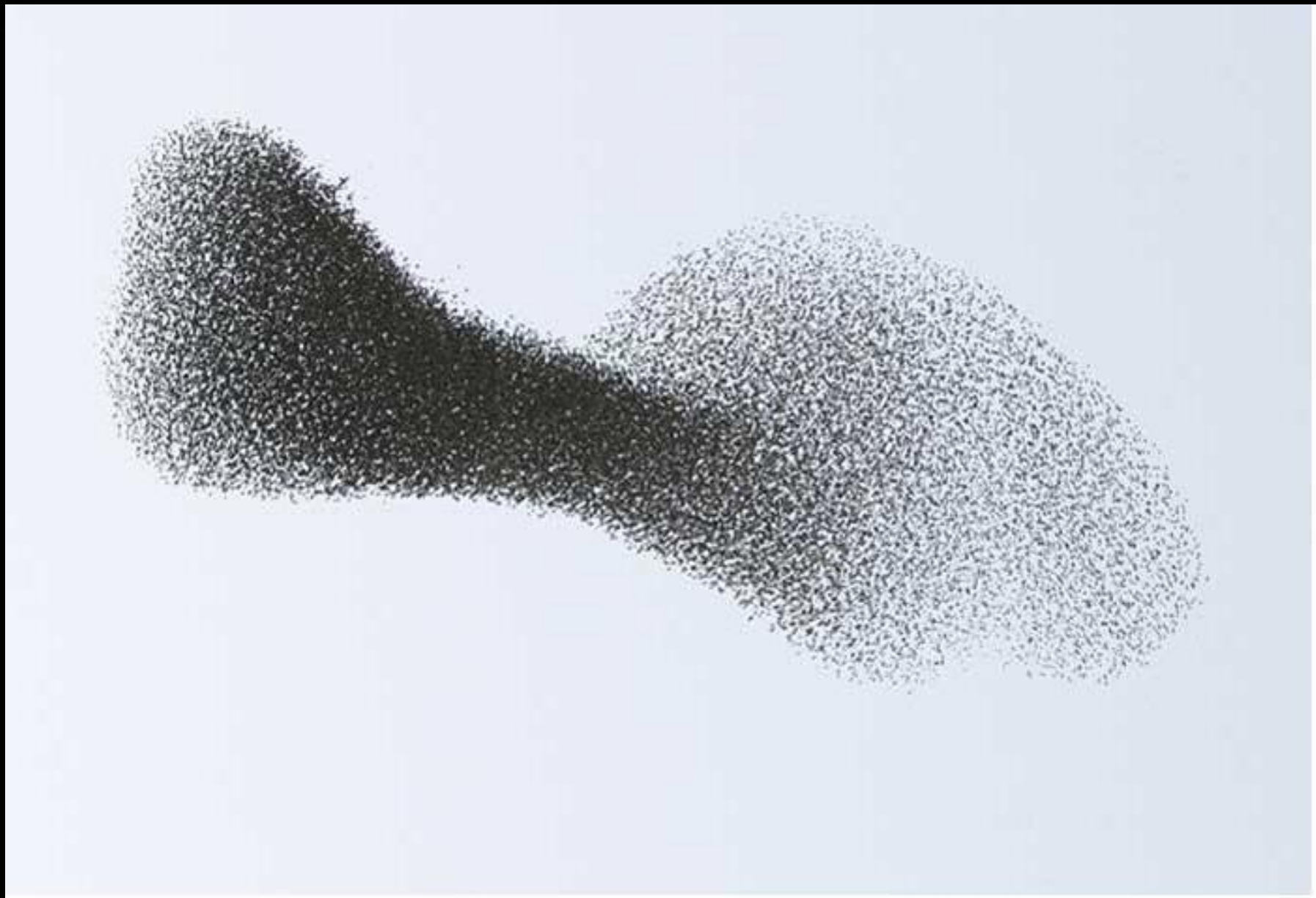
"At the heart of the technology is a Google-made topographical map that gives the car a sense of what it should expect. The cars depend on this prebuilt map, which is why their urban excursions are limited to Mountain View for now…"

- Seth Rosenblatt (@sethr) of cnet.com

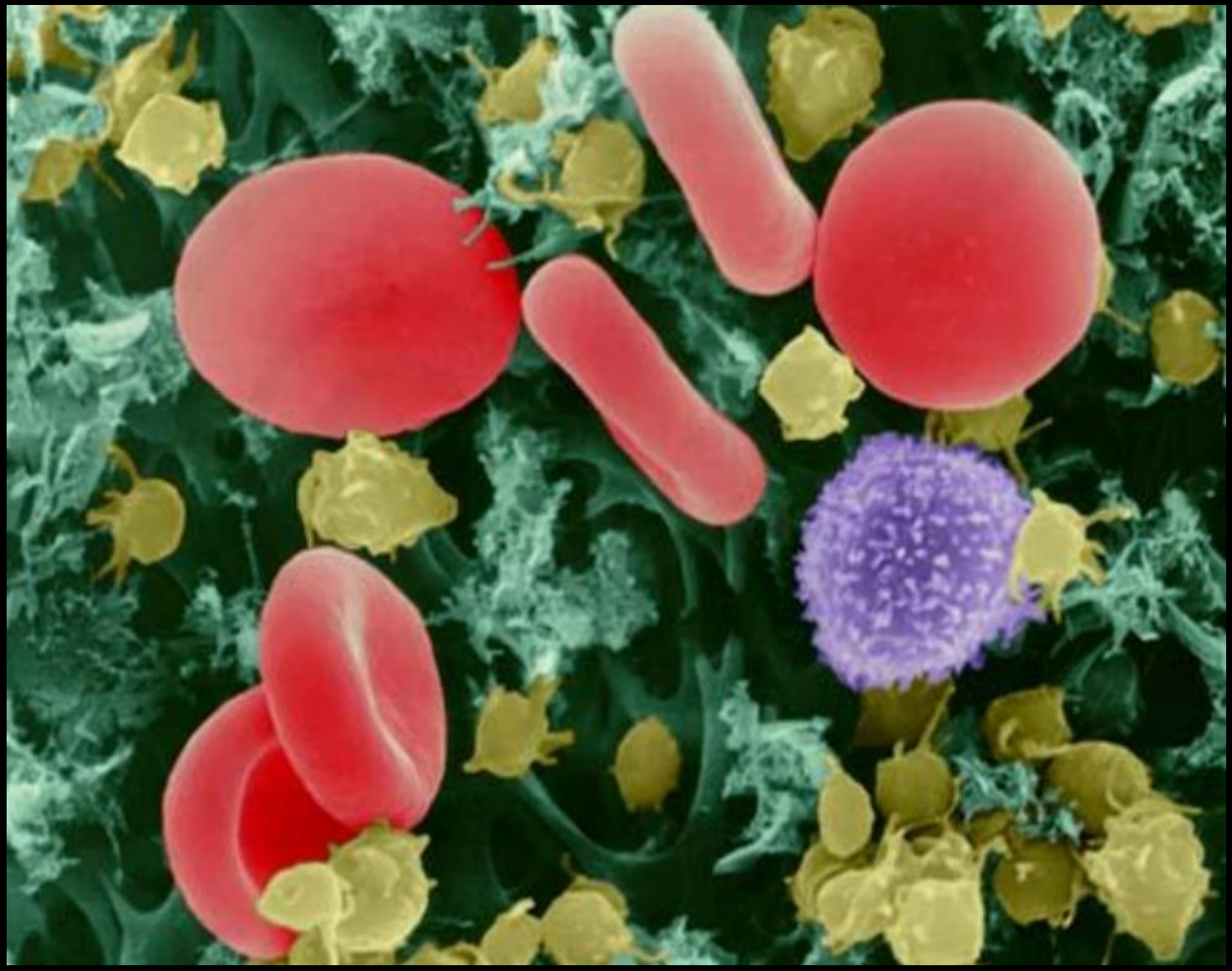

Cruise
35 MPH
SPEED
LIMIT
35


WORKERS ON
ROAD
SLOW DOWN

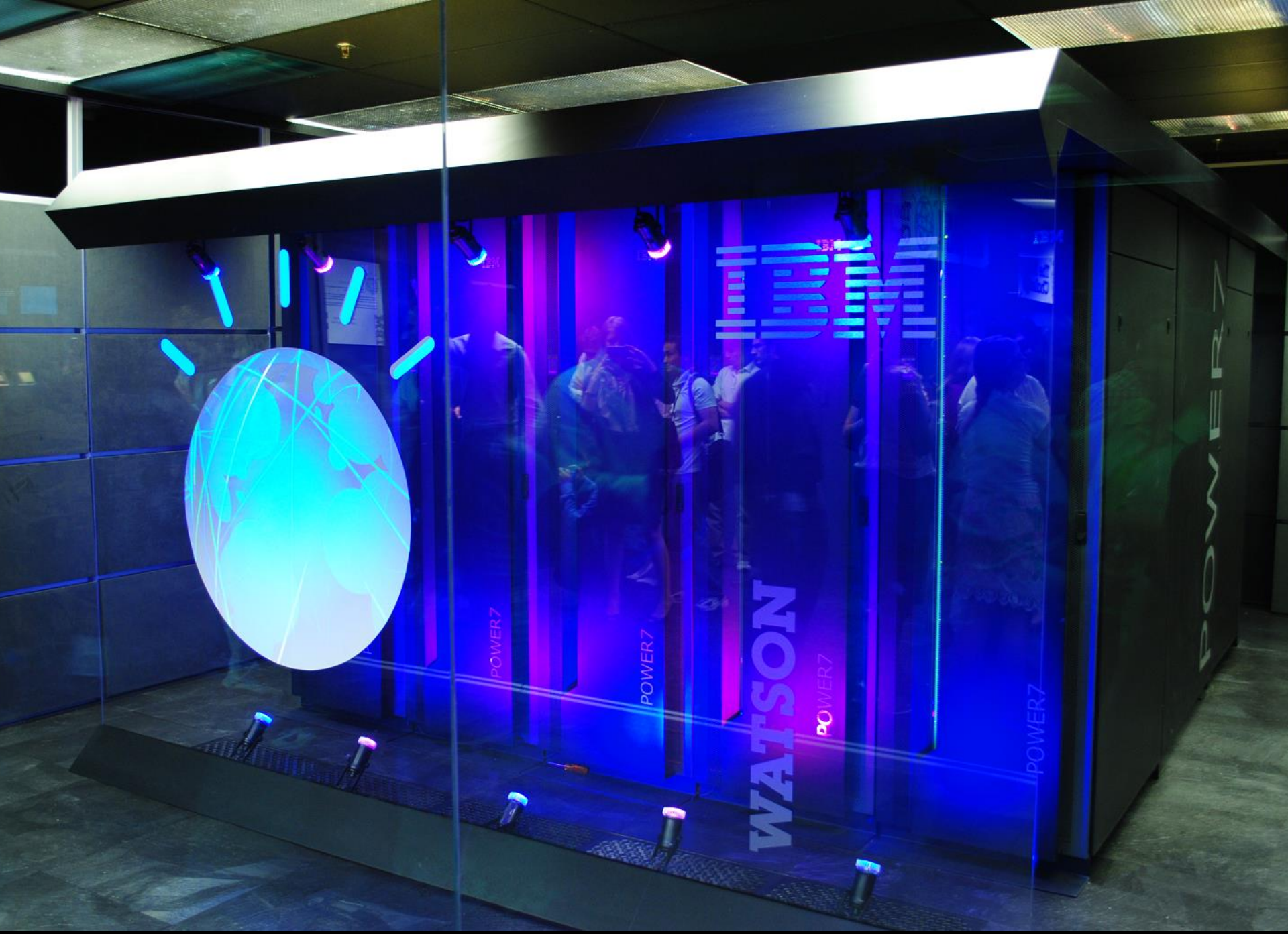

04.28 M
CTE +0.2
Plan +3.6m



Photograph by Manuel Presti



Complexity is not statistical.


IBM
WATSON
POWER7
POWER7
POWER7
POWER7

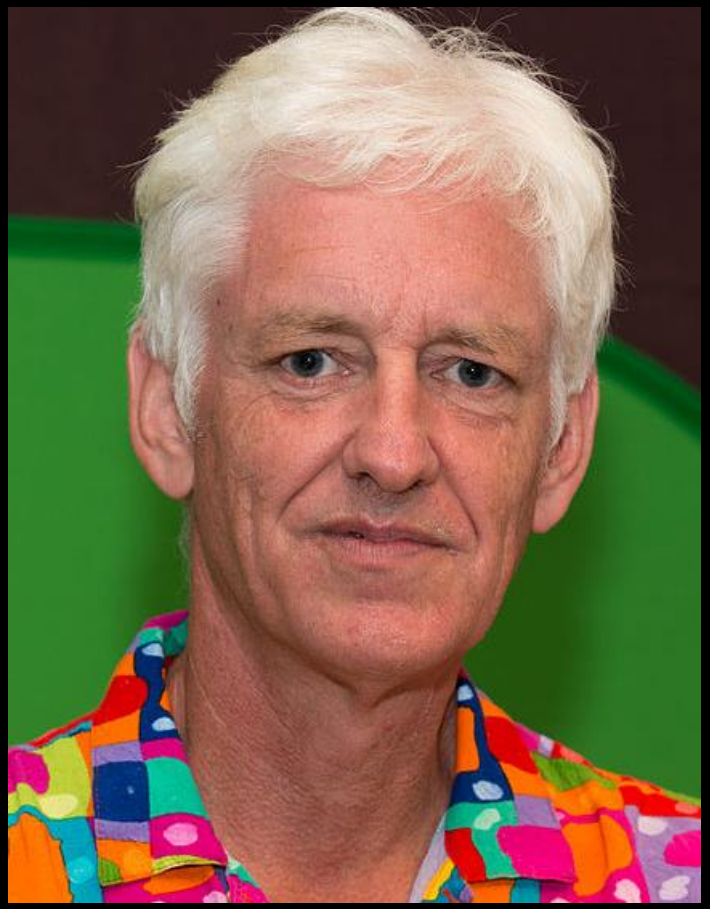
“Watson Analytics offers you the benefits of advanced analytics without the complexity.”

-- IBM’s Watson Analytics Website

“Watson Analytics offers you the benefits of advanced analytics **without the complexity**.”

-- IBM’s Watson Analytics Website


Google



"As we gain more data, how much better does our system get? It's still improving — but we are getting to the point where we get less benefit than we did in the past."

- Peter Norvig
Dir of Research
Google

Learning is complex

Statistics are not learning

Autonomous Web

Background

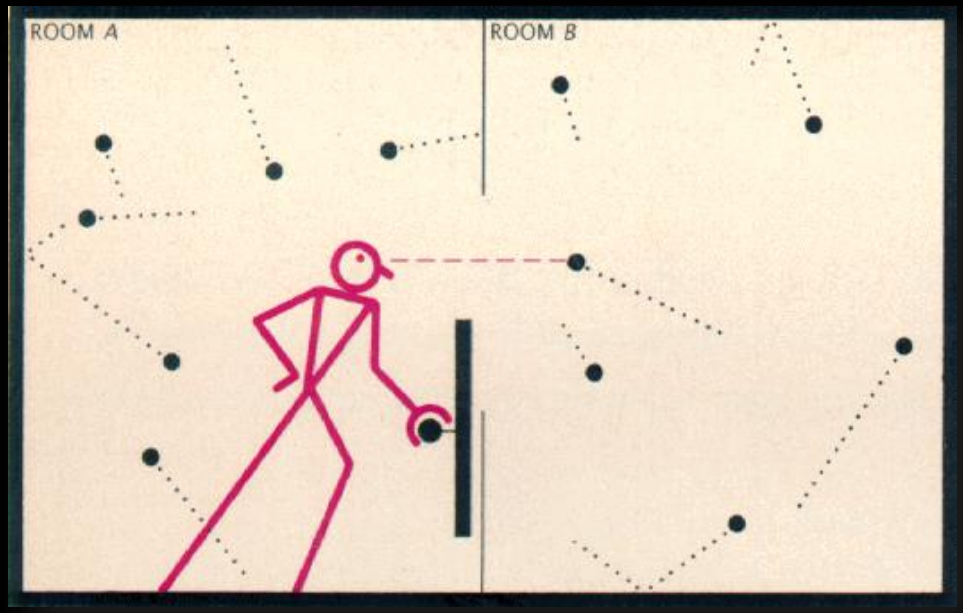
Information Theory, Complex Systems, and Hypermedia

Maxwell's Demon

James Clerk Maxwell (1831 - 1879)

"... if we conceive of a being whose faculties are so sharpened that he can follow every molecule in its course…"

Second Law of Thermodynamics *"has only a statistical certainty"*



Boltzmann

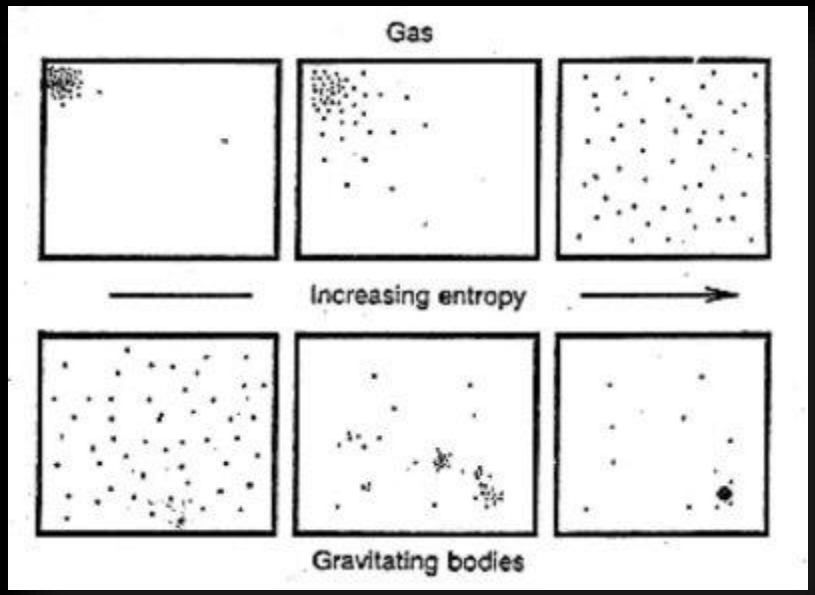
Ludwig Boltzmann (1844 - 1906)

“Boltzman entropy”

Macro- & micro-states

Each possibility is a microstate

The probability of a macrostate is the function of all the microstates.



Shannon & Information

Claude Shannon (1916 – 2001)

“The number of bits needed to represent the result of an uncertain event is given by its entropy.”

Surprisal: the "surprise" of seeing the outcome - a highly improbable outcome is very surprising. (Tribus, 1961)

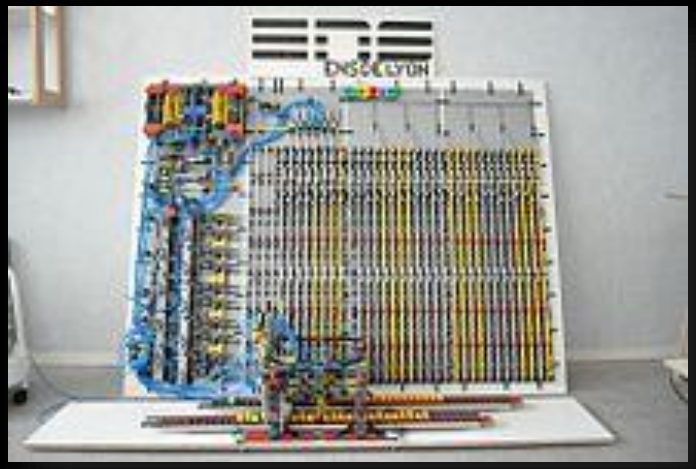
Turing, Tapes, & Halting

Alan Turing (1912 – 1954)

A **Turing machine** is a hypothetical device that manipulates symbols on a strip of tape according to a table of rules.

“Turing's paper ... contains, in essence, the invention of the modern computer.” (Minsky, 1967)

“… decide whether the program finishes running or continues to run forever”

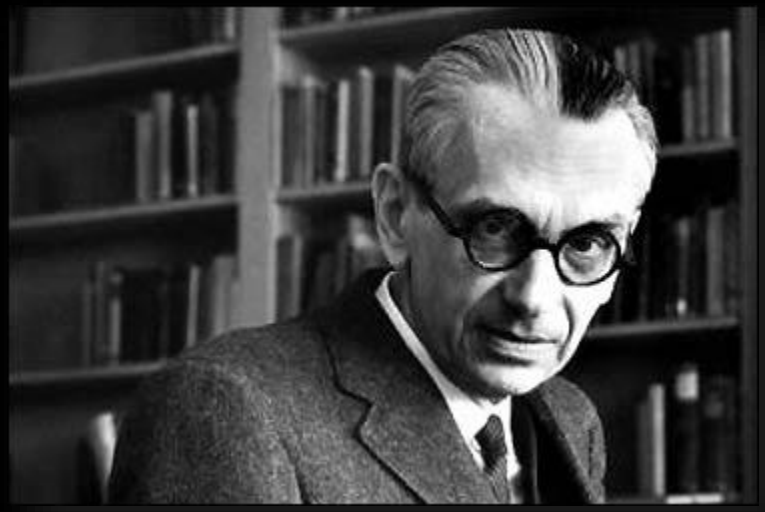


Gödel and Incompleteness

Kurt Gödel (1906 – 1978)

“This statement is unprovable.”

*Treats the string as both **data** and **program***

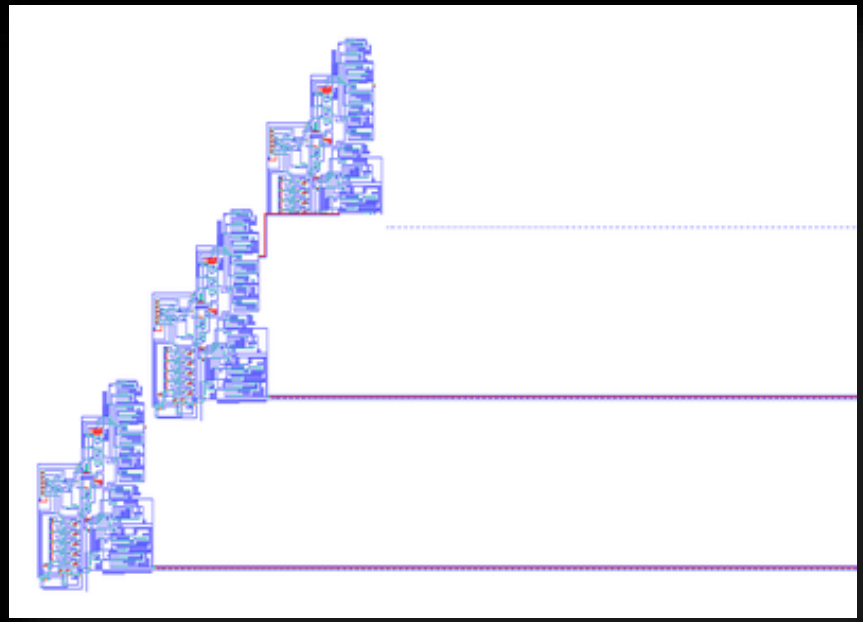


Von Neumann computing

John von Neumann (1903 – 1957)

*Described a computer architecture in which the **data** and the **program** are both stored in the computer's memory in the same address space."*

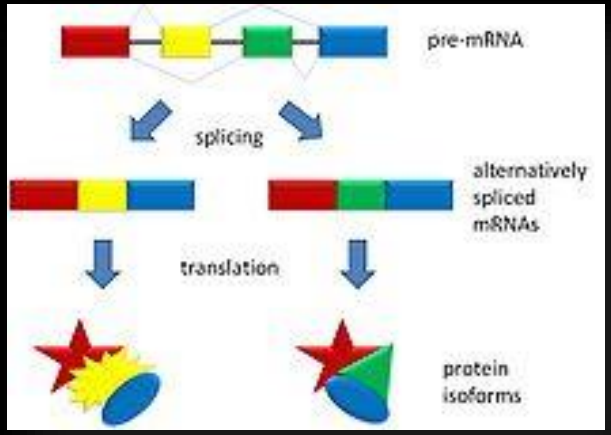
Theory of Self Reproducing Automata (1966)



Genes

DNA/RNA store both the **data** and **program**.

mRNA uses “alternative splicing” where it greatly increases biodiversity.



Fielding architecture

Roy Fielding (1965 -)

"*Architectural Styles and the Design of Network-based Software Architectures" (2001)*

"each component cannot "see" beyond the immediate layer with which they are interacting."

"…the information becomes the affordance…"

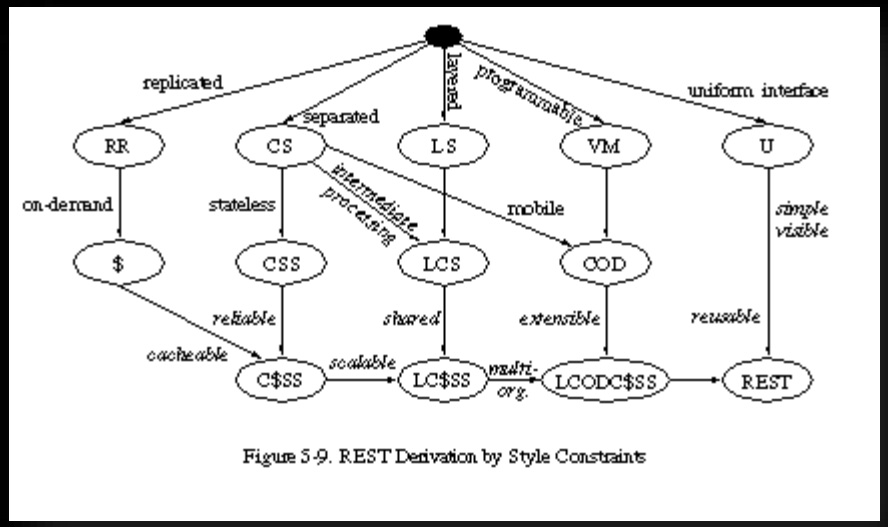
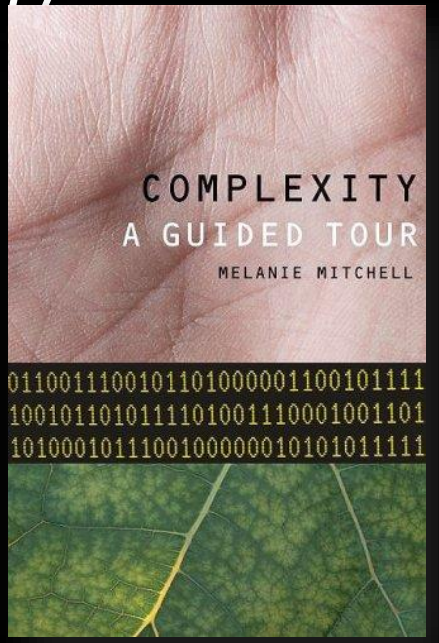


Figure 5-9. REST Derivation by Style Constraints

Complex Systems

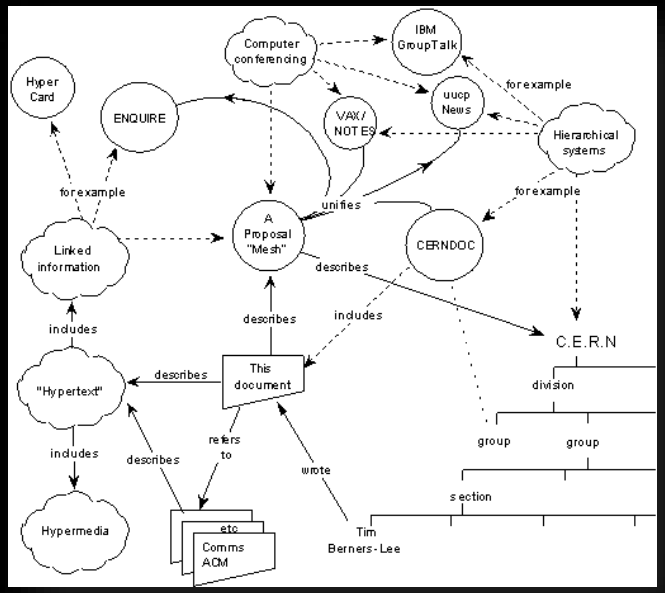
"Large networks of components with no central control and simple rules of operation give rise to collective behavior, sophisticated information processing, and adaptation via learning or evolution." (Mitchell, 2001)

"Exhibits non-trivial emergent and self-organizing behavior."



The Web

"The Web … [has] many large scale properties … which lead to "adaptive" behavior for the system as a whole." (Mitchell 2001)



So much for the background!

Current State

Media Types, HTTP, and Kelvin-ism

Media Types

More registered hypermedia-style designs in the last two years than in the last ten.

- Maze+XML (experimental)
- HAL (XML, JSON)
- Collection+JSON
- Siren (JSON)
- Hydra (JSON-LD)
- JSON-API
- UBER (pending)

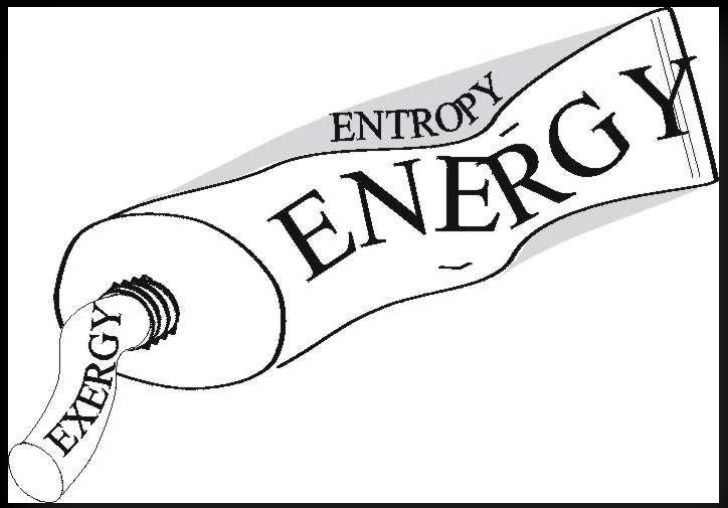
Media Types and entropy

Designs vary in their level of “surprise”

“surprisal” == “entropy”

Lower the entropy, the less value the information

Higher the entropy, the more energy needed to process the information.



Media Types and entropy

`text/uri-list`

Low entropy/surprisal

Low energy needs

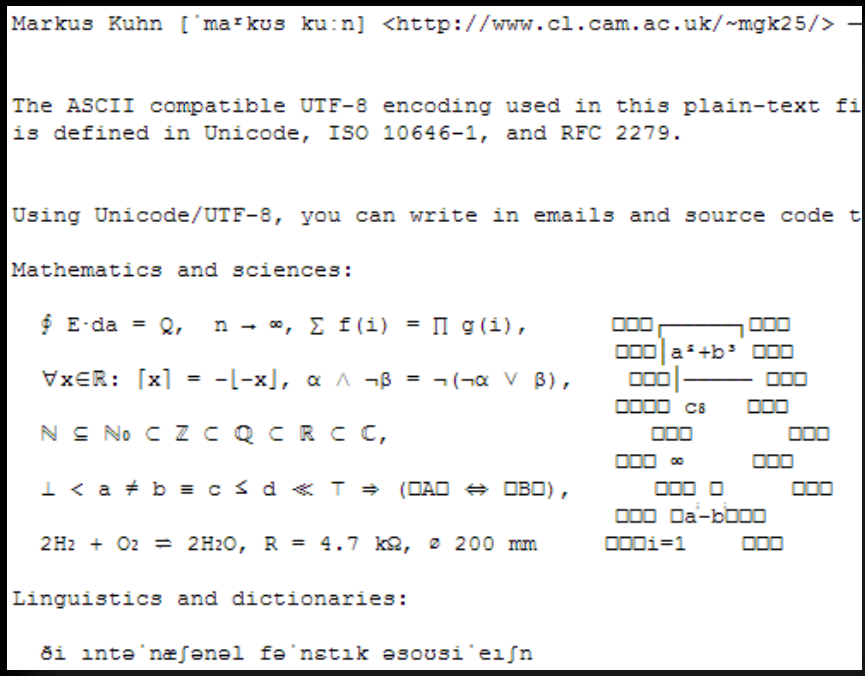
```
urn:isbn:0-201-08372-8
http://www.huh.org/books/foo.html
http://www.huh.org/books/foo.pdf
ftp://ftp.foo.org/books/foo.txt
```

Media Types and entropy

`text/plain`

High entropy/surprisal

High energy needs



Media Types and entropy

`text/html`

Moderate entropy/surprisal

Moderate energy needs

```
<!DOCTYPE html>
<html>
  <body>

    <form action="..." class="add-user">
      First name: <input type="text" name="fi
      Last name: <input type="text" name="las
    </form>

    <a href="..." rel="users">Users</a>

  </body>
</html>
```

Media Types and entropy

From the “machine point of view”…

What is the balance between entropy and energy?

Energy = computing power (coding time, source code, memory, etc.)

Media Types and entropy

Most applications on the Web are “one-off” affairs - custom-coded for each solution.

This is “high-energy computing!”

HTTP

Hypertext Transfer Protocol
Ver 0.9 (1991) – Ver 1.1 (1999) *<10 years*

HTTPbis (2013?) *~15 years since 1.1*

HTTP 2.0 (20??) *>20 years since 1.1?*

No protocol-level changes, but several transport-level changes.

HTTP

The Web is currently *highly dependent* on a single protocol.

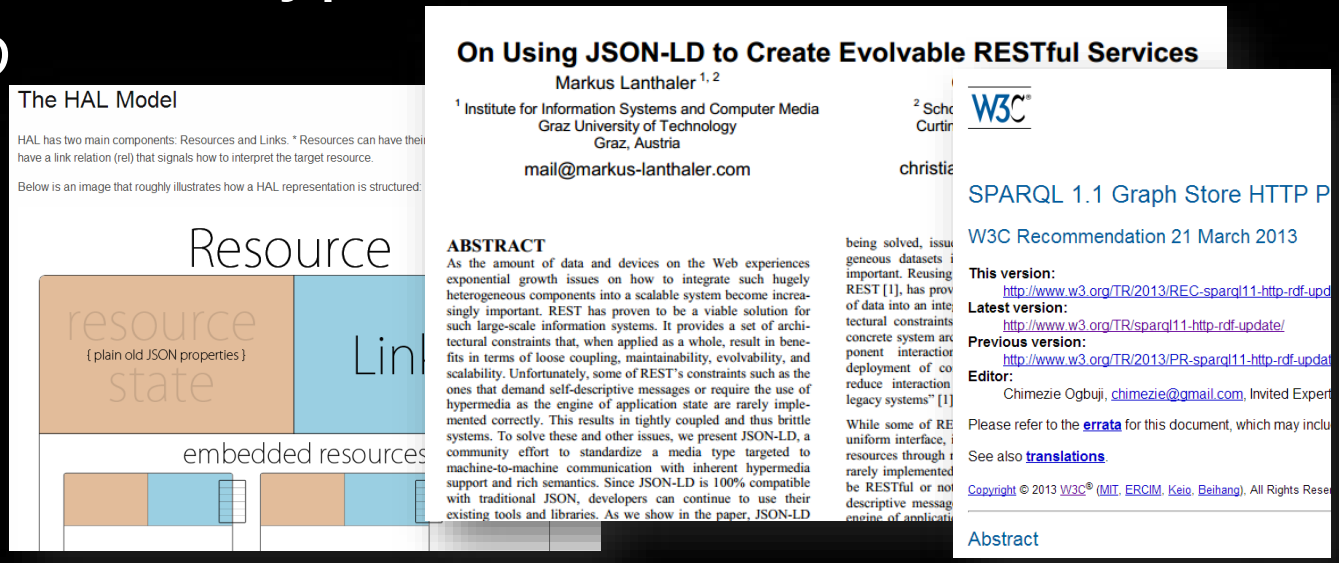
Most new “protocols” build upon HTTP

SPARQL 1.1 Graph Store HTTP Protocol.

Most new media types assume HTTP

JSON-LD

HAL



The Irony of HTML and HTTP is…

"When all you have is a hammer, everything looks like a nail."

-- Abraham Maslow

Questions for you…

How long will HTTP last?

When will HTML no longer be dominant?

How will this affect your own thinking?

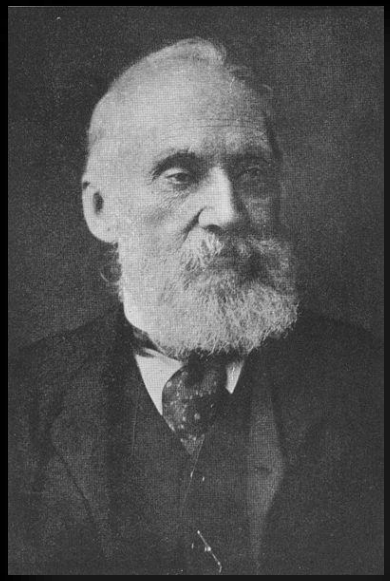
How will this affect the Web?

Kelvin-ism

Lord Kelvin computed the age of the earth based on “heat decay” and concluded:

“…it was more than 20 and less than 40 million year old, and probably much nearer 20 than 40”. (Kelvin, 1897)

To his dying day, Kelvin refused to accept the validity of other points of view.



Near Term

Lowering entropy, decoupling protocols, focusing on networks

Near Term – Lowering entropy

We need *more* media type designs

We need to design for low-entropy and high information

We need to design for machines, not humans

Near Term – Lowering entropy

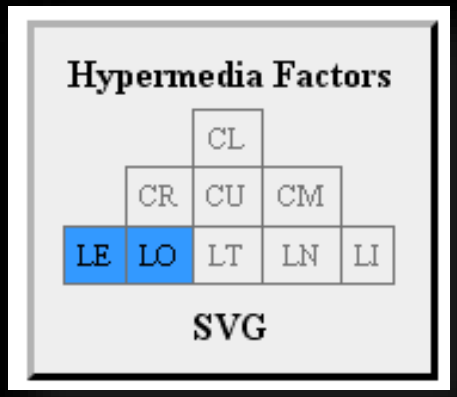
- Three semantic levels in network messages
  - Structure (XML, JSON, YAML, etc.)
  - Protocol (H-Factors)
  - Semantics (Domain concepts)
- We commonly see:
  - Structure = low surprise
  - Protocol = high surprise
  - Semantics = high surprise

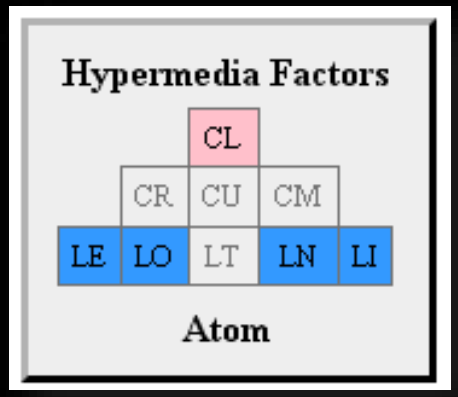
The higher the surprise in the message, the higher the dependence on custom code on the client/server.

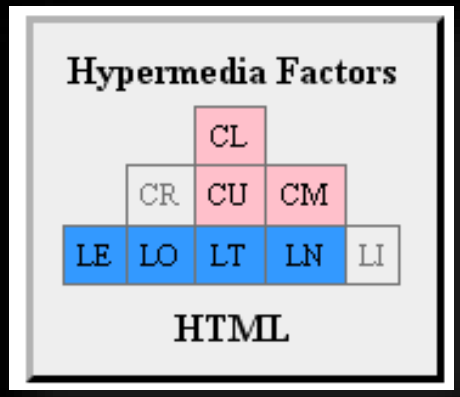
Near Term – Lowering entropy

Hypermedia Factors can lower Protocol Surprise

Many designs are still unexplored.



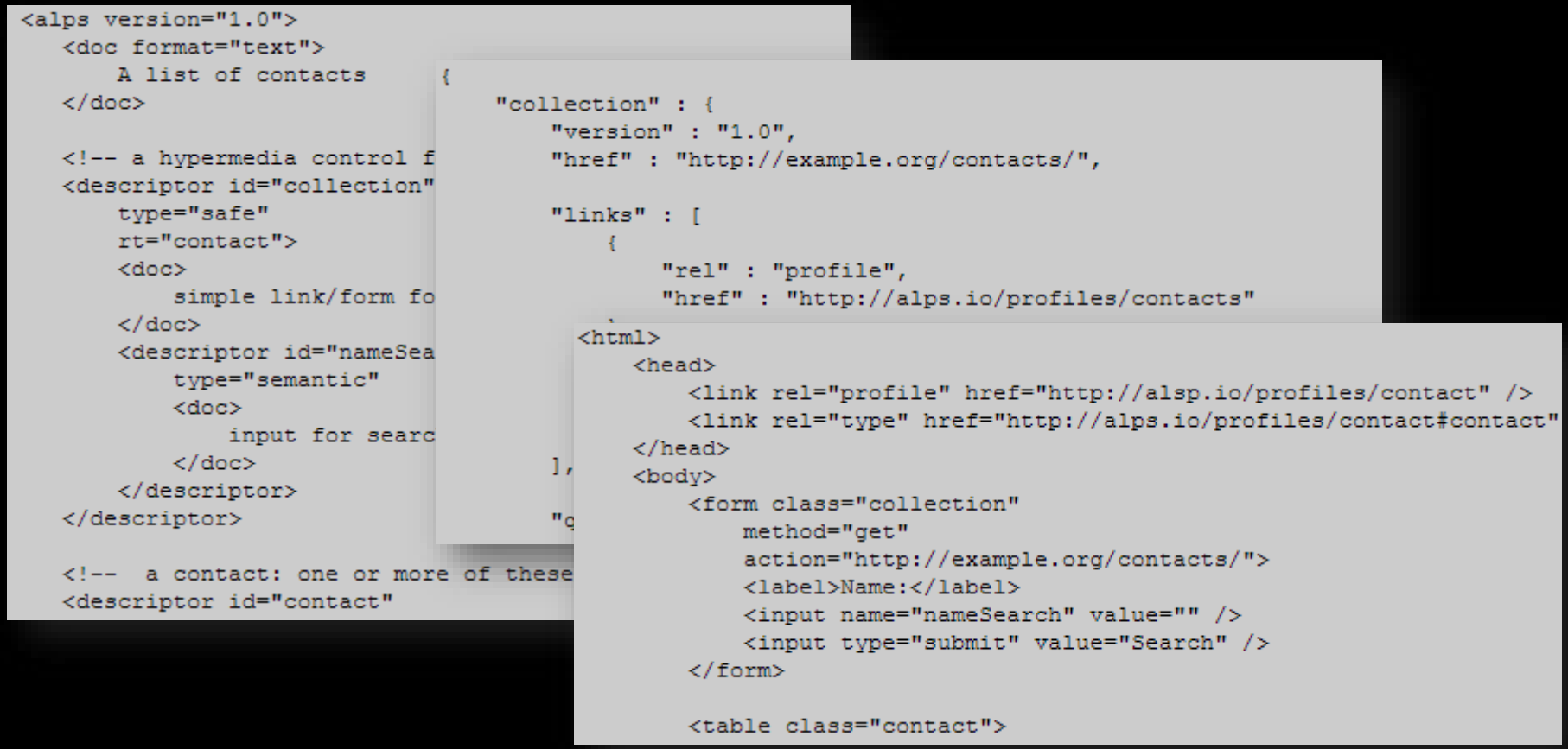




Near Term – Lowering entropy

Profiles can lower Semantic Surprise

http://alps.io



```
<alps version="1.0">
   <doc format="text">
       A list of contacts
   </doc>

   <!-- a hypermedia control f
   <descriptor id="collection"
       type="safe"
       rt="contact">
       <doc>
           simple link/form fo
       </doc>
       <descriptor id="nameSea
           type="semantic"
           <doc>
               input for searc
           </doc>
       </descriptor>
   </descriptor>

   <!--  a contact: one or more of these
   <descriptor id="contact"
```

```
{
    "collection" : {
        "version" : "1.0",
        "href" : "http://example.org/contacts/",

        "links" : [
            {
                "rel" : "profile",
                "href" : "http://alps.io/profiles/contacts"
            ],

            "q
```

```
<html>
    <head>
        <link rel="profile" href="http://alsp.io/profiles/contact" />
        <link rel="type" href="http://alps.io/profiles/contact#contact"
    </head>
    <body>
        <form class="collection"
            method="get"
            action="http://example.org/contacts/">
            <label>Name:</label>
            <input name="nameSearch" value="" />
            <input type="submit" value="Search" />
        </form>

        <table class="contact">
```

Near Term – Lowering entropy

We need more machine-oriented media types.

Text can add entropy for machines.

`rel="users"`

vs.

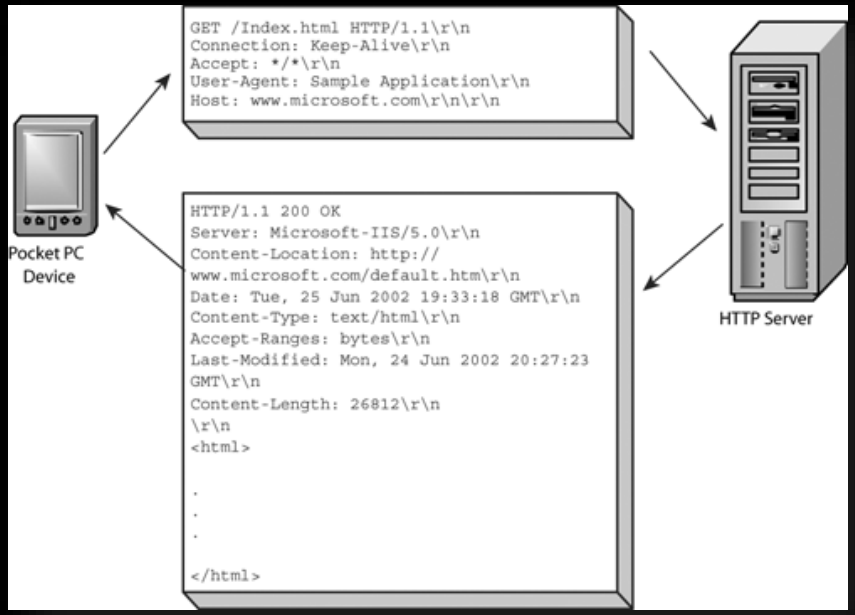
`<a … >Users</a>`

Imagine a hypermedia type that humans could not understand, but machines could.

The higher the dependence on machine-readable messages, the lower the entropy.

Near Term – Decoupling protocols

Most media type designs today assume a dependence on a single protocol – HTTP.

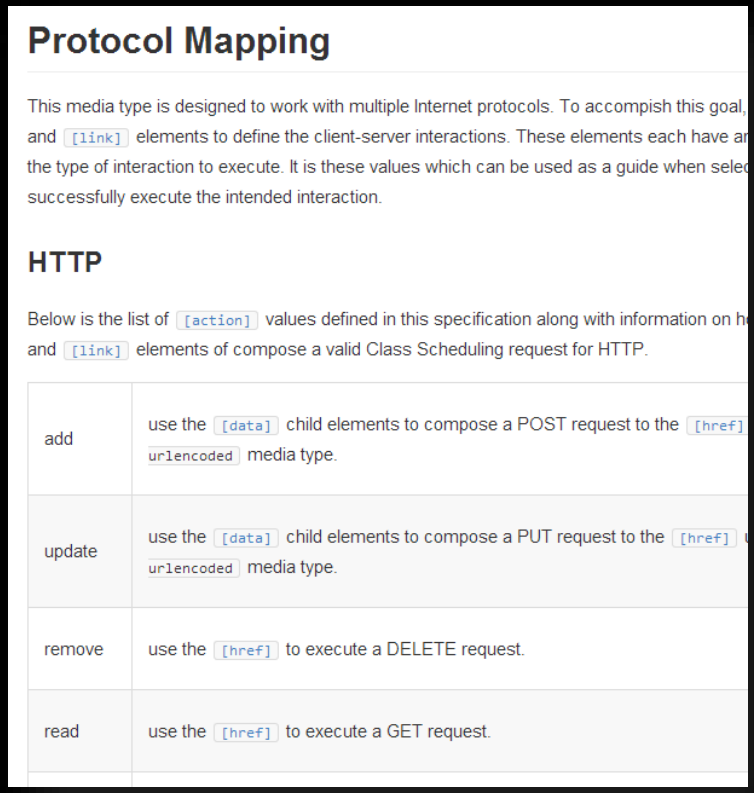


Near Term – Decoupling protocols

Message designs should be protocol-agnostic.

Use “Protocol Mapping” to associate media-type keywords with a selected protocol (HTTP, FTP, WS, CoAP, etc.)

http://g.mamund.com/class-sked



Protocol Mapping

This media type is designed to work with multiple Internet protocols. To accompish this goal, and `[link]` elements to define the client-server interactions. These elements each have ar the type of interaction to execute. It is these values which can be used as a guide when selec successfully execute the intended interaction.

HTTP

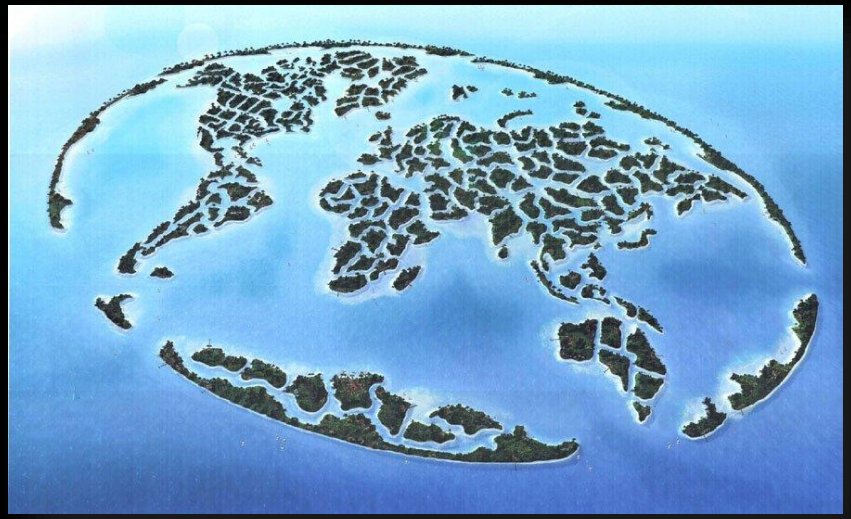
Below is the list of `[action]` values defined in this specification along with information on h and `[link]` elements of compose a valid Class Scheduling request for HTTP.

add	use the `[data]` child elements to compose a POST request to the `[href]` `urlencoded` media type.
update	use the `[data]` child elements to compose a PUT request to the `[href]` `urlencoded` media type.
remove	use the `[href]` to execute a DELETE request.
read	use the `[href]` to execute a GET request.

Near Term – Focusing on networks

Most implementations are stand-alone, one-off models.

We treat the Web as a sea filled with islands, each one only barely aware of the others.



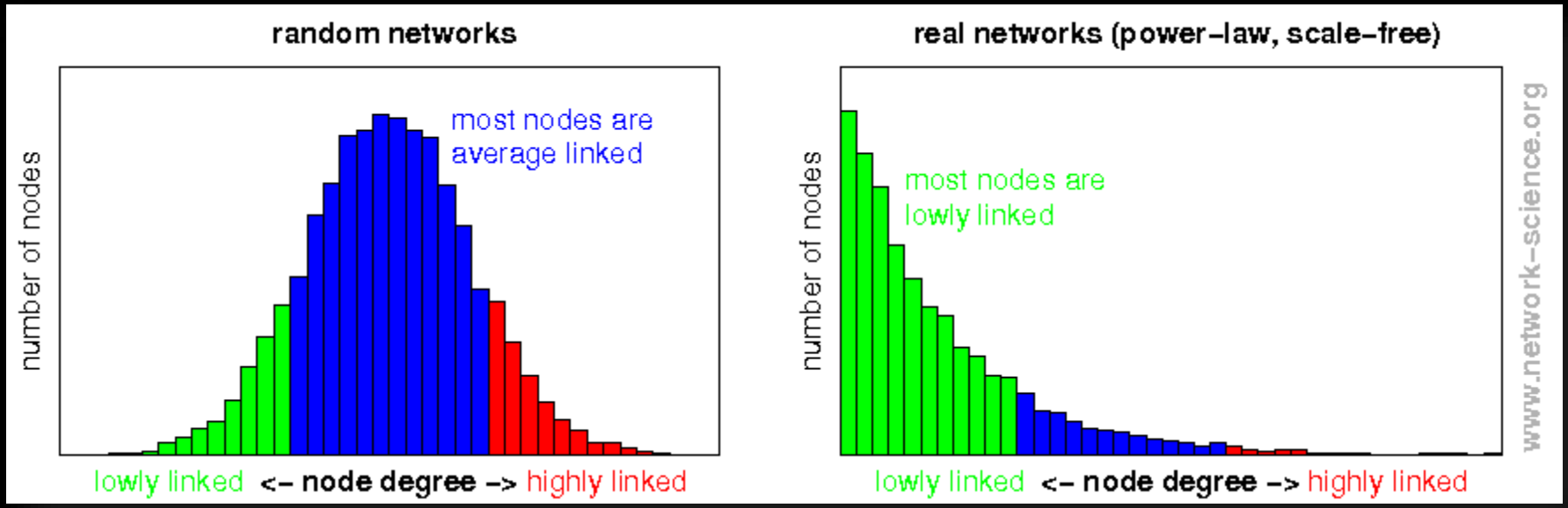
“The WWW is fundamentally a distributed hypermedia application.”

Richard Taylor (2010)

Near Term – Focusing on networks

The Web, biology, & social communities exhibit properties of a “scale-free” network

Barabási-Albert model for “preferential attachment” (1999)



Near Term

Lower entropy in messages

Reduce protocol dependence

Treat the network as the application

And there are some hard things, too.

Futures

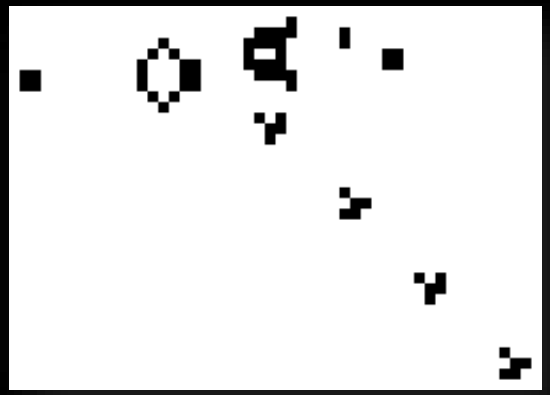
No more central control, adaptation through variation, competing for resources

Futures – No more central control

If the WWW is the application, where is the CPU? The storage? The program?

Cellular Automata (Ulam & Von Neumann, 1940s)

Conway's Game of Life (1970s)

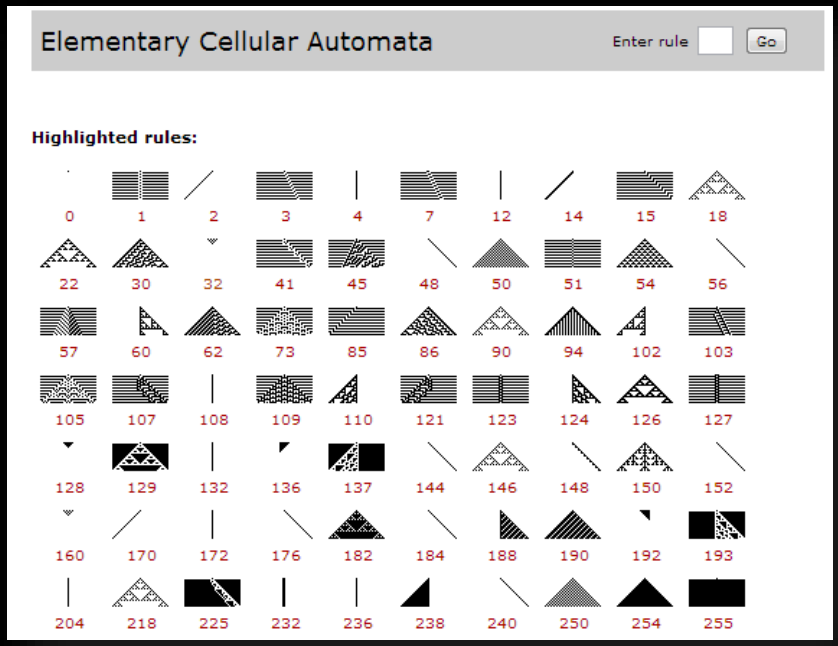


Futures – No more central control

Cellular automata are *discrete*, *abstract computational systems*

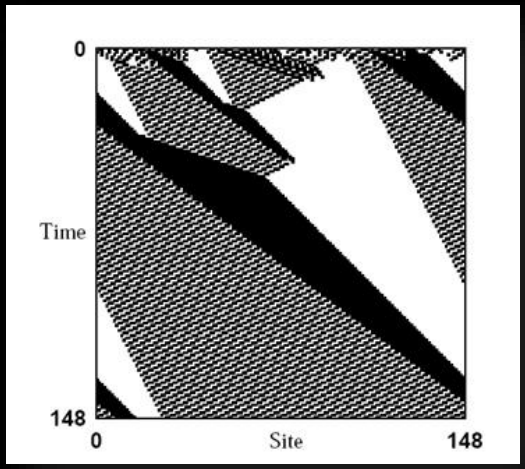
In cellular automata information appears as statistical probabilities.

See Wolfram's Atlas
http://atlas.wolfram.com/01/01/



Futures – No more central control

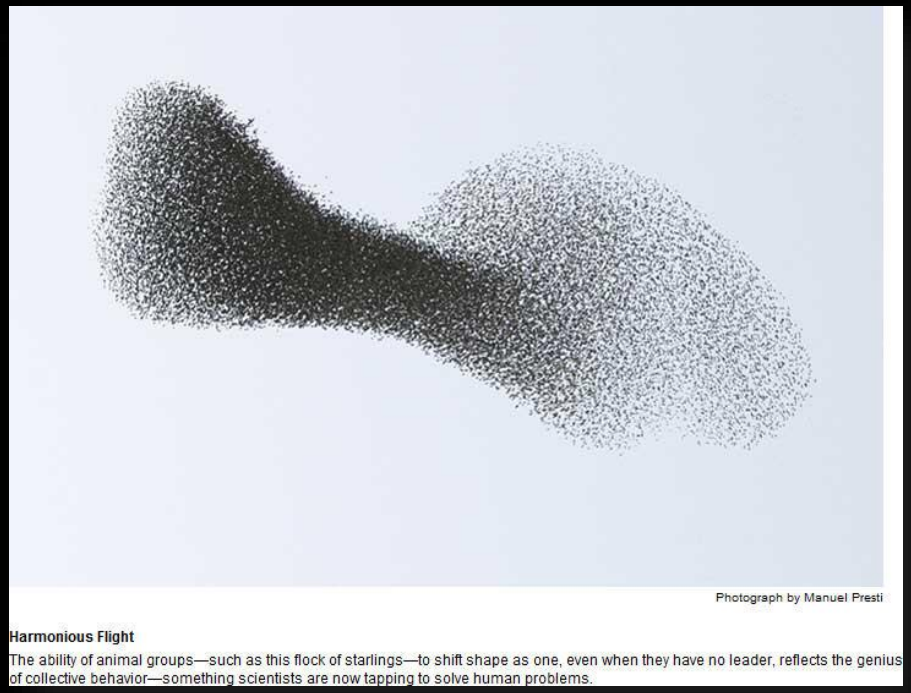
- Basic principles for automata
  - Information takes the form of statistics and patterns across the system
  - Information is communicated via sampling
  - There exists some level of random behavior
  - Rely on fine-grained architecture, large numbers of simple elements.



Futures – No more central control

In “Future Web” we will create discrete, abstract programs and they will interact across the network.

“What gets done on the ‘net stays on the ‘net.”



Photograph by Manuel Presti

Harmonious Flight

The ability of animal groups—such as this flock of starlings—to shift shape as one, even when they have no leader, reflects the genius of collective behavior—something scientists are now tapping to solve human problems.

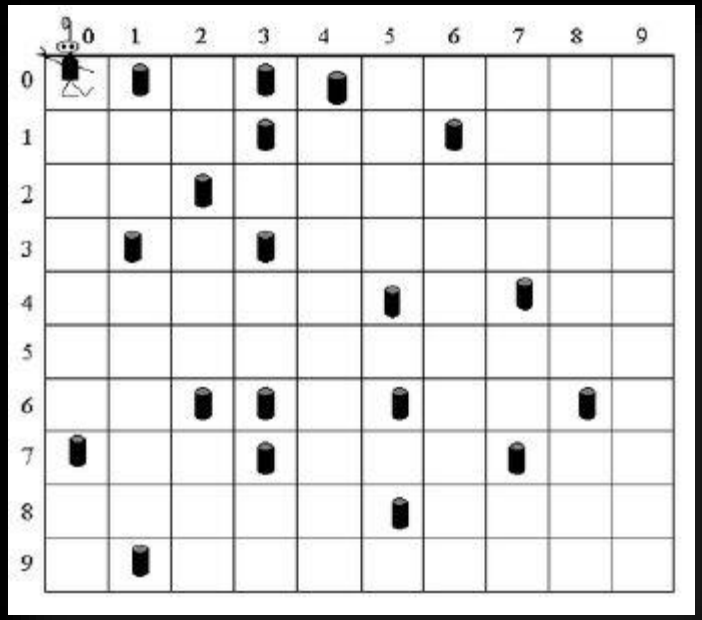
Futures – Adaptation via variation

Machines will need to adapt to conditions, learn and pass on traits.

Learning happens via many passes and survival of the ‘most fit’ for the task.

“Robby” and the soda cans

- Start w/ 1xxx random attempts
- Score highest 2, splice
- Add random mutation
- Repeat



http://g.mamund.com/robby

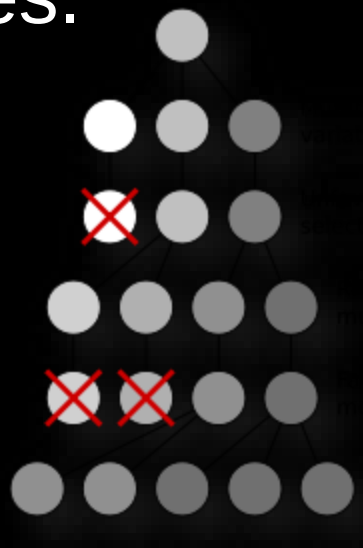
How can we model adaptation on the Web?

Futures – Competing for resources

With Robby – there is a “score-keeper” for the entire system.

On the Web there is no score-keeper.

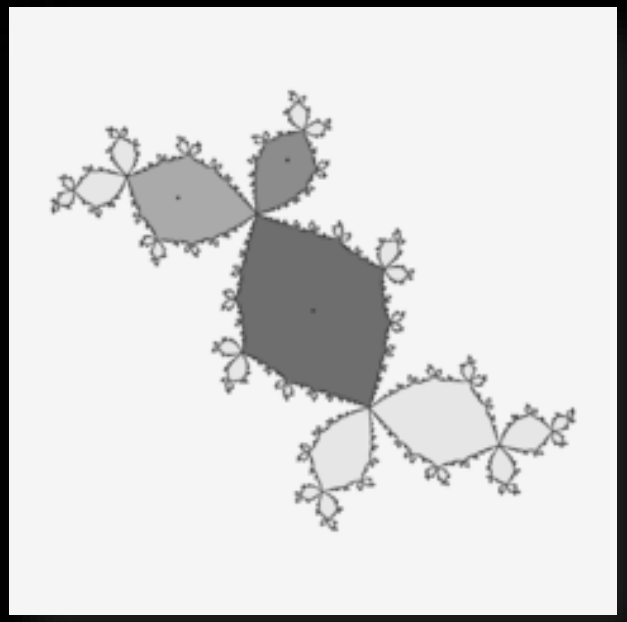
In living systems, ‘scoring’ is done through competing for limited resources.



Futures – Competing for resources

In “Future Web” programs may compete for scarce resources such as memory, storage, cycles.

RBNs (Random Boolean Networks) offer a way to “keep score” without central control. (Kauffman, 1969).



Uses attractors

- Fixed
- Oscillating
- Random

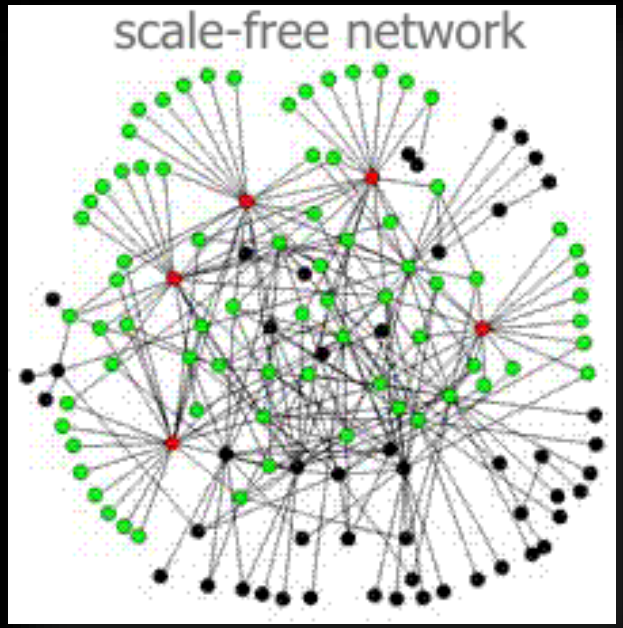
How can we model competition on the Web?

Summary

Time to head back toward shore…

Summary

Information theory, complex biological systems, hypermedia and the Web all share some similar properties

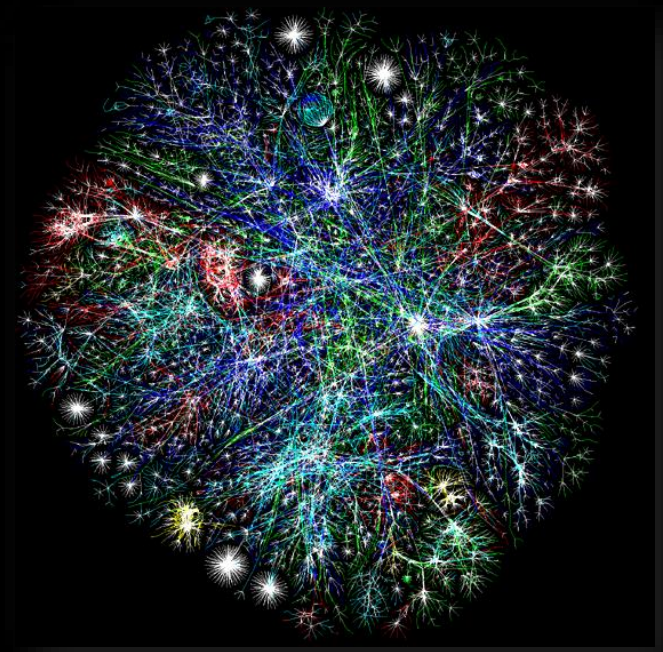


Summary

However, our current efforts ignore these features and contain a high degree of entropy, coupling, and lack interdependence.

Summary

We can start today by creating low-entropy machine-oriented messages, decouple from network protocols, and treat the network as a single application space.



Summary

In the future we'll need to give up central control, we'll build discrete automata, and we'll create a network where variation and competition are possible.

However, in order to accomplish all that…

How long before we realize this Autonomous Web?

Hofstader's Law

"Things take longer than you think, even if you take Hofstader's Law into account."

- Douglas Hofstader

Just remember…

“Those who ignore the mistakes of the future are bound to make them.”

Joseph D. Miller, 2006


We must be willing to lose sight of the shore.

Dreams, Lies, and the Autonomous Web

Mike Amundsen
CA Technologies
@mamund

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