

Networking and Information Technology

Computer Science

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National Science Foundation

President's Council of Advisors on Science and Technology

Washington, DC

September 2, 2010

Computing Technology (R)Evolution



Canon



Economic Impact

ORACLE



amazon.com



Google



EXPERIENCE. RESULT

SanDisk



YAHOO!

Microsoft



DELL



at&t

ARROW ELECTRONICS, INC.

XEROX



FLEXTRONICS
Where people make the difference

Adobe



TANDEM COMPUTERS

NORTEL



AMD
Smarter Choice



Alcatel-Lucent

QUALCOMM



Intuit



Social Impact

iRobot

NETFLIX

twitter

ebay

facebook

LinkedIn

skype

liveHarmony



WIKIPEDIA
The Free Encyclopedia



gaia
ONLINE

myspace.com
a place for friends

flickr
BLOG

Nintendo

You Tube
Broadcast Yourself



travelocity

BRIGHTPOINT
OnLine

XING

EXTRADE
FINANCIAL

OnlineGames.net
THE FUN NEVER STOPS!



Shopping.com

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

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

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:



Larry Page

<http://www.google.com/corporate/execs.html#sergey>



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.



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

Please see
(1998). Bo
Bibliograph

URL(s):

<http://www-diglib.stanford.edu>

Description:

Other Specific Products

Product Type:

Data or databases

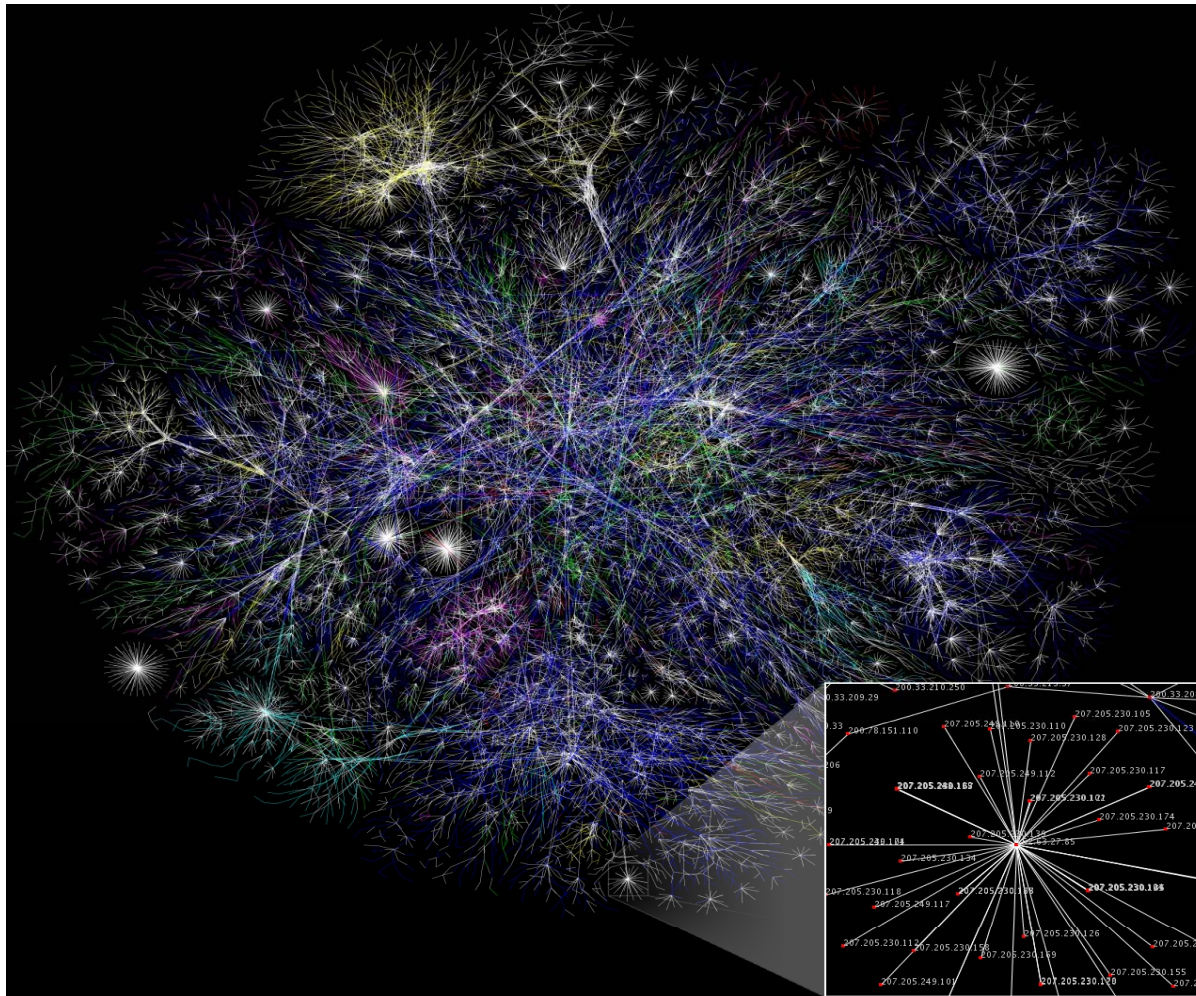
Product Description:

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



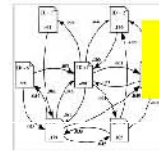
Search



Natural Language Processing,
Text and Information
Retrieval, User Interfaces

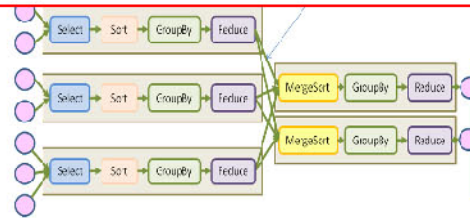
PageRank

$$PR(u) = \sum_{v \in B_u} \frac{PR(v)}{L(v)}$$



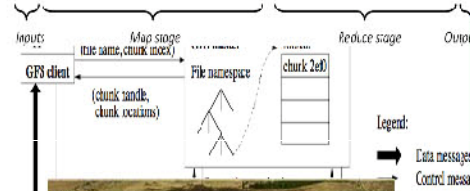
Algorithms, Data Structures

MapReduce



Programming Languages,
Software Engineering

GFS, BigTable, Chubby

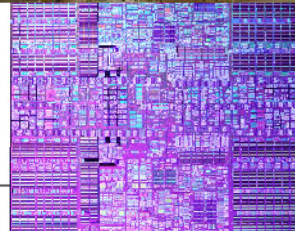


Reliability, File Systems,
Operating Systems, Consensus

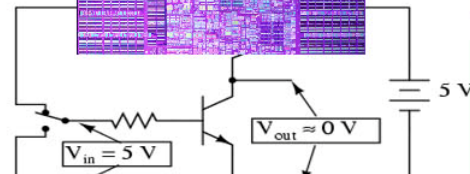
Server Farm



Distributed Systems, Networking,
Storage Systems



Computer Architecture, Parallel
Computing



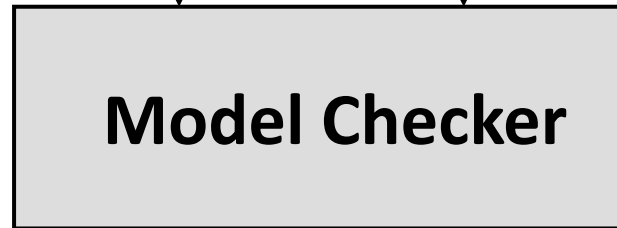
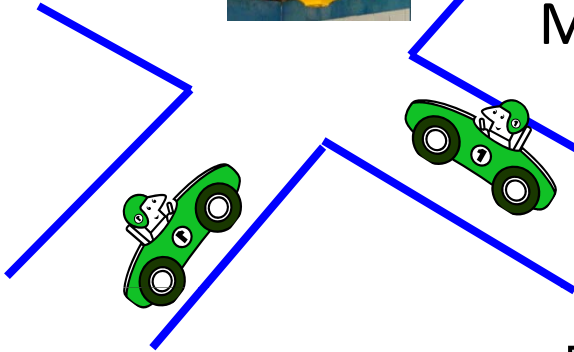
Electronics, Digital Circuits, Signal
Processing

Story 2: Model Checking



M: Traffic Light
Controller

P: No Collisions



Does M satisfy P?

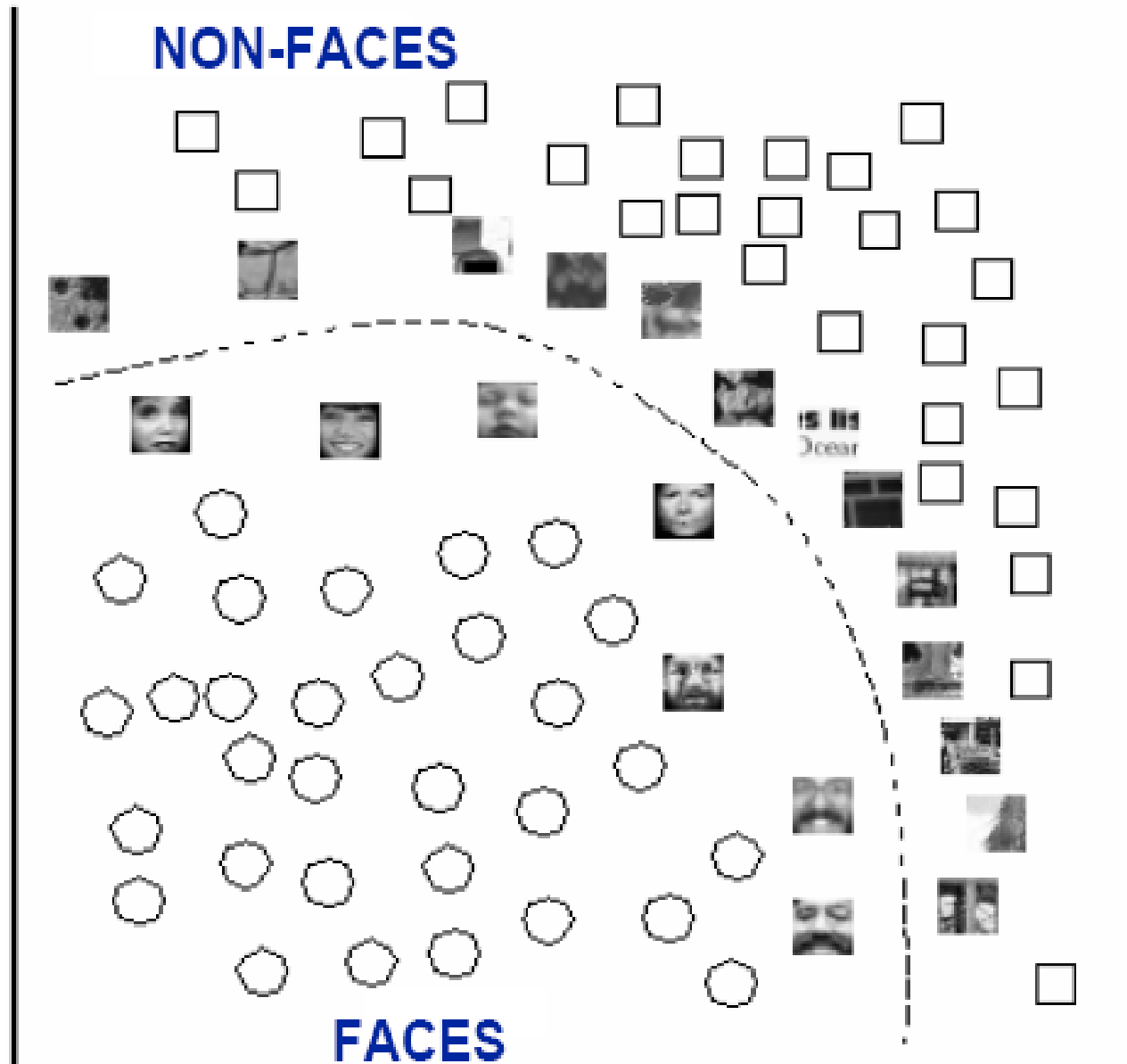


Yes!



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

Story 3: Machine Learning



Drivers of Computing



Society

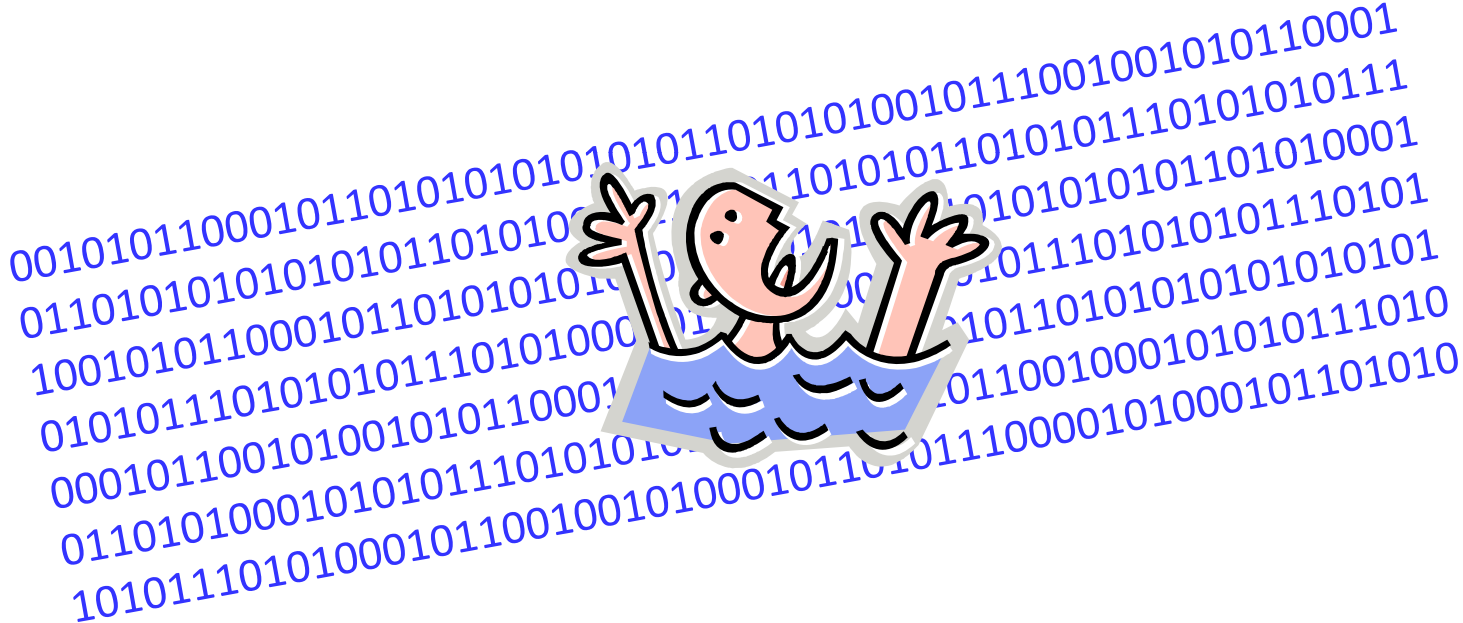
Science

Technology

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



Data to Knowledge to Action

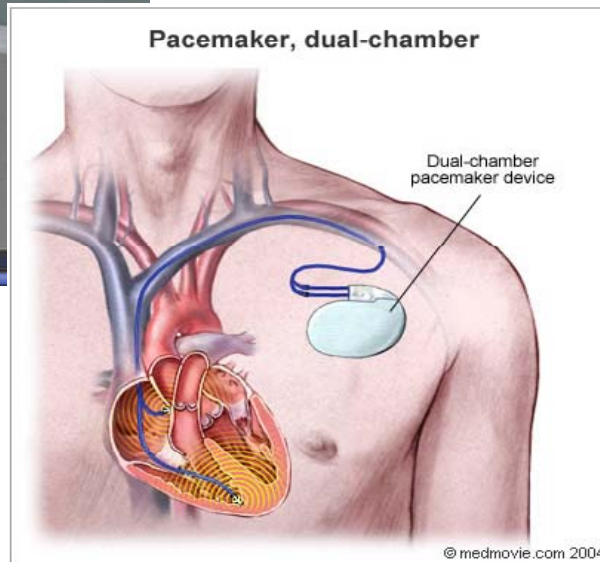


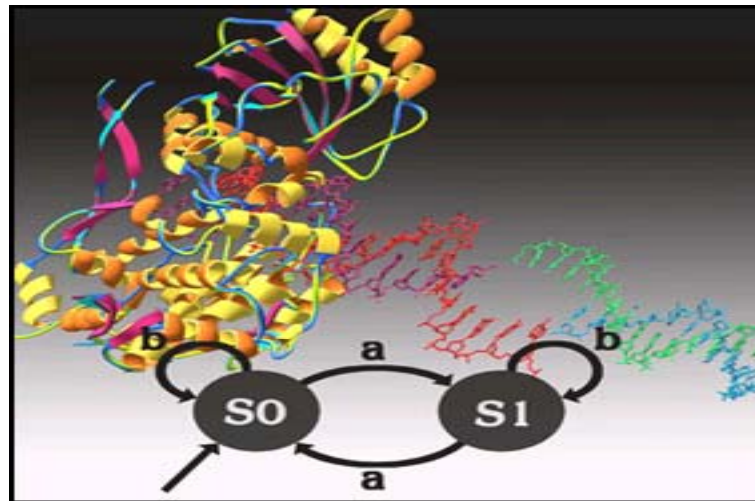
Cell + Cloud



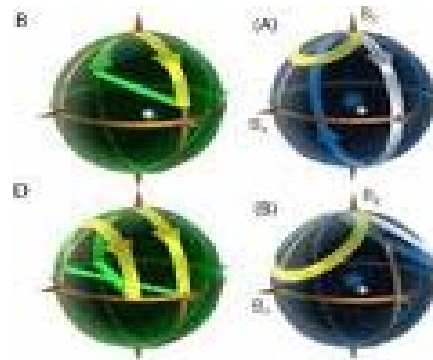
credit: M. Lam

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



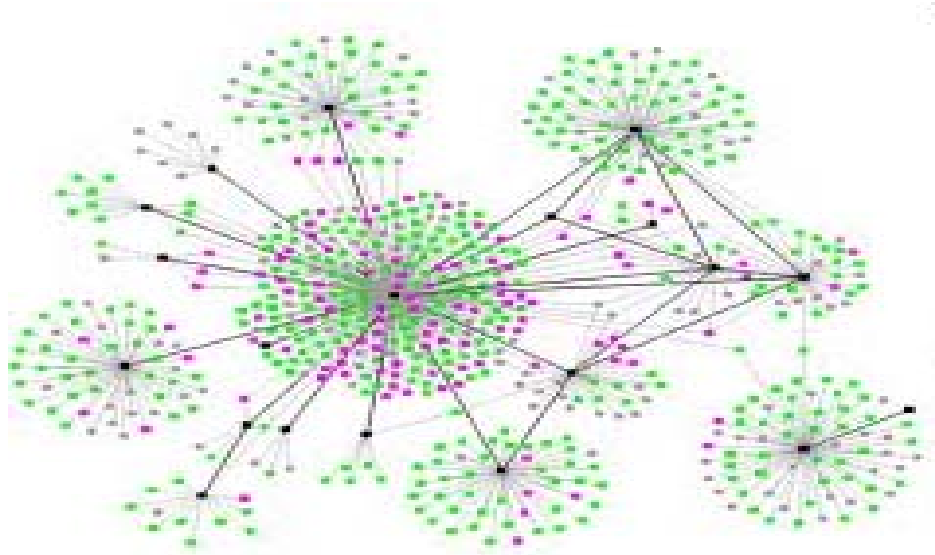


Bio + Nano + Info



Quantum

Humans + Computers ("Socially Intelligent Computing")



Societal Drivers

High Expectations

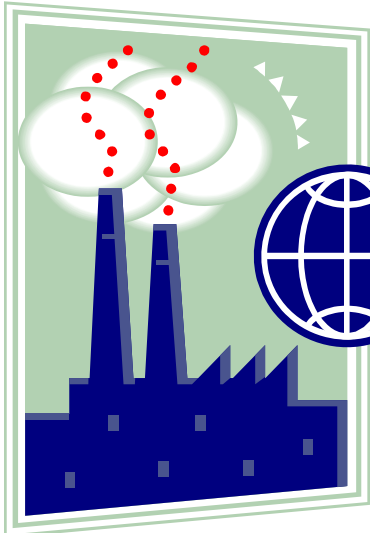
24/7, 100%, anyone, anything, anytime, anywhere

Diversity in Classes

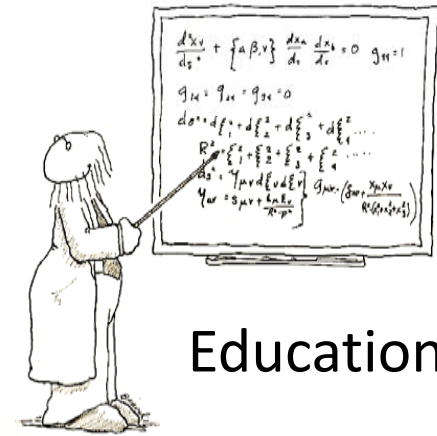


Personalized

Societal Grand Challenges

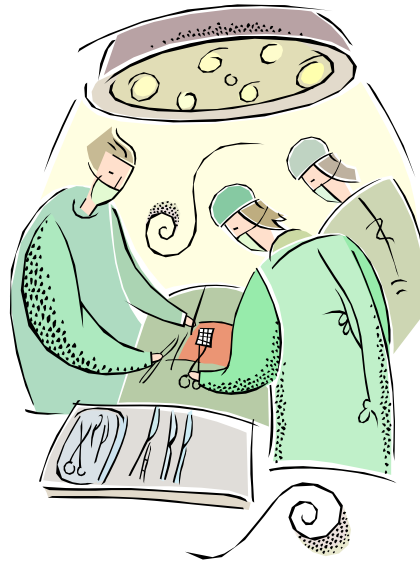


Energy
Environment
Climate Change
Sustainability

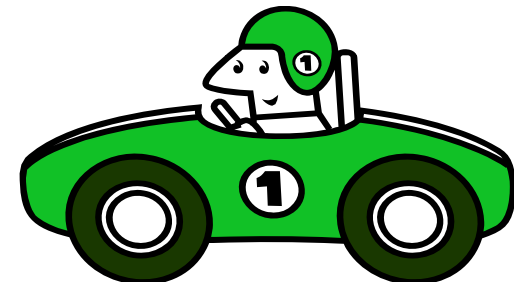


Education

Food, Water



Healthcare



Transportation

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.”

General Information

Program Title:
Cyber-Enabled Discovery and Innovation (CDI)

Synopsis of Program:
Cyber-Enabled Discovery and Innovation (CDI) is NSF's bold five-year initiative to create evolutionary science and engineering research outcomes made possible by innovations and advances in computational thinking. Computational thinking is defined comprehensively to encompass computational concepts, methods, models, algorithms, and tools. Applied in challenging science and engineering research and education



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

BOARD ON SCIENCE EDUCATION
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site_navigation

BOSE HOME

[Conceptual Framework for New Science Education Standards](#)

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

Technology

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

