

COMPUTING: NOW AND FOREVER

Henry C. Foley
University of Missouri
CI Day October 10, 2013



To Compute

com·pute  *verb* \kəm-'pyüt\
: to find out (something) by using mathematical processes

com·put·ed | **com·put·ing**

Full Definition of COMPUTE



transitive verb

: to determine especially by mathematical means; *also* : to determine or calculate by means of a **computer**

AN ENCYCLOPÆDIA
BRITANNICA COMPANY



m-w.com

Why do we compute?



For any x what are the values of $f(x)$?

$$f(x) = 9x^2 + 3x^3 - 7$$

$$f(0) = 9 \cdot 0 + 3 \cdot 0 - 7 = -7$$

$$f(1) = 9 \cdot 1 + 3 \cdot 1 - 7 = 12 - 7 = 5$$

$$f(2) = 9 \cdot 2^2 + 3 \cdot 2^3 - 7 = 9 \cdot 4 + 3 \cdot 8 - 7 = 36 + 24 - 7 = 53$$

$$f(3) = 9 \cdot 3^2 + 3 \cdot 3^3 - 7 = 9 \cdot 9 + 3 \cdot 27 - 7 = 81 + 81 - 7 = 162 - 7 = 155$$

$$f(4) = 9 \cdot 4^2 + 3 \cdot 4^3 - 7 = 9 \cdot 16 + 3 \cdot 64 - 7 = 144 + 192 - 7 = 336 - 7 = 329$$

$$f(5) = 9 \cdot 5^2 + 3 \cdot 5^3 - 7 = 9 \cdot 25 + 3 \cdot 125 - 7 = 225 + 375 - 7 = 600 - 7 = 593$$

$$f(6) = 9 \cdot 6^2 + 3 \cdot 6^3 - 7 = 9 \cdot 36 + 3 \cdot 216 - 7 = (180 + 54) + (600 + 48) - 7 = \\ (200 + 30 + 600 + 45) = 830 + 45 = 875$$

“Hal --- I am tired, please take over for me!”

$f(x) = 9x^2 + 3x^3 - 7$ in Excel

x	$f(x) = 9x^2 + 3x^3 - 7$
0	$9*A2^2 + 3*A2^3 - 7$
1	$9*A3^2 + 3*A3^3 - 7$
2	$9*A4^2 + 3*A4^3 - 7$
3	$9*A5^2 + 3*A5^3 - 7$
4	$9*A6^2 + 3*A6^3 - 7$
5	$9*A7^2 + 3*A7^3 - 7$
6	$9*A8^2 + 3*A8^3 - 7$
7	$9*A9^2 + 3*A9^3 - 7$
8	
9	
10	
11	
12	
13	



x	$f(x) = 9x^2 + 3x^3 - 7$
0	-7
1	5
2	53
3	155
4	329
5	593
6	965
7	1463
8	2105
9	2909
10	3893
11	5075
12	6473
13	8105

Brute Force Direct Approach

$$f(x) = 9x^2 + 3x^3 - 7$$

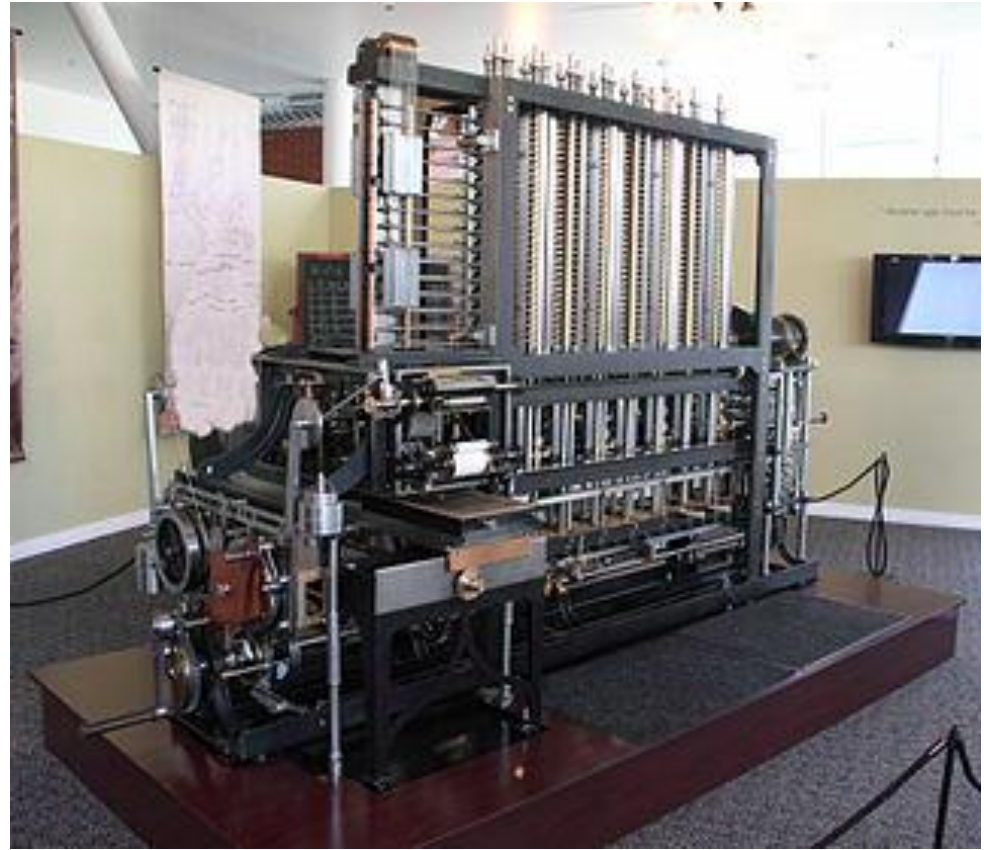
nth difference of an nth order polynomial is a constant

x	$f(x) = 9x^2 + 3x^3 - 7$	$Del1(x) = f(x+1) - f(x)$	$Del2(x) = Del1(x+1) - Del1(x)$	$Del3(x) = Del2(x+1) - Del2(x)$
0	-7	12	36	18
1	5	48	54	18
2	53	102	72	18
3	155	174	90	18
4	329	264	108	18
5	593	372	126	18
6	965	498	144	18
7	1463	642	162	18
8	2105	804	180	18
9	2909	984	208	18
10	3893	1192		
11	5085			
12				
13				

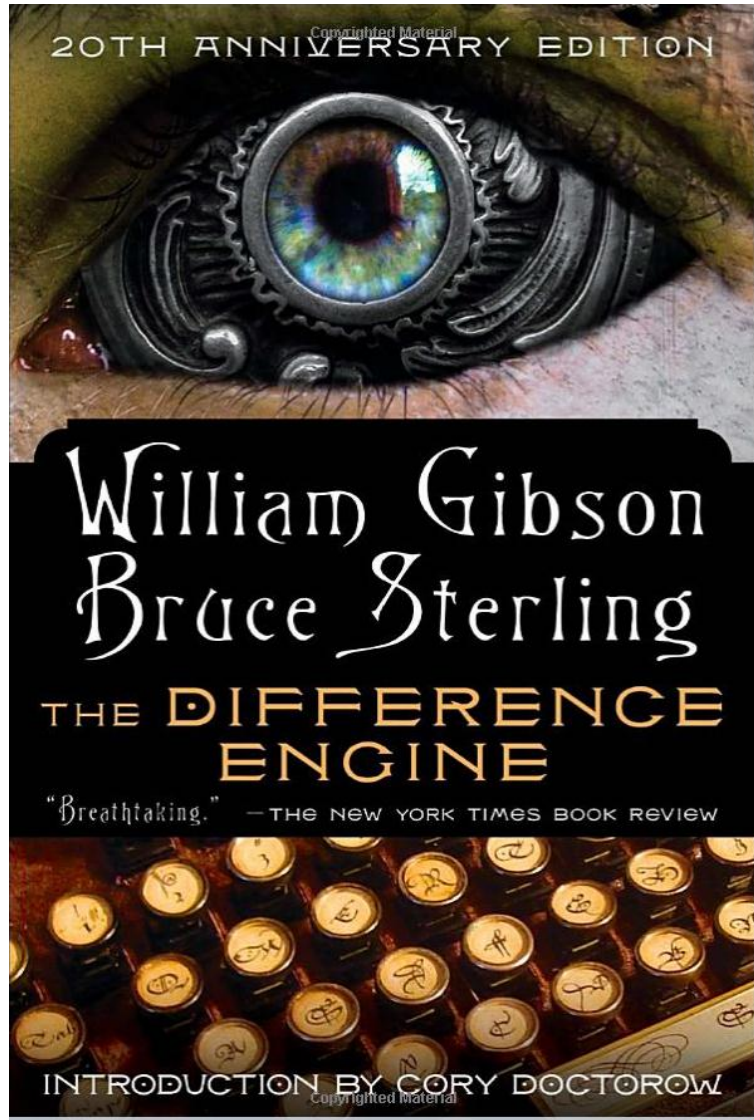
Indirect Algorithm Shortcut

Knowing more fundamentals is better

Babbage's Difference Machine



Cyber-Punk Literature



Lady Ada Lovelace

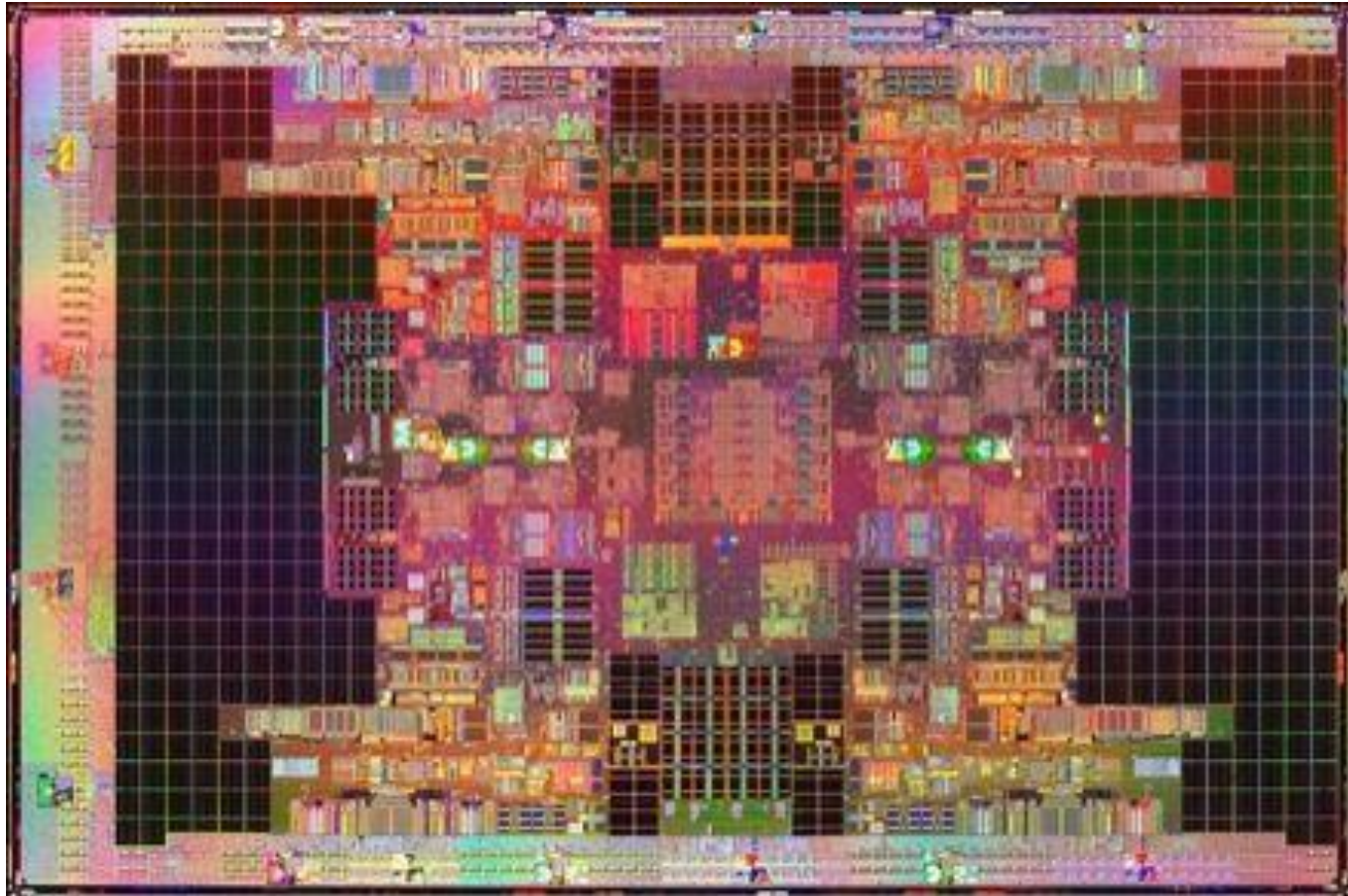
What material to use to make these gears ?



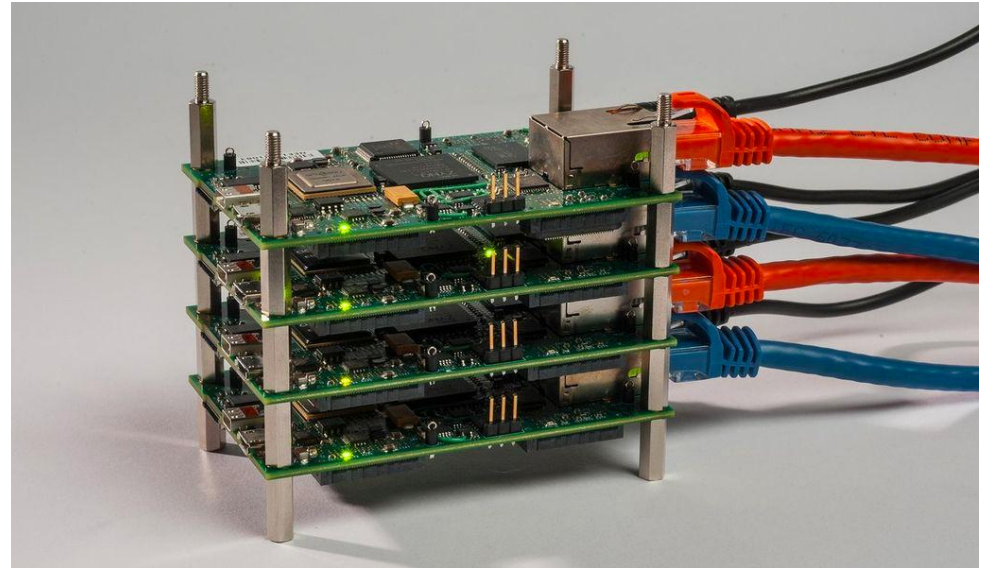
Forget about them



Very Large Scale Integration



Beowulf (or Grendel)

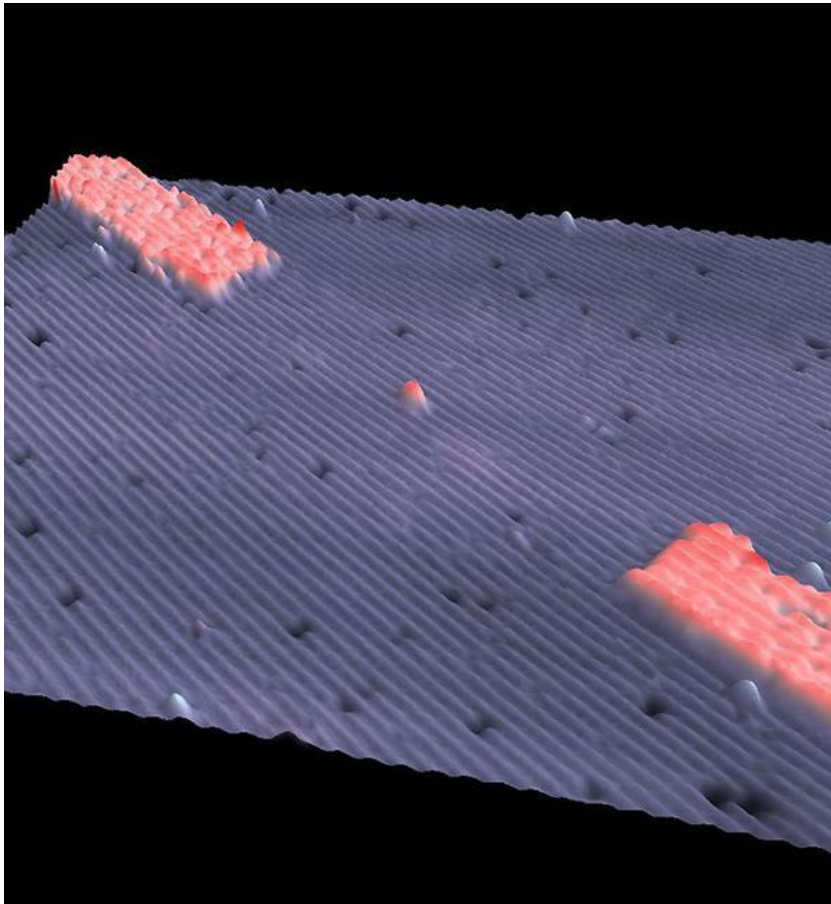


Fast enough? Never



Tianhe-2, or Milky Way-2, clocked in at number one with a performance of 33.86 petaflops per second,
HCP

The smallest transistor



nature
nanotechnology

[nature.com](#) > [journal home](#) > [archive](#) > [issue](#) > [letter](#) > [full text](#)

NATURE NANOTECHNOLOGY | LETTER



A single-atom transistor

Martin Fuechsle, Jill A. Miwa, Suddhasatta Mahapatra, Hoon Ryu, Sunhee Lee, Oliver Warschkow, Lloyd C. L. Hollenberg, Gerhard Klimeck & Michelle Y. Simmons

[Affiliations](#) | [Contributions](#) | [Corresponding author](#)

Nature Nanotechnology 7, 242–246 (2012) | doi:10.1038/nnano.2012.21

Received 16 December 2011 | Accepted 26 January 2012 | Published online 19 February 2012



PDF



Citation



Reprints



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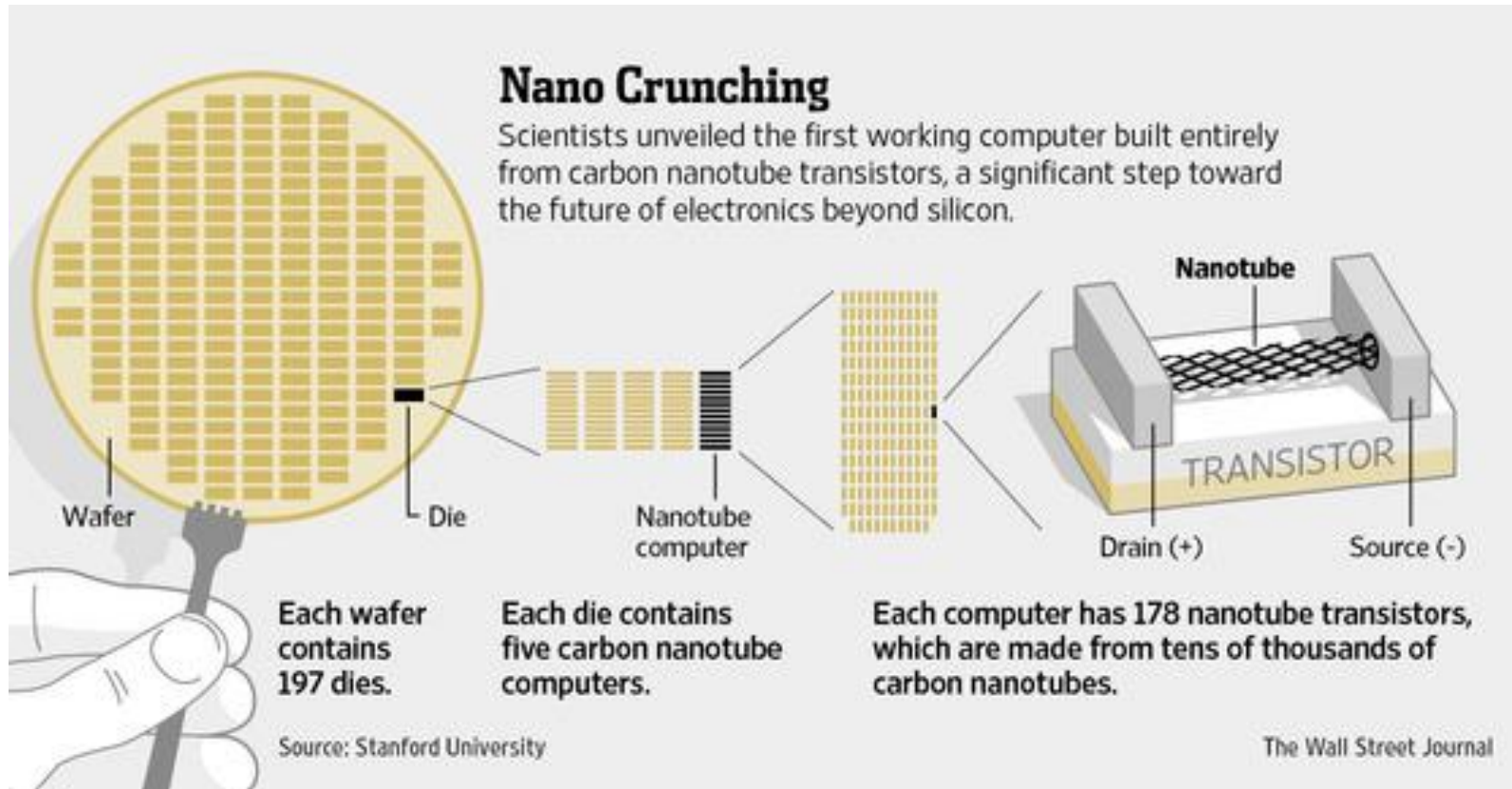
Article metrics

Abstract

[Abstract](#) · [Main](#) · [Methods](#) · [References](#) · [Acknowledgements](#) · [Author information](#)

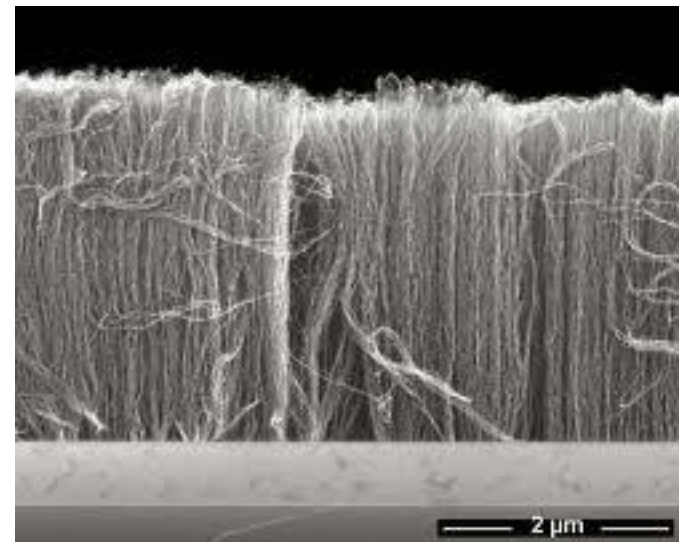
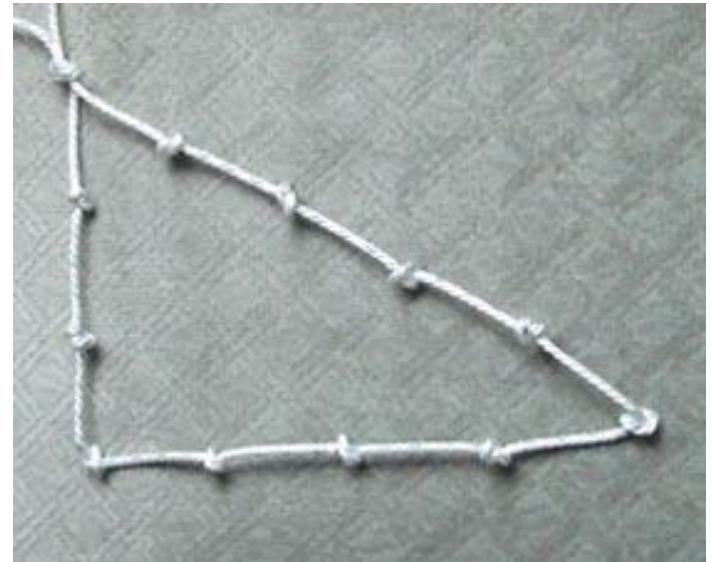
The ability to control matter at the atomic scale and build devices with atomic precision is central to nanotechnology. The scanning tunnelling microscope¹ can manipulate individual atoms² and molecules on surfaces, but the manipulation of silicon to make atomic-scale logic circuits has been hampered by the covalent nature of its bonds. Resist-based strategies have allowed the formation

Carbon Nanotube Computer



Upshots and Observations

- We used to compute because “computing” was painfully hard work, subject to human error and, yet, very necessary
- We compute today for the these reasons and a plethora of other reasons that involve pleasure as well as utility/pain
- For the most part computing is still a brute force technology – human intuition and insight are very different
 - Knowing more is better and powerful
 - Quantum Mechanics/Quantum Information Theory
- Progress in Computing and progress in materials science go hand-in-hand
 - From the knots in ropes to brass gears, to silicon crystals to carbon nanotubes one drives the other
 - Be aware of biological science



SCIENTIFIC AMERICAN

The Search For the Origins of Mass

MARCH 2005
WWW.SCIAM.COM

\$4.99

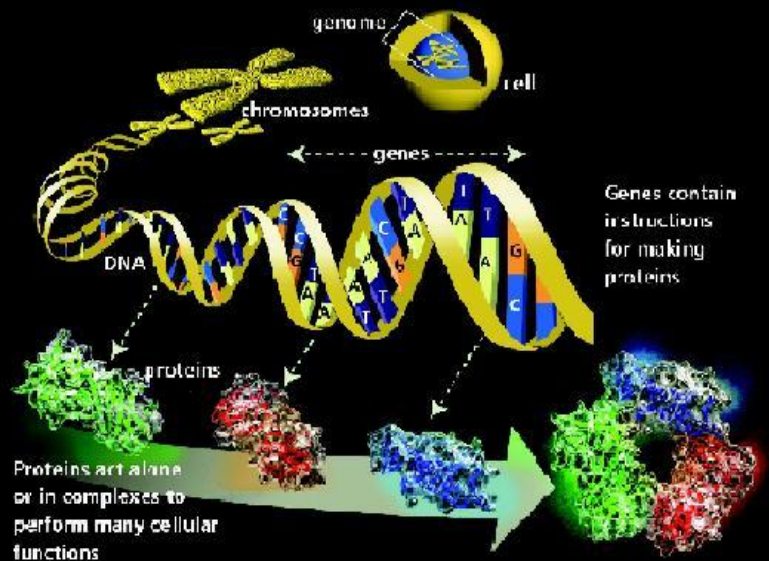
DNA Computers

BIOLOGICAL DECISION MAKING
MOLECULAR MACHINES
SPEAK DIRECTLY TO CELLS

The Birth of
The Amazon

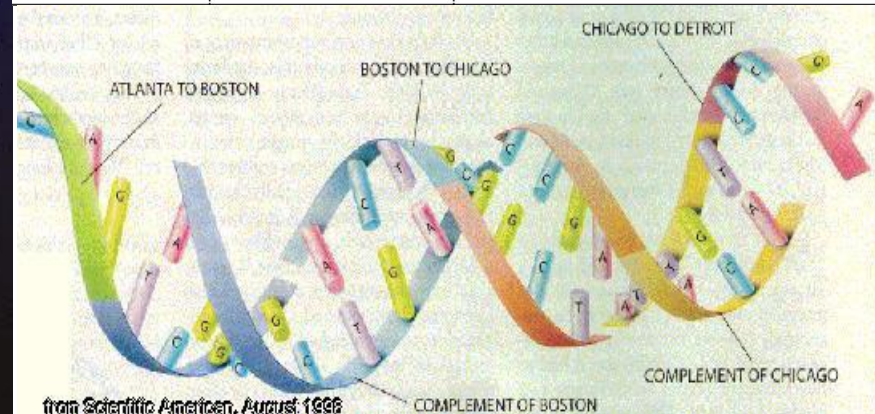
Rise and Fall of
The Slide Rule

The Future of
Giant Telescopes



U.S. DEPARTMENT OF ENERGY

input $w_{1,2}$ (1x)		S_1 T S_2 <ACCTCTCATCTATCACCCACTCTTTATCAATCTAC>
gate/output $g_{2,2,3}$ (10x)		S_2 T S_3 <TCTTTATCAATCTACCCACCTCCCAACCTTCAT> >GGTGGAGAAATAGTTAGATGGGTGG> T' S_2' T'
fuel $w_{2,4}$ (10x)		S_2 T S_4 <TCTTTATCAATCTACCCACCACATCCCCATTACC>
threshold $th_{1,2,2}$ (0.5x)		S_2 <TCTTTATCAATCTAC> >AGTGGTGGAGAAATAGTTAGATG> S_1' T' S_2'



For any x what are the values of f(x)?

$$f(x) = 9x^2 + 3x^3 - 7$$

```
In[1]:= f[x_] := 9*x^2 + 3*x^3 - 7
Table[{x, f[x]}, {x, 0, 100}];
Timing[%]
```

Wolfram's Mathematica
2 GHz Intel Core i7
MacBook Air

```
Out[3]= {5. × 10-6, {{0, -7}, {1, 5}, {2, 53}, {3, 155}, {4, 329}, {5, 593}, {6, 965},
{7, 1463}, {8, 2105}, {9, 2909}, {10, 3893}, {11, 5075}, {12, 6473}, {13, 8105},
{14, 9989}, {15, 12143}, {16, 14585}, {17, 17333}, {18, 20405}, {19, 23819},
{20, 27593}, {21, 31745}, {22, 36293}, {23, 41255}, {24, 46649}, {25, 52493},
{26, 58805}, {27, 65603}, {28, 72905}, {29, 80729}, {30, 89093}, {31, 98015},
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{44, 272969}, {45, 291593}, {46, 311045}, {47, 331343}, {48, 352505}, {49, 374549},
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{71, 1119095}, {72, 1166393}, {73, 1215005}, {74, 1264949}, {75, 1316243},
{76, 1368905}, {77, 1422953}, {78, 1478405}, {79, 1535279}, {80, 1593593},
{81, 1653365}, {82, 1714613}, {83, 1777355}, {84, 1841609}, {85, 1907393},
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{91, 2335235}, {92, 2412233}, {93, 2490905}, {94, 2571269}, {95, 2653343},
{96, 2737145}, {97, 2822693}, {98, 2910005}, {99, 2999099}, {100, 3089993}}}
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Computing Writ Large

The [ACM Computing Curricula 2005](#)^[1] defined "computing" as follows:

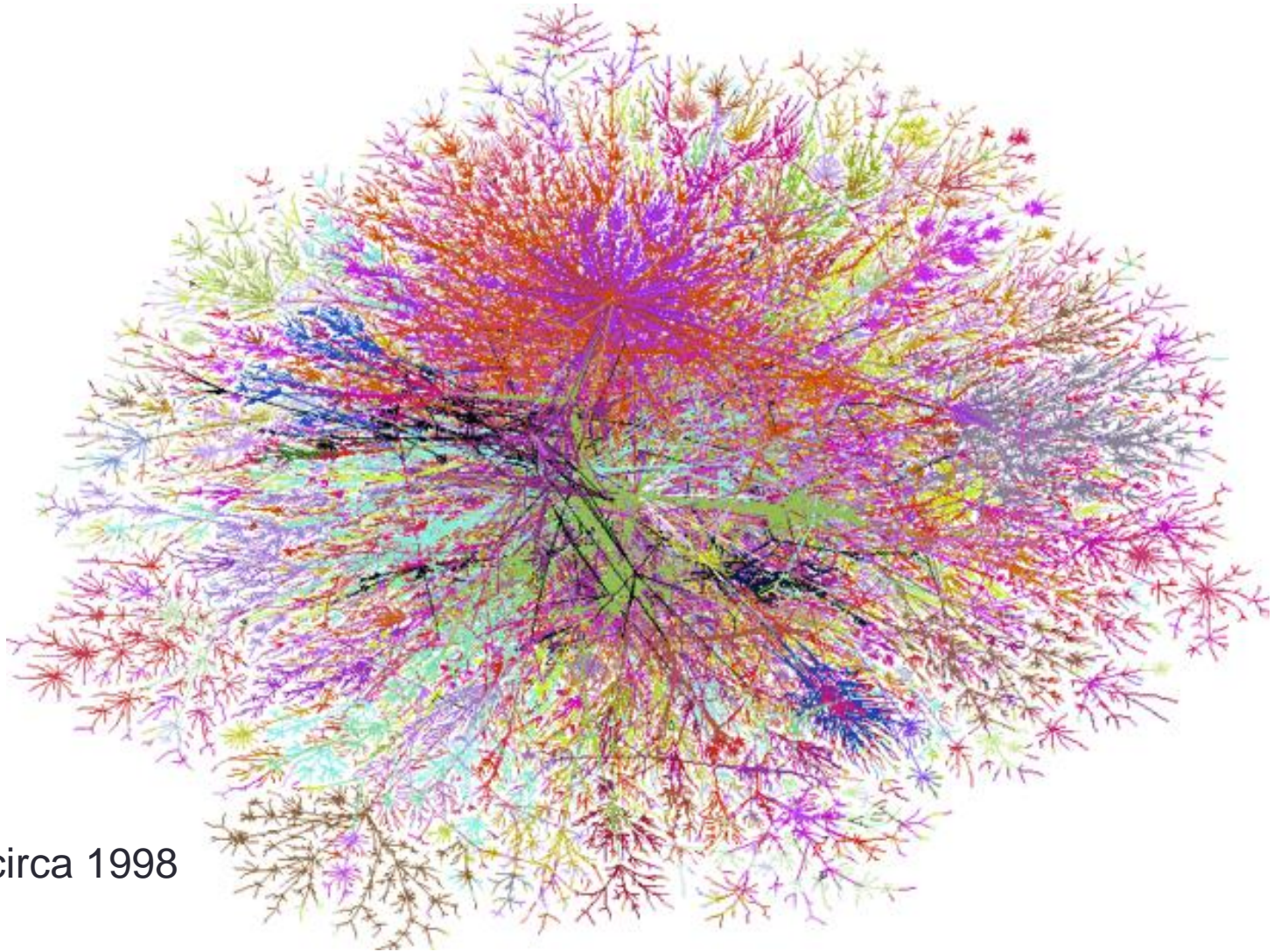
"In a general way, we can define computing to mean any goal-oriented activity requiring, benefiting from, or creating computers. Thus, computing includes designing and building hardware and software systems for a wide range of purposes; processing, structuring, and managing various kinds of information; doing scientific studies using computers; making computer systems behave intelligently; creating and using communications and entertainment media; finding and gathering information relevant to any particular purpose, and so on. The list is virtually endless, and the possibilities are vast."

and it defines five sub-disciplines of the *computing* field: [Computer Science](#), [Computer Engineering](#), [Information Systems](#), [Information Technology](#), and [Software Engineering](#).^[2]

BIG Data and Really BIG data



2.5 Quintillion bytes of data every day



Internet circa 1998

Beyond Yottabytes to “Hellabytes” of Data



NSA Center in Bluffdale, UTAH



Growing Haystack

The NSA's demand for space to store its giant piles of communications data is growing rapidly. Experts estimate the new center in Utah can store data by the exabyte or zettabyte.

One kilobyte/KB (1,000 bytes): A small email text is about 2 KB

One megabyte/MB = 1,000 KB

A floppy disk from the 1980s held around 1.44 megabytes



One gigabyte/GB = 1,000 MB

A common flash drive holds 16 gigabytes



One terabyte/TB = 1,000 GB

The base storage on a new Apple iMac



One petabyte/PB = 1,000 TB

250,000 DVDs or a digital library of all books ever written in any language



One exabyte/EB = 1,000 PB

250 million DVDs; 175 exabytes of data traversed the Internet in 2010



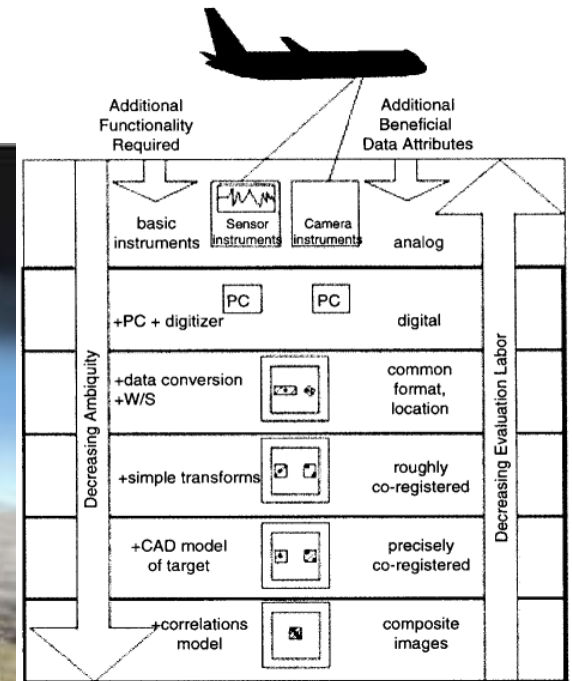
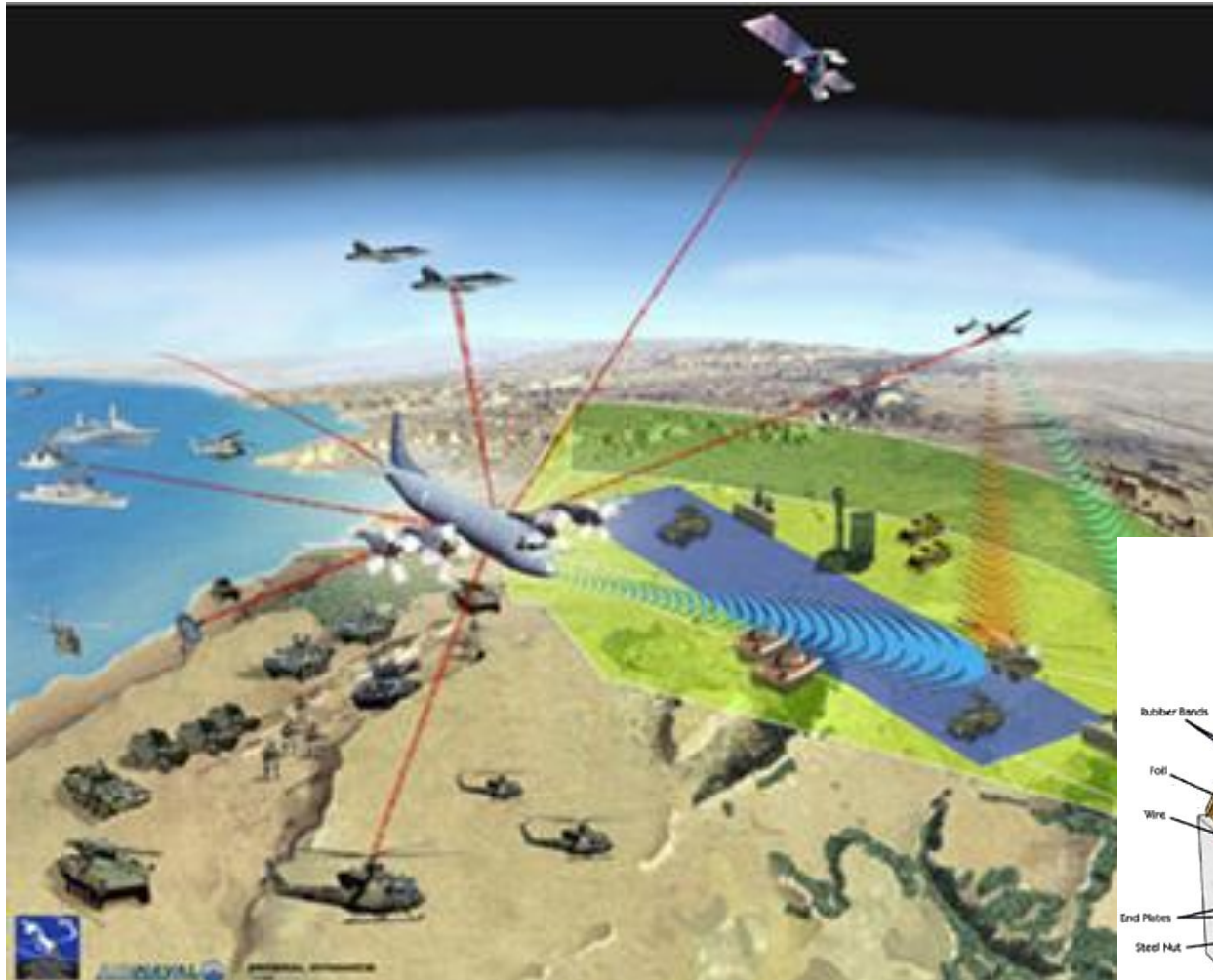
One zettabyte/ZB = 1,000 EB

250 billion DVDs or about half of the world's data created or copied in 2011

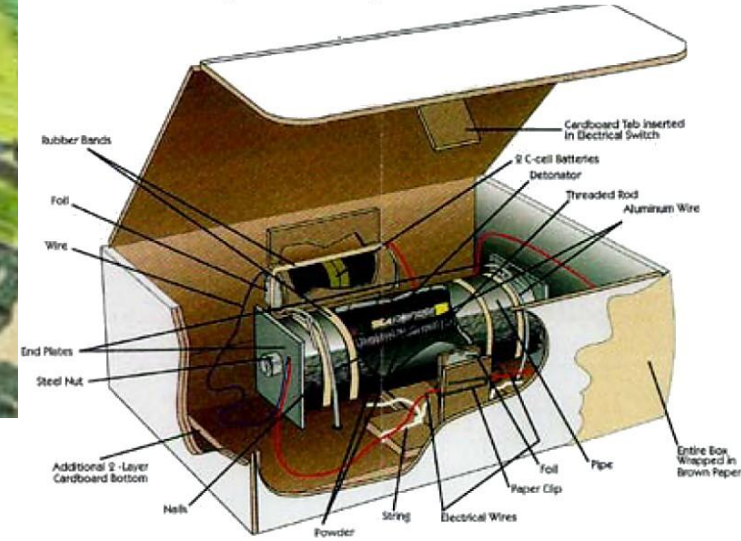


Exabytes or zettabytes: Estimated range of amount of data stored by the NSA in Bluffdale, Utah

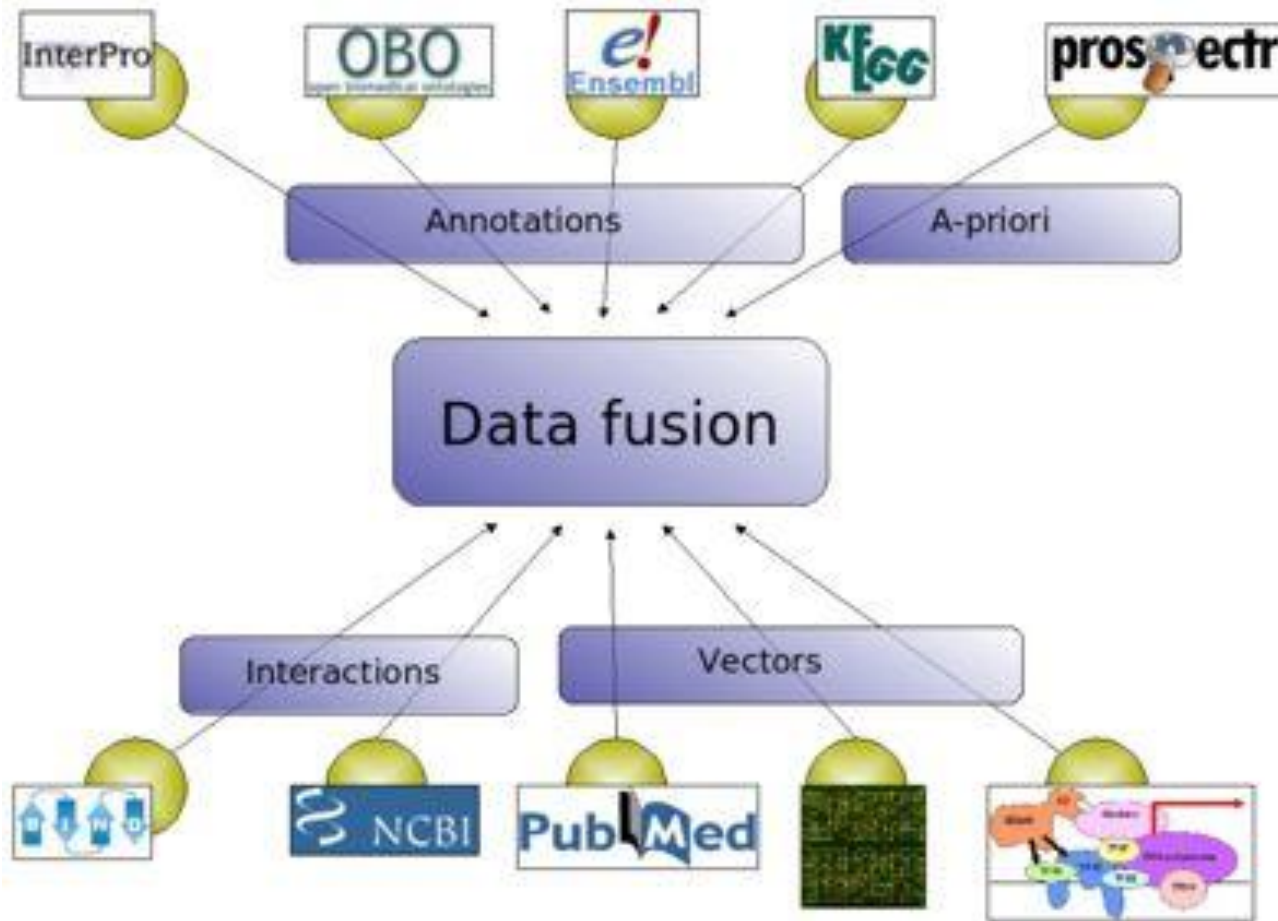
Data Fusion



Improvised Explosive Device



Military to Civilian Transition



Google Translate: "Statistical Machine Translation"

What is Google Translate?

Google Translate is a free translation service that provides instant translations between dozens of different languages. It can translate words, sentences and web pages between any combination of our supported languages. With Google Translate, we hope to make information universally accessible and useful, regardless of the language in which it's written.



How does it work?

When Google Translate generates a translation, it looks for patterns in hundreds of millions of documents to help decide on the best translation for you. By detecting patterns in documents that have already been translated by human translators, Google Translate can make intelligent guesses as to what an appropriate translation should be. This process of seeking patterns in large amounts of text is called "statistical machine translation". Since the translations are generated by machines, not all translation will be perfect. The more human-translated documents that Google Translate can analyse in a specific language, the better the translation quality will be. This is why translation accuracy will sometimes vary across languages.

What languages does Google Translate support?

Google Translate currently supports:

- | | | | | |
|------------|-----------|------------|------------|------------|
| Afrikaans | Dutch | Hindi | Malay | Spanish |
| Albanian | English | Hungarian | Maltese | Swahili |
| Arabic | Esperanto | Icelandic | Norwegian | Swedish |
| Belarusian | Estonian | Indonesian | Persian | Thai |
| Bosnian | Filipino | Irish | Polish | Turkish |
| Bulgarian | Finnish | Italian | Portuguese | Ukrainian |
| Catalan | French | Japanese | Romanian | Vietnamese |
| Chinese | Galician | Korean | Russian | Welsh |
| Croatian | German | Latvian | Serbian | Yiddish |
| Czech | Greek | Lithuanian | Slovak | |
| Danish | Hebrew | Macedonian | Slovenian | |

Supported languages:
71

Current alpha languages are:

- | | | | | |
|-------------|----------------|----------|---------|--------|
| Armenian | Cebuano | Hmong | Lao | Telugu |
| Azerbaijani | Georgian | Javanese | Latin | Urdu |
| Basque | Gujarati | Kannada | Marathi | |
| Bengali | Haitian Creole | Khmer | Tamil | |

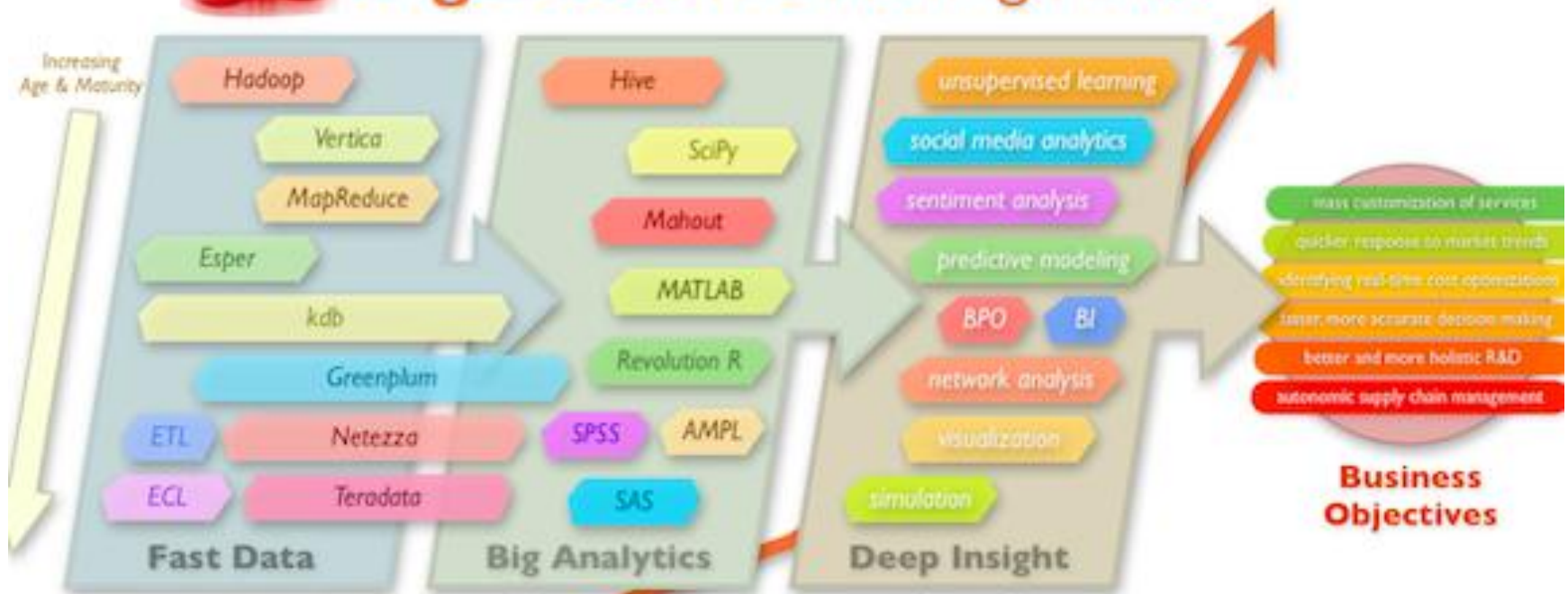


Google Translate tests other languages, called "alpha languages", that may have less-reliable translation quality than our supported languages. We are always working to support other languages and will introduce them as soon as the translation quality meets our standards.

From Terabytes to Zettabytes



Big Data: The Moving Parts



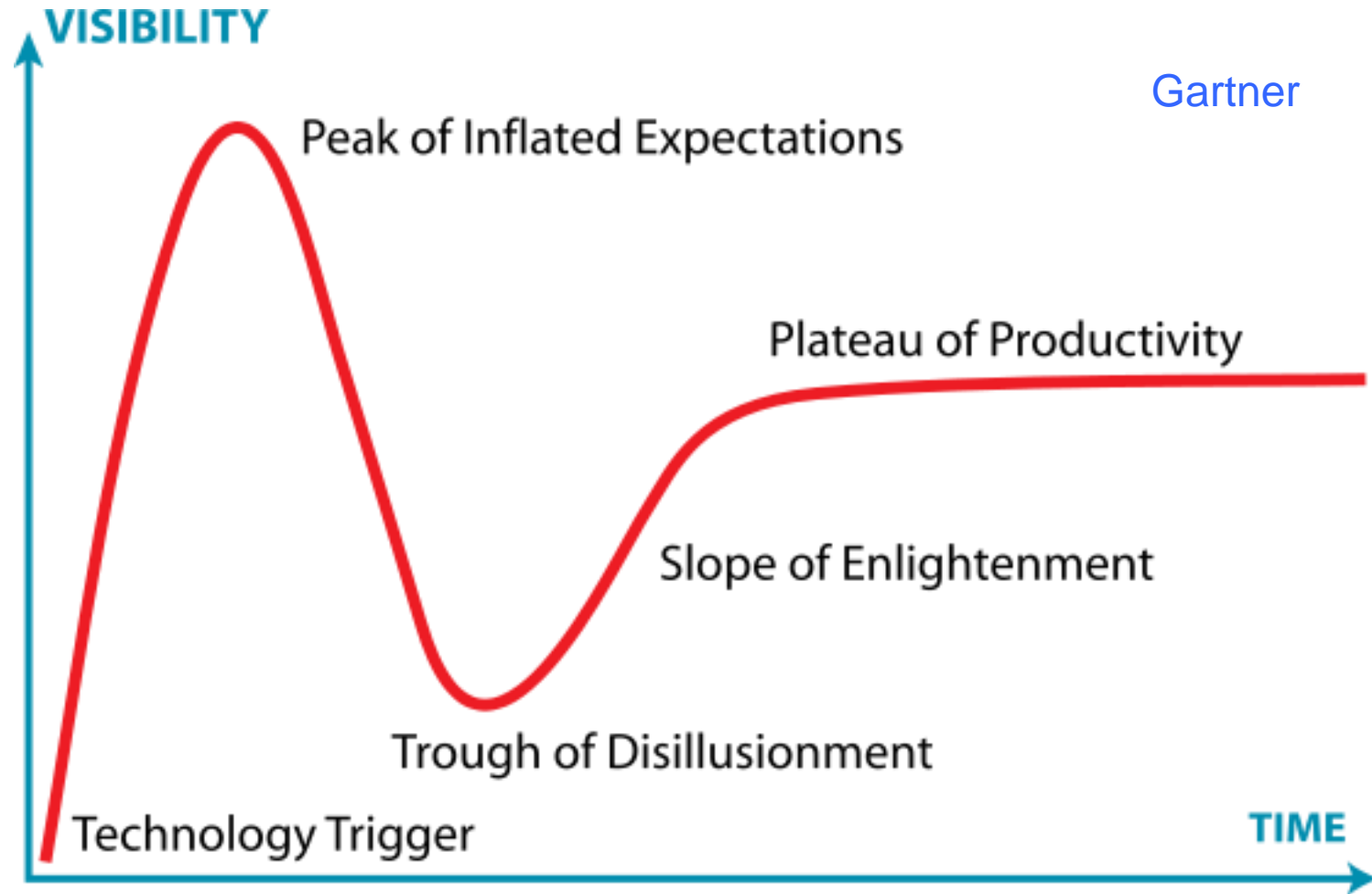
From <http://blogs.zdnet.com/Hirschcliff>

the growth of data will be exponential for the foreseeable future

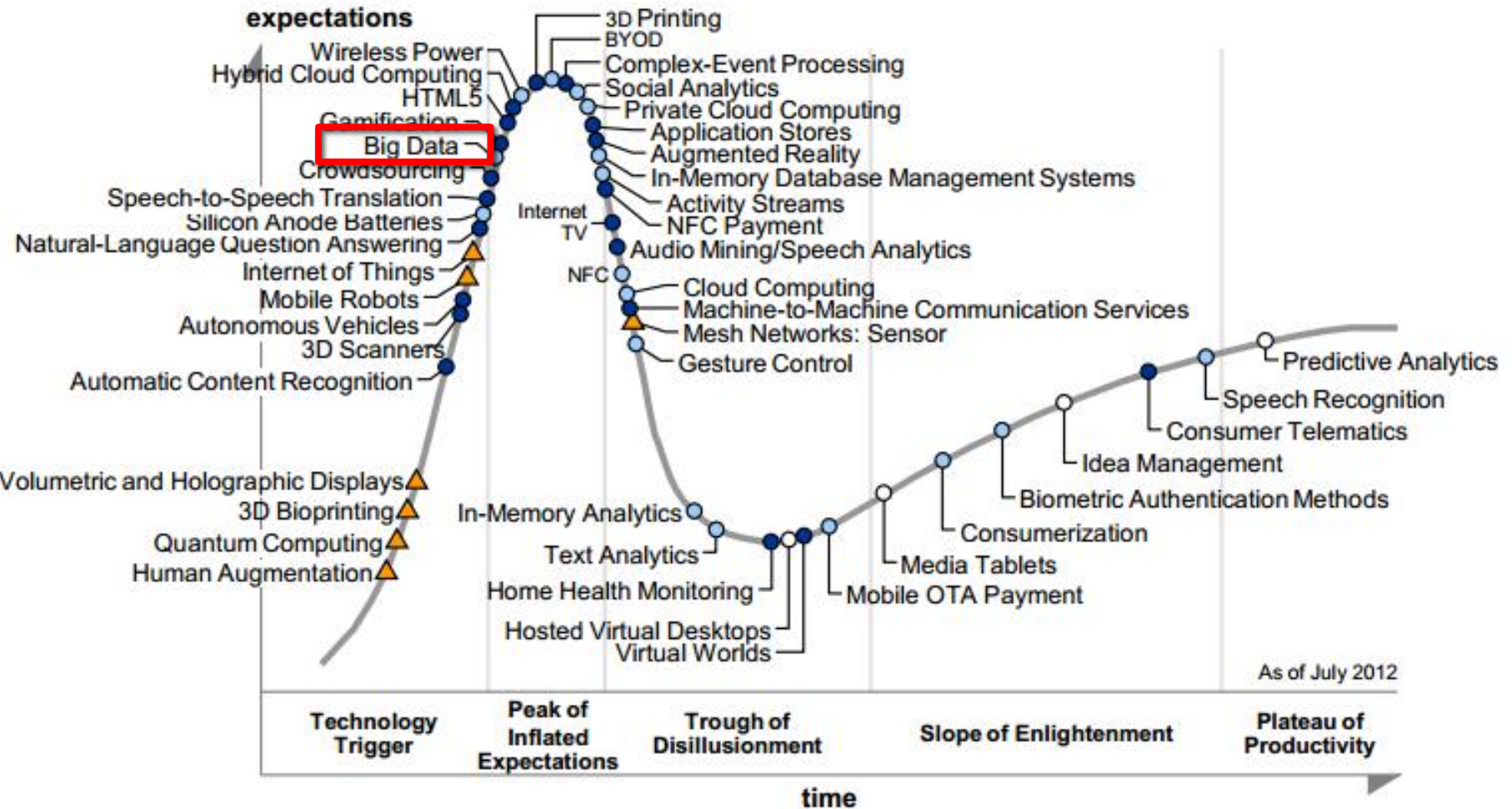


the amount of data stored by the average company today

Generalized HYPE CYCLE



Emerging Technologies Hype Cycle 2012



Plateau will be reached in:

○ less than 2 years

● 2 to 5 years

● 5 to 10 years

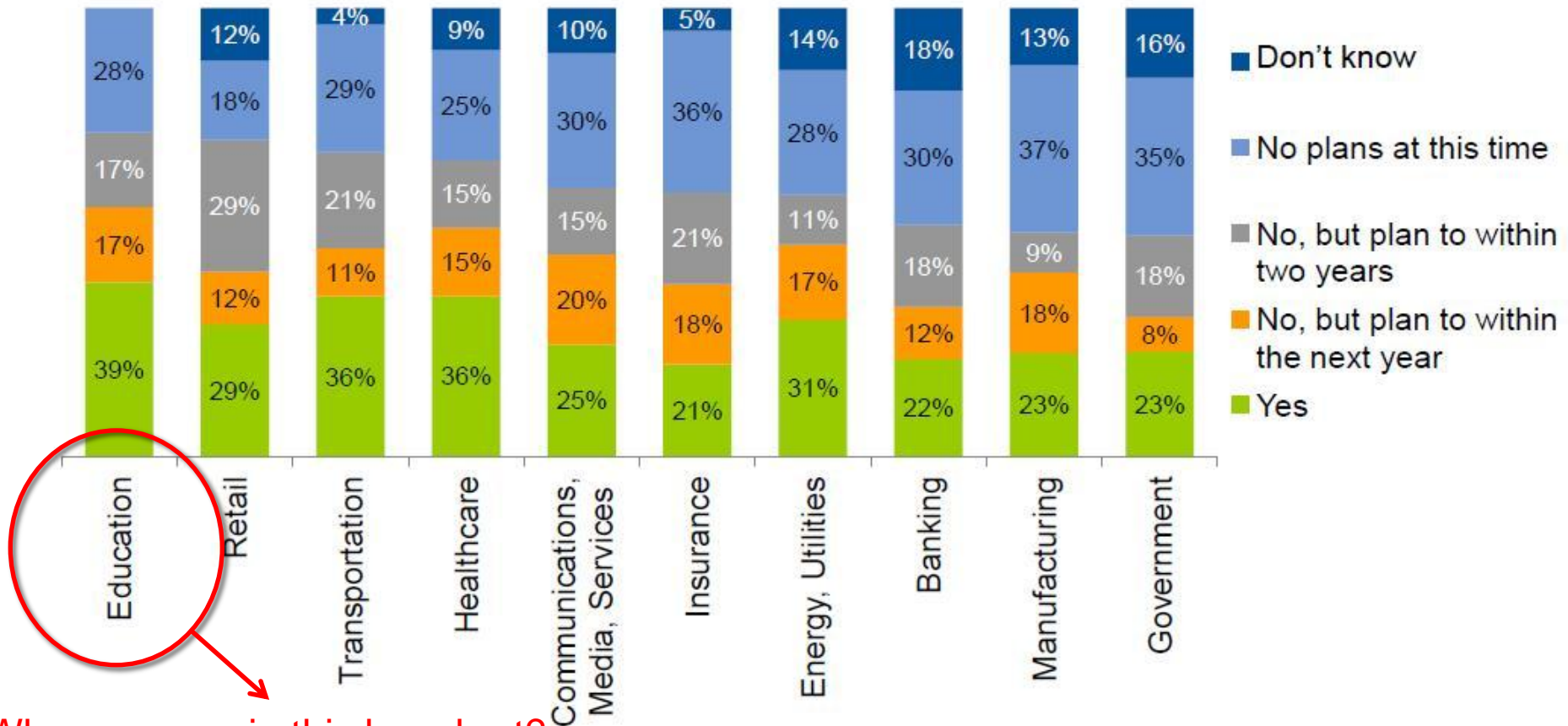
▲ more than 10 years

⊗ obsolete

⊗ before plateau

Big Data Investments by Industry

Has your organization already invested in technology specifically designed to address the big data challenge?



Where are we in this bar chart?

Source: Gartner (July 2012)

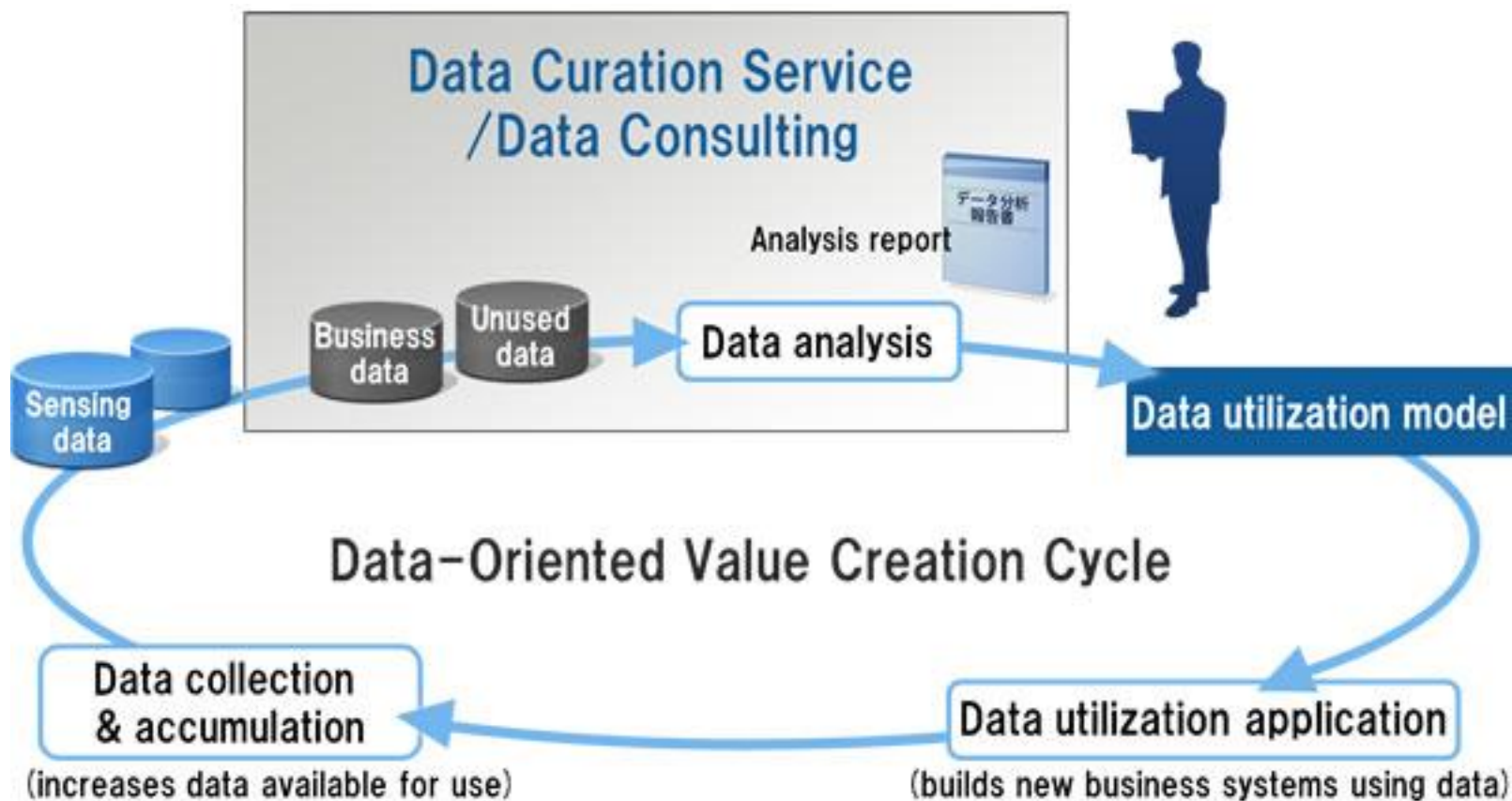
Big “Dirty” Data: GIGO

Big Data Catches All

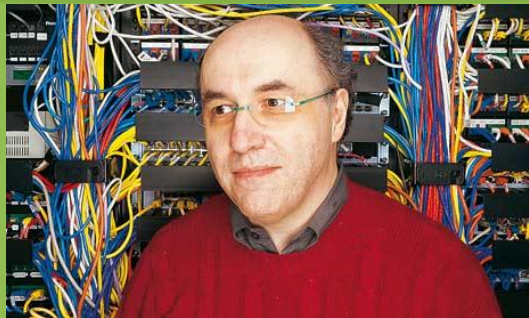
The catchall term of big data skills came in fifth as the most popular among hiring managers in addition to Hadoop. Big data is a collection of data sets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications. The challenges include capture, **curation**, storage, search, sharing, transfer, analysis and visualization.



Data Curation



New: Visual examples help you explore hundreds of topics.



 **WolframAlpha** computational knowledge engine


Enter what you want to calculate or know about:

 [Examples](#) [Random](#)



Alpha's Data must be Reliable ERGO Curation

Experience the next big step in computational knowledge: [Wolfram|Alpha Pro](#) >>



computational... knowledge engine

Assuming any type of spruce wood | Use [North American Engelmann spruce](#) or [more](#) instead

Input interpretation:
spruce wood | ultimate tensile strength
orientation | parallel

Average result: **12 ksi** (kips-force per square inch)
(based on 2 types of spruce wood) [Show metric](#) [Show details](#)

Members: [black spruce, dry](#) | [black spruce, green](#) | [Canadian spruce](#) | ... (15) [More](#)

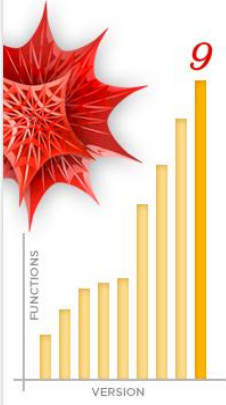
Unit conversions: [More](#)
1800 ksf (kips-force per square foot)
86 MPa (megapascals)
0.086 GPa (gigapascals)
 8.6×10^7 Pa (pascals)
12 000 psi (pounds-force per square inch)

Computed by [Wolfram Mathematica](#) [Sources](#) [Download page](#)

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Access: [Mobile](#) [Tablet](#) [Laptop](#) [Settings](#)

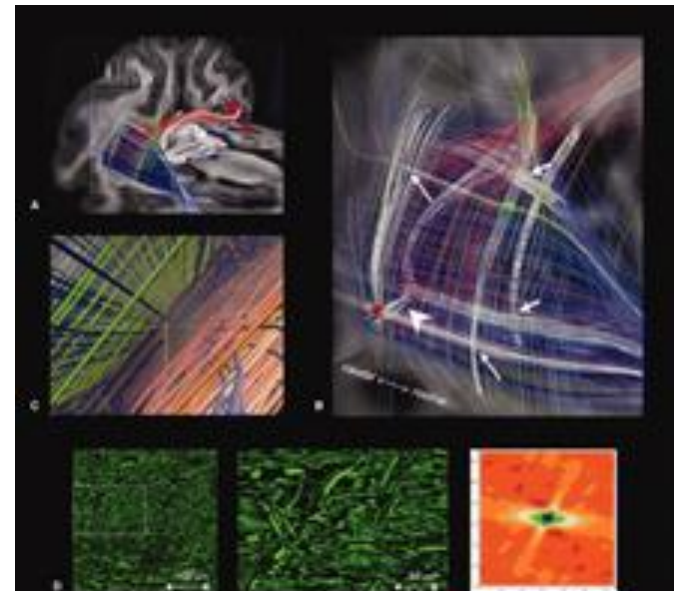
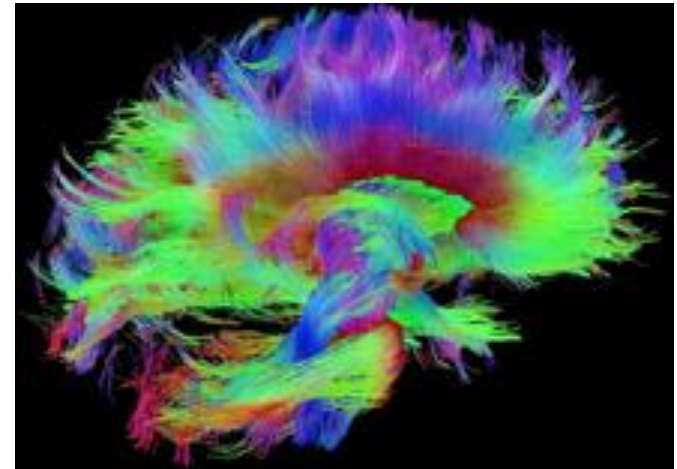
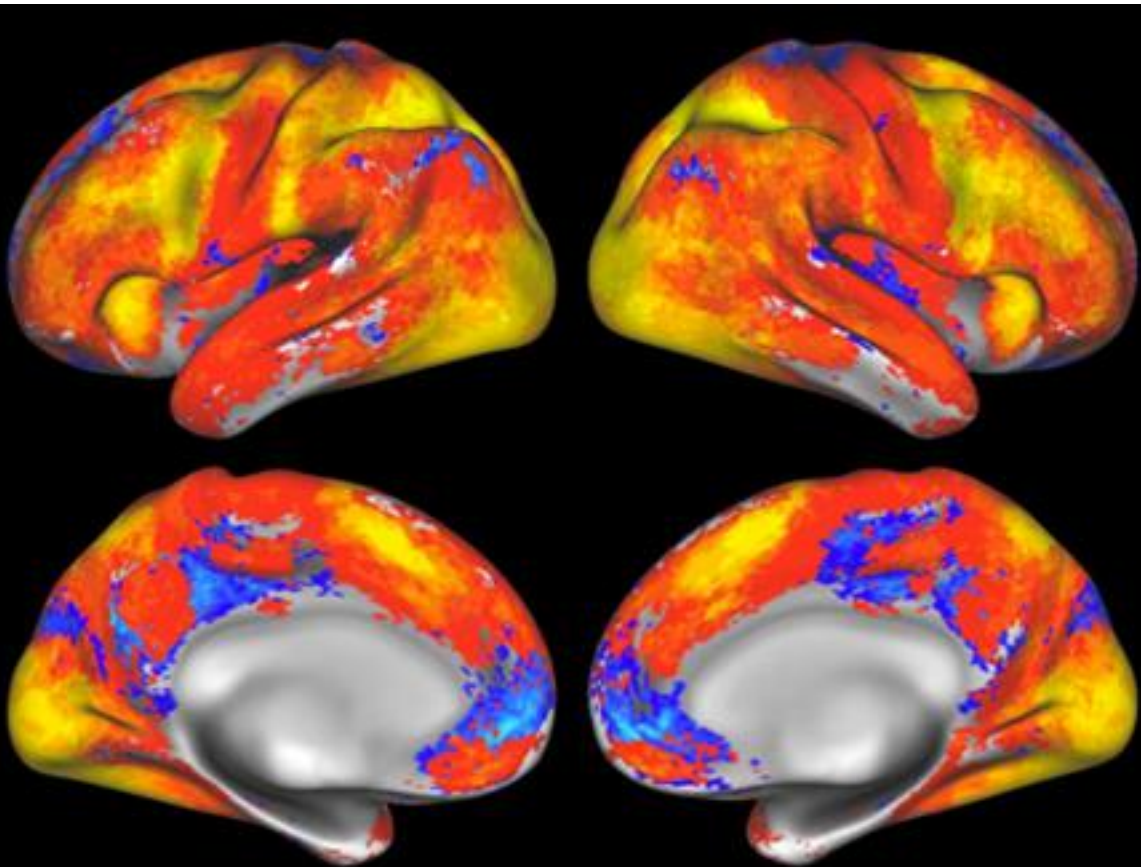
New Mathematica[®] 9
*Scores of new ideas,
100s of new functions,
& some surprises >>*



FUNCTIONS

VERSION

Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative



EU Diving Deeply into the HBP



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THE HUMAN BRAIN PROJECT

Project

Gaining profound insights into what makes us human, developing new treatments for brain diseases and building revolutionary new computing technologies.



[More about the Human Brain Project](#)



Advanced Manufacturing, 3D Printing and Robotics



The Internet of Everything

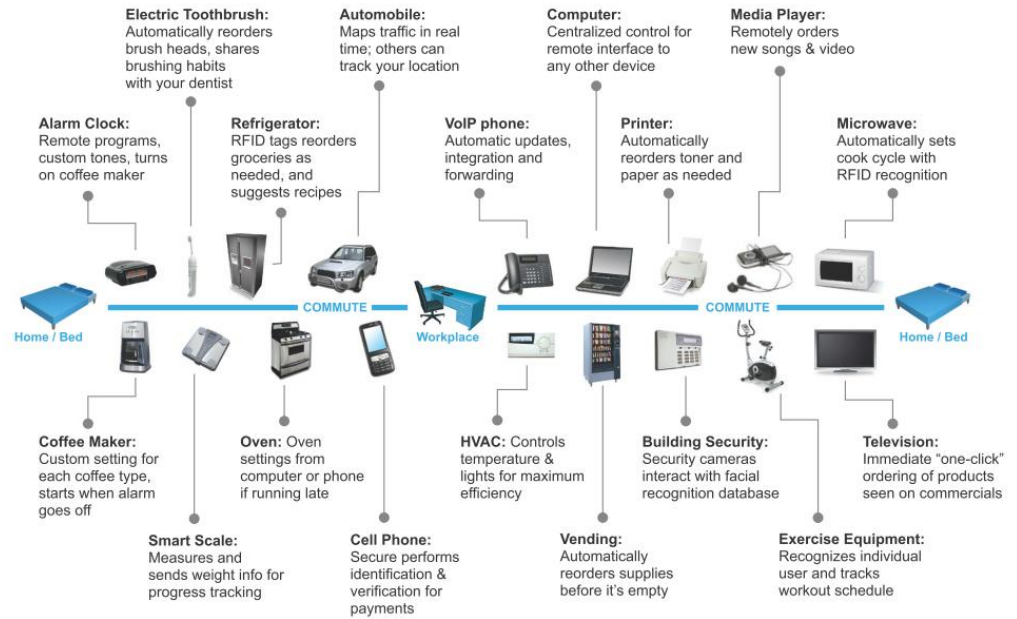
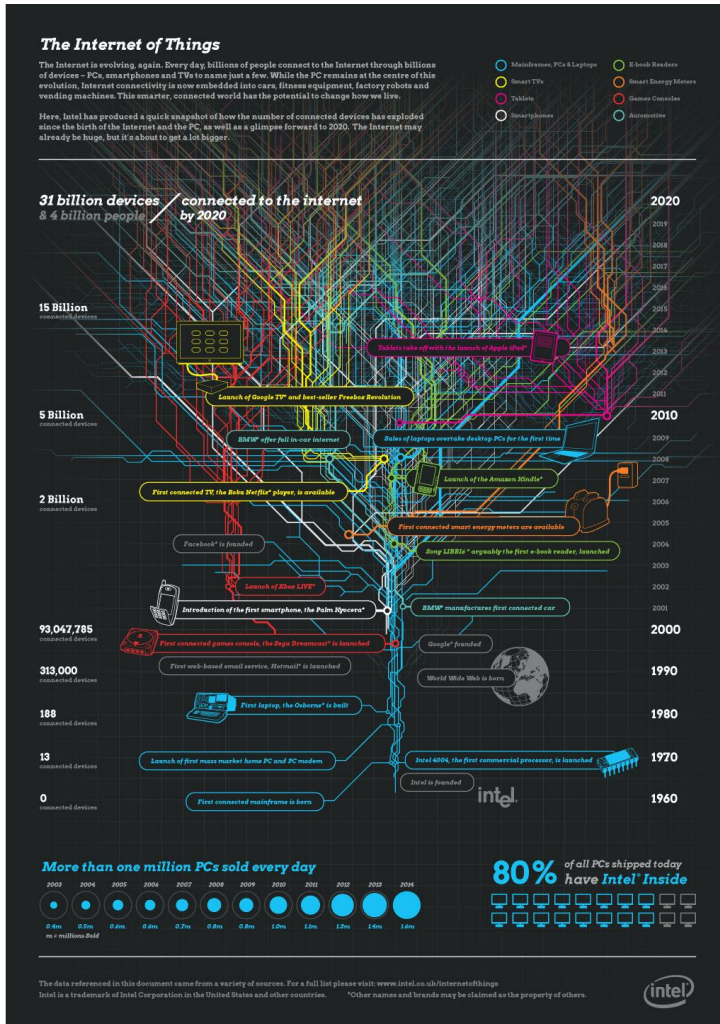


Figure 3. The Internet of Things

Libelium Smart World

Air Pollution

Control of CO₂ emissions of factories, pollution emitted by cars and toxic gases generated in farms.

Forest Fire Detection

Monitoring of combustion gases and preemptive fire conditions to define alert zones.

Wine Quality Enhancing

Monitoring soil moisture and trunk diameter in vineyards to control the amount of sugar in grapes and grapevine health.

Offspring Care

Control of growing conditions of the offspring in animal farms to ensure its survival and health.

Sportsmen Care

Vital signs monitoring in high performance centers and fields.

Structural Health

Monitoring of vibrations and material conditions in buildings, bridges and historical monuments.

Quality of Shipment Conditions

Monitoring of vibrations, strokes, container openings or cold chain maintenance for insurance purposes.

Smartphones Detection

Detect iPhone and Android devices and in general any device which works with Wifi or Bluetooth interfaces.

Perimeter Access Control

Access control to restricted areas and detection of people in non-authorized areas.

Radiation Levels

Distributed measurement of radiation levels in nuclear power stations surroundings to generate leakage alerts.

Electromagnetic Levels

Measurement of the energy radiated by cell stations and WiFi routers.

Traffic Congestion

Monitoring of vehicles and pedestrian affluence to optimize driving and walking routes.



Smart Roads

Warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.

Smart Lighting

Intelligent and weather adaptive lighting in street lights.

Intelligent Shopping

Getting advices in the point of sale according to customer habits, preferences, presence of allergic components for them or expiring dates.

Noise Urban Maps

Sound monitoring in bar areas and centric zones in real time.

Water Leakages

Detection of liquid presence outside tanks and pressure variations along pipes.

Vehicle Auto-diagnosis

Information collection from CanBus to send real time alarms to emergencies or provide advice to drivers.

Item Location

Search of individual items in big surfaces like warehouses or harbours.

Waste Management

Detection of rubbish levels in containers to optimize the trash collection routes.

Smart Parking

Monitoring of parking spaces availability in the city.

Golf Courses

Selective irrigation in dry zones to reduce the water resources required in the green.

Water Quality

Study of water suitability in rivers and the sea for fauna and eligibility for drinkable use.

“Post Capitalist” Entrepreneurship

Capital Intensive



HCF

Capital Negligible



facebook

Connect with friends and the world around you on Facebook.



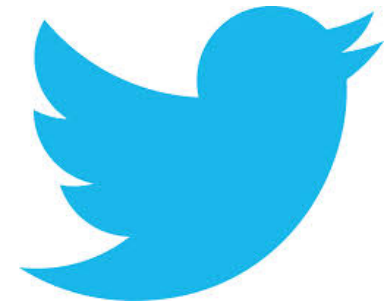
See photos and updates from friends in News Feed.



Share what's new in your life on your Timeline.

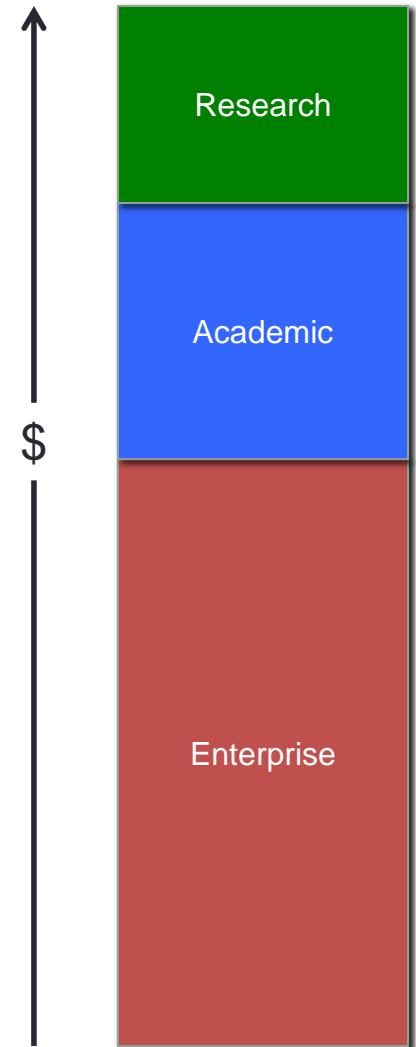


Find more of what you're looking for with Graph Search.



What does this all mean for UM?

- Invest wisely and invest *sufficiently* in computing across the board
 - Lots of input on decision making – faculty and staff working in cooperation
 - *It is an investment not an expense*
- Examine what we do at the cutting edge –
 - Where are we at the cutting edge?
 - What are we doing there?
 - Why are we there?
 - How do we go further faster than others?
- Integrate learning with discovery at all levels
- Be ready to capitalize on new trends, but don't jump too quickly



Keep your eyes peeled for the future



Thank you!