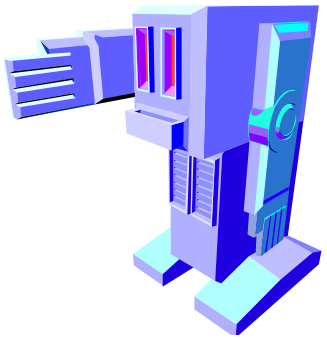
IRA A. FULTON SCHOOLS OF engineering

school of computing, informatics, & decision systems engineering

Introduction to Engineering Using Robotics Experiments

Computer Science and Related Engineering Disciplines



Dr. Yinong Chen

http://www.public.asu.edu/~ychen10/

Computer Science and Engineering

- **Computer Science and Engineering** includes the disciplines
  - **Computer Science**,

    There are many sub disciplines in computer science
  - **Computer Engineering**,

    There are many sub disciplines in computer engineering
  - **Computer System Engineering**:

    Emphasizing on the overlapping part between computer science and computer engineering

Computer Science

- is the study of the **theoretical** foundations of **information** (**data**) and computation, and of **practical** techniques for their implementation and application in computer systems;
- is frequently described as the systematic study of algorithmic processes (**algorithms**) that describe and transform information.
- answers the fundamental question:

  What can be (efficiently) automated?

Computer Engineering

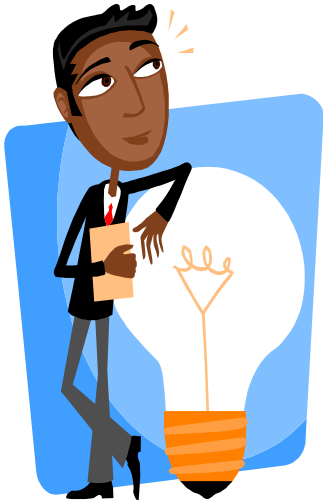
- has two emphases:
  - **Electronic and Computer Engineering,** emphasizing the overlap with the EE; such as chip design, circuit design, signal processing (analog/digital transformation), and lower levels of communication.
  - **Computer Systems Engineering**, emphasizing the overlap with the CS; such as software hardware co-design, embedded system, firmware, controller, input-output devices, robotics, and the software development related to devices.
- concerns the practical question:

  How can a system (hardware and/or software) be created to automate a process?

What is Engineering?

- **Engineering** is the application of scientific and technical knowledge to solve human problems;
- **Engineering** is the application of a systematic, disciplined, quantifiable and optimal approach to the development, operation, and maintenance of an object or a system.
- As with all modern scientific and technological efforts, computers and software play an increasingly important role.
- Few systems today can be engineered without computers and software.

What Does an Engineer Do?



Engineers think and design solutions to challenging problems in everyday life.

Engineers use imagination, judgment and reasoning to apply science, technology, mathematics, and practical experience.

Characteristics of a Good Engineer

Analytical thinking

Reasoning skills

Independent thinking

Creative thinking

Team spirit and collaborative work

High standard in ethics

Good communication skills

…

Degrees @ ASU Ira A. Fulton Schools of Engineering http://engineering.asu.edu/schools

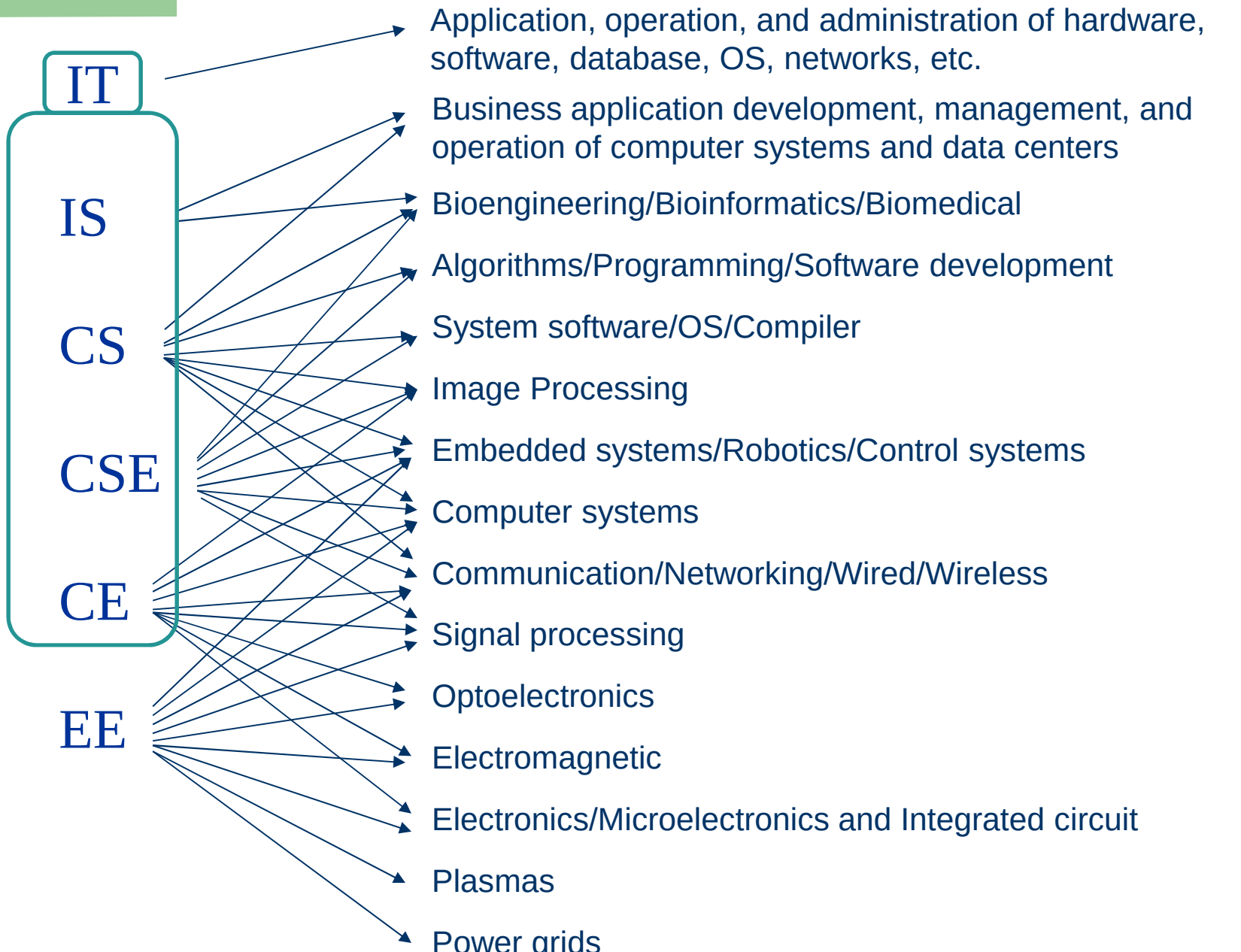
- **School of Computing, Informatics & Decision Systems Engineering**
  - Computer Science
  - Computer Systems Engineering
  - Informatics
  - Industrial Engineering
  - Engineering management
- **School for Engineering of Matter, Transport and Energy**
  - Mechanical Engineering
  - Aerospace Engineering
  - Chemical Engineering
  - Materials Science & Engineering
  - Solar Energy Engineering and Commercialization
- **School of Biological and Health Systems Engineering**
  - Bioengineering
  - Biomedical Informatics
- **School of Sustainable Engineering & the Built Environment**
  - Civil Engineering
  - Construction Engineering
  - Construction Management
- **School of Electrical, Computer, and Energy Engineering**
  - Electrical Engineering

ASU
School of Computing, Informatics & Decision Systems Engineering

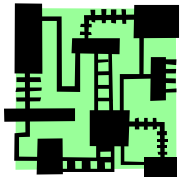
http://cidse.engineering.asu.edu/

- **Computer Science**
  - Database and Information systems
  - Distribution systems
  - Software engineering
  - Search engines, Web services, Cloud computing
  - Mobile computing
  - Computer networking and Gaming systems
- **Computer Systems Engineering**
  - Computer networks and communication
  - Embedded and ubiquitous systems, robotics
  - High performance computer systems
  - Individual digital components
- Industrial Engineering
  - Engineering managers and teachers
  - Human factors engineers and Ergonomists
  - Industrial engineering technicians
  - Industrial and Manufacturing engineers
- Informatics
  - User experience designer
  - Usability engineer
  - Information architect
  - Interaction and Instructional designer
  - IT Consultant and Digital artist
  - E-commerce and Multimedia specialist
- Engineering management
  - Project management team member
  - Project team lead
  - System specification specialist
  - Customer relationship management specialist
  - Production supervisor
  - Supply logistics engineering

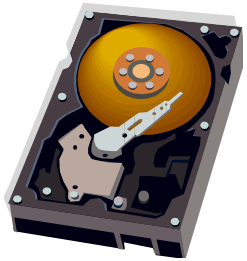
EE, NC, CSE, CS, IS: A Typical Partition

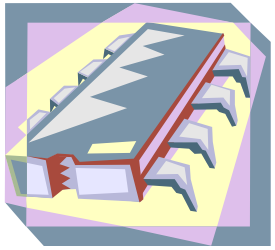


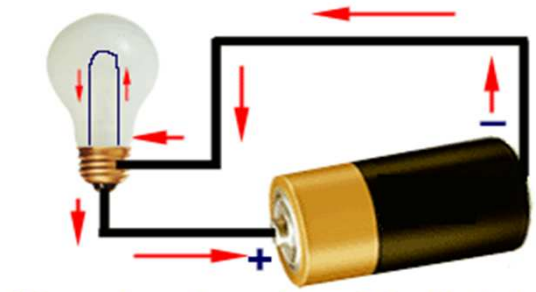
Electrical Engineers

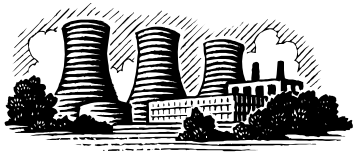


- Design, develop, test, and supervise the manufacture of electrical and electronic equipment;
- Specialize in different areas: power generation, transmission, and distribution; communications; industrial control



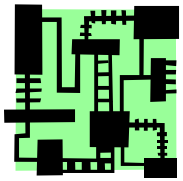


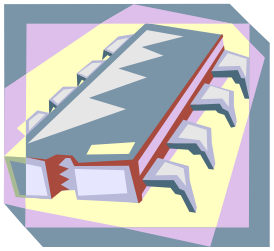


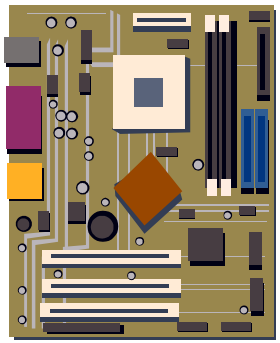


Computer Hardware Engineers

- Research, design, develop, and test computing and communication hardware
- Supervise hardware manufacture and installation

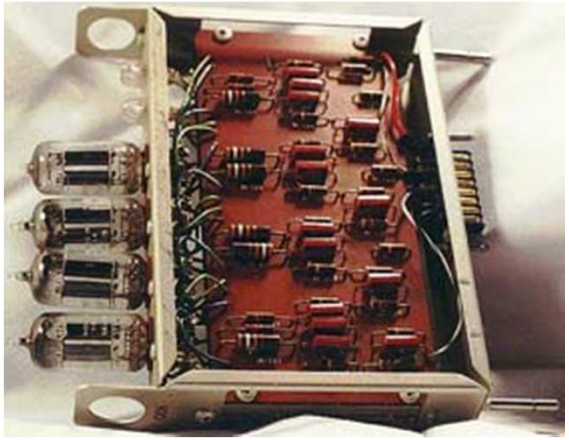






Development of Computers

Vacuum tubes



4-bit memory based on vacuum tubs

10^9-Byte memory
1GB

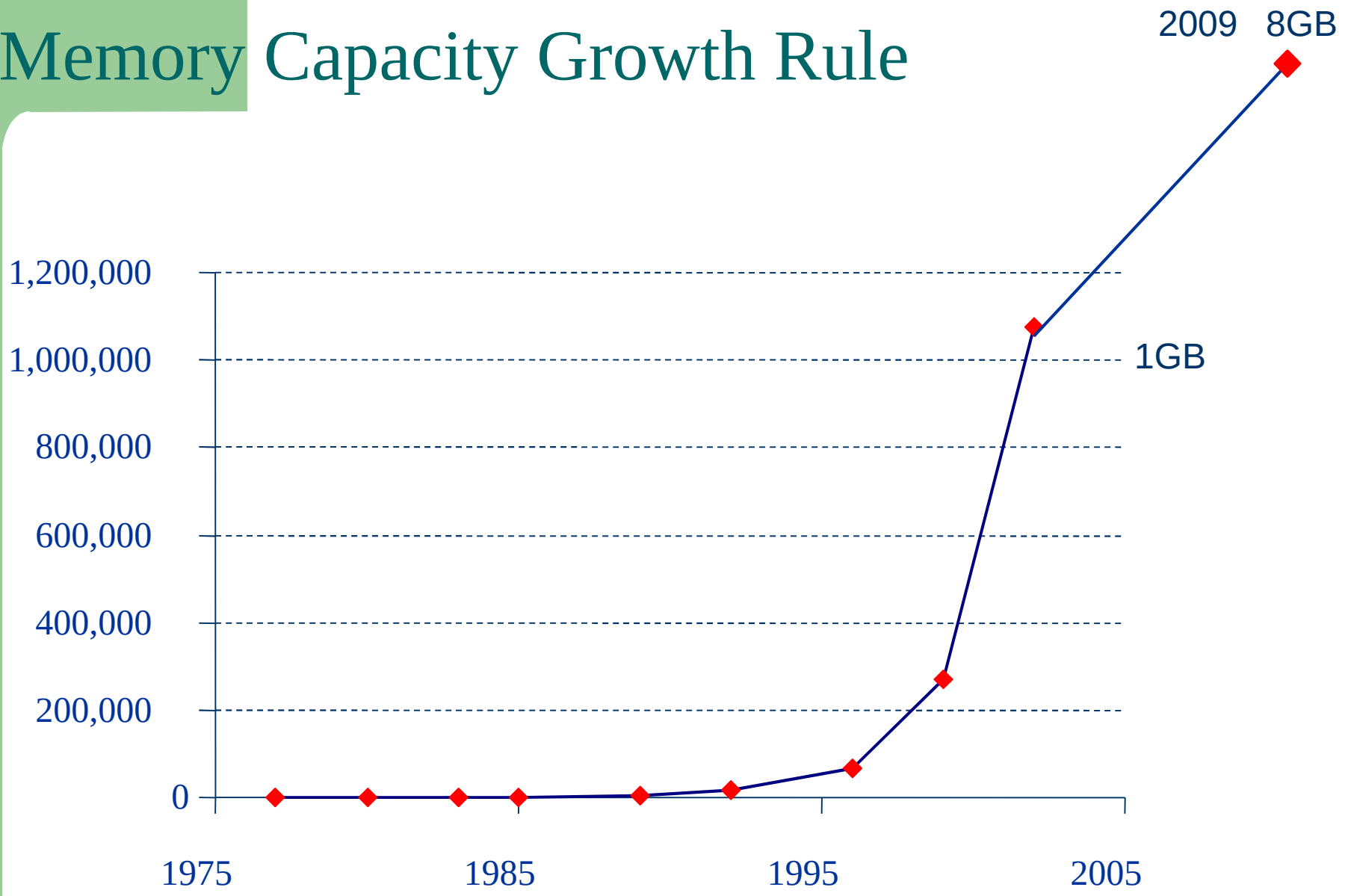
Mark I, 1944. It was built using 765,000 components, hundreds of miles of wire, amounting to a size of 51 feet in length, eight feet in height, and two feet deep. It had a weight of about 10,000 pounds.

450 MHz Clock
512 MB memory

Development of Integrated Circuits and Microprocessors

generation	technology	cost / performance
1 (1940s -1950s)	vacuum tube	1
2 (1960s)	transistor	35
3 (1970s)	integrated circuit	900
4 (1980s -)	very large scale integrated (VLSI) circuit, with increasing density	400 000 and up

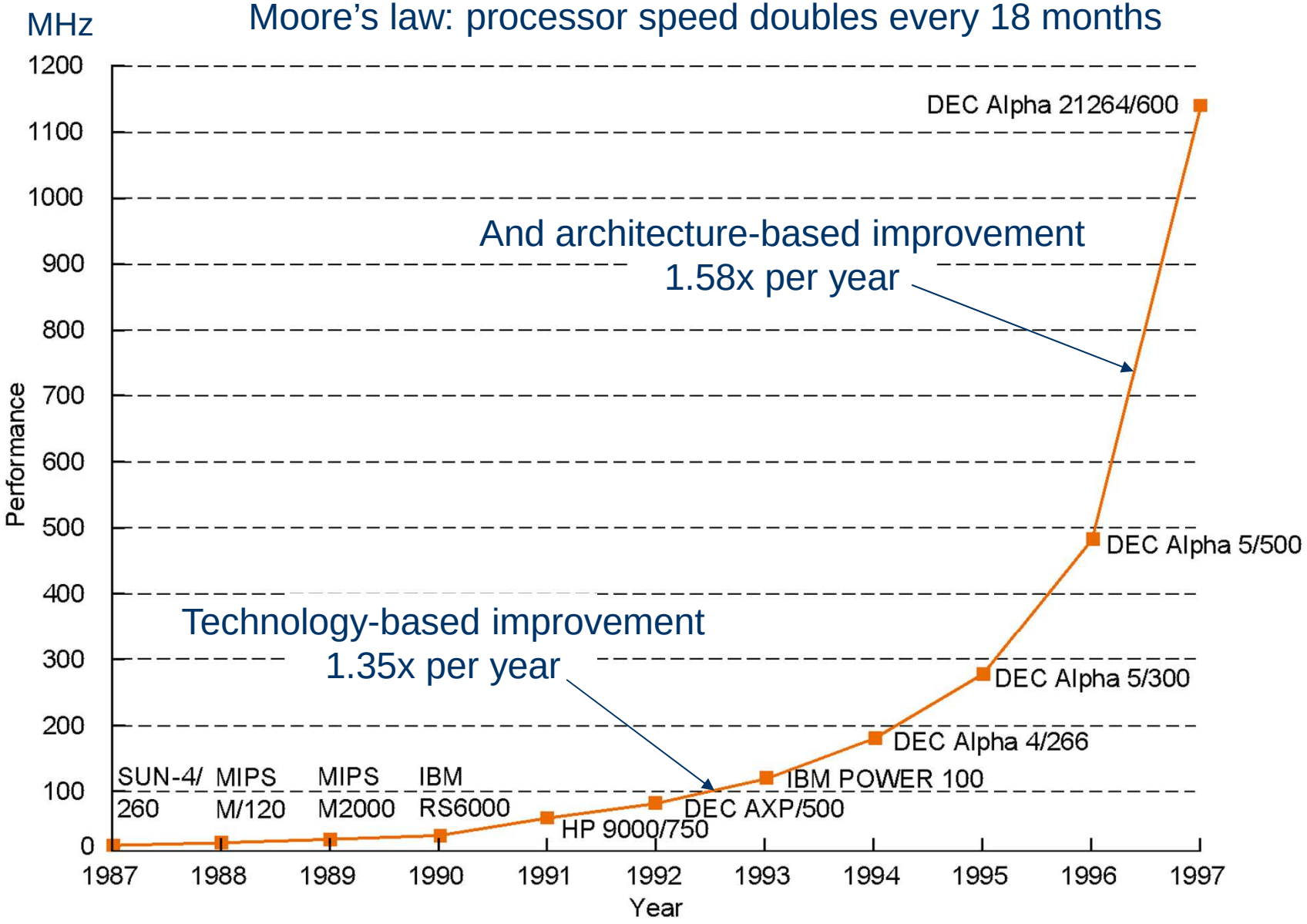
Memory Capacity Growth Rule



DRAM Capacity Growth Rule:
Bit capacity increases 4 times every 3 years
Remarkably consistent over last 30 years

Processor Performance Growth

Moore's law: processor speed doubles every 18 months



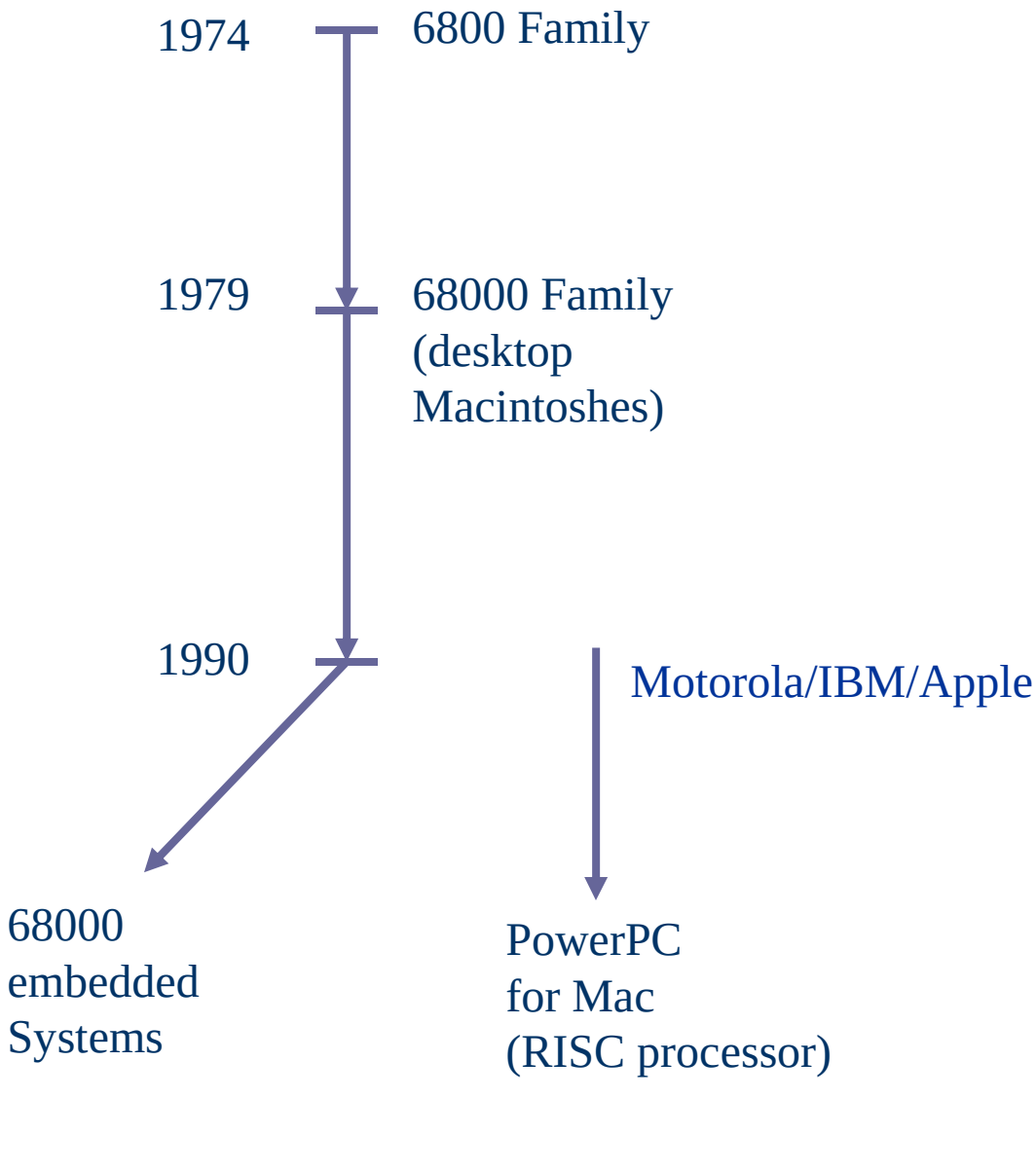
Processor Development: Intel

Processor	Year	Data / bus length	Typical clock rate
4004	1971	4	
8080	1974	8	2 MHz
8088	1979	16 / 8	5 MHz
80286	1982	16	6 MHz
80386	1985	32	16 MHz
80486	1989	32	25 MHz
Pentium	1993	32 / 64	60 MHz
Pentium II	1997	32 / 64	233 MHz
Pentium III	1999	32 / 64	450 MHz
Pentium IV	2000	32 / 64	1 GHz
Multi Cores	2005	32 / 64	N x 2GHz

Processor Development: Motorola

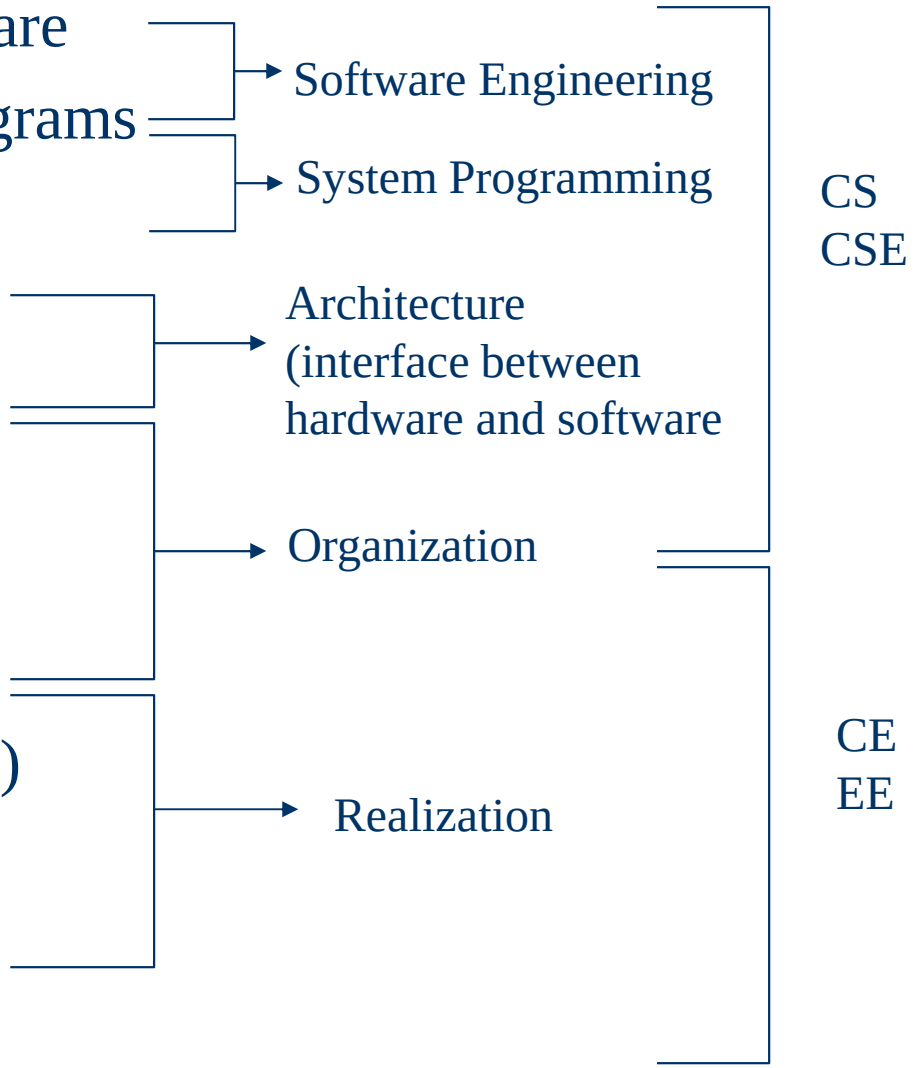
Processor	Year	Data / bus length	clock rate
6800	1974	8 / 8	1 MHz
6802	1974	8 / 8	2 MHz
6809	1977	8 / 16	2 MHz
68HC11	1978	8 / 16	8 MHz
68000	1979	32 / 16	8 MHz
68010	1984	32 / 32	12 MHz
68020	1984	32 / 32	20 MHz
68030	1988	32 / 32	40 MHz
68040	1989	32 / 32	50 MHz
68060	1990	32 / 32	66 MHz

Processor Development: Motorola



Layers of a Computer System

- Component-based Software
- High-level language Programs
- Assembly Program
- Machine Code
- Instruction Set
- Module Layer
- Register-Transfer Layer
- Logic Layer (gates)
- Circuit Layer (transistors)
- Semiconductor Layer
- …



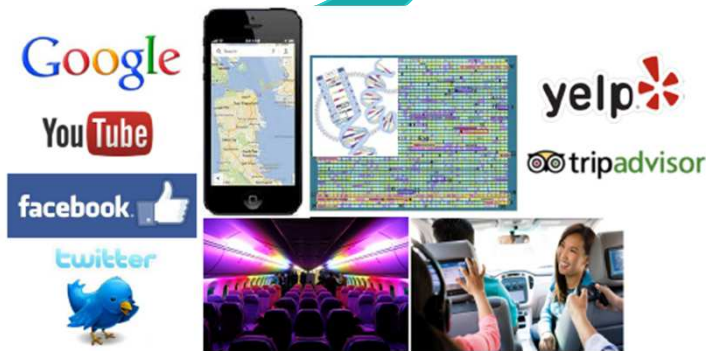
The World of IoT

IoT Device-Generated Data

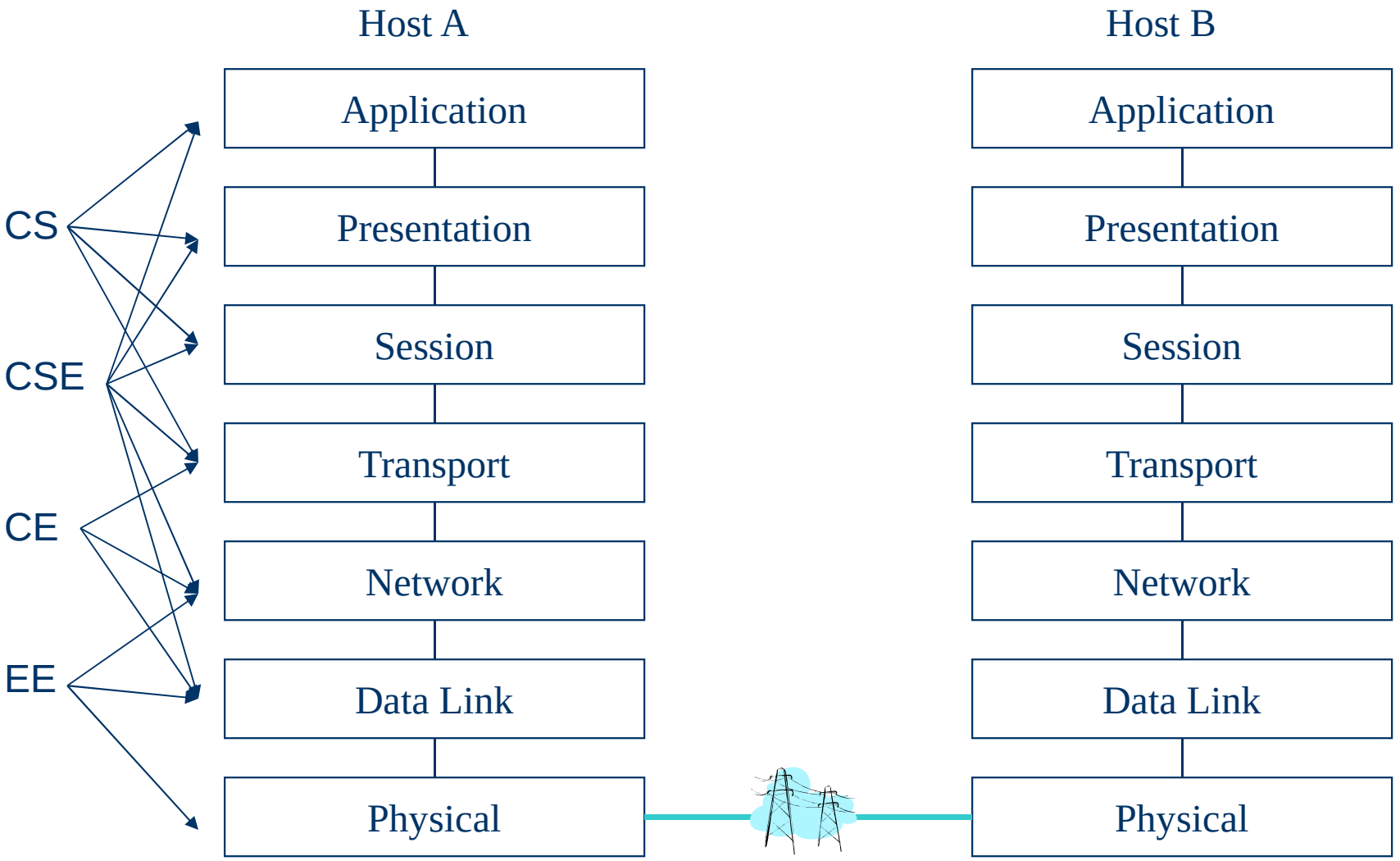
Big Data

Human-Generated Data

Cloud Computing



Communication and Networking

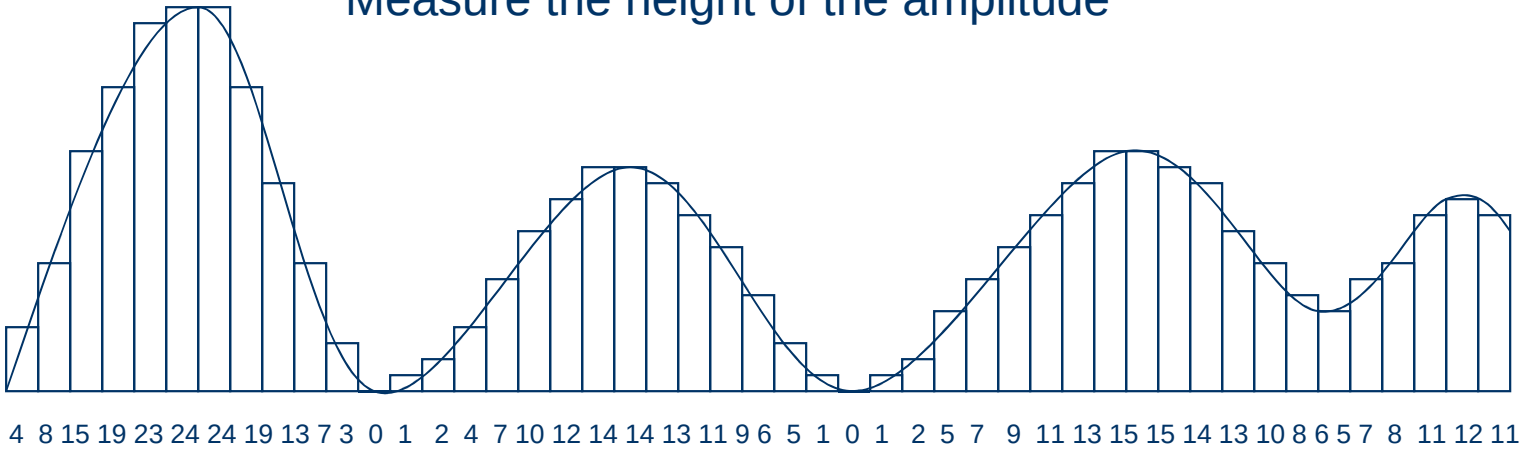


Open System Interconnection (OSI) 7-layer reference model

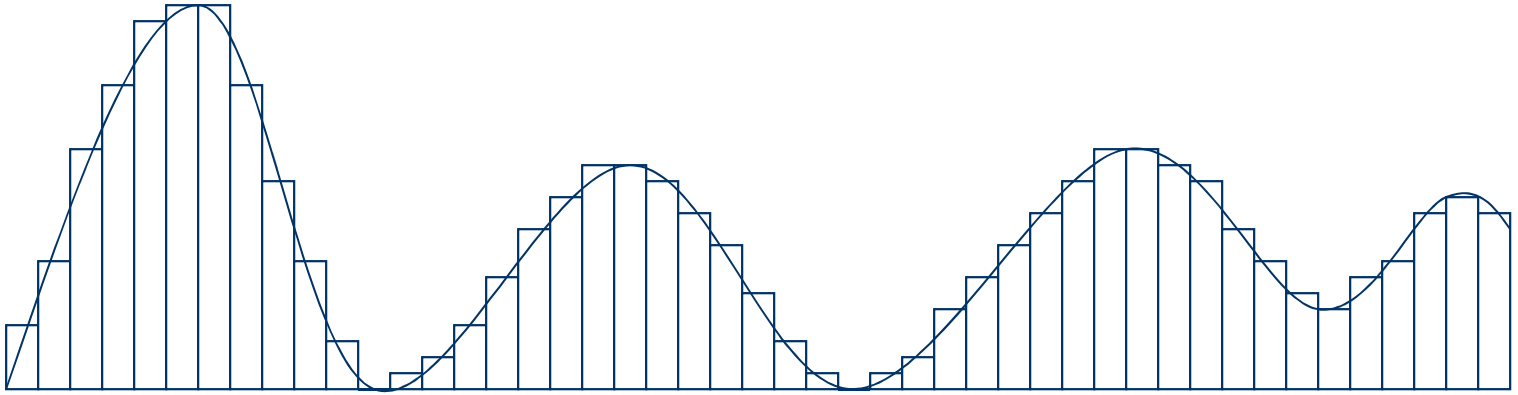
Conversion from Analog to Digital Signals

Measure the height of the amplitude

Sender



Receiver



Engineering and Engineering Career

The data and statistics on the following slides are mostly from the

Occupational Outlook Handbook

http://www.bls.gov/oco/

published by the

U.S. Department of Labor (http://www.bls.gov/).

Engineers (U.S. DoL OCO Handbook 2010-2011)

http://www.bls.gov/oco/

Occupational Title	Employment, 2008	Projected Employment, 2018	Change, 2008-18	
			Number	Percent
Engineers	1,571,900	1,750,300	178,300	11
All Engineers	**1,571,900**	**1,750.300**		**11**
Biomedical engineers	16,000	27,600	11,600	72
Chemical engineers	31,700	31,000	-600	-2
Civil engineers	278,400	345,900	67,600	24
Computer hardware engineers	74,700	77,500	2,800	4
Electrical and electronics engineers	301,500	304,600	3,100	1
Electrical engineers	157,800	160,500	2,700	2
Electronics engineers, except computer	143,700	144,100	400	0
Environmental engineers	54,300	70,900	16,600	31
Industrial engineers, including health and safety	240,400	273,700	33,200	14
Health and safety engineers, except mining safety engineers and inspectors	25,700	28,300	2,600	10
Industrial engineers	214,800	245,300	30,600	14
Marine engineers and naval architects	8,500	9,000	500	6
Materials engineers	24,400	26,600	2,300	9
Mechanical engineers	238,700	253,100	14,400	6
Mining and geological engineers, including mining safety engineers	7,100	8,200	1,100	15
Nuclear engineers	16,900	18,800	1,900	11
Petroleum engineers	21,900	25,900	4,000	18
All other engineers	183,200	195,400	12,200	7

Software Engineers and CS Occupations (There are many more) in U.S. DoL Occupational Outlook Handbook

All Engineers	**1,571,900**	**1,750.300**	**11**

Occupational title	Employment in 2008	Employment in 2018	Change in number	Change in percentage
software engineers	909,600	1,204,800	295,200	32
Computer systems analysts	532,200	640,300	108,100	20
Computer network, systems, and database administrators	961,200	1,247,800	286,600	30
Computer programmers	426,700	414,400	-12,300	-3
Computer support specialists	565,700	643,700	78,000	14
Computer and information systems managers	293,000	342,500	49,500	17
	2,7788	**3,2887**		

BEST JOBS IN AMERICA Top 50

MONEY Magazine and Salary.com rate careers on salary and job prospects.

April 12, 2006

http://money.cnn.com/magazines/moneymag/moneymag_archive/2006/05/01/8375749/index.htm

Rank	Career	Growth	Salary	Rank	Career	Growth	Salary
1	Software engineer	46.07%	$80,427	26	Social service manager	25.52%	$74,584
2	College professor	31.39%	$81,491	27	Paralegal	29.75%	$61,204
3	Financial advisor	25.92%	$122,462	28	Health services manager	22.76%	$92,211
4	Human resources manager	23.47%	$73,731	29	Advertising sales agent	16.33%	$112,683
5	Physician assistant	49.65%	$75,117	30	Physician/Surgeon	23.98%	$247,536
6	Market research analyst	20.19%	$82,317	31	Management analyst	20.12%	$63,426
7	Computer/IT analyst	36.10%	$83,427	32	Occupational therapist	33.61%	$51,973
8	Real estate appraiser	22.78%	$66,216	33	Mental health counselor	27.18%	$53,150
9	Pharmacist	24.57%	$91,998	34	Landscape architect	19.43%	$50,383
10	Psychologist	19.14%	$66,359	35	Biotechnology research scientis	17.05%	$66,393
11	Advertising manager	20.34%	$107,049	36	Urban planner	15.17%	$60,891
12	Physical therapist	36.74%	$54,883	37	Lawyer	14.97%	$153,923
13	Technical writer	23.22%	$57,841	38	Speech-language pathologist	14.57%	$58,329
14	Chiropractor	22.40%	$84,996	39	Meeting and convention planne	22.21%	$56,072
15	Medical scientist	34.06%	$70,053	40	Dietitian/Nutritionist	18.30%	$52,244
16	Physical scientist	12.18%	$80,213	41	Biological scientist	17.03%	$61,317
17	Engineer	13.38%	$76,100	42	Financial analyst	17.33%	$66,203
18	Curriculum developer	27.53%	$55,793	43	Dentist	13.52%	$122,883
19	Editor	14.77%	$78,242	44	Accountant	22.43%	$62,575
20	Public relations specialist	22.61%	$84,567	45	Environmental scientist	17.11%	$59,027
21	Sales manager	19.67%	$135,903	46	Lab technologist	20.53%	$51,502
22	Optometrist	19.73%	$93,670	47	Registered nurse	29.35%	$68,872
23	Property manager	15.30%	$78,375	48	Sales engineer	13.96%	$78,875
24	Actuary	23.16%	$81,509	49	Veterinarian	17.39%	$79,923
25	Writer	17.72%	$60,519	50	School Administrator	14.55%	$73,767

BEST JOBS IN AMERICA

MONEY Magazine and Salary.com rate careers on salary and job prospects.

CNNMoney.com A Service of CNN, Fortune & Money **2009**

http://money.cnn.com/magazines/moneymag/bestjobs/2009/sectors/

Job Sector	Job Title	Growth	Rank
Information Technology	Systems Engineer	45%	1
Information Technology	Information Technology Project Manager	16%	5
Information Technology	Computer/Network Security Consultant	27%	8
Information Technology	Software Developer	28%	12
Information Technology	Software Product Manager	28%	16
Information Technology	Business Analyst, IT	29%	17
Information Technology	Technical Writer	20%	28
Information Technology	Telecommunications Network Engineer	53%	30
Information Technology	Computer Software Program Manager	28%	39
Information Technology	Applications Systems Analyst	29%	40

10
40

CNNMoney.com A Service of CNN, Fortune & Money

BEST JOBS IN AMERICA 2010

http://money.cnn.com/magazines/moneymag/bestjobs/2010/sectors/#I

Sector	Job Title	Rank in top 40
Information Technology	Software Architect	1
	Database Administrator	7
	Information Systems Security Engineer	17
	Software Engineering / Development Director	18
	Information Technology Manager	20
	Telecommunications Network Engineer	21
	Network Operations Project Manager	24
	Information Technology Business Analyst	26
	Information Technology Consultant	28
	Test Software Development Engineer	30
	Information Technology Network Engineer	31
	Information Technology Program Manager	33
	Computer and Information Scientist	35
	Programmer Analyst	37
	Applications Engineer	38

15
40

CNNMoney.com
A Service of CNN, Fortune & Money

BEST JOBS IN AMERICA 2012

Rank	Job Title	Median Salary	2011 Job number	10 year growth rate	2021 Job number
1	Biomedical Engineer	$79,500	15,700	61.7%	25,387
2	Marketing Consultant	$92,100	282,700	41.2%	399,172
3	**Software Architect**	**$119,000**	**3,426,000**	**24.6%**	**4,268,796**
4	Clinic Research Associate	$90,700	100,000	36.4%	136,400
5	**Database Administrator**	**$87,200**	**110,800**	**30.6%**	**144,705**
6	Financial Adviser	$90,200	206,800	32.1%	273,183
7	Market Research Analyst	$63,100	282,700	41.2%	399,172
8	Physical Therapist	$76,700	198,600	39.0%	276,054
9	**Software Developer**	**$84,200**	**3,426,000**	**24.6%**	**4,268,796**
10	Occupational Therapist	$74,900	108,800	33.5%	145,248
11	Management Consultant	$110,000	718,800	21.9%	876,217
12	Optometrist	$105,000	34,200	33.1%	455,20
13	**IT Consultant**	**$96,400**	**544,400**	**22.1%**	**664,712**
14	**IT Network Engineer**	**$73,400**	**347,200**	**27.8%**	**443,722**
15	**IT Security Consultant**	**$102,000**	**347,200**	**27.8%**	**443,722**

- Biomedical Engineer: 25,387 jobs in 10 years
- **Software Architect: 4,268,796** in 10 years
- **What does it mean?**

Biomedical Engineer

- 50 states: 25,387 / 50 = 508
- Assume each person holds the job for 30 years
  New jobs available will be 508/ 30 = 17
- Arizona Universities graduate 100 students
  The chance of finding a job is: 17%

Software Architect

- 50 states: 4,268,796 / 50 = 85375
- Assume each person holds the job for 30 years
  New jobs available will be 85375 / 30 = 2845
- Even if Arizona Universities graduate 1000 students
  there are 1845 positions cannot be filled.
- What about the other CS jobs?