中国科学院大学
University of Chinese Academy of Sciences

CS101

Overview

The field of CS and IT

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小调查结果（共375人）

是否拥有笔记本电脑	否	0.8%	
	是	99.2%	
是否有程序设计经历	否	70%	
	是	学过VB, C, Python, C++, Pascal, 单片机, …	18%
		通过学业水平测试	7.2%
		信息学奥赛获奖、写过不错的程序	4.8%

SEP新资源

- 新上传资源
  - 2021计导-概述2-1.pdf
  - 2021计导-概述2-2.pdf
  - CS101-Index in English-Chinese.pdf
  - CS101-Programming Basics, Index.pdf
  - Golang Programming Notes.pdf
- 下周更新资源
  - CS101-chapters 1-2.pdf

感谢姚森瀚同学

- Page 23, Para 4
  - “During this compilation process, the compiler also checks for various syntactic errors, called **compile-time errors**, in the high-level language program fib-10.go.”
- Changed to
  - “During this compilation process, the compiler also checks for and reports various **compile-time errors**, such as syntactic errors in program fib-10.go.”
- 原文陈述不严谨，修改后的更加严谨
- 要点是理解编译错误、运行时错误、bug的区别
  - 例子演示
- 学习高德纳老师，奖励姚森瀚同学$2.56 = ￥17
  - 见中文版教科书第75-76页

Bug的两大类

- 编译时错误的例子
  - 程序fib-10.go本身的错误
    - 括号不匹配
    - 没有定义（没有声明）、没有赋初值
    - 类型不匹配
  - 与运行程序fib-10.go的环境不匹配，如import “fmt1”
- 运行时错误
  - || 运算符 误写为 &&
    - 编译器无法判断程序员的“真实”意图，只能按照代码规定编译出二进制码（即机器代码、可执行代码）
    - 较好的情况：执行时计算机系统报错
  - 最糟糕的情况：正常执行完毕，系统产生错误结果但不报错
    - 例如，+ 误写为 *

Outline

- CS supports information society
  - Four facts of IT, ICT, digital economy, IT professionals
  - Four hypotheses on why CS permeates
- CS shows three wonders
  - Of exponentiation, of simulation, of cyberspace
- CS has three persuasions (basic problems)
  - Babbage's problem
  - Bush’s problem
  - Turing’s problem

These slides acknowledge sources for additional data not cited in the textbook

1. CS supports information society

- History has seen three main forms (eras) of human civilizations
  - Agrarian society, Industrial society
  - **Information society**
- Four facts of the CS and IT profession
  - Fact 3: CS supports information society
- Four hypotheses on why CS permeates

- CS is the academic discipline
- IT is the professional field
- Often they are used as synonyms

1.1 Four facts of the CS & IT profession

- Fact 1: CS directly supports the IT industry
  - The *information technology* **(IT)** industry provides computer and network hardware & software products and services. Worldwide IT spending passed US$2 trillion in 2013.
  - The *information and communication technology* **(ICT)** industry adds telecommunication sector to IT. Worldwide ICT spending in 2019 was about US$3.7~5 trillion.
- People sometimes use IT to mean ICT
  - Partly because IT and CT are merging
  - Example: “Gartner Says Worldwide IT Spending to Grow 4% in 2021”

Spending in US$ billion	2019 Spending	2020 Spending	2021 Spending
Data Center Systems	215	208	219
Enterprise Software	477	459	492
Devices	712	616	641
IT Services	1,040	992	1,033
Communications Services	1,373	1,333	1,370
Overall IT	**3,816**	**3,609**	**3,755**

Data source:
https://www.gartner.com/en/newsroom/press-releases/2020-10-20-gartner-says-worldwide-it-spending-to-grow-4-percent-in-2021

什么是信息技术（IT）？

- 中国：
  - 信息技术=计算机科学技术与通信技术
  - 信息化=计算机科学技术与通信技术的应用
- 国际：
  - 信息技术（IT）= 计算机科学技术
  - ICT = 计算机科学技术与通信技术
  - 国际上在向中国看齐
- 用户通过三种载体消费信息技术（产品与服务）
  - 硬件产品（如桌面电脑、智能手机、服务器）
  - 软件产品（如操作系统软件、数据库软件、游戏服务）
  - 信息服务（如信息系统优化服务、互联网视频服务、微信服务）

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  - The information and communication technology **(ICT)** industry adds telecommunication sector to IT. Worldwide ICT spending in 2019 was about US$3.7~5 trillion.
- Fact 2: CS supports digital economy
  - which is ICT plus its impact on other economic output
    - Foundational digital economy (ICT, 基础型信息经济),
    - Productivity-enhancing digital economy (效率型信息经济),
    - Convergence digital economy (融合型信息经济),
    - Emergence digital economy (新生型信息经济), and
    - Welfare digital economy (福利型信息经济).
  - By traditional definition, Facebook is not IT but advertisement company
  - Worldwide digital economy was estimated at US$11.5 trillion in 2017

1.1 Four facts of the CS & IT profession

- Fact 3: CS supports the information society
- Human civilizations are entering the third era of development
  - Agrarian age, Industrial age, **Information age**
    - By January 2021, the worldwide Internet penetration rate has passed 53%, and an average Internet user spent 6 hours 54 minutes daily to use the Internet
- Information society is not just economic, but a mega trend
  - A new era of human civilizations

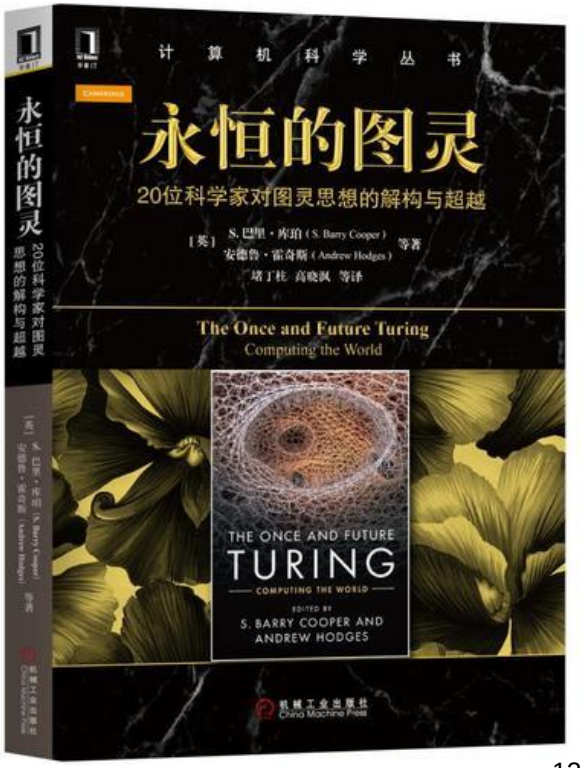
Year	Worldwide Internet Users/Population
1996	1%
2001	8%
2006	18%
2011	31%
2016	44%
2021	53%

Country	Daily Time Spent Using Internet 2021
Brazil	10:08 (10 hours 08 minutes)
Indonesia	08:25
Russia	07:52
USA	07:11
Worldwide	06:54
Germany	05:26
China	05:22
Japan	04:25

Data sources: International Telecommunications Union, Datareportal

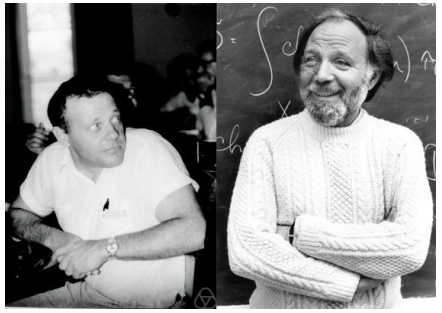
数学与计算机科学融合

- 希尔伯特第十问题
  - 1900年：希尔伯特在世界数学家大会上提出23个重大数学问题，其中第十问题（也称为丢番图方程问题）是
    - **找到一个算法，能判定：整系数多项式方程是否存在整数解**
  - 不可解性定理
    - **存在不可判定的可列集**
  - 1950年，戴维斯提出猜想
    - **猜想：每个可列集都是丢番图集**
  - 1970年，马季亚谢维奇定理（ DPRM定理）
    - **Martin Davis，纽约大学计算机科学系教授**
    - Hilary Putnam，美国哲学学会主席
    - Julia Robinson，美国数学学会主席
    - 尤里·弗拉基米罗维奇·马季亚谢维奇，俄罗斯数学家 (Юрий Владимирович Матиясевич)
    - **定理：每个可列集都是丢番图集**
- 重要诀窍：**斐波那契数列**



实例：‘Outsiders’ Crack 50-Year-Old Math Problem

https://www.quantamagazine.org/computer-scientists-solve-kadison-singer-problem-20151124



- Kadison-Singer问题
  - 受狄拉克启发，Kadison与Singer在1959提出
    - 物理问题：
      - 海森堡不确定性原理（粒子的动量和位置不可精确确定）
      - 已知尽可能多的相容量构成的子系统状态，能否推断出全系统状态？
      - 粒子在连续线上移动，答案是“否”。那么，颗粒（granular）空间如何？
    - 数学问题：C*-代数、阿贝尔群、希尔伯特空间
- 1959-2013，出现很多中间结果和猜想，成为数学和工程学科的重要问题
  - Anderson’s Paving Conjectures (‘79, ‘81)
  - Bourgain-Tzafriri Conjecture (‘91)
  - Feichtinger Conjecture (‘05)
  - Many others
    - 例如，“鸡尾酒会问题”
      - 能否在鸡尾酒会的嘈杂声音中，还原出每个人的谈话
- 2013年，Spielman与博士后、博士生给出了证明（关键是**看成网络问题**）

Three computer scientists, Nikhil Srivastava, Adam Marcus, and Daniel Spielman, solved the famous Kadison-Singer problem in 2013.

2014年George Pólya数学奖

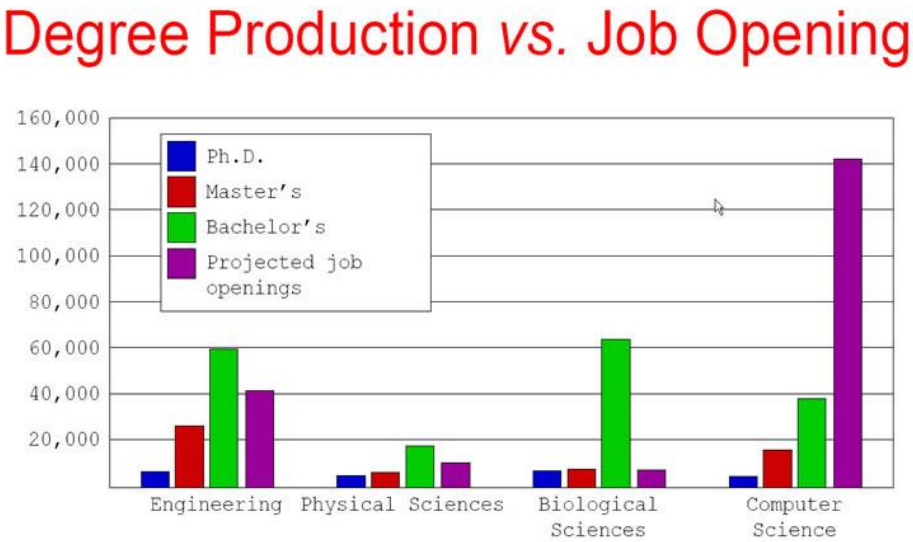
1.1 Four facts of the CS & IT profession

- Fact 4: There are not enough CS or IT professionals
  - Definition and observation by David Grier (IEEE Computer Society)
    - IT professionals are people who (1) have earned a bachelor degree and (2) work in research, education, development, management and services of computing knowledge, products and services
    - There are only about 3~10 million IT professionals worldwide
      - Roughly one IT professional serving 1000 people worldwide

  - One minute quiz: the CS department at Harvard University did a survey of the work titles of their graduates. The top two titles start with a P. They are:
    (a) President
    (b) Producer
    (c) Production-line worker
    (d) Professor
    (e) Programmer

计算机科学的教育与人力资源

- 学位教育
  - 计算机科学技术
  - Computer Science
  - Computer Engineering
  - Information Systems
  - Informatics
- 专业人员队伍
  - 全球300~1000万人
  - 中国接近100万人



Sources: http://cs.stanford.edu/~eroberts/talks/SIGCSE-2008/RediscoveringThePassion.ppt
Adapted from a presentation by John Sargent, Senior Policy Analyst, Department of Commerce, at the CRA Computing Research Summit, February 23, 2004. Original sources listed as National Science Foundation/Division of Science Resources Statistics; degree data from Department of Education/National Center for Education Statistics: Integrated Postsecondary Education Data System Completions Survey; and NSF/SRS; Survey of Earned Doctorates; and Projected Annual Average Job Openings derived from Department of Commerce (Office of Technology Policy) analysis of Bureau of Labor Statistics 2002-2012 projections. See http://www.cra.org/govaffairs/content.php?cid=22.

Professional Communities

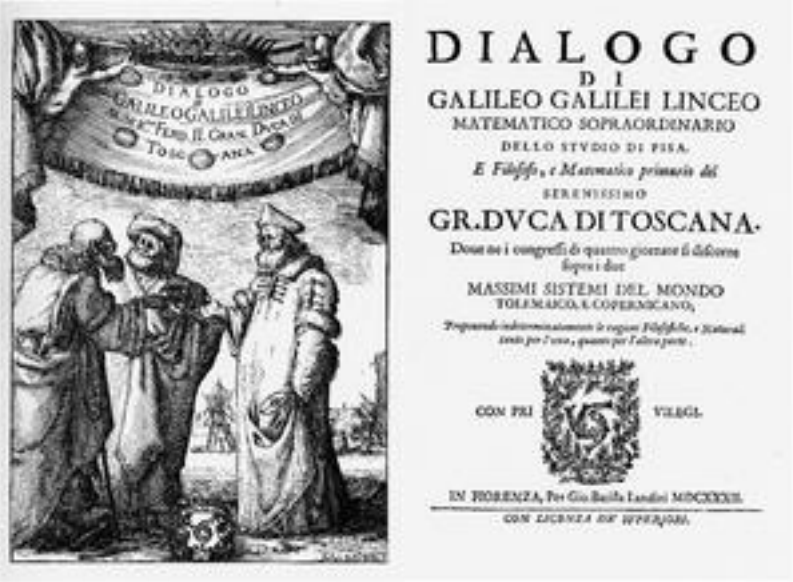
- International Societies
  - **ACM**
    - Association for Computing Machinery
    - about 100,000 members
    - Flagship magazine: *Communications of ACM*
  - IEEE CS
    - **IEEE Computer Society**
    - about 70,000 members
    - Flagship magazine: *Computer*
- **CCF** 中国计算机学会
  - China Computer Federation
  - about 70,000 members
  - Flagship magazine: *Communications of CCF*

1.2 Four hypotheses on why CS permeates

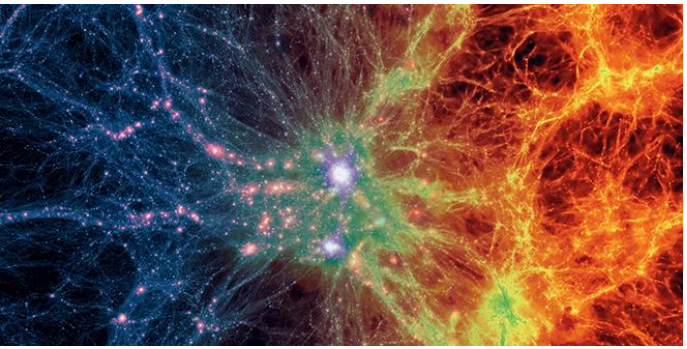
- Why Computer Science Permeates Our Civilizations
  - Chomsky's digital infinity principle: A finite set of digital symbols can be combined to produce infinite expressions in many domain languages.
  - Karp's computational lens thesis: Many processes in Nature and human Society are also computational processes. Nature computes. Society computes. We can understand Nature and Society better through the computational lens.
  - Babayan's gold metaphor: Computing speed is like gold, a hard currency that can be exchanged for anything.
  - Boutang's bees metaphor： ICT is like bees, producing two types of outputs. The indirect output (pollination) of bees has economic value that is orders of magnitude larger than the value of the direct output (honey). Similarly, the value of digital economy (indirect output) is much larger than that of the ICT market (direct output).

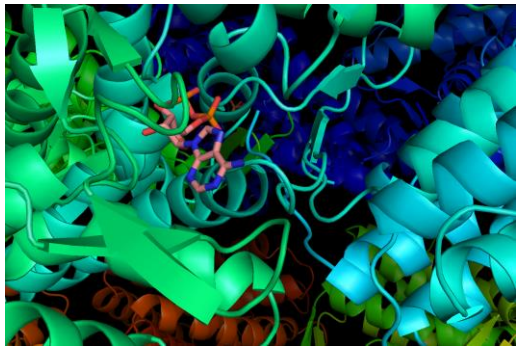
为什么计算机科学可以解决多类问题？

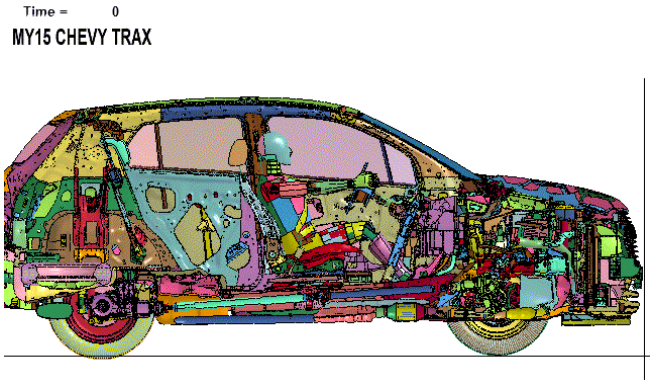
- 乔姆斯基数字无穷性假说（也称为离散无穷性）
- 维基百科： **Digital infinity** is a technical term in theoretical linguistics. Alternative formulations are "discrete infinity" and "the infinite use of finite means". The idea is that all human languages follow a simple logical principle, according to which a limited set of digits—irreducible atomic sound elements—are combined to produce an infinite range of potentially meaningful expressions.
- 据说来源于伽利略： In his *Dialogo*, Galileo describes with wonder the discovery of a means to communicate one‘s “most secret thoughts to any other person ... with no greater difficulty than the various collocations of twenty-four little characters upon a paper.” This is the greatest of all human inventions, …



为什么计算机科学渗透广而深？







科学、技术、经济、社会的各种问题和过程

各领域的专业表达

都可以用该领域的语言表示

数字无穷性假说
+
计算透镜假说

有穷数字符号的组合可表达无穷语言
+
Nature computes.
Society computes.

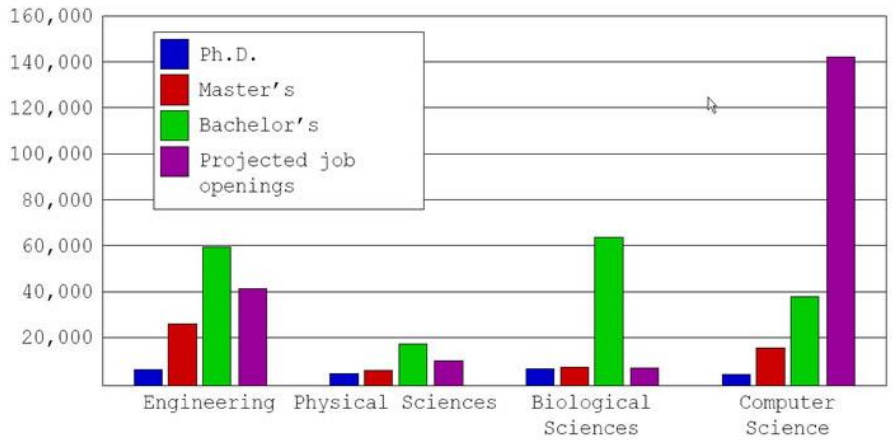
计算问题和计算过程

给地球做CT

计算机科学的教育与人力资源

- 学位教育
  - 计算机科学技术
  - Computer Science
  - Computer Engineering
  - Information Systems
  - Informatics
- 专业人员队伍
  - 全球300~1000万人
  - 中国接近100万人

Degree Production *vs.* Job Openings



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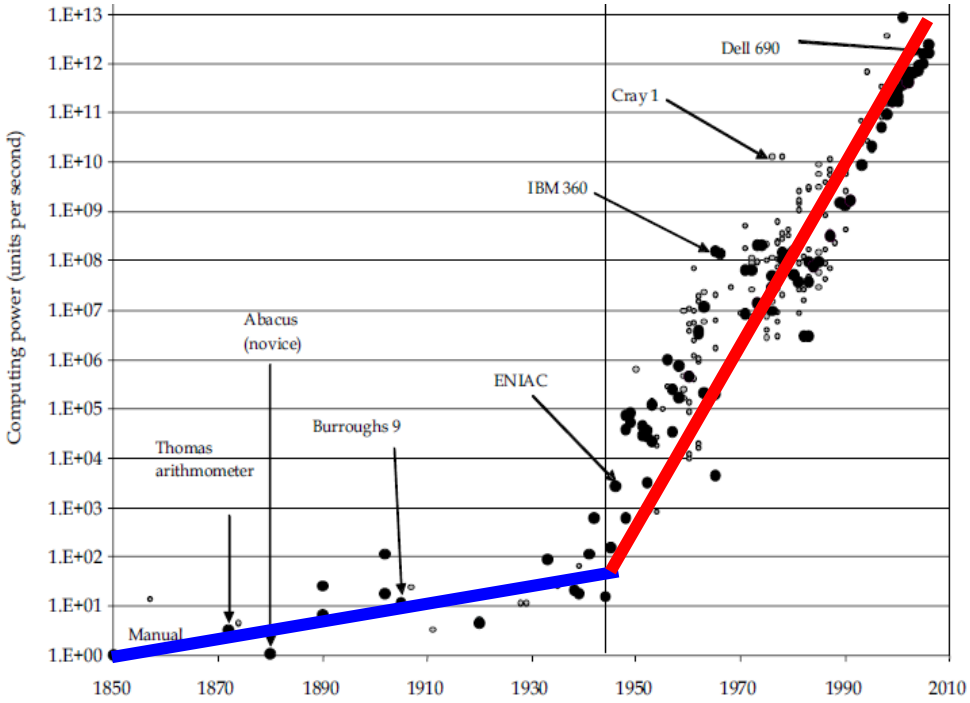
2. CS shows three wonders

- Wonder of exponentiation
- Wonder of simulation
- Wonder of cyberspace

2.1 Wonder of exponentiation

- For many problems
  - the number of operations grows exponentially, 2^n
    - E.g., using a brute-force method, the number of operations in protein folding ≈ 3^{300} ≈ 10^{143}, where the problem size n = 300
      - Challenge: reduce it to 1.2^n, or even n^k, where k is a small constant
    - Sources of much interesting research

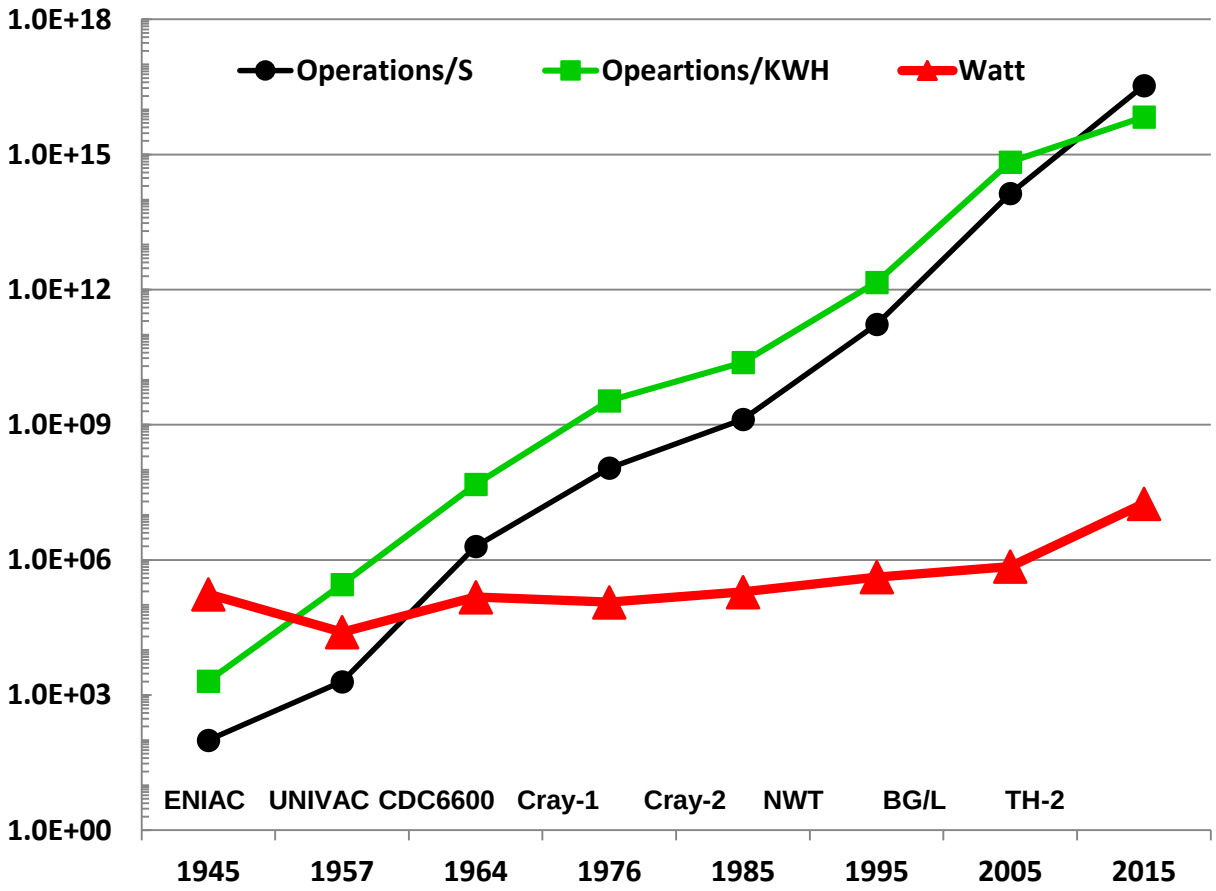
- Computing speed grows exponentially
  - Nordhaus's law: During 1945-2006, the speed of a computer increased 50% annually
  - Growth before was much smaller
  - Why?



Nordhaus W D. Two Centuries of Productivity Growth in Computing. Journal of Economic History, 2007, 67(1):128-159.

More recent trends on speed growth

- Energy efficiency becomes a big challenge
  - 将能效曲线扳回上方！可能吗？



Growth trends of computing speed, energy efficiency, and power consumption of the world's fastest computers (supercomputers) from 1945 to 2015. Special thanks to Drs. Gordon Bell, Jonathan Koomey, Dag Spicer and Ed Thelen for providing data for the first three computers.

More recent trends on speed growth

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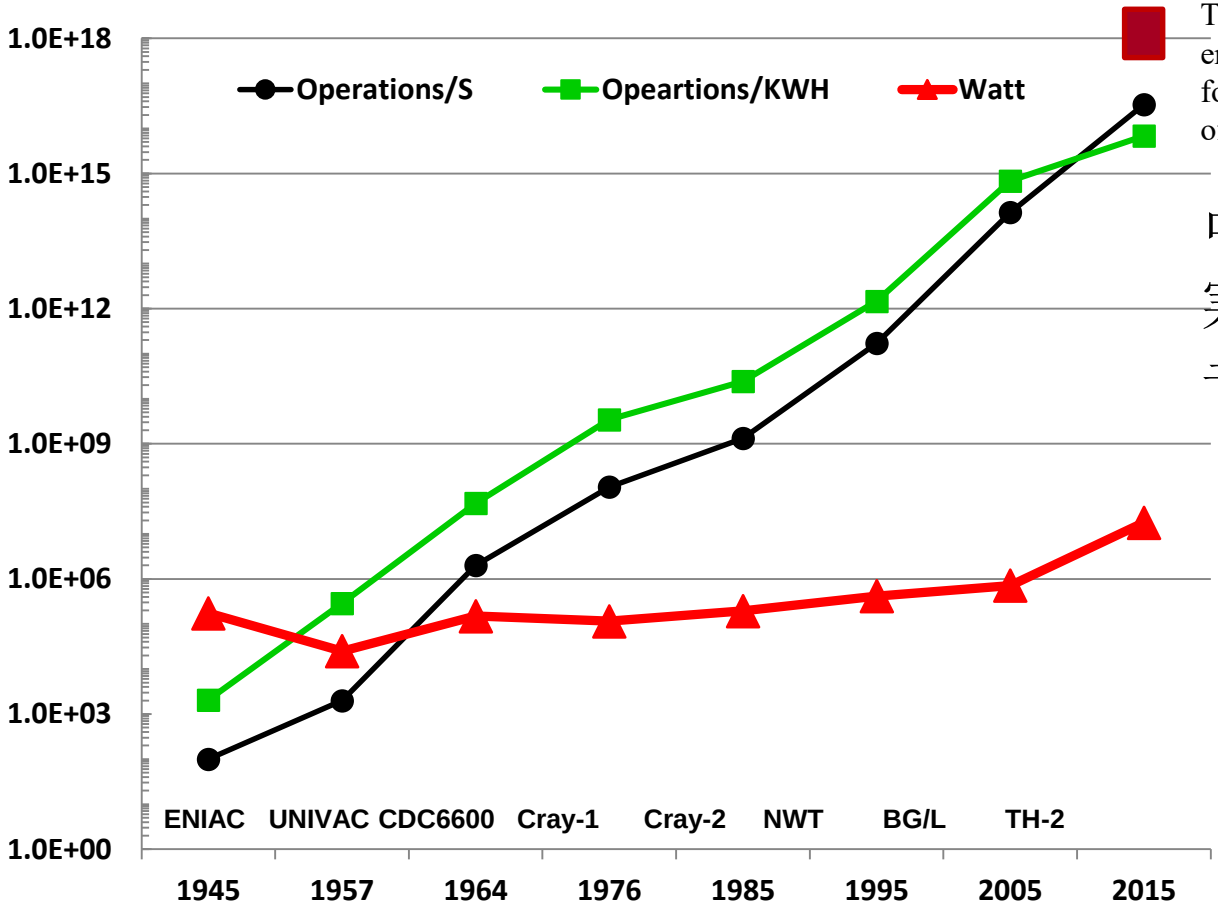


Chen, Y., Chen, T., Xu, Z., Sun, N., & Temam, O. (2016). DianNao family: energy-efficient hardware accelerators for machine learning. Communications of the ACM, 59(11), 105-112.

中科院计算所的寒武纪机器学习专用处理器研究

Growth trends of computing speed, energy efficiency, and power consumption of the world's fastest computers (supercomputers) from 1945 to 2015. Special thanks to Drs. Gordon Bell, Jonathan Koomey, Dag Spicer and Ed Thelen for providing data for the first three computers.

2.1 Wonder of exponentiation

- Not just computing speed

- William Nordhaus (2007)
  - Nordhaus's law: computer speed grew exponentially with time, increasing 50% per year from 1945 to 2006.
- Gordon Moore (1975)
  - Moore's law: the number of transistors in a semiconductor chip grows exponentially with time, doubling every two years or so.
- Donald Keck (2015)
  - Keck's law: the data transmission rate of a single optical fiber grows exponentially with time, increasing about 100 times in 10 years.

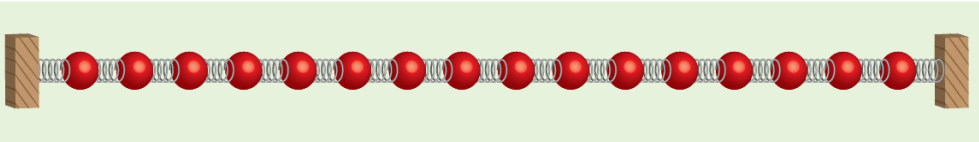
2.2 Wonder of simulation

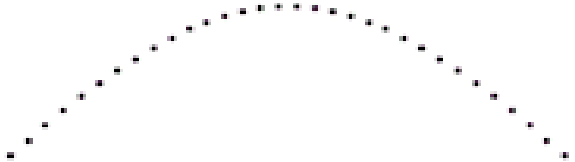
- Simulation is to mimic physical or social processes
  - by executing computer programs (computational processes)
    - Aka computer simulation, computer experiment, numerical experiment
- The first computer simulation was conducted in 1953
  - By physicists Enrico Fermi, John Pasta, and Stanislaw Ulam
    - to solve a physics problem later known as “the Fermi-Pasta-Ulam paradox”.
- Computer simulation provides a third paradigm for scientific enquiry besides theory and observation/experiment
  - “a third way of doing science...helped scientists to see the invisible and imagine the in-conceivable”, as commented by Steven Sttogatz
- Example: Atoms in the Surf

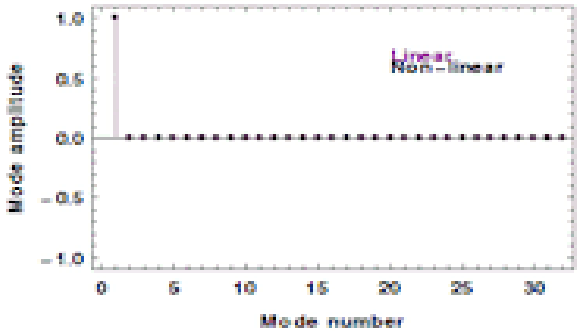
Porter, Mason A., et al. "Fermi, Pasta, Ulam and the Birth of Experimental Mathematics: A numerical experiment that Enrico Fermi, John Pasta, and Stanislaw Ulam reported 54 years ago continues to inspire discovery." *American Scientist* 97.3 (2009): 214-221.

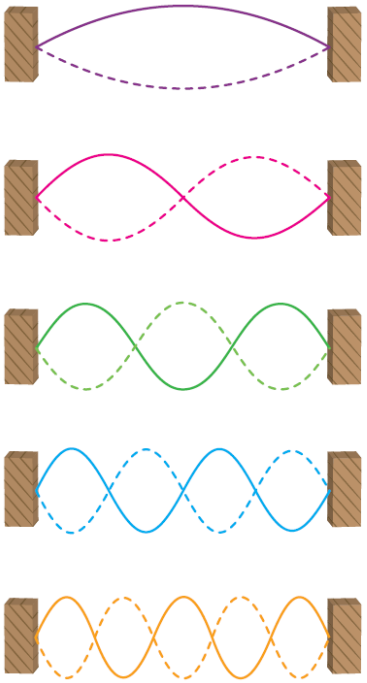
1953年，费米等发明计算机模拟

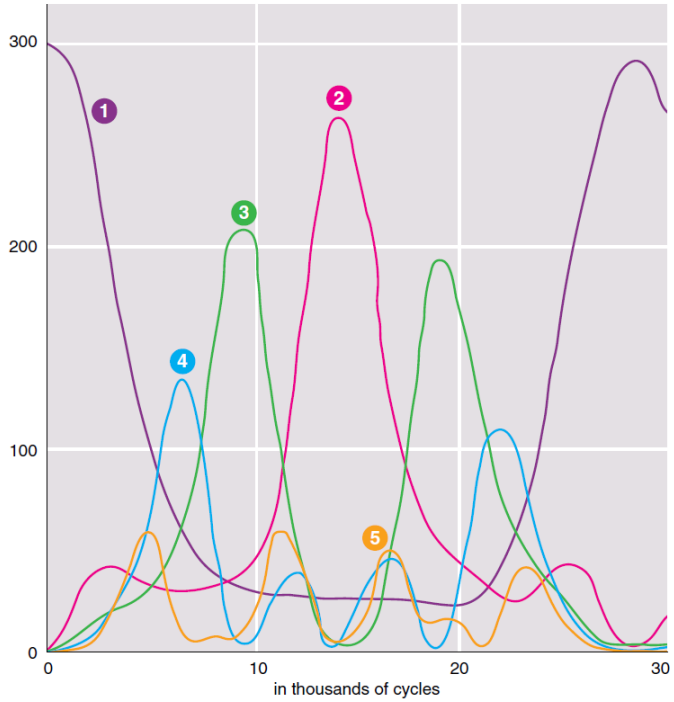
- 第三种科学研究方法
  - 在Maniac计算机上求解
- Fermi–Pasta–Ulam悖论
  - FPU Recurrence, 1955
- 部分解直到2015才出现
  - Onorato, et al, PNAS 2015











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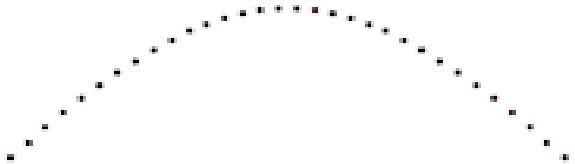
en.wikipedia.org/wiki/Fermi–Pasta–Ulam–Tsingou_problem

1953年，费米等发明计算机模拟

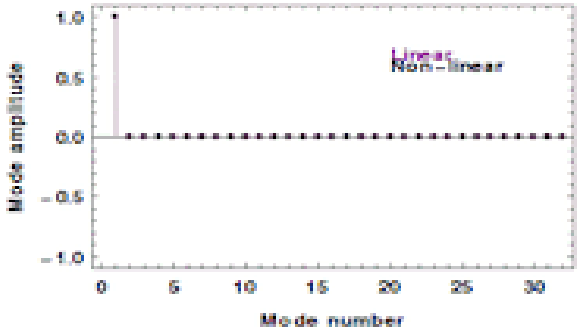
- 开启了第三种科学研究方法
  - 在Maniac计算机上求解
- By Mary Tsingou
- “Let us refer from now on to the Fermi-Pasta-Ulam-Tsingou problem.”

  Dauxois, *Physics Today*, 2008



Mary Tsingou in 1955

与她先生一起(2019)
91岁了！



en.wikipedia.org/wiki/Fermi–Pasta–Ulam–Tsingou_problem

“They thought nuclear energy was going to change the world,” she says, “but it’s the computers that have changed the world.”

https://www.lanl.gov/discover/publications/national-security-science/2020-winter/mary-tsingou.shtml

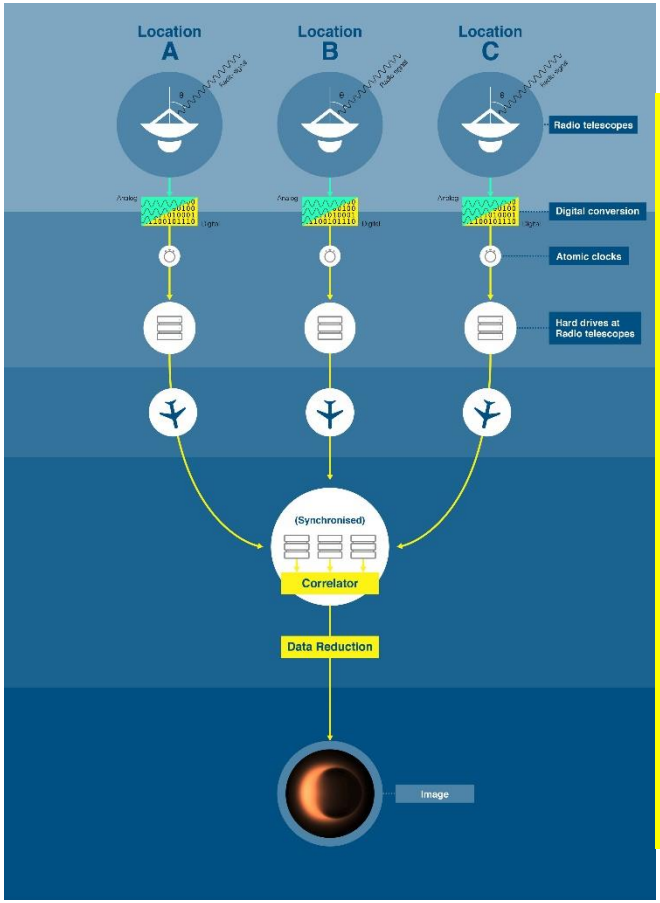
2.3 Wonder of cyberspace

- There are three worlds (spaces)
  - Human society
  - Physical world (Nature and human-built things)
  - Cyberspace
- The cyberspace is created by humans
  - Human is the designer, and in control (usually)
  - Enable virtual things or virtual worlds that may not be possible in the physical world
    - A shopping mall hosting a million vendors
    - A bookstore holding a billion books
    - A thousand-floor library
    - Computer games which follow their own laws
    - Counterfactuals

Human-Cyber-Physical
ternary computing system

- First photographs of a blackhole

  by Earth-diameter virtual telescope EHT



Data captured
April 5-11 2017

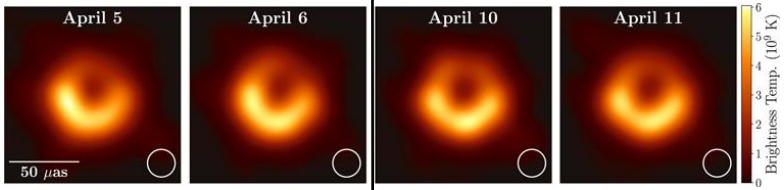
Hard disks shipped
to supercomputers

Data correlation
and reduction took
two years

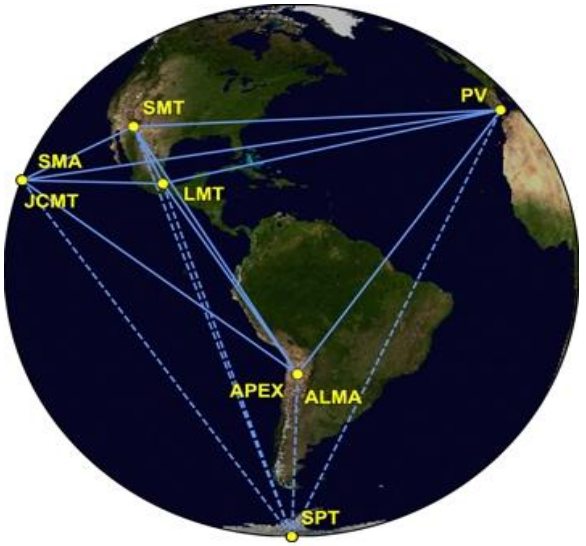
Images published
April 2019

Messier 87 Galaxy –
apod.nasa.gov/
apod/ap100520.html

55 Mly



2017



Event Horizon Telescope Collaboration et al., ApJL 875, April 2019

3. CS has three persuasions

- Recurring problems to be solved again and again

- Babbage's problem
  - How to design computers
- Bush’s problem
  - How to use computers
- Turing’s problem
  - How to make computers intelligent

3.1 Babbage's problem

- How to build efficient, programmable computers?
- Milestones
  - 2000 BCE
    - Abacus
  - 1703-1936
    - Leibniz invented binary arithmetic
    - Babbage proposed Difference Machine
  - 1936-Present
    - 1936, Turing machines
      first universal abstract computer
    - 1946, ENIAC
      first real general-purpose digital electronic computer
    - 1960, first CS department at Purdue University

Birth year of modern CS

3.1 Babbage's problem

- Three types of computers
  - Client-side computers
    - Users see and use them directly
  - Server-side computers
    - Users use them indirectly (remotely)
  - Embedded computers
    - Computers embedded (hidden) in other systems

A server example

3.1 Babbage's problem

- Bell's law: Computers develop by following three design styles, to generate a new computer class roughly every 10 years.
  - Develop the most capable computers
  - Improve performance but maintain a constant price
  - Minimal-priced computer

- 10 classes from 1950-2007
  - Supercomputers
  - Mainframes, such as IBM S360
  - Minicomputers, such as DEC PDP-11
  - Clusters (systems of interconnected computers), such as IBM SP2
  - Workstation, with graphics processing and display capability
  - Personal computers (desktop PC), such as Apple 2
  - Portable computers, such as laptop computers
  - Dedicated personal devices, such as a game device, a digital camera
  - Smartphone, such as Apple iPhones
  - Wearable devices, such as a smart watch

3.2 Bush's problem

- How to use computers effectively?
  - Relationship between *thinking man and the sum of human knowledge*
  - How to best connect people, computers, and information
- Usage mode

	Memex
The intended user community	scientists
The organization style of information	hyperlinked records
The style of human-computer interaction	interactive read, write & select

- Styles of human-computer interaction
  - Batch
  - Interactive
  - Personal computing
  - GUI
  - Multimedia
  - Portable computing
  - Network computing
  - Mobile Internet

3.3 Turing's problem

- How to make computing *application* systems intelligent?
- Three Types of computer applications
  - Scientific computing
    - for scientists and engineers
    - solve equations, do simulations, process scientific data
  - Enterprise computing (business computing)
    - for organizations
      - companies, government agencies, and not-for-profit institutions
    - business workflows, transaction processing, data analytics, decision support
  - Consumer computing
    - for individual consumer users (the masses)

One minute quiz

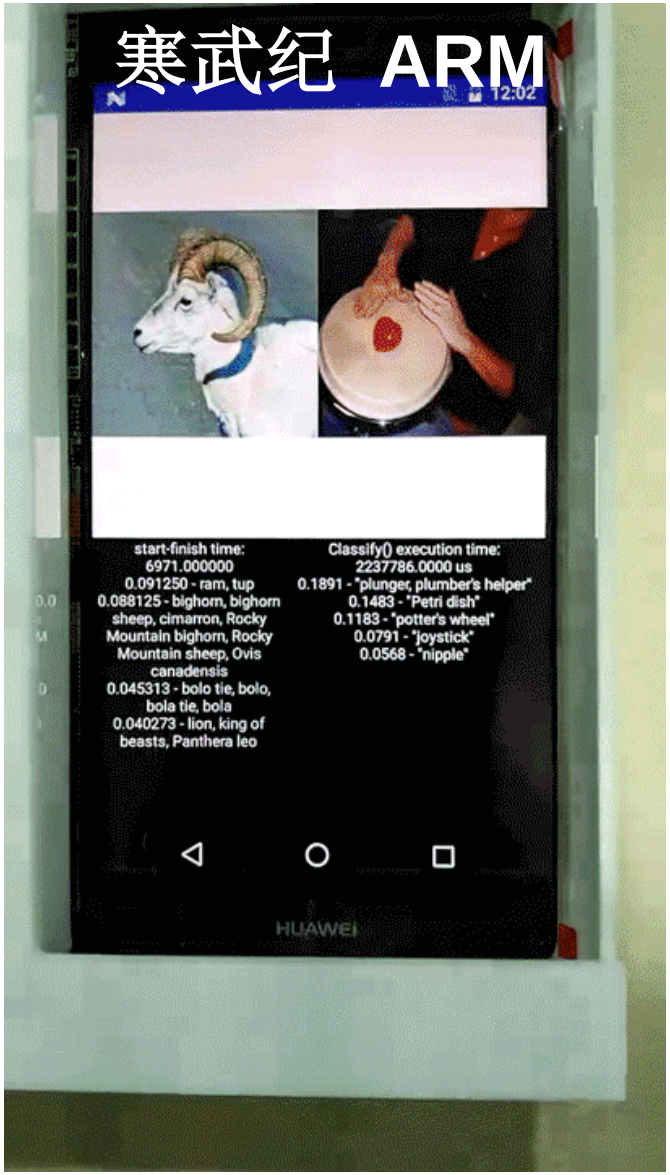
- Connect items on the left to the items on the right by placing the correct letter between parentheses for each line

• “to B” refers to ()	U. products or services for business
• “to C” refers to ()	V. products or services for consumers
• B2B refers to ()	W. company serving other companies
• B2C refers to ()	X. company serving consumers
• C2C refers to ()	Y. consumers serving one another
• C2B refers to ()	Z. company providing personalized service

- Which class does Taobao belong to?
- Which class does Tmall belong to
- Which class does a web search engine belong to?

Examples of intelligent applications

- Turing's Test
  - Imitation Game
- Examples
  - Beat human players in games
    - Chess, Go, Poker, and DOTA
  - Image recognition
    - ImageNet
  - Natural language translation
  - Autonomous vehicles
  - Robotics
- A subfield called artificial intelligence (AI)



许锦波的基础研究

https://ttic.uchicago.edu/~jinbo/

- 计算所1999届硕
- Toyota Technological Institute in Chicago教授，蛋白质结构预测领域的知名专家
- “人工智能在蛋白质结构预测上的突破吸引越来越多的关注。明年诺贝尔基金会在瑞典斯德哥尔摩组织一个50人的小型研讨会，探讨怎么结合实验技术和计算技术对人类三维蛋白质组进行精确的描述。希望这个活动能促进学术届【界】和工业界对这个领域的更多支持。”

THE NOBEL PRIZE | KUNGL. VETENSKAPS AKADEMIEN | FAMILJEN ERLING-PERSSONS STIFTELSE | Knut and Alice Wallenberg Foundation | UNIVERSITET STOCKHOLMS

Dear Prof Jinbo Xu

We are pleased to invite you to participate in the **NS184 Nobel Symposia on "Towards characterizing the human 3D-proteome" to be held in Stockholm May 19-22, 2022**.

This symposium aims to bring together experts from various fields with the explicit goal of outlining a joint worldwide strategy to obtain a structural map of the human proteome. In addition to determining the structure and composition of all human proteins and their interactions, it would also require understanding the flexible and dynamic supra-molecular structures in living cells, such as multi-component membraneless organelles. A few key findings from the last years make us believe that this goal is achievable. First, detailed knowledge of composition (splice forms, PTMs) and expression levels in different cells are becoming available. Secondly, Cryo-EM has revolutionized the structural determination of large protein complexes. Finally, using co-evolution and advances in deep-learning, it is now possible to predict the structure of many individual proteins and complexes directly using no other information than the sequences and their evolutionary history. In the next few years, combining the progress in these three areas will provide an opportunity to provide unprecedented molecular insights into the function of cells. Theoretical methods combined with ever-increasing sequence information will enable understanding sequence and structural variation within populations, both in humans and disease-causing organisms.

The Nobel Foundation's symposium activities were initiated in 1965. Over the years, they have achieved a high international standing. The symposia are devoted to science areas where breakthroughs are occurring. Therefore, we plan the meeting to consist of (i) a half-day open session for the public and then three days of a private meeting of the participants and a few young scientists in the area. We, therefore, ask you to prepare to actively participate in the discussions, give a short presentation, **and contribute to a white-paper with the outcomes of the meeting**. Hopefully, this meeting and white-paper can act as a similar inspiration as the 1995 summit in Bermuda did for genomics.

We will cover accommodation and other costs during the meeting attendance. We will do our best to contribute to cover travel costs (economy class), but as we are not allowed to apply for extra funding, the total cost must be within the budget. Due to the Nobel Symposia's exceptional character, we expect you to participate in the discussions and stay throughout the full meeting. **The meeting will be limited to 50 according to the foundation's rules and is by invitation only**.

Please confirm (or decline) your participation as soon as possible by email to arne@bioinfo.se. Closer to the meeting, I will contact you with more details and an outline of the white-paper. Feel free to contact me if you have any questions or suggestions.

Yours sincerely,

Arne Elofsson

Prof. Arne Elofsson, Stockholm University, on behalf of the organization committee (Björn Wallner, Erik Aurell. Petras Kundrotas, Christine Orengo, David T Jones, Edward Marcotte, Lori Passmore, Martin Weigt, Michael Levitt, Shoshana Wodak).

邹永强创业实践

- 计算所2010年博
- 云账户公司创始人兼CTO
  - 5%→10%人口合规交税（个人所得税）
    - 美国44%
  - 4年来发展迅猛
    - 1.2亿注册用户
    - 4900万活跃用户
    - 400亿元收入，32亿利税
    - 200名工程师
- 技术
  - 分布式系统
    - 整合多种应用框架
  - 秒级到账
  - 快速迭代：每天千次更新

华为涂丹丹模型

- 计算所2011届博
- 华为云EI创新孵化实验室主任
- 领导开发云计算AI应用系统
  - 快速解决业务痛点
  - 平均半年体现亿元收入
    - 票单OCR
    - 设备数据库梳理
    - 高铁机车巡检
    - 智慧机场
    - 智慧油田
    - 智慧煤矿

任正非接受《南华早报》采访纪要

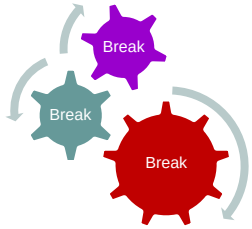
2020-05-11 14:37 发表在园子[Huawei Facts] 70886 100 只看楼主

任正非接受《南华早报》采访纪要

2020年3月24日

我们也把批判谷歌军团的文章同时放在网上，一边支持、一边接受批判，也是组成团体。这个世界单打独斗是不会成功的。例如我们公司推行“涂丹丹模型”，涂丹丹是一个小女孩，领导一个团队，她是领军人。她提出的模型是三个博士、两个硕士组成一个团，我们后面补了两个实验工程师，一个秘书或文员。一些事务性工作让文员做，实验性的工作实验工程师可以做。实验工程师可

Take-Home Messages



- Learn the elementary and the way of thinking
  - The two (CS & CT) are essentially the same thing
    - **Overview** of the CS discipline and the IT field
    - **Ability** to create computers and computer applications
    - **Principles** of computational thinking
  - Focus on the elementary
- Learn by the method of 知行合一
  - Unity of Knowledge and Action (UKA)
  - Mind-active and hands-on learning (动脑动手主动式学习)
    - Most bodies of knowledge are learned as UKA units
    - Aim at upper layers of Bloom's Taxonomy
    - Enable students to pass Knuth's Test