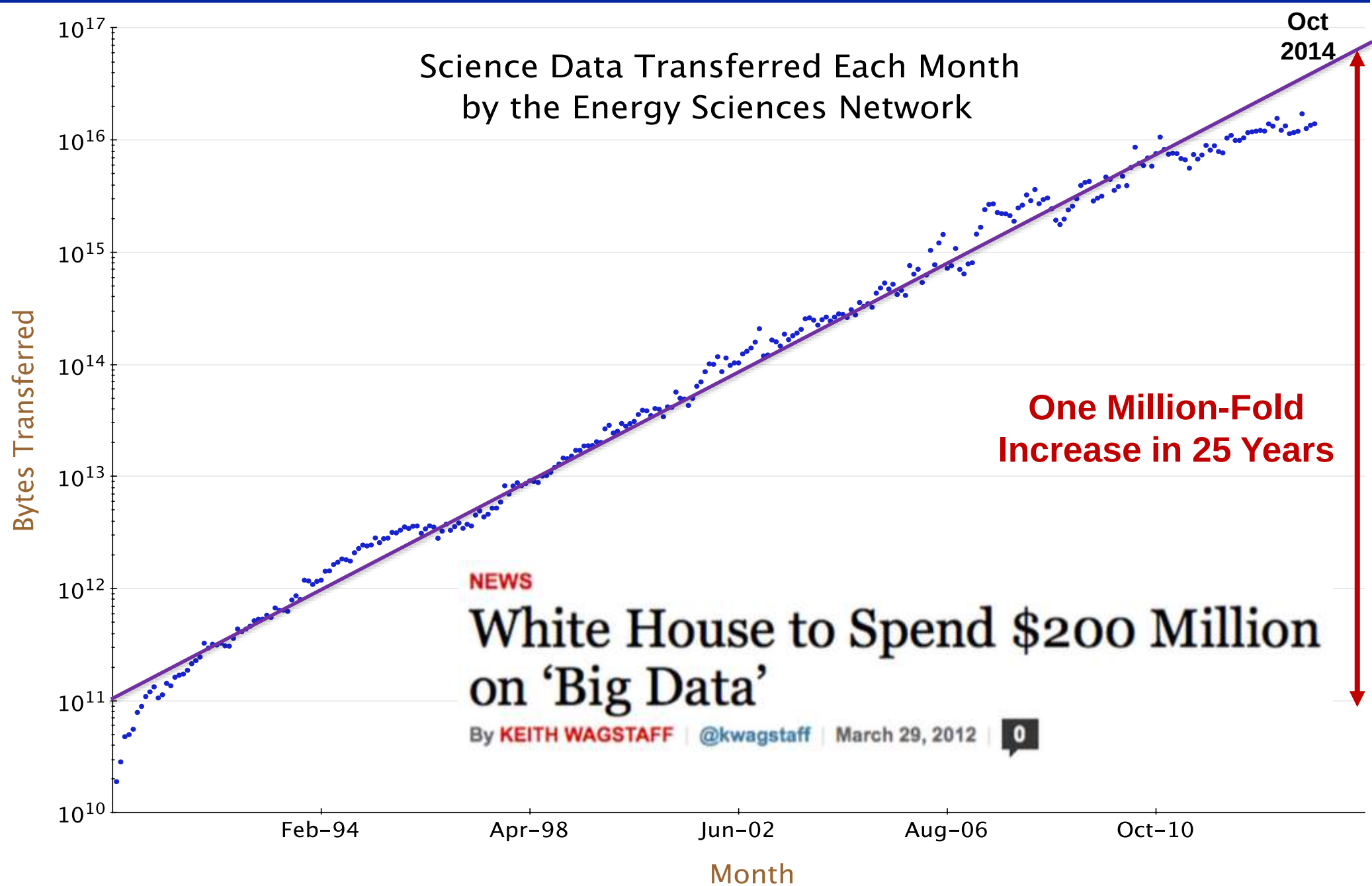
"Advances and Breakthroughs in Computing – The Next Ten Years"

Invited Talk
CTO Forum
San Francisco, CA
November 5, 2014

Dr. Larry Smarr
Director, California Institute for Telecommunications and Information Technology
Harry E. Gruber Professor,
Dept. of Computer Science and Engineering
Jacobs School of Engineering, UCSD



Exponential Growth
Has Brought Us to the "Big Data" Era



Moving Big Data
Requires Wide-Area SuperNetworks

DOE



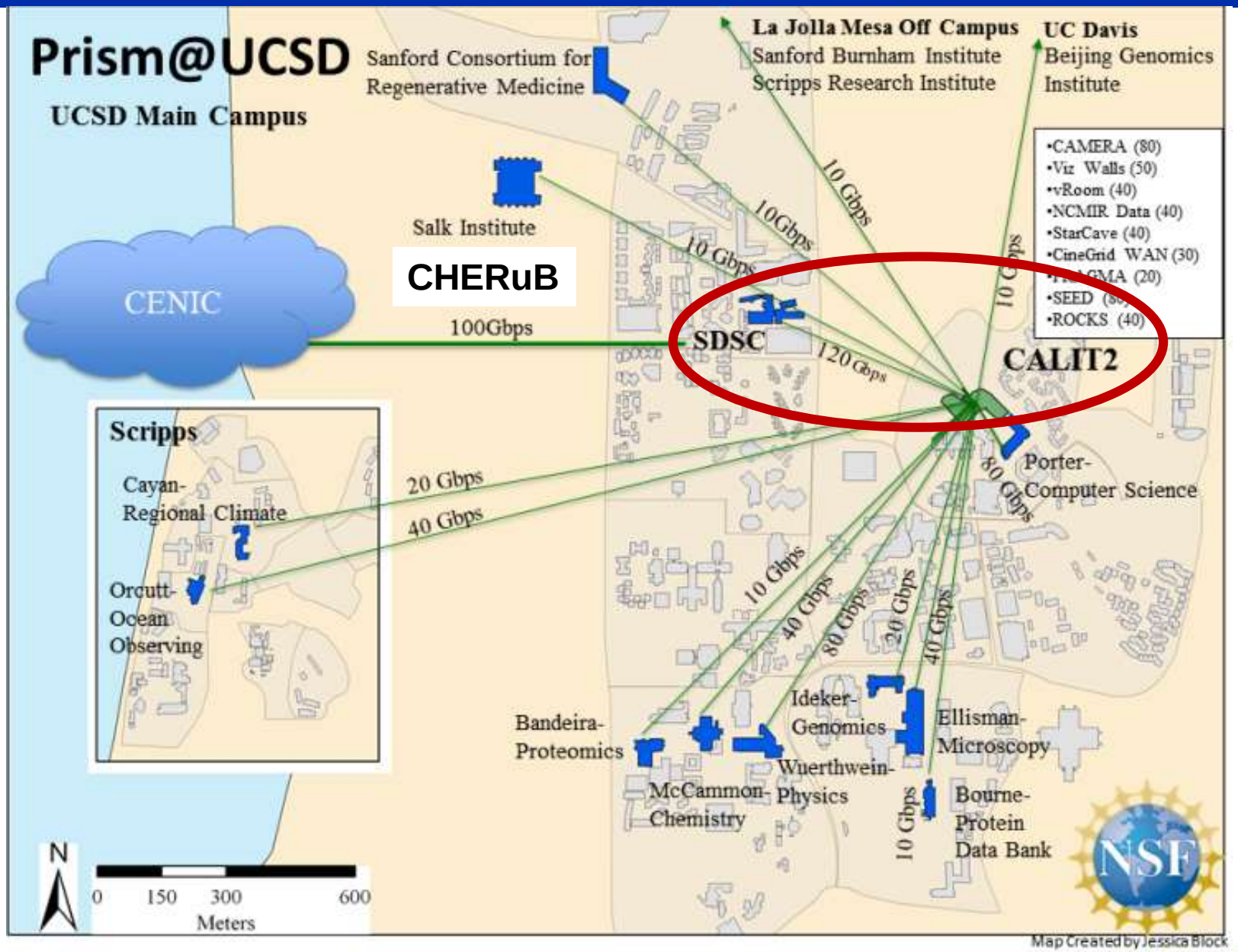
cenic

Internet2



it²

Connecting Data Generators and Storage/Compute Across a Campus at the Speed of a Cluster Backplane



NSF CC-NIE Has Awarded 130 Such Grants To Over 100 U.S. Campuses

SDSC

it²

Big Data Compute/Storage Facility - Interconnected at Over 1 Trillion Bits Per Second

# of Parallel 10Gbps Optical Light Paths

Arista Router
Can Switch
576 10Gps Light Paths



COMET
VM SC 2 PF

128

SDSC Supercomputers

Gordon
Big Data SC

128

128

128 x 10Gbps = 1.3Tbps

Oasis Data Store

6000 TB
> 800 Gbps

SDSC
SAN DIEGO SUPERCOMPUTER CENTER

Source: Philip Papadopoulos, SDSC/Calit2

Dedicated Exascale Supercomputer and Terabit/Sec Networks Will be Needed for Single Instruments Within a Decade

IBM to build exascale supercomputer for the world's largest, million-antennae telescope

By Sebastian Anthony on April 2, 2012 at 11:48 am | 8 Comments



IBM has until 2024 to develop a computer that can process a few exabytes of data per day.

Cisco Predicts daily global IP traffic will surpass 3 exabytes threshold in 2016.

This Time Will Be Different…

I Have Participated in the Last Billion-Fold Increase in Supercomputer Speed:

- **MegaFLOPS**
  - 1965 CERN CDC 6600
- **GigaFLOPS**
  - 1985 NCAR Cray-2
- **TeraFLOPS**
  - 1996 Sandia Intel's ASCI Red
- **PetaFLOPS**
  - 2008 LANL IBM Roadrunner

FLOP = Floating Point Operations Per Second

- **Next Transition is the ExaFLOP 2018-2024**
  - The Speed Will Approach or Exceed That of the Human Brain

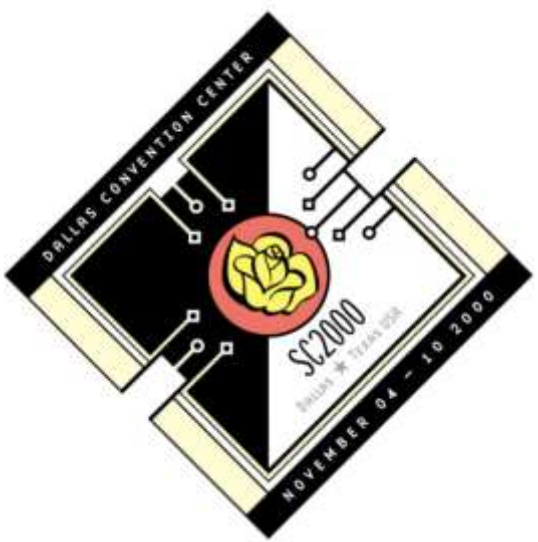
The Fastest Supercomputer Today - Only 20x More to the ExaFLOP

NEWS

China surpassing U.S. with 54.9 petaflop supercomputer

Computerworld | Jun 3, 2013

The Tianhe-2 Has 3.1 Million Intel Cores



MEGACOMPUTERS
Moderator: Larry Smarr
Panelists: Andrew Chien, *Entropia*
Ian Foster, *Argonne National Laboratory*
Thomas Sterling, *JPL*

Predicted in 2000

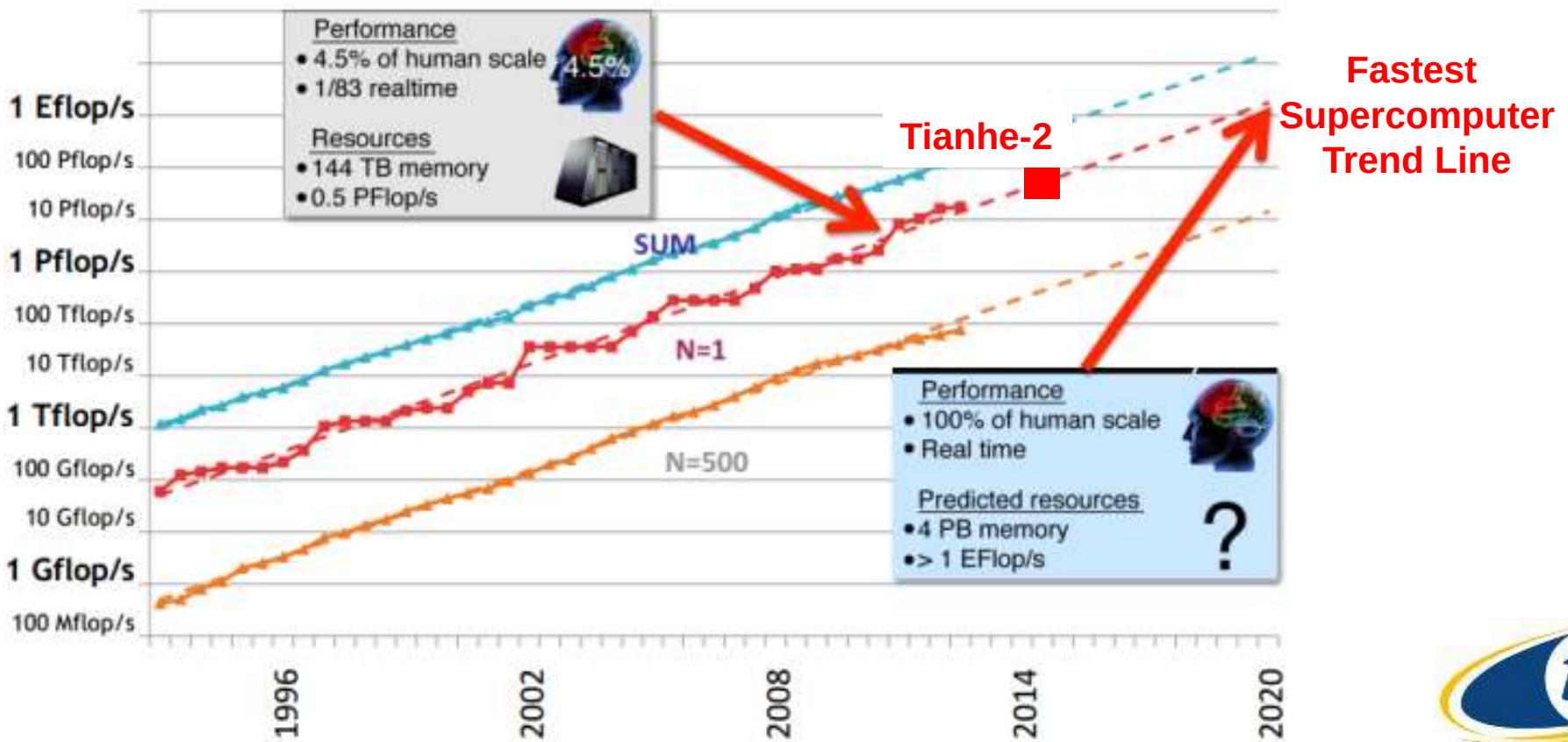
Realtime Simulation of Human Brain Possible Within the Next Ten Years With Exascale Supercomputer

IBM Simulates 4.5 percent of the Human Brain, and All of the Cat Brain

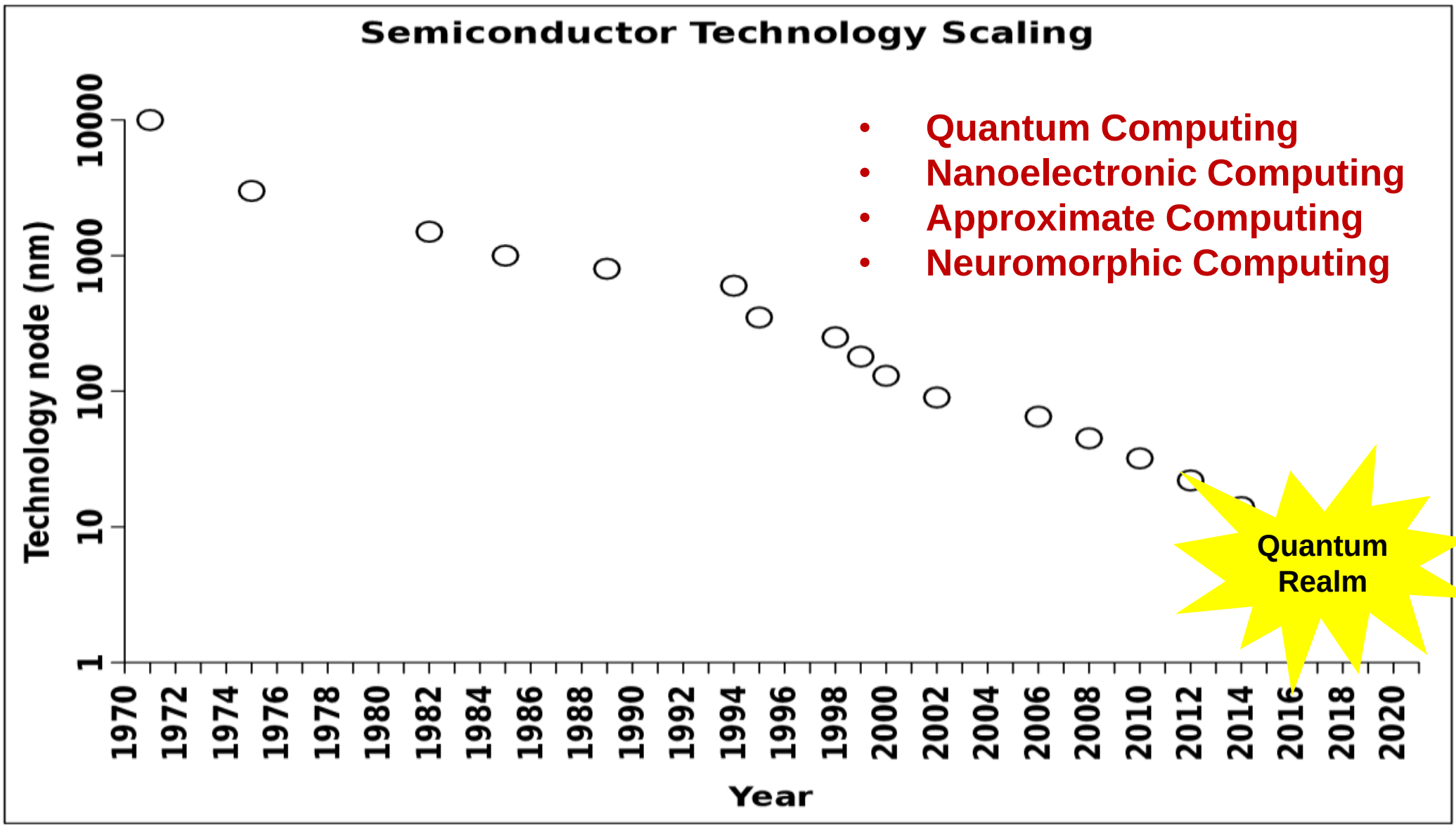
SCIENTIFIC AMERICAN™ October 25, 2011

Towards Exascale

Horst Simon, Deputy Director,
Lawrence Berkeley National Laboratory's
National Energy Research Scientific Computing Center



New Computing Architectures Will Be Necessary In the Coming Decade



Graph source: www.iue.tuwien.ac.at/phd/filipovic/node20.html

Massive Public Private Partnership to Accelerate Brain-Inspired Computers



Over $100 Million

DARPA SyNAPSE Program

HRL

GM BOEING

IBM

Jan/Feb 2014



Brainlike Computers, Learning From Experience

By JOHN MARKOFF

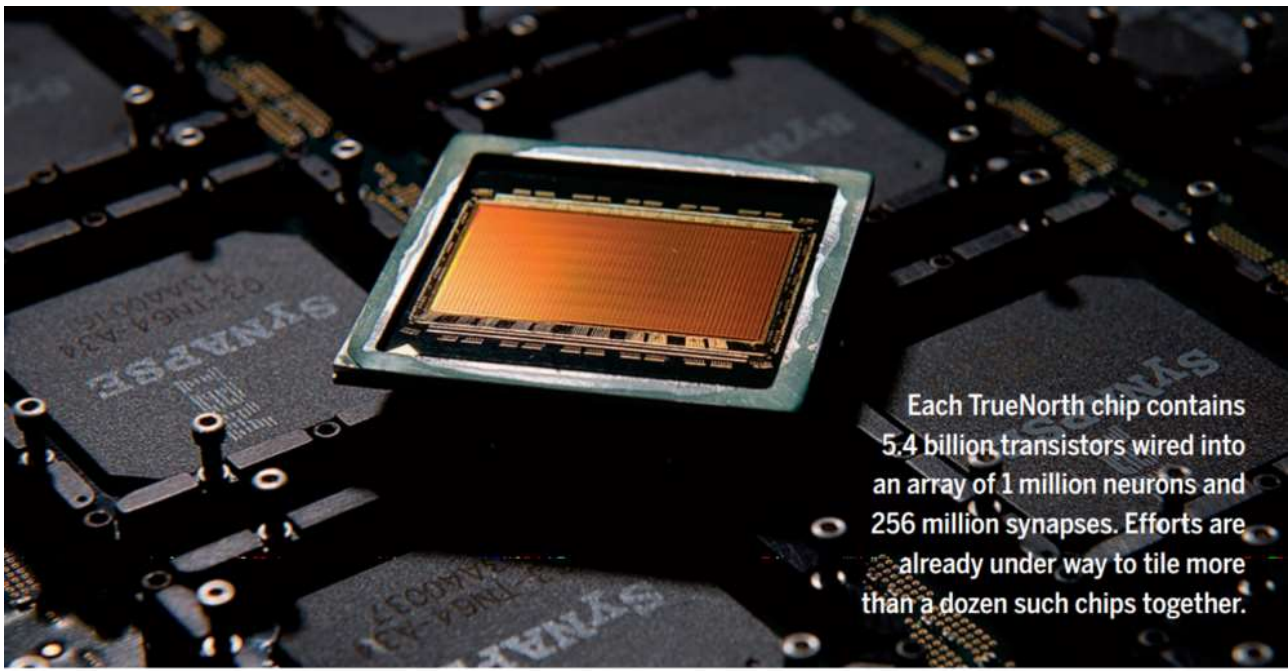
Published: December 28, 2013

The New York Times

it²

Brain-Inspired Processors
Are The Start of the non-von Neumann Architecture Era





IBM

“On the drawing board are collections of 64, 256, 1024, and 4096 chips. ‘It’s only limited by money, not imagination,’ Modha says.”

Source: Dr. Dharmendra Modha
Founding Director, IBM Cognitive Computing Group

Reverse Engineering of the Brain Is Accelerating Under the Federal Brain Initiative



www.whitehouse.gov/infographics/brain-initiative

Massive Amounts of Data Combined With Planetary-Scale Computing Leads to Deep Learning

How Ray Kurzweil Will Help Google Make the Ultimate AI Brain

BY STEVEN LEVY 04.25.13 | 9:30 AM | PERMALINK

WIRED

Facebook's Quest to Build an Artificial Brain Depends on This Guy

BY DANIELA HERNANDEZ 08.14.14 | 6:30 AM | PERMALINK

Exclusive: Google to Buy Artificial Intelligence Startup DeepMind for $400M

January 26, 2014, 4:25 PM PST ‹re/code›

Deep Learning



With massive amounts of computational power, machines can now recognize objects and translate speech in real time. Artificial intelligence is finally getting smart.

MIT Technology Review

April 2013

it²

Two Examples of Disruption This Cyberinfrastructure Will Drive

- **Quantified Selves and Healthcare**
- **Quantified Machines and the Industrial Internet**

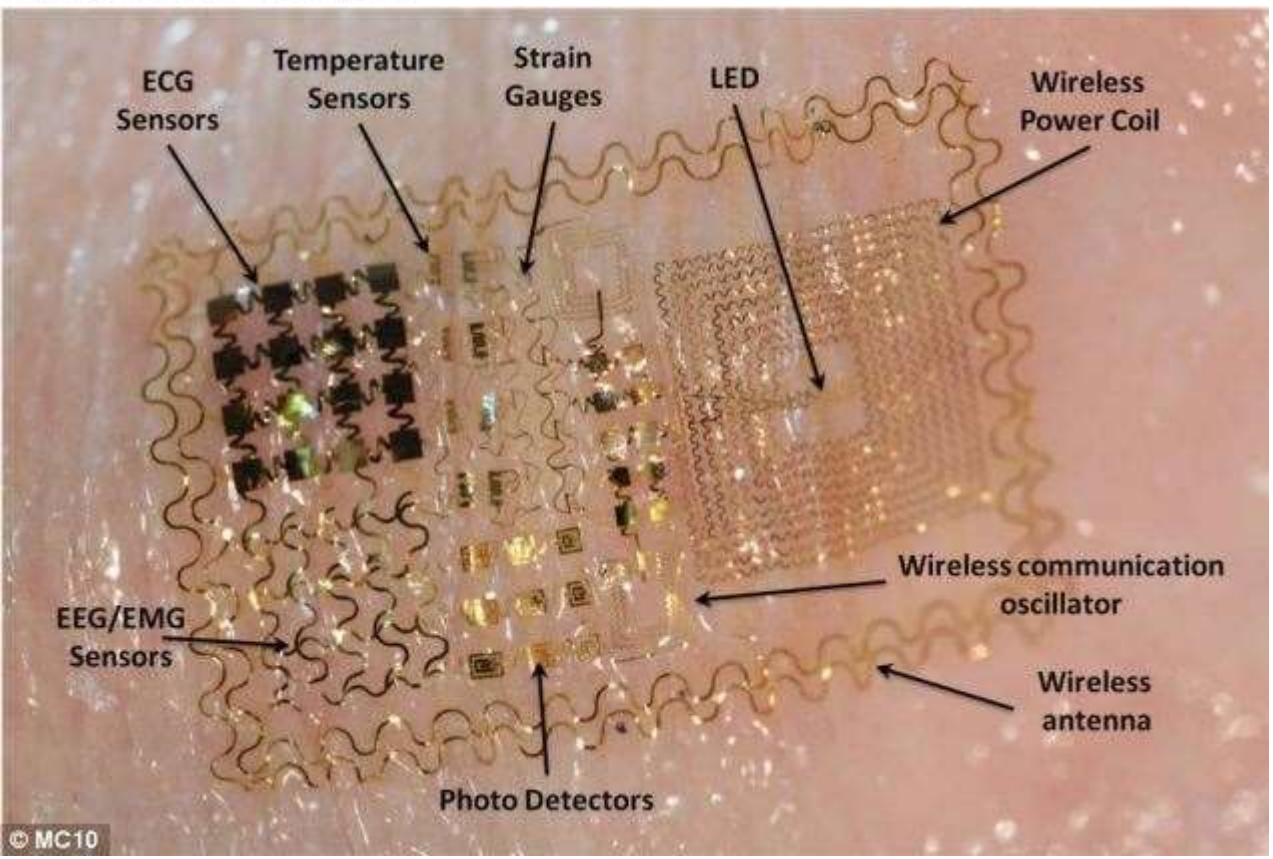
A New Generation of Human Body Sensors Will Provide Continuous Readouts

FASHION & STYLE | DISRUPTIONS

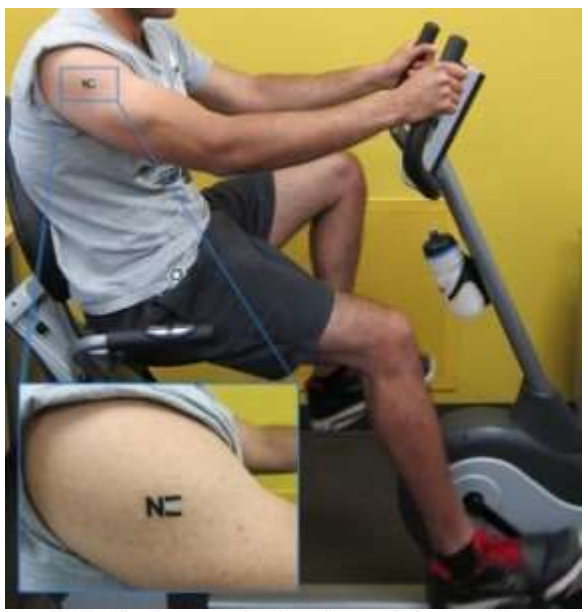
The New York Times

Wearable Technology That Feels Like Skin

By NICK BILTON OCT. 8, 2014



Startup MC10 Working With UIUC



Tattoo biobatteries produce power from sweat

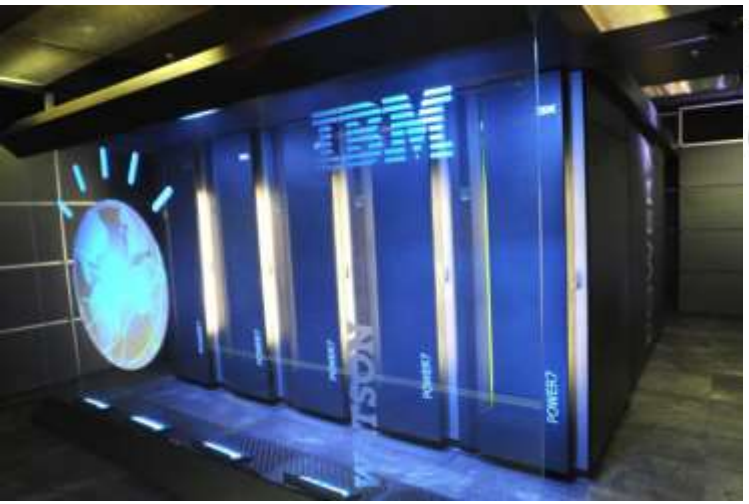
Aug. 13, 2014

ACS Chemistry for Life®

UC San Diego

it²

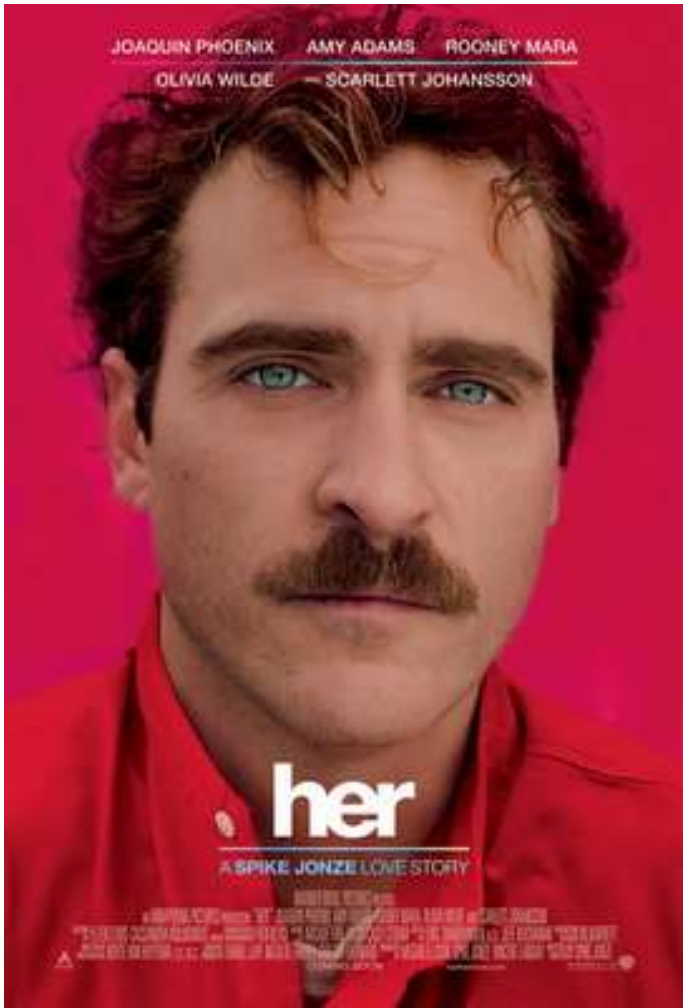
Deep Learning Will Provide Personalized Assistants to Coach Us to Wellness



IBM's Watson supercomputer gets its own $1 billion business

IBN Live **January 10, 2014**

Where Medicine Coaching is Now



Where Wellness Coaching is Going

A Vision for Healthcare in the Coming Decades

Using this data, the planetary computer will be able to build a computational model of your body and compare your sensor stream with millions of others. Besides providing early detection of internal changes that could lead to disease, cloud-powered voice-recognition wellness coaches could provide continual personalized support on lifestyle choices, potentially staving off disease and making health care affordable for everyone.

ESSAY

The New York Times Science

An Evolution Toward a Programmable Universe

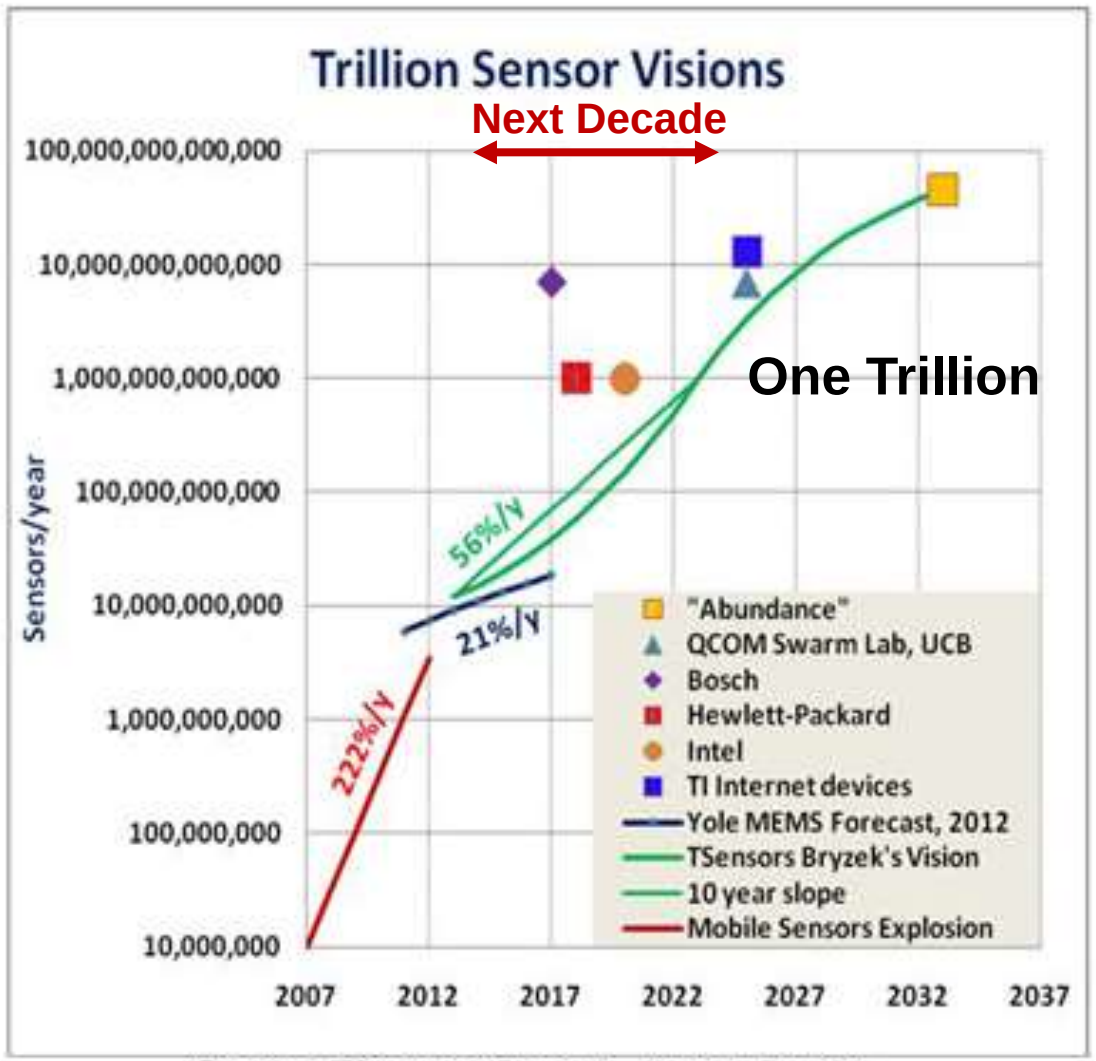
By LARRY SMARR

Published: December 5, 2011

The Planetary Computer Fed by a Trillion Sensors Will Drive a Global Industrial Internet

T SENSORS SUMMIT™ FOR TRILLION SENSOR ROADMAP

www.tsensorssummit.org



Source: TSensors Summit, Janusz Bryzek

"Within the next 20 years the Industrial Internet will have added to the global economy an additional $15 trillion."
--General Electric

www.ge.com/docs/chapters/Industrial_Internet.pdf

www-bsac.eecs.berkeley.edu/frontpagefiles/BSACGrowingMEMS_Markets_%20SEMI.ORG.html

This Next Decade's Computing Transition Will Not Be Just About Technology



"Those disposed to dismiss an 'AI takeover' as science fiction may think again after reading this original and well-argued book." —*Martin Rees, Past President, Royal Society*



Elon Musk
@elonmusk

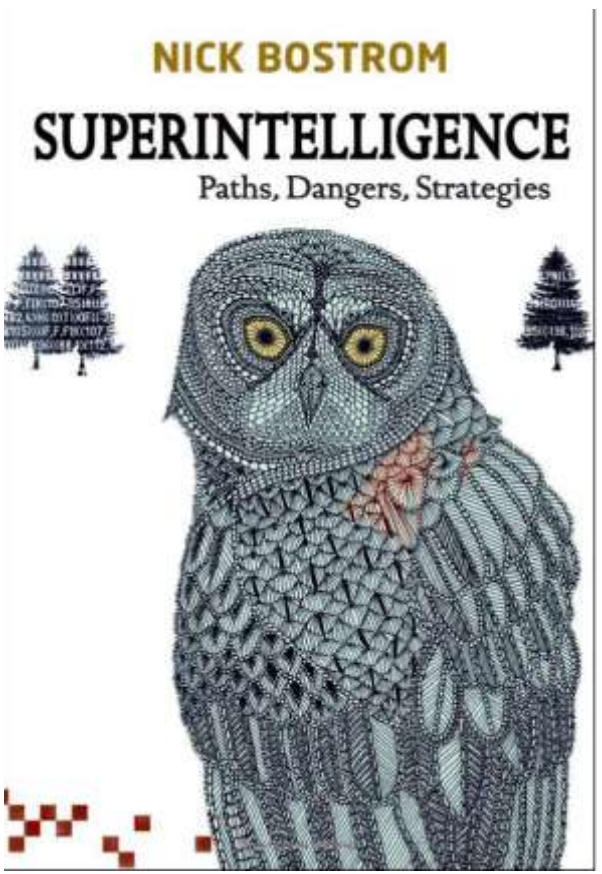
Follow

Worth reading Superintelligence by Bostrom. We need to be super careful with AI. Potentially more dangerous than nukes.

7:33 PM - 2 Aug 2014



If our own extinction is a likely, or even possible, outcome of our technological development, shouldn't we proceed with great caution? – *Bill Joy*





Success in creating AI would be the biggest event in human history. Unfortunately, it might also be the last, unless we learn how to avoid the risks.
– *Steven Hawking*