Networking and Information Technology

Computer Science

Jeannette M. Wing

President's Professor of Computer Science and Department Head

Carnegie Mellon University
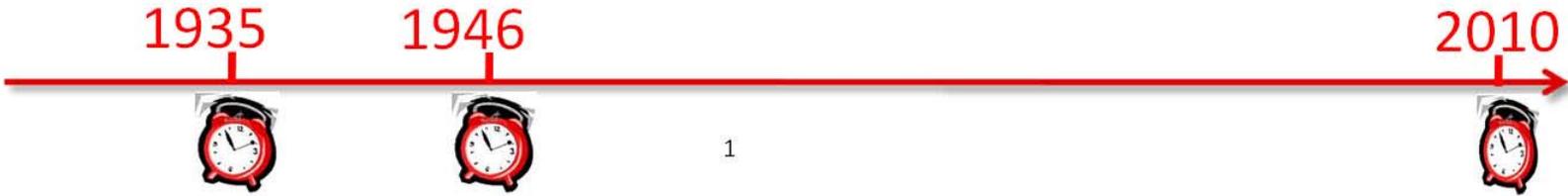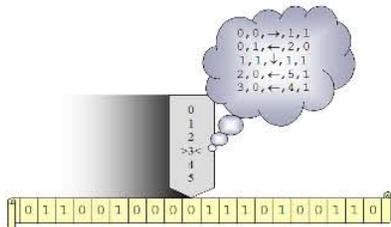*Former Assistant Director for Computer and Information Science and Engineering*

National Science Foundation

President's Council of Advisors on Science and Technology
Washington, DC
September 2, 2010

Computing Technology (R)Evolution

1935   1946   2010

1

Economic Impact

Intuit

Social Impact

iRobot

NETFLIX

twitter

ebaY

facebook

Linked in

skype

liveHarmony

myspace.com
a place for friends

Wikipedia
The Free Encyclopedia

gaia ONLINE

flickr BLOG

friendster

SECOND LIFE

Nintendo

WORLD of WARCRAFT

You Tube
Broadcast Yourself

travelocity

BRIGHTPOINT OnLine

XING

E*TRADE FINANCIAL

palm

Shopping.com

OnlineGames.net
THE FUN NEVER STOPS!

BETA GuildCafe

match.com
love is complicated. match is simple.

Three Stories:

Google
Model Checking
Machine Learning

Final Report for Period: 09/1994 - 08/1999

Principal Investigator: Garcia-Molina, Hector .

Organization: Stanford University

Title:

The Stanford Integrated Digital Library Project

Submitted on: 05/15/2000

Award ID: 9411306

...pants

Senior Personnel

Name: Garcia-Molina, Hector

Worked for more than 160 Hours:　　Yes

Contribution to Project:

Name: Paepcke, Andreas

Worked for more than 160 Hours:　　Yes

Contribution to Project:

Project Director

Post-doc

Graduate Student

Larry Page

Name: Page, Larry

Worked for more than 160 Hours:　　Yes

Contribution to Project:

Name: Chang, Ed

Worked for more than 160 Hours:　　Yes

Contribution to Project:

Name: Chang, Kevin

Worked for more than 160 Hours:　　Yes

Contribution to Project:

Sergey Brin

Co-Founder & President, Technology

Sergey Brin, a native of Moscow, received a bachelor of science degree with honors in mathematics and computer science from the University of Maryland at College Park. He is currently on leave from the Ph.D. program in computer science at Stanford University, where he received his master's degree. Sergey is a recipient of a **National Science Foundation Graduate Fellowship** as well as an honorary MBA from Instituto de Empresa. It was at Stanford where he met Larry Page and worked on the project that became Google. Together they founded Google Inc. in 1998, and Sergey continues to share responsibility for day-to-day operations with Larry Page and Eric Schmidt.

- Sergey's research interests include search engines, information extraction from unstructured sources, and data mining of large text collections and scientific data. He has published more than a dozen academic papers, including *Extracting Patterns and Relations from the World Wide Web; Dynamic Data Mining: A New Architecture for Data with High Dimensionality*, which he published with Larry Page; *Scalable Techniques for Mining Casual Structures; Dynamic Itemset Counting and Implication Rules for Market Basket Data*; and *Beyond Market Baskets: Generalizing Association Rules to Correlations*.

- Sergey has been a featured speaker at several international academic, business and technology forums, including the World Economic Forum and the Technology, Entertainment and Design Conference. He has shared his views on the technology industry and the future of search on the *Charlie Rose Show*, CNBC, and CNNfn. In 2004, he and Larry Page were named "Persons of the Week" by ABC World News Tonight.

Journal Publications

Please see http://www-diglib.stanford.edu for a list of publications., "Please see http://www-diglib.stanford.edu for a list of publications.",
Please see http://www-diglib.stanford.edu for a list of publications.

Please see [ ]',
(1998). Bc
Bibliograph

URL(s):
http://www-diglib.stanford.edu
Description:

The Google search engine was developed as part of the project.
It is now a company (www.google.com)

Other Specific Products

Product Type:

Data or databases

Product Description:

The Google search engine was developed as part of the project.
It is now a company (www.google.com)

Sharing Information:

The engine is publicly available

Layers of Abstraction

Search

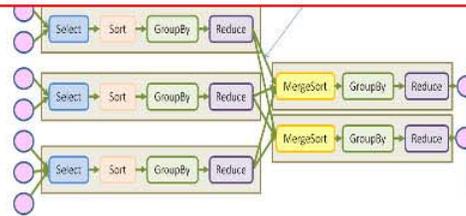Natural Language Processing, Text and Information Retrieval, User Interfaces

PageRank

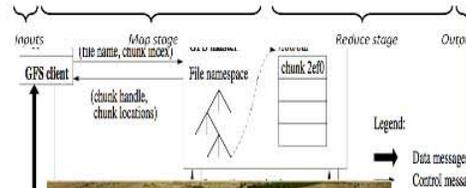$$PR(u) = \sum_{v \in B_u} \frac{PR(v)}{L(v)}$$
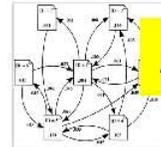
Algorithms, Data Structures

MapReduce

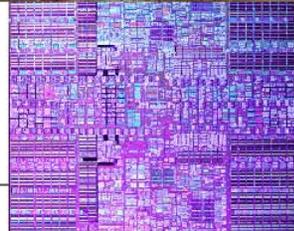Programming Languages, Software Engineering

GFS, BigTable, Chubby

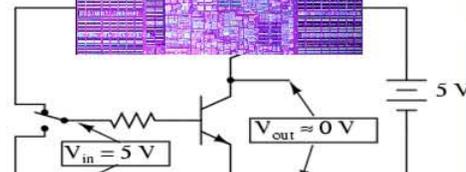Reliability, File Systems, Operating Systems, Consensus

Server Farm

Distributed Systems, Networking, Storage Systems
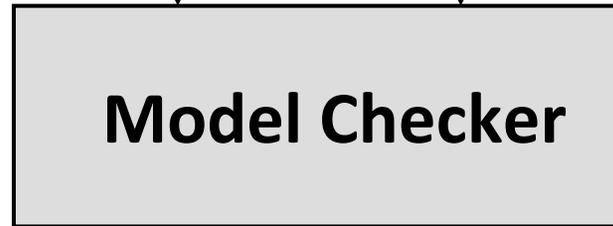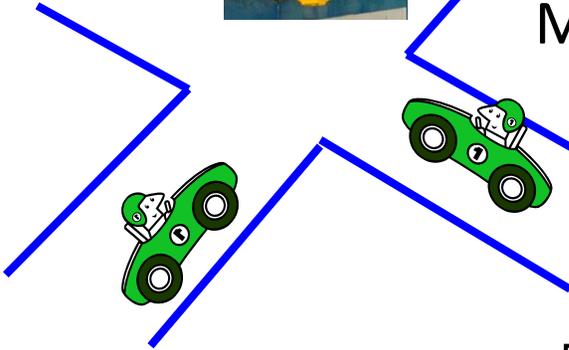
Computer Architecture, Parallel Computing

Electronics, Digital Circuits, Signal Processing

Story 2: Model Checking
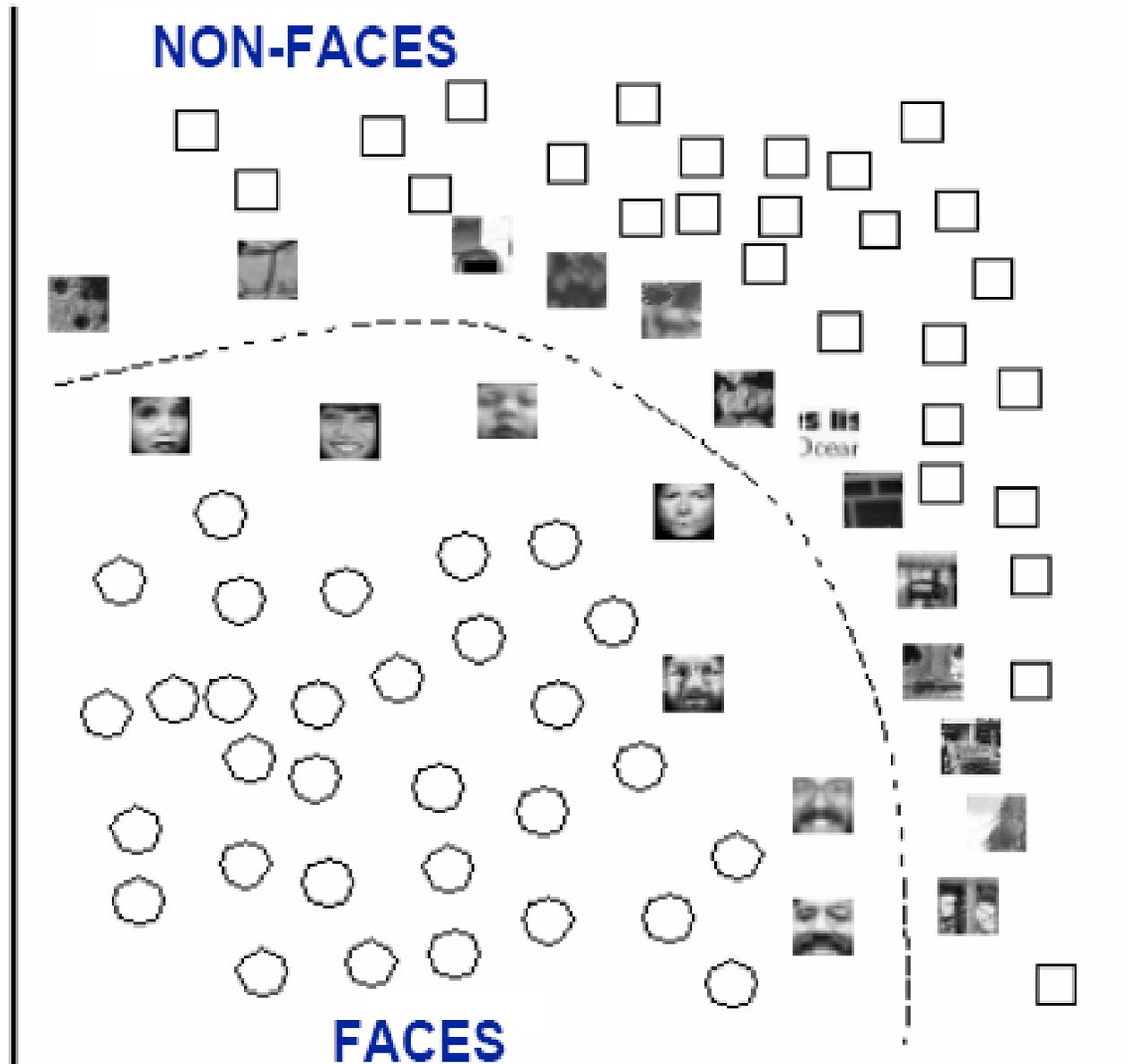
M: Traffic Light Controller

P: No Collisions

Model Checker

Does M satisfy P?

Yes!

No, and here's an example of why not.

Story 3: Machine Learning

Drivers of Computing

Society

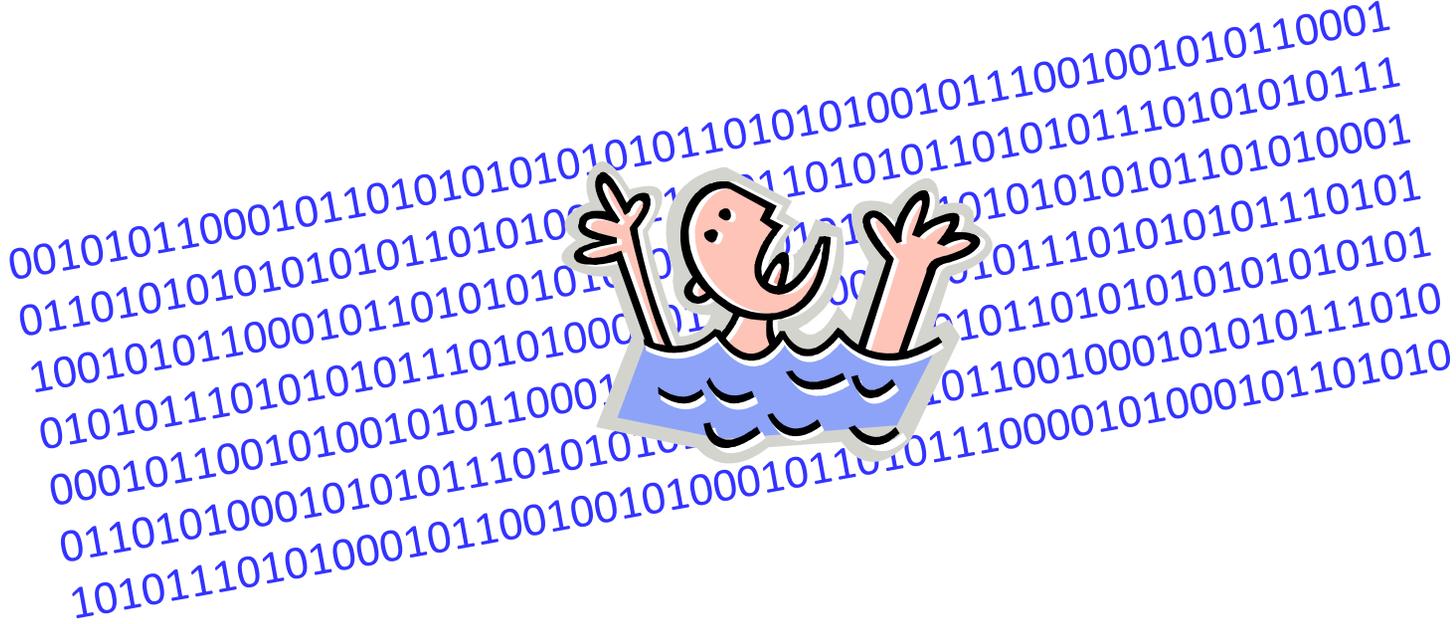## Science

- What is computable?
- P = NP?
- What is intelligence?
- What is information?
- (How) can we build complex systems simply?
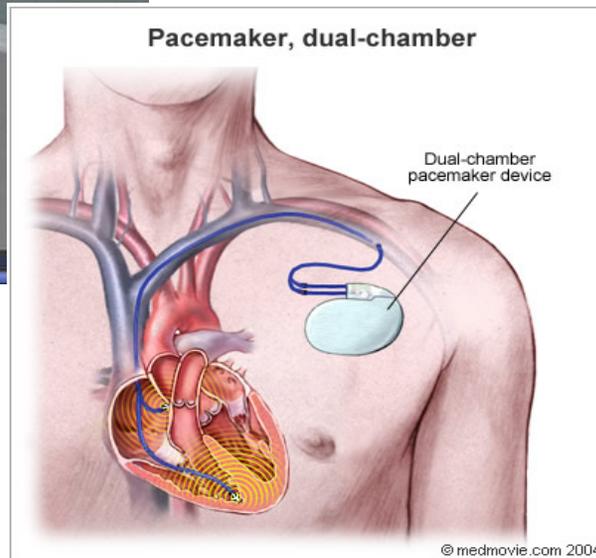
Technology
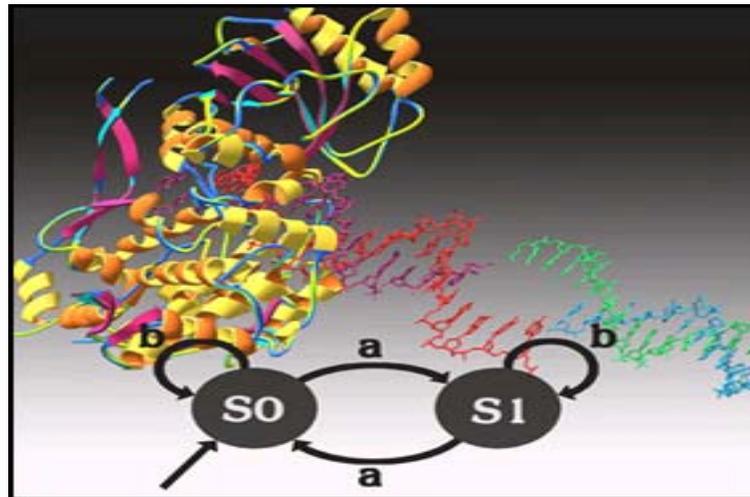

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Data to Knowledge to Action
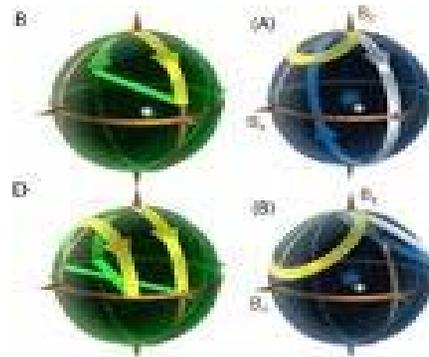
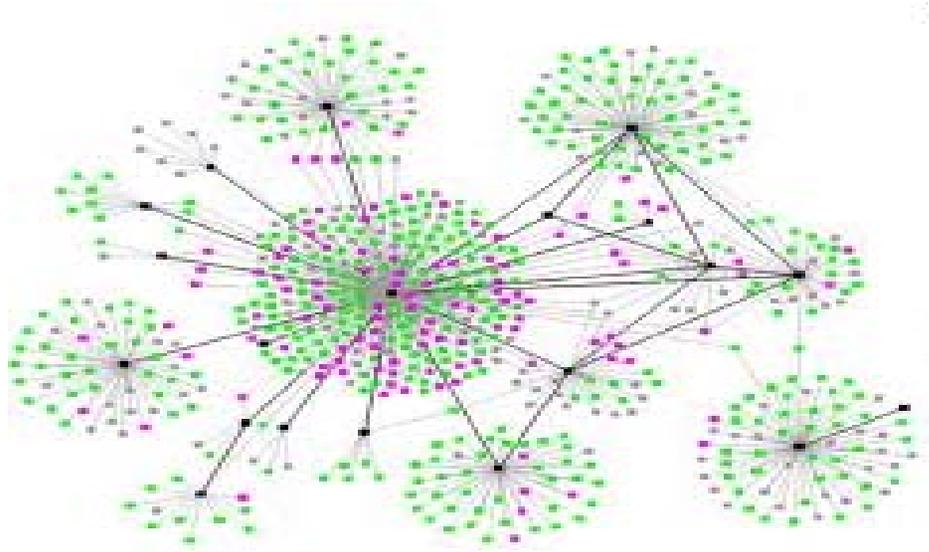Cell + Cloud

Cyber + Physical (e.g., "Smart X")

Bio + Nano + Info

Quantum

Humans + Computers ("Socially Intelligent Computing")

Societal Drivers

High Expectations
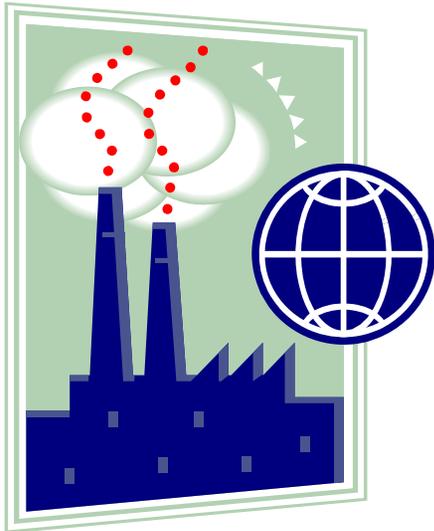
24/7, 100%, anyone, anything, anytime, anywhere
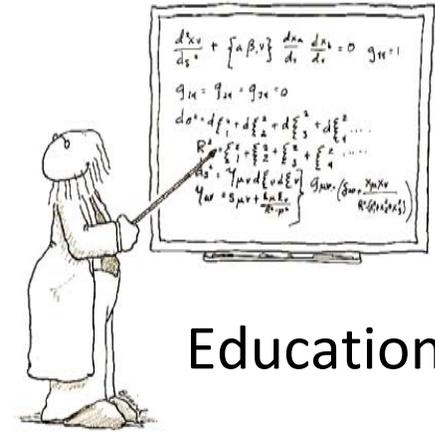
Diversity in Classes

Personalized

Societal Grand Challenges

Energy
Environment
Climate Change
Sustainability

Education

Transportation

Food, Water

Healthcare

Security,
Safety

Science: Five Deep Questions in Computing

- What is computable?

- P = NP?

- What is intelligence?

- What is information?

- (How) can we build complex systems simply?

High-Level Remarks:

Education

NITRD

Administration Priorities

Education: Computer Science is Part of STEM

- Every educated person in the 21st Century needs to know core computer science concepts (aka "computational thinking"):
    - Abstraction, algorithmic thinking, representing data, expressing computations, finding patterns, verifying and debugging,…

- "Computation is the third pillar of science, along with theory and experimentation."

- *Recommendation: Add **Core Ideas in Computer Science** to the National Academies "Conceptual Framework for New Science Education Standards" report.*

NITRD and Federal Agencies

- Computer science goes way beyond high-speed computing, the current major focus of NITRD.
  - *Recommendation: NITRD should rebalance its foci and update its portfolio.*
- Coordination has worked reasonably well and NITRD is responsive to the fast-track requests.
- For Energy, Dept of Energy needs to broaden its view of the role of computer science, networking and information technology.
- For Healthcare, it's about knowledge-based lifelong patient-centric wellness, not just electronic health records. NITRD should work with non-NITRD agencies, e.g., ONC, VA, CDC, …
- For Education, it's about advanced computing technologies to enhance learning, not just computers in the classroom. Ensure computer science is part of STEM.   NITRD should work with Dept. of Education.
- For Cybersecurity, leadership needs to come from the top
  - Government + Industry + Academia, Classified + Unclassified

Computer Science and FY12 Administration Priorities

- **Economic prosperity, competitiveness, innovation**
- Healthcare
- Energy
- Climate change
- Sustainability
- **National security**

Advances in computer science will be instrumental to make progress in all these areas.

High-Level Takeaway Points

- Advances in computer science are a key driver of economic competitiveness and innovation.
  - Innovation in computer science happens at an unparalleled rapid pace.
- Advances in computer science transform society.
- Advances in computer science are instrumental in addressing our major national and societal challenges, e.g., energy and the environment, education and life-long learning, healthcare, open government, and national security.
  - Tackling these challenges requires advances in computer science, not merely the application of existing technology.
- Advances in computer science accelerate the pace of discovery and innovation in nearly all other fields.
- Sustained federal investment in long-term fundamental computer science research has had high payoff and needs to be continued.
- Computer science has a rich intellectual agenda.
  - It is the discipline that underlies networking and information technology.
- Well-educated citizens of the 21st C should learn core computer science concepts.

Thank You!

Drivers of Computing

Society

Science

- What is computable?
- P = NP?
- What is intelligence?
- What is information?
- (How) can we build complex systems simply?

Technology