Careers in Computing -- How to Prepare and What to Expect

Dennis J. Frailey

(Retired) Principal Fellow, Raytheon Company

Adjunct Professor of Computer Science, SMU

Frailey@ACM.ORG

Frailey@Lyle.smu.edu

This Presentation
is Jointly Sponsored by

IEEE computer society

AND

Association for Computing Machinery

Advancing Computing as a Science & Profession

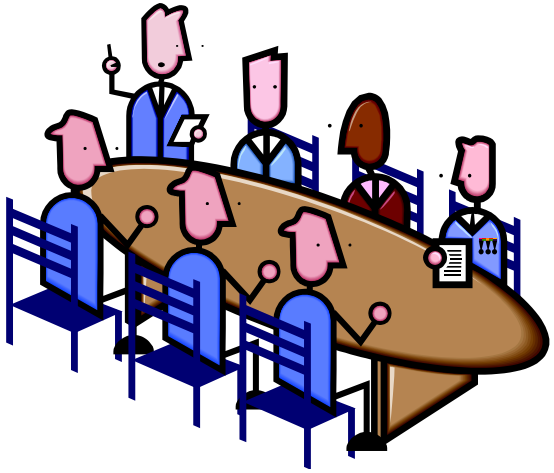
Topics

- My Story
- Real Projects
- Where Are the Jobs?
- What Do Computing Professional Do?
- What Skills are Required?
- What Do Employers Look For?

My Story

How I Got Into the Computer Field
and
What I Did When I Got There

Choosing a Career – Mathematics or Computer Science

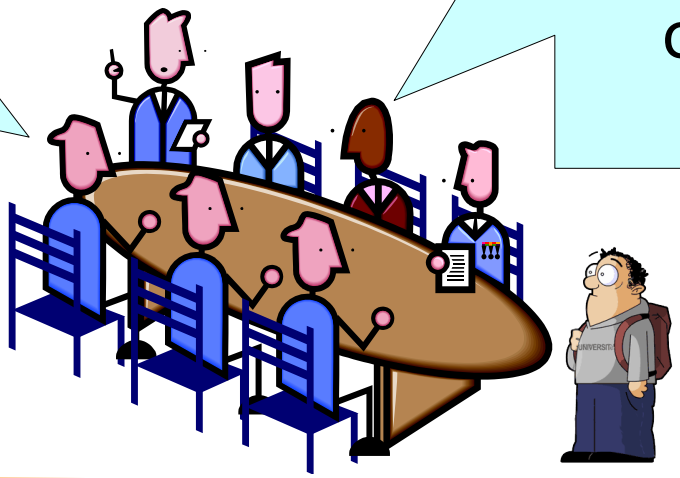


Reasons to Choose Math over Computer Science

Computing lacks the intellectual depth of mathematics and you would waste your talents by going into that field

Computer science is a fad, likely to die out quickly and you would have a worthless degree

There are many wonderful opportunities in the field of mathematics and you can be assured of a stable, comfortable career

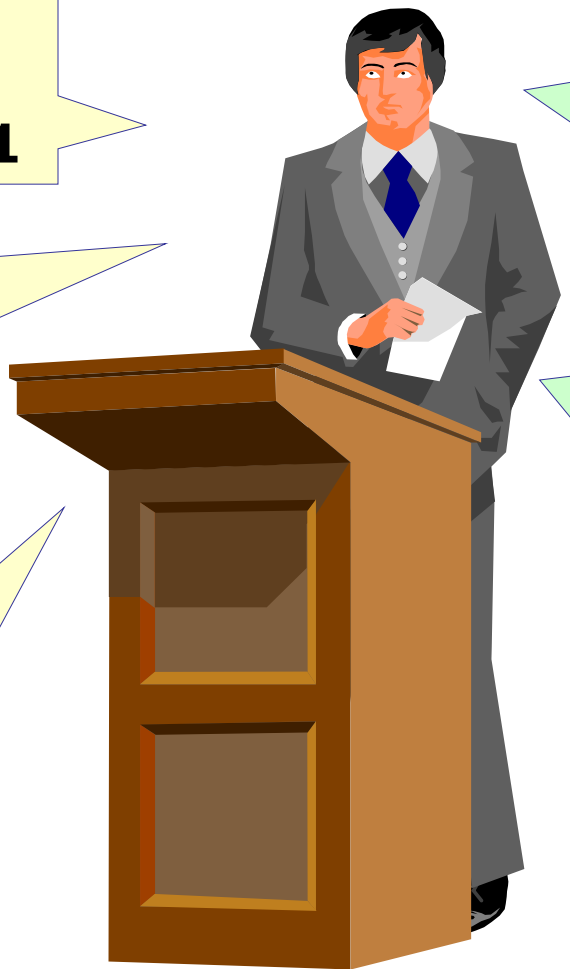


So What Happened?

PhD in Computer Science in 1971

Computer Science professor for 7 years

Teach computer science & software engineering as adjunct professor



Started computing career in 1962 as a Fortran programmer

Work in industry for 36 years:

compiler design, computer design, operating systems, many software applications

What I Did in Industry

Assist software development projects with technical and management issues

Develop a lot of complex software

Hire students from universities

Lead/manage many software projects

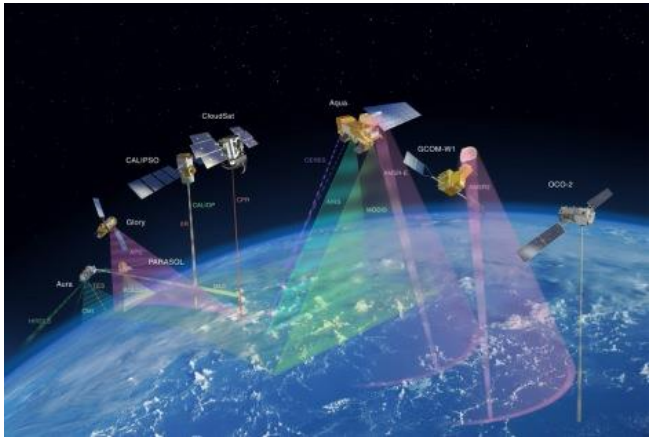
Teach courses on software development topics

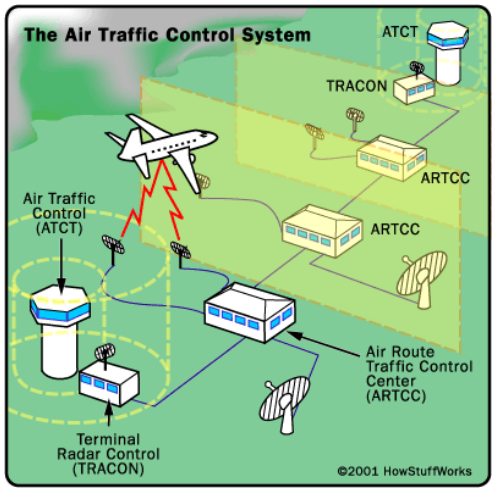
Study ways to improve how we develop software

Real Projects for Real Customers

Most Projects are Big, Complex and Challenging

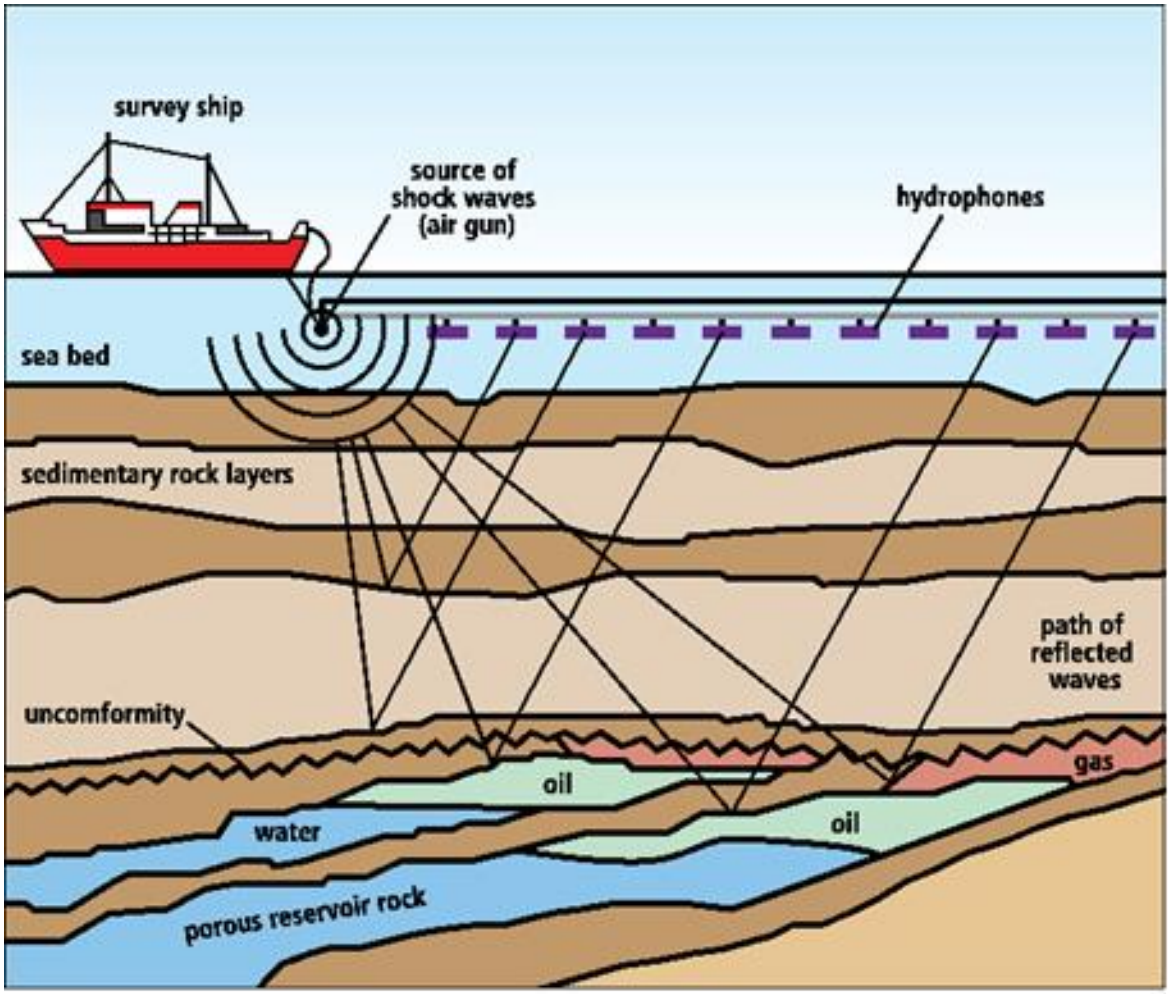
Projects are Often Big & Complex





A Typical Difficult Computing Problem

Marine Seismic Exploration



Characteristics of Big Projects

- **Lots of People – hundreds or even thousands**
- **Millions of lines of code**
- **Many different companies may be involved**

- **Multiple locations**
- **Many different disciplines**
  - **Systems engineers**
  - **Quality engineers**
  - **Mechanical engineers**
  - **Software engineers**
  - **Electrical engineers**
  - **Logistics engineers**
  - **Safety engineers**
  - **Financial experts**
  - **Project managers**
  - **Subcontract managers**
  - **…**

A Typical Fiasco Involving Poorly Designed Software

Berlin's Airport Project Delays Shame Germans

"Willy Brandt International Airport … was supposed to have been up and running in late 2011. After four publicly announced delays, officials acknowledged the airport won't be ready by the latest target: October 2013. To spare themselves further embarrassment, officials have refused to set a new opening date.

…

"It's so advanced that technicians can't figure out what's wrong with it."

[Hint: among the problems cited are overly complex software with poor design.]

Associated Press, April 7, 2013

Update on Berlin Airport

Wikipedia, February, 2015

"… an opening prior to late 2016 is unlikely."

"Remarks made in August 2014, by airport CEO Hartmut Hehdorn point toward 2017 or 2018."

Where Are the Jobs?

Most of them Aren't with Small Companies or even Computer Companies

Many Companies Develop Computer Based Products

Here are three I've done work for

- **Securities Industry Automation Corp**
  - Writes all of the software for the New York Stock Exchange
- **Transcore**
  - Develops hardware and software for toll road tag systems and traffic control systems
- **Alcatel**
  - Hardware and software for telecommunications equipment

These companies all need products to be reliable. They want software and computer engineering!

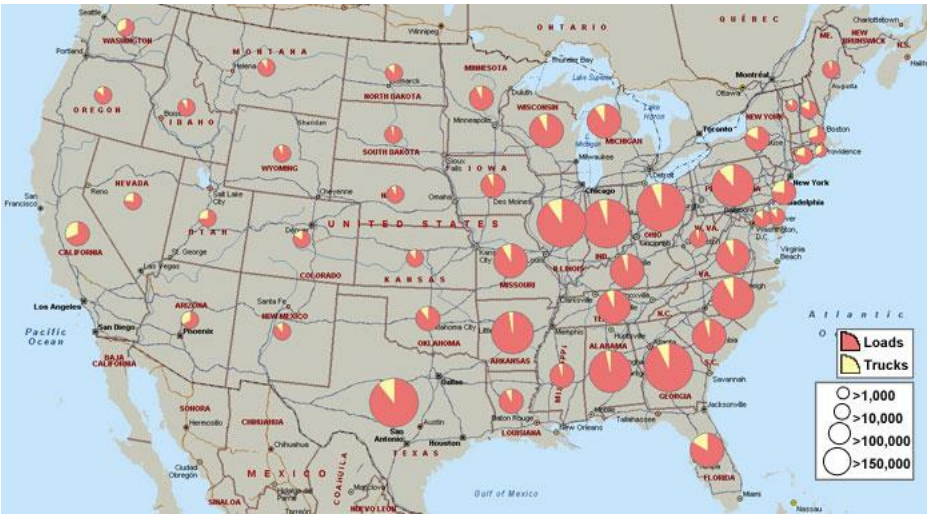
New York Stock Exchange

Millions of dollars flow through their computer systems every second.

- A proprietary system almost 100% controlled and managed by computers
- The software must be highly reliable and very fast

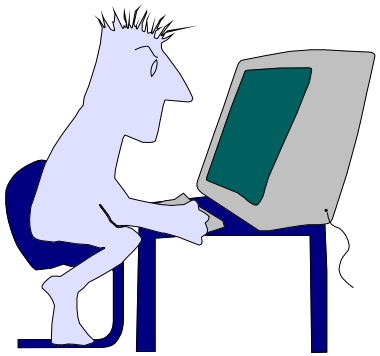
Keeping track of vehicle traffic on highways throughout the US

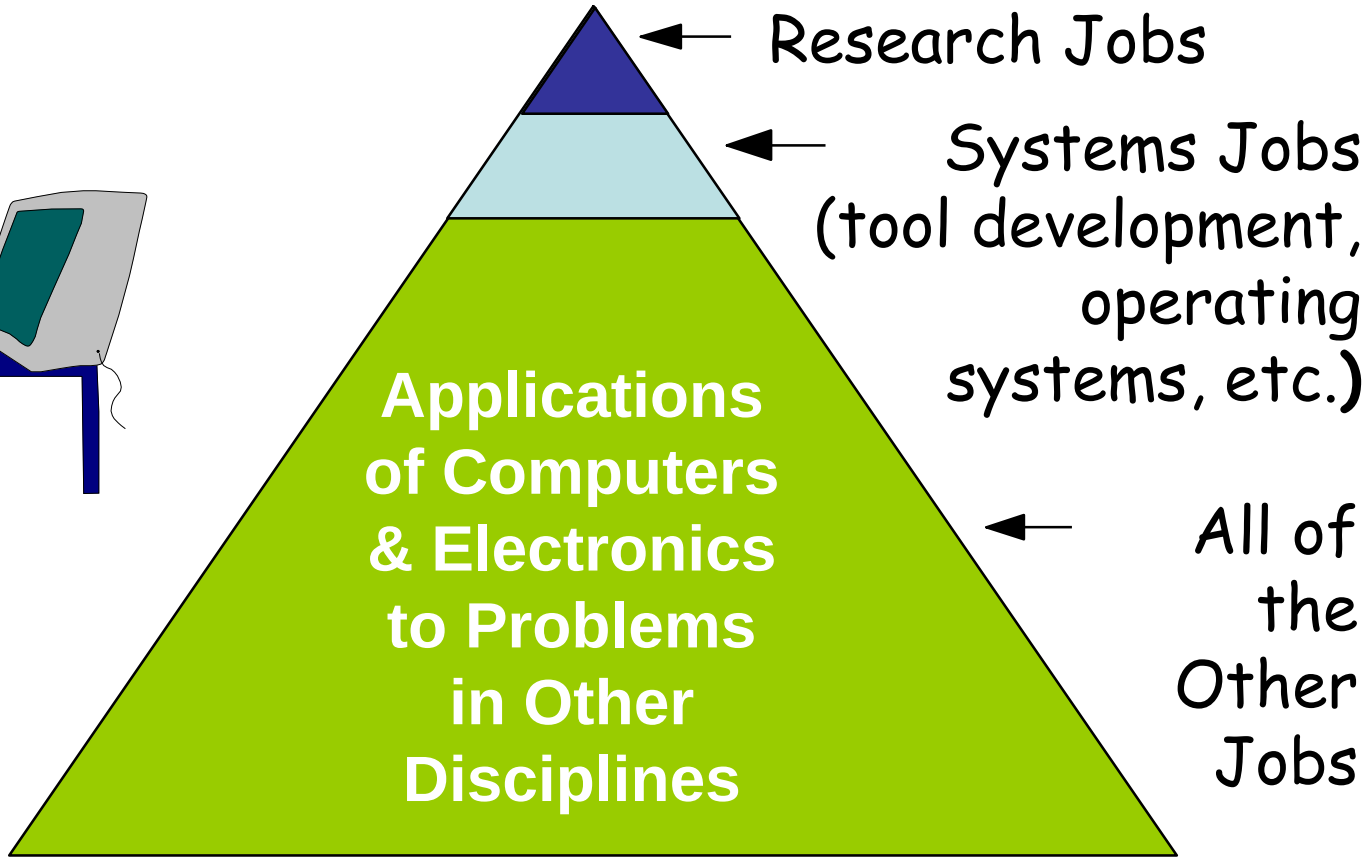
- Hundreds of thousands of sensors and toll collection systems, feeding a massive data base in real time



Their digital switches are the backbone of much of the US and European telephone systems

Where Are The Computer Science & Engineering Jobs?





Jobs by Firm Size from US Bureau of Labor Statistics

Company Size	Percent of US Employment
500+	50.6%
100+	65.1%
20+	82.2%

s 2008 data http://www.census.gov/epcd/susb/2008/us/US--.HTM

	Company Size	No of Firms	No of Employees	Avg/firm	Percent of Total	Cum Percent
Large Business	10000+	981	33,025,346	33,665	27.3%	27.3%
	5000-9999	975	6,773,466	6,947	5.6%	32.9%
	2500-4999	1,934	6,726,611	3,478	5.6%	38.5%
	2000-2499	904	2,011,244	2,225	1.7%	40.1%
	1500-1999	1,533	2,653,392	1,731	2.2%	42.3%
	1000-1499	3,044	3,720,654	1,222	3.1%	45.4%
	500-999	9,098	6,298,847	692	5.2%	50.6%
Small Business	100-499	90,386	17,547,567	194	14.5%	65.1%
	20-99	526,307	20,684,691	39	17.1%	82.2%
	10-19	633,141	8,497,391	13	7.0%	89.3%
	1-9	4,661,829	12,964,342	3	10.7%	100.0%
Total		5,930,132	120,903,551		100.0%	
	500+	18,469	61,209,560	3,314	50.6%	

28 of the 500 Largest US Companies

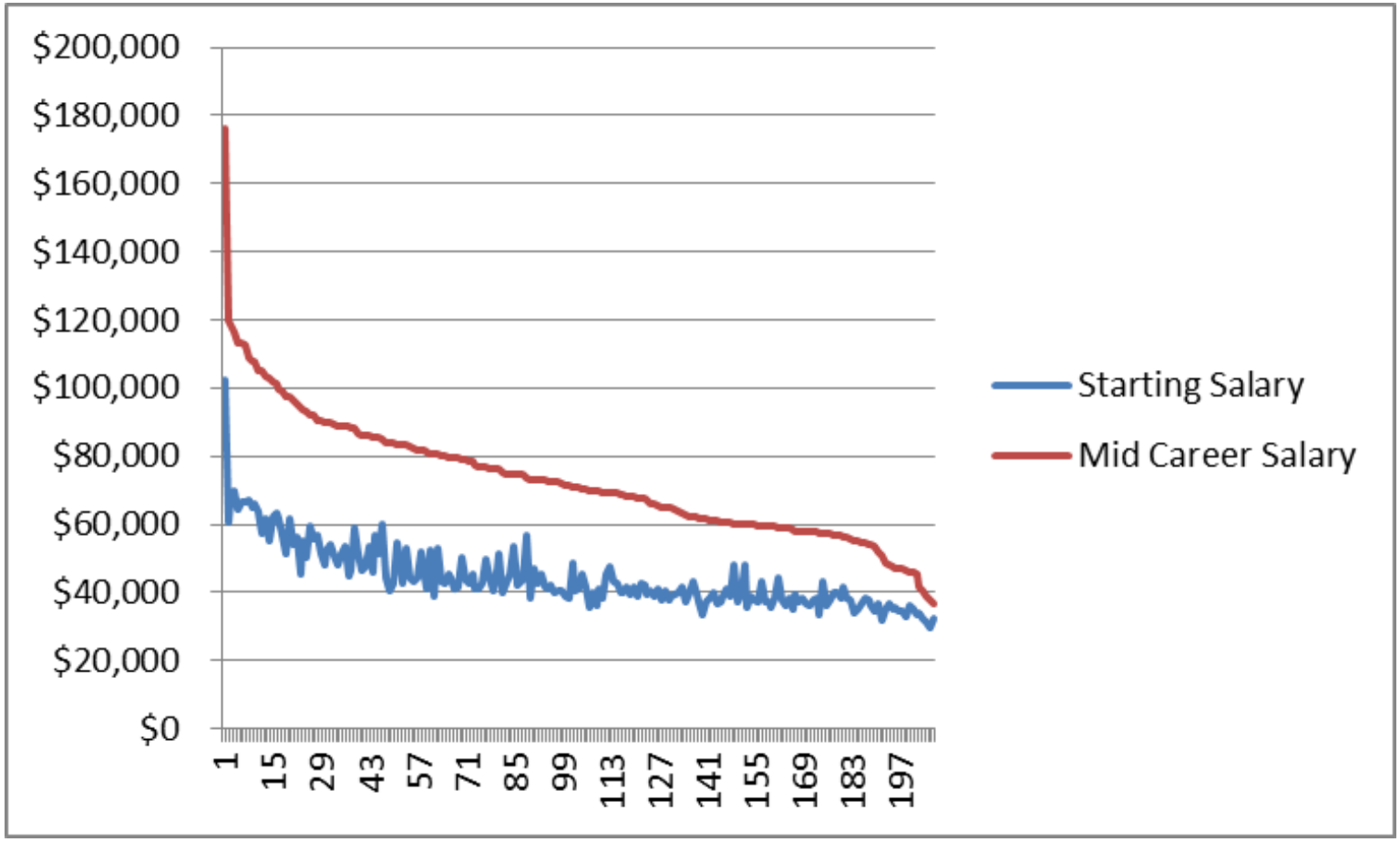
3M Company	Industrials
Abbott Laboratories	Health Care
AbbVie	Health Care
Accenture plc	Information Technology
Activision Blizzard	Information Technology
Adobe Systems Inc	Information Technology
ADT Corp	Industrials
Advance Auto Parts	Consumer Discretionary
AES Corp	Utilities
Aetna Inc	Health Care
Affiliated Managers Group Inc	Financials
AFLAC Inc	Financials
Agilent Technologies Inc	Health Care
AGL Resources Inc.	Utilities
Air Products & Chemicals Inc	Materials
Airgas Inc	Materials
Akamai Technologies Inc	Information Technology
Alcoa Inc	Materials
Alexion Pharmaceuticals	Health Care
Allegion	Industrials
Allergan plc	Health Care
Alliance Data Systems	Information Technology
Allstate Corp	Financials
Alphabet Inc Class A	Information Technology
Alphabet Inc Class C	Information Technology
Altria Group Inc	Consumer Staples
Amazon.com Inc	Consumer Discretionary
Ameren Corp	Utilities

Source: Wikipedia – List of S&P 500 Companies

BestJobsUSA.com 500: America's Employers of Choice

1 Coca-Cola
2 Sun Microsystems
3 Hewlett-Packard
4 Lucent Technologies
5 Xerox
6 Marriott International
7 IBM
8 Compaq Computer
9 Cisco Systems
10 PepsiCo
11 Unisys
12 Honeywell
13 Merck
14 Gannett
15 Owens Corning
16 Knight Ridder
17 Champion Int'l
18 Microsoft
19 General Electric
20 Intel
21 Caterpillar
22 Johnson & Johnson
23 Texas Instruments
24 Abbott Laboratories
25 Eastman Kodak
26 Lear
27 Ingersoll-Rand
28 Philip Morris
29 General Motors
30 Ford Motor
31 Motorola
32 United Parcel Service
33 Procter & Gamble
34 Dell Computer
35 Texaco
36 Raytheon
37 International Paper
38 Dow Chemical
39 AT&T
40 Johnson Controls
41 Deere & Co
42 Whirlpool
43 SBC Comm.
44 Georgia Pacific
45 Schering Plough
46 American Home Prod
47 Gateway
48 Toyota Motor Corp
49 TRW
50 Kimberly-Clark
51 Eli Lilly
52 Anheuser-Busch
53 Fluor Daniel
54 Colgate Palmolive
55 R R Donnelley
56 Parker Hannifin
57 Boise Cascade
58 Times Mirror
59 Becton Dickinson
60 Hitachi
61 Lockheed Martin
62 Chevron
63 Exxon
64 Bristol-Myers Squibb
65 Sara Lee
66 Alcoa
67 Time Warner
68 Ameritech
69 AlliedSignal
70 Pfizer
71 Dana
72 U S West
73 Oracle
74 Northrop Grumman
75 Weyerhaeuser
76 ConAgra
77 Philips Petroleum Co
78 Goodyear Tire
79 Kaiser Permanente
80 IBP
81 Seagate Technology
82 Textron
83 3Com Corp
84 Apple Computer
85 Sherwin-Williams
86 Avon Products
87 PPG Industries
88 ITT Industries
89 Quantum
90 Computer Associates
91 Masco
92 Crown Cork & Seal
93 Mead
94 Thomson Cons. Elec.
95 Harris
96 Reynolds Metals Co
97 Olsten
98 Williams Companies
99 Fortune Brands
100 VF
101 Silicon Graphics
102 Pitney Bowes
103 Air Products & Chem
104 Medtronic
105 Cooper Industries
106 Lexmark International
107 Smurfit Stone Contnr.
108 Tribune
109 Temple-Inland
110 Phelps Dodge
111 Boeing
112 Sprint Comm.
113 MCI WorldCom Inc
114 United Technologies
115 GTE
116 Citigroup
117 Wells Fargo
118 BellSouth
119 American Express
120 Chase Manhattan
121 Aetna
122 AMR
123 Wal-Mart Stores
124 E.D.S
125 Allstate
126 Cigna
127 Emerson Electric
128 Daimler Chrysler
129 J P Morgan
130 Sears Roebuck
131 Archer Daniels Mid.
132 Union Pacific
133 Merill Lynch & Co
134 PG&E
135 Gillette
136 Matsushita
137 First Union Corp
138 NCR
139 Bank One
140 Rockwell Int'l
141 Monsanto
142 Bell Atlantic
143 Warner Lambert
144 J C Penney
145 Avnet
146 Alltel
147 Sysco
148 Paccar
149 Eaton
150 Navistar International
151 Atlantic Richfield
152 Cummins Engine
153 Baxter International
154 Fort James
155 Tenneco
156 Ryder System
157 Praxair
158 Tyson Foods
159 Case
160 Occidental Petroleum
161 American Standard
162 Litton Industries
163 Unocal
164 Bethlehem Steel
165 Applied Materials
166 Andersen Consulting
167 Yellow
168 Illinois Tool Works
169 Baker Hughes
170 McGraw Hill
171 Lawson Software
172 Ashland
173 Tektronix
174 Allegheny Teledyne
175 Thermo Electron
176 EMC Corp
177 Dover
178 Western Digital
179 Dow Jones
180 Nucor
181 Corning
182 Ryerson Tull
183 Ball
184 Leggett & Platt
185 Burlington Industries
186 USG
187 New York Times
188 U S Industries
189 Enron Corp
190 Siemens
191 Engelhard
192 Ingram Micro
193 Ernst & Young
194 Prudential Insurance
195 America Online
196 du Pont
197 Federated
198 Southern Co
199 Bayer
200 Bridgestone Firestne

Majors by Salary Potential
PayScale.com – 2015-16



http://www.payscale.com/college-salary-report/majors-that-pay-you-back/

Payscale.com – Top 20 Bachelors Degrees – 2015-16

1 Petroleum Engineering
2 Nuclear Engineering
3 Actuarial Mathematics
4 Chemical Engineering
5 Electronics & Communications Eng.
6 Computer Science & Engineering
7 Electrical & Computer Engineering (tie)
7 Systems Engineering (tie)
9 Aeronautical Engineering
10 Computer Engineering (tie)
10 Mining Engineering (tie)
12 Electrical Engineering (tie)
12 Mechanical & Aeronautical Engineering (tie)
14 Aerospace Engineering (tie)
14 Computer Science & Mathematics (tie)
16 Industrial Distribution (tie)
16 Physics (tie)
18 Computer Science (tie)
18 Materials Science & Engineering (tie)
20 (4 tied)

Most Valuable College Majors (ranked by projected *job growth*) www.Forbes.com

Rank	Major	Job Growth	Starting	Mid Career
1	Biomedical Engineering	61.7%	$53800	$97800
2	Biochemistry	30.8%	$41700	$84700
3	**Computer Science**	24.6%	$56600	$97900
4	**Software Engineering**	24.6%	$54900	$87800
5	Environmental Engineering	21.9%	$51700	$88600
6	Civil Engineering	19.4%	$53100	$90200
7	Geology	19.3%	$45300	$83300
8	Management Info Systems	18.1%	$51000	$88200
9	Petroleum Engineering	17%	$97900	$155000
10	Applied Mathematics	16.7%	$52600	$98600

Careercast.com
The 10 Best Jobs of 2013

The geeks strike back: despite enduring an industry bubble and the threat of outsourcing, Software Engineer ranks as the Best Job of 2013.

1. Software Engineer

Researches, designs, develops and maintains software systems along with hardware development for medical, scientific, and industrial purposes.

Overall Score: 60.00
Income: $87,140.00
Work Environment: 150.000
Stress: 10.400
Physical Demands: 5.00
Hiring Outlook: 27.40

Careercast.com
The 10 Best Jobs of 2015
The 10 Worst Jobs of 2015

Best

1. Actuary
2. Audiologist
3. Mathematician
4. Statistician
5. Biomedical Engineer
6. Data Scientist
7. Dental Hygienist
8. Software Engineer
9. Occupational Therapist
10. Computer Systems Analysis

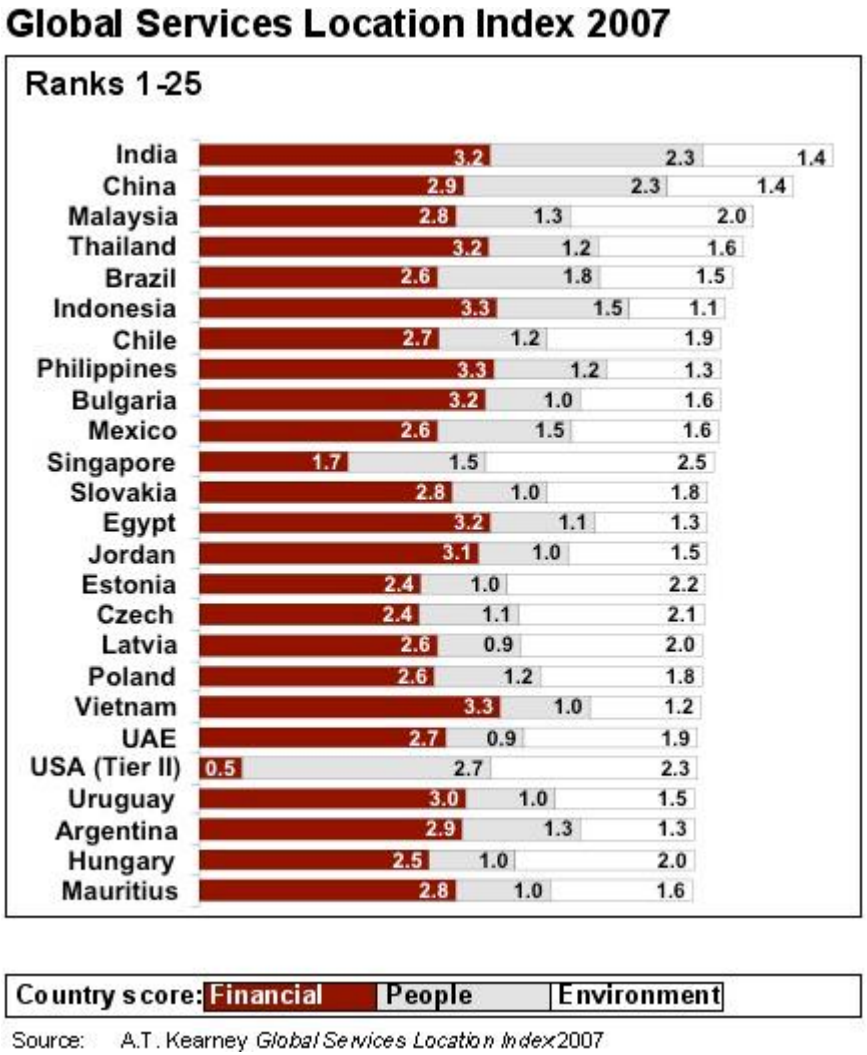
Worst

191. Mail Carrier
192. Firefighter
193. Taxi Driver
194. Corrections Officer
195. Photojournalist
196. Broadcaster
197. Cook
198. Military – Enlisted
199. Lumberjack
200. Newspaper Reporter

What About Outsourcing?

Outsourcing is a Fact of Life in a Global Economy

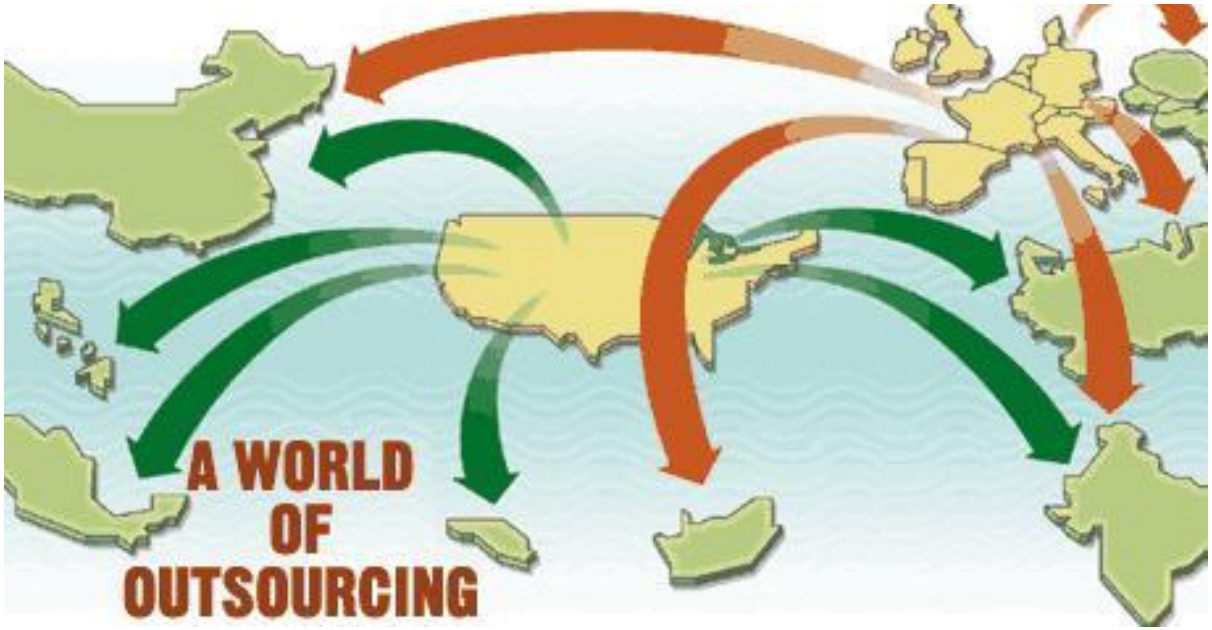
- Asia, Eastern Europe and South America are awakening giants in terms of
  - potential competition for jobs -- and
  - potential customers!



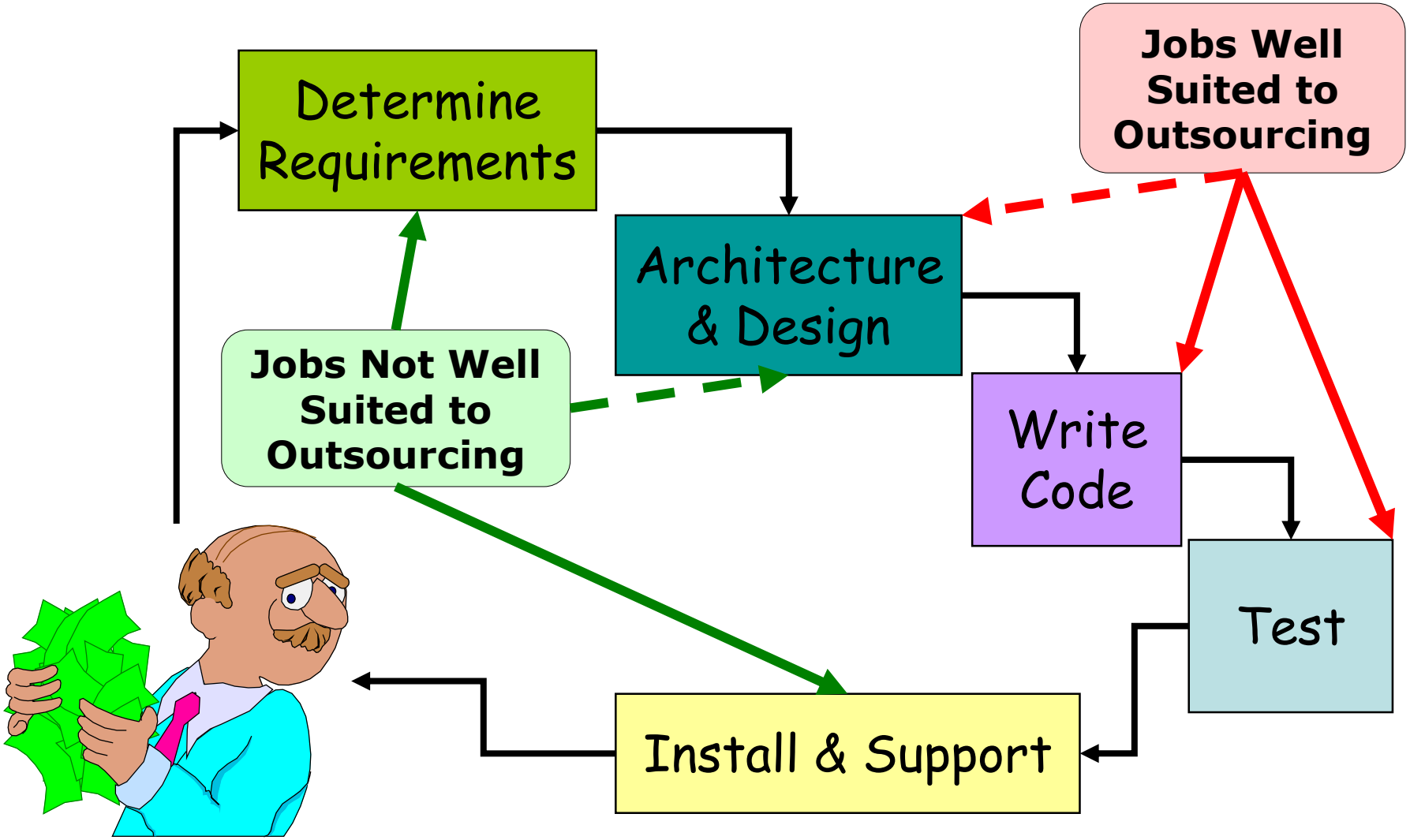
What Jobs are Being Outsourced?

The jobs most likely to be outsourced will be those requiring

- the ***least knowledge of the application***
- and ***the least contact with the customer***



Some Jobs Require Detailed Understanding of the Customer



What do Computing Professionals Actually Do?

Hint:

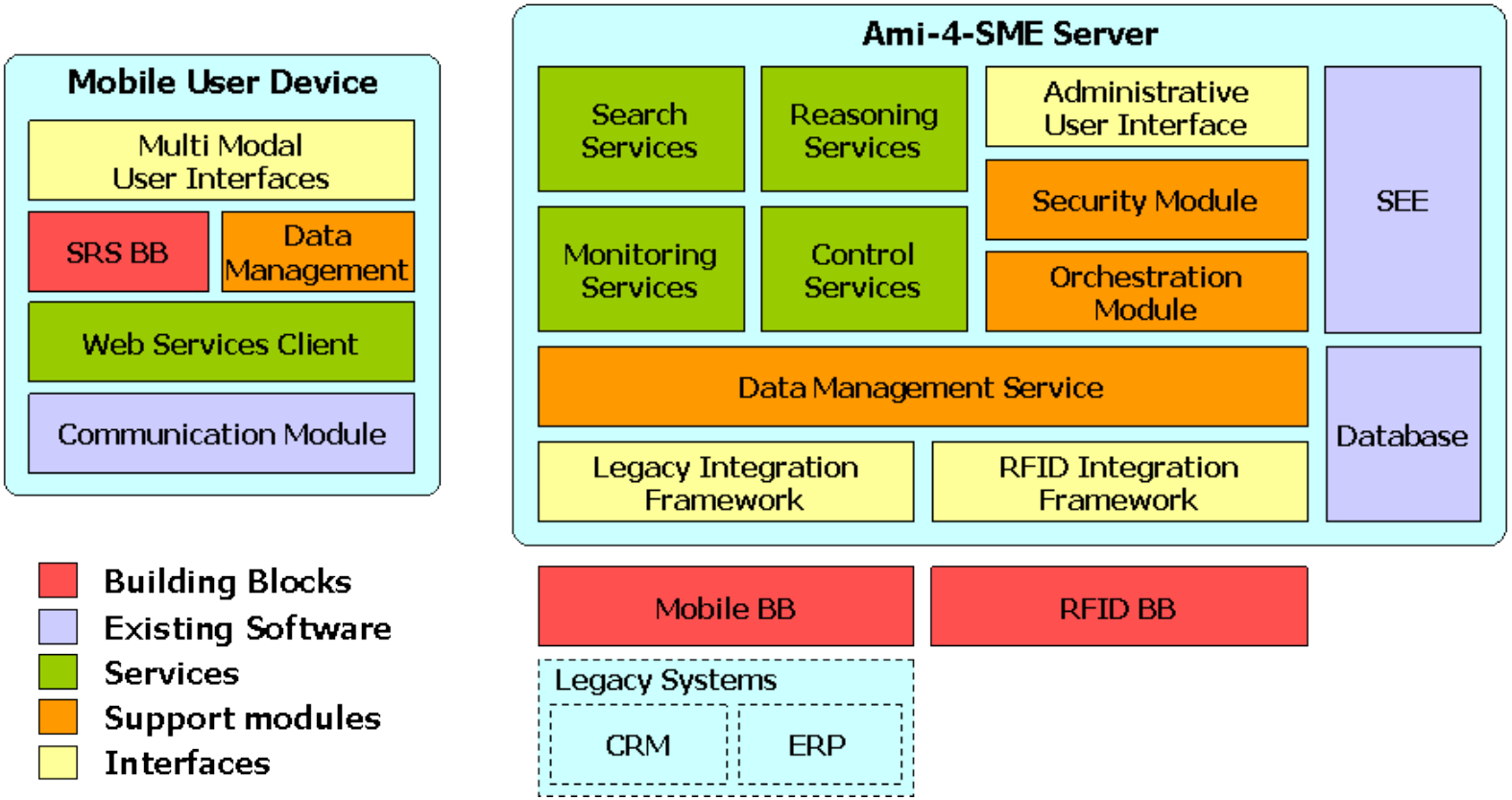
Programming is Only an Entry Skill
for many employers

Entry Level: Develop Software and/or Hardware

- Produce a *detailed design* ("blueprint") of the software / hardware
- Thoroughly *evaluate* the software / hardware design before starting to write code or manufacture hardware
- *Write code* or *build hardware*
- *Integrate* the software and hardware together and test the result

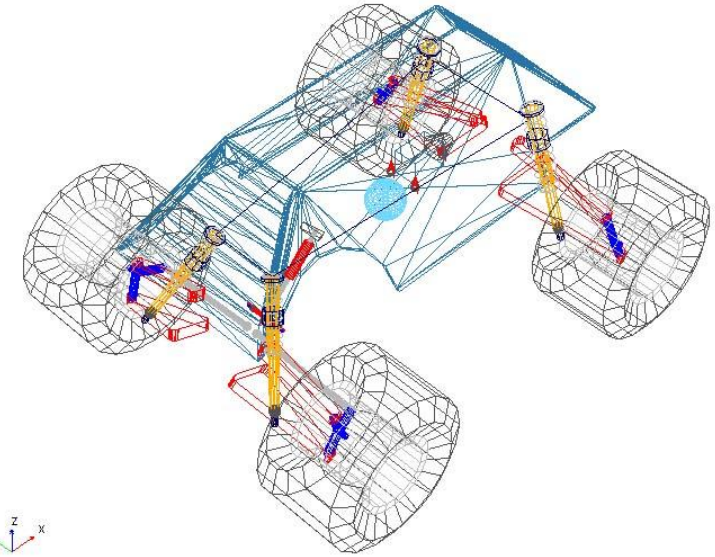
After A Few Years of Experience …

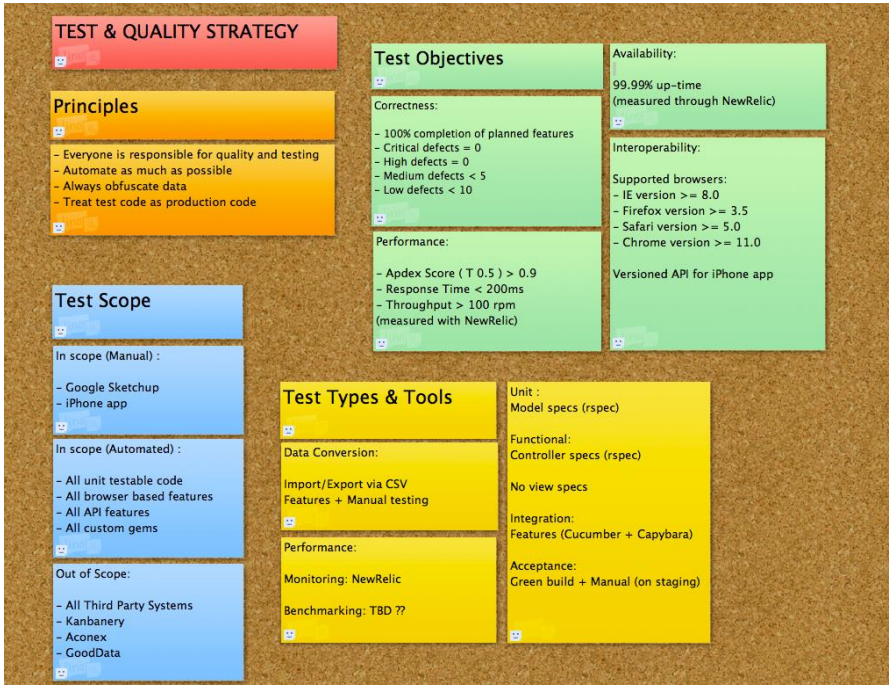
Design the *architecture* of the software and hardware that will implement a larger system



After More Experience …

Develop a *simulation model* of the system, to help *analyze* performance

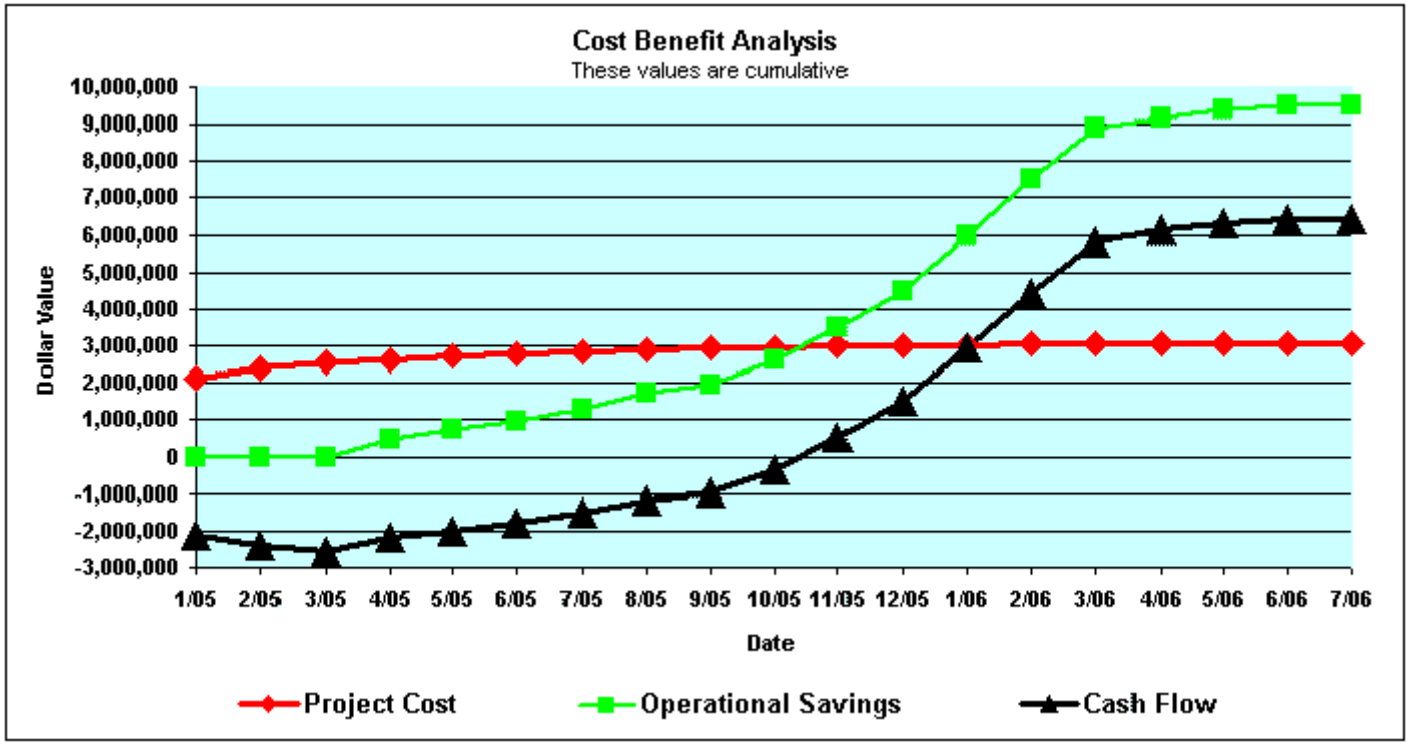




Devise a thorough *test strategy* based on the requirements of the system

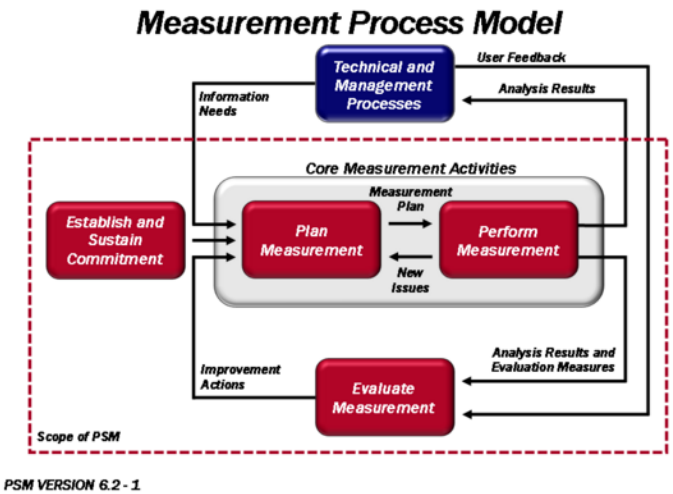
With Increased Leadership Responsibility …

Analyze the projected *cost and reliability* of the software or hardware to make sure it satisfies requirements at acceptable cost



Some "Process" Things a Computer Engineer or Software Engineer Does

- ***Measure*** **the development process to identify bottlenecks or sources of mistakes**
- ***Improve*** **productivity and cycle time by "*optimizing*" how the engineers do their work**
  - For example, by rethinking the test process so test equipment does not become a bottleneck at the end of the project



Some "Management" Things a Software or Hardware Engineer Does

- ***Estimate*** **size, cost and schedule of a proposed development project**
- ***Organize and Lead*** **a team of developers to achieve a desired objective**
- ***Track*** **progress**
- ***Report*** **progress and issues to higher level management**
- ***Manage*** **risks and changes**

Assuring Quality

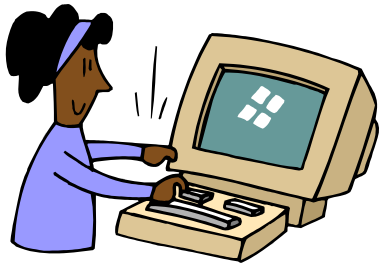
- **Professional software must work**
- **But it must also satisfy the customer's needs**

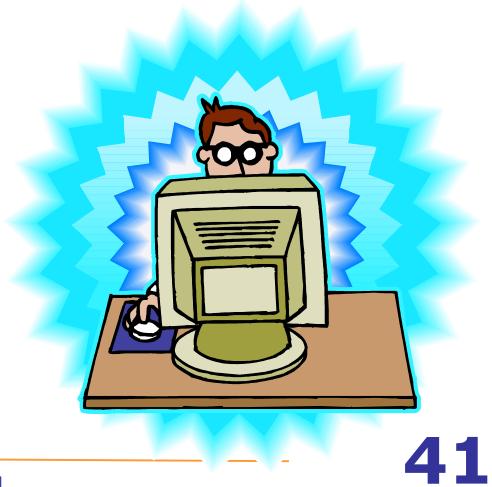
What Skills and Knowledge are Most Needed?

Assuming You Want a Long, Profitable Career

Programming and Building Hardware are Fundamental, but are Only Part of the Job

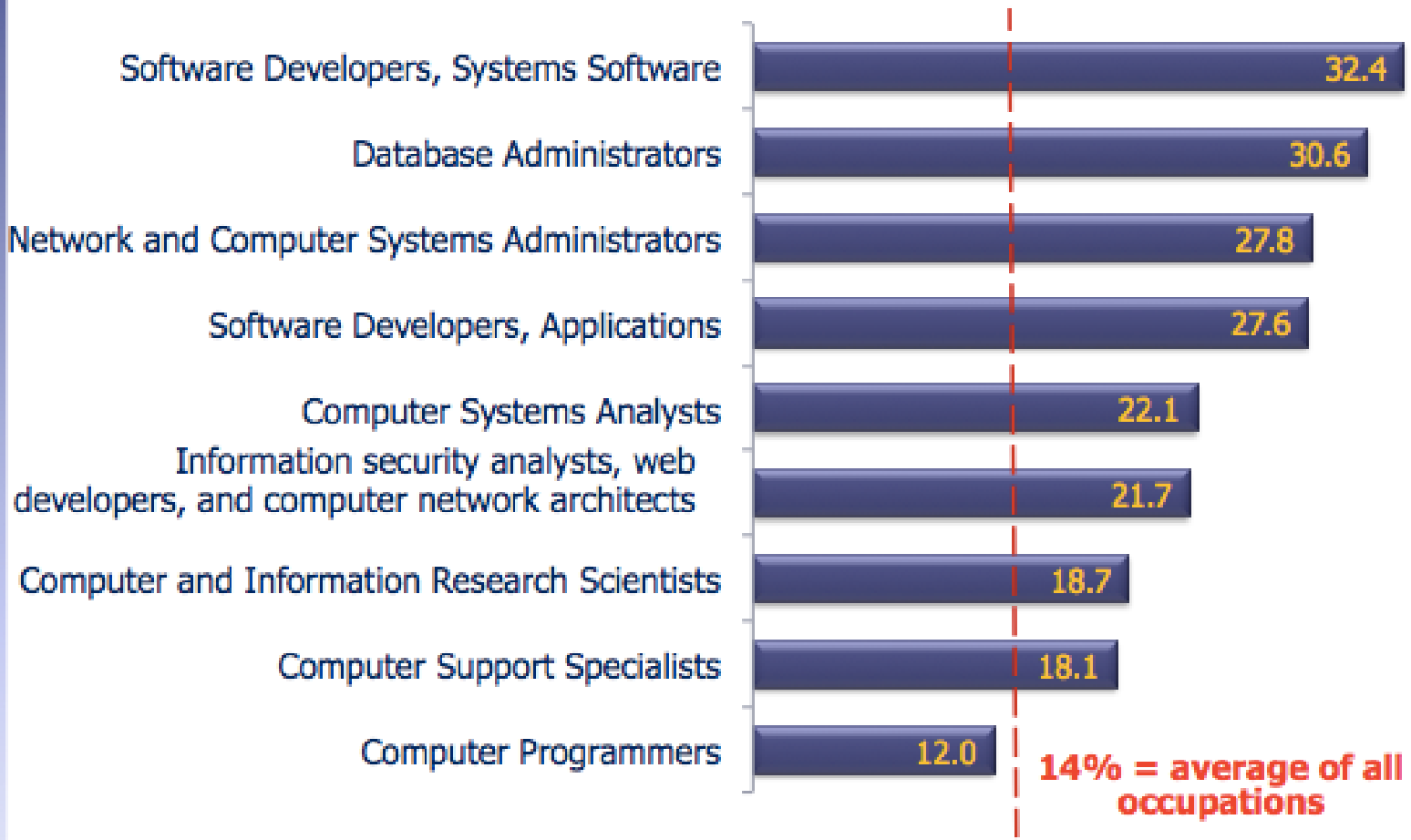
- **More and more, we *generate code* or manufacturing and testing details *from design models***
- **Or *outsource* these tasks**
- **On average, the job of the computing professional is less than 15% programming or building hardware**





Percent Change in Employment of Computer Occupations

Percent change, projected 2010-20



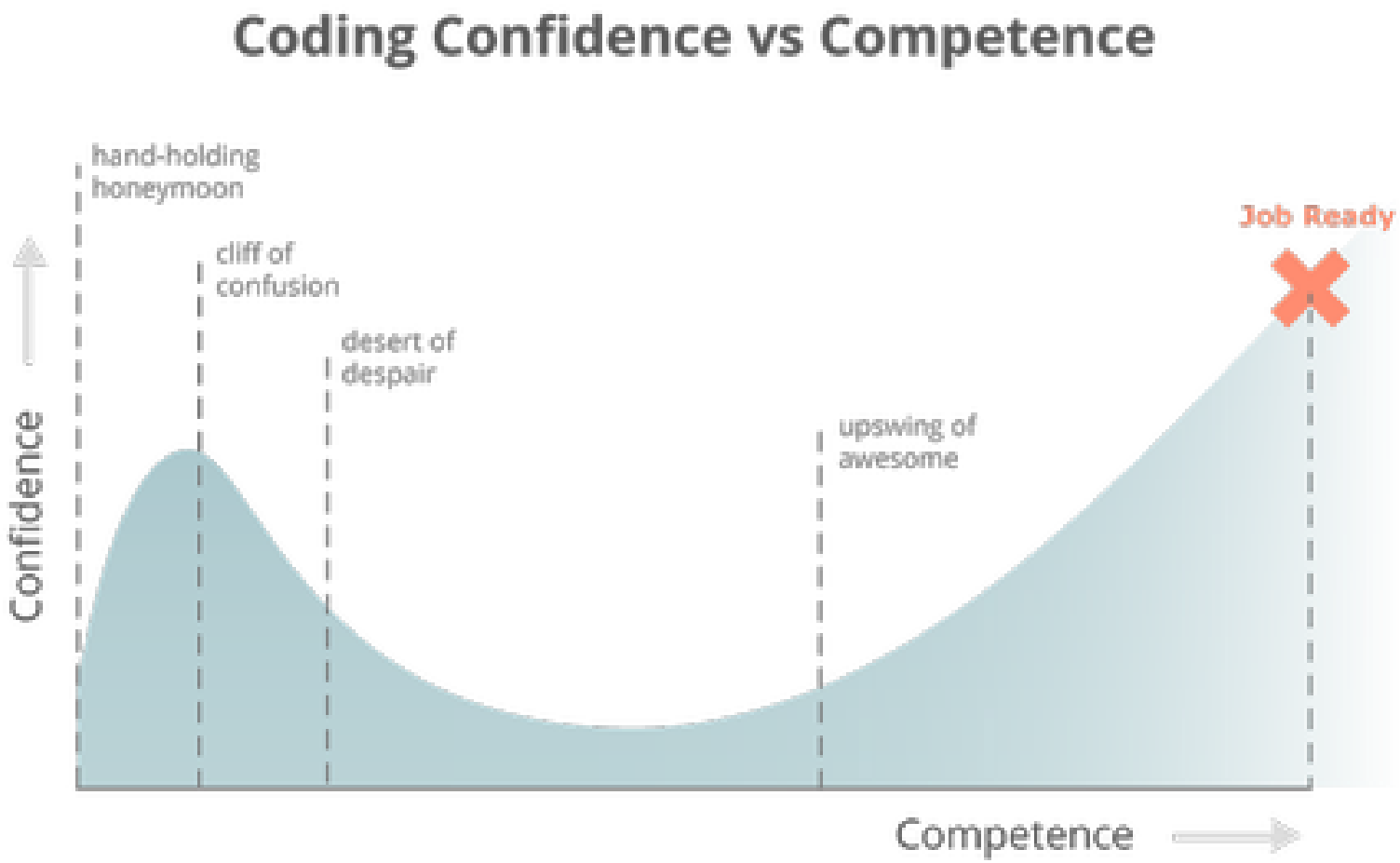
BLS

Product Development Involves Many, Diverse Skills

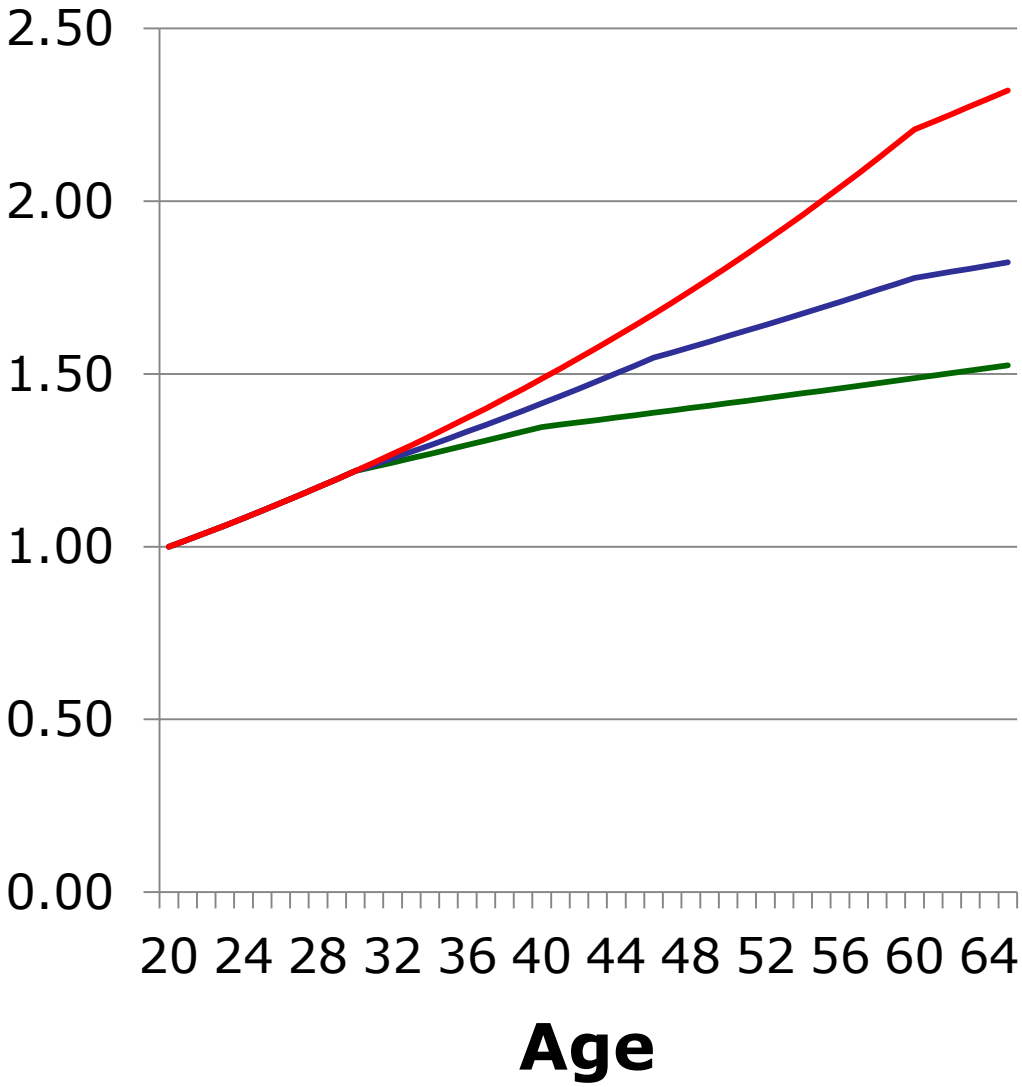
- Project Management
- Requirements Management
- System and Software Architecture
- Software Quality Assurance
- Software Configuration Management
- Software and System Integration and Test / Verification and Validation
- Supplier Oversight and Management
- …

The future is in understanding requirements, designing the solution, and making it work

It Takes Time to Develop True Competence



The Career Plateau: Salary Adjusted for Inflation



Good Programmer
Good Organizer
Good Leader

This is a notional chart – numbers not based on any specific data.

Computing is a Changing Field

- **Every ten years the field is very different**
- **The half-life of computer knowledge is five years**
- **You must plan on a career of continuous learning**

The Changes in Computing

	1950's	1960's	1970's	1980's	1990's	2000's	2010's
Hardware Technology	Vacuum Tubes	Transis tors	Integrated Circuits	LSI	VLSI	ULSI	Nano-systems
Programming Languages	Binary Assembly	Fortran, Cobol	Pascal, Algol	Ada, C, Lisp	C++ GUI Java	C# PhP XML, F#	Python, Ruby, SCALA, …
Computing Paradigm	1 user Mainframe	Batch	Time Sharing	Personal Computer	LAN, WEB	.NET, SOA	Mobile Devices
Operating System	none	1 user	multi user	multi user linked	networked	Web, Open source	Cloud, Android, iPhone
Data Base Methods & Languages	none	Linear (tapes)	Hier-archical	Relational	Object Oriented	SQL, X Query	SQLJ, OLAP, MONGO, Oracle RAC
Software Design	pad and pencil	Flow Charts	Structure d Design	Data Flow	Object Oriented	RAD, XP, RUP	MDE, Node.JS

What Do Employers Look For

It Depends Somewhat on the Employer and their Business

But Certain Things Stand Out

Employers Want Strong Technical Skills

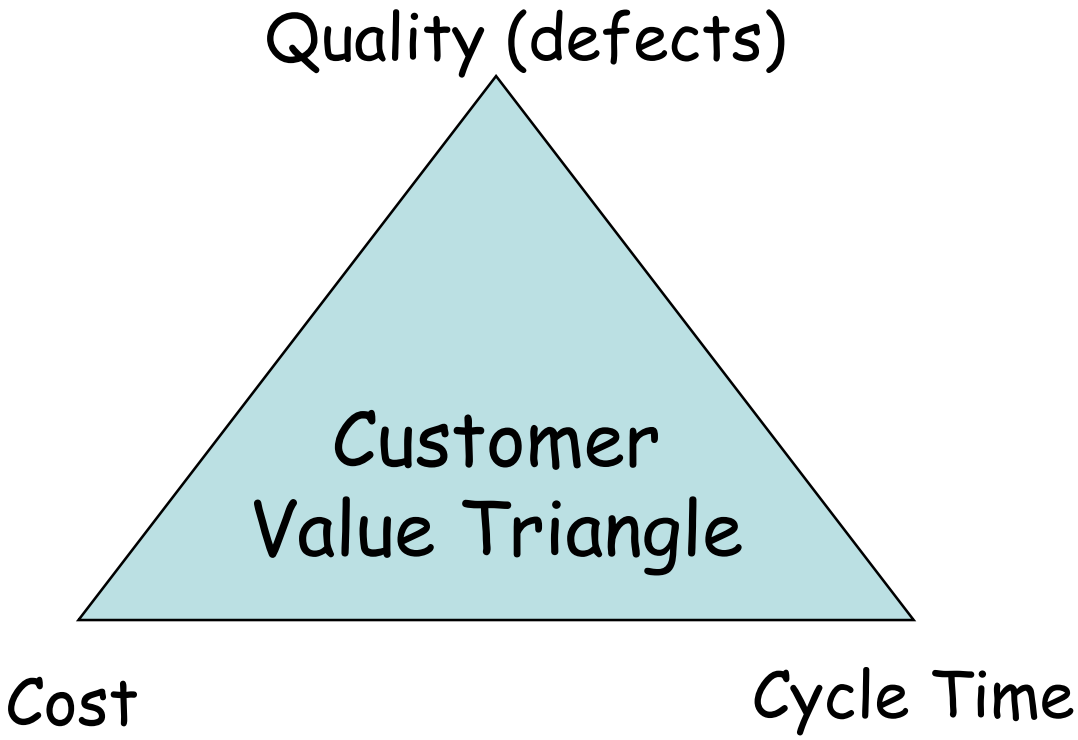
Individuals who can:

- **Understand a complex, technical product or application, and**
- **Develop good quality hardware and software for that product or application**
  - Basic science and mathematics backgrounds
  - Sound fundamentals in chosen technical discipline
  - Broad understanding of related technical disciplines
  - Computer literacy and use of computers in chosen discipline
    - Today, even secretaries must be highly computer literate

But Most Employers Are Running a Business

- **Computing professionals must also be able to estimate costs and manage projects to meet cost and schedule goals**
  - Economics, principles of management
- **They must deliver a competitive, useful product to a customer**
  - Documentation
  - Support
  - Packaging
  - Reliability
  - …

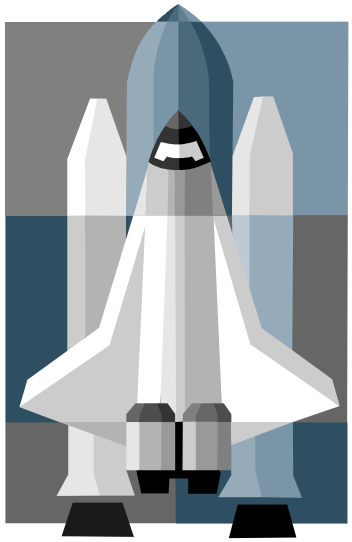
The Goal: High Quality Products With Competitive Cost and Short Cycle Time



WE MUST "SHRINK THE TRIANGLE"

Hardware and Software are Only a Part of a Larger System

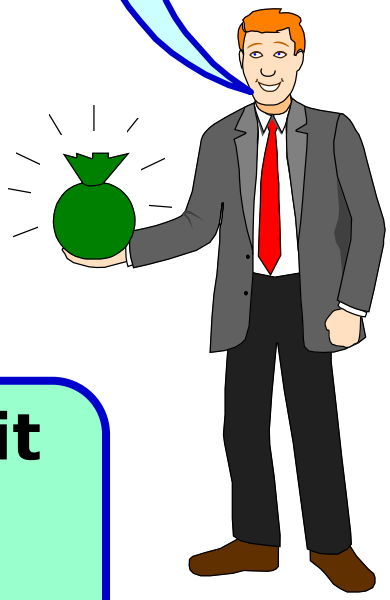
- **Engineering Techniques Involve Many Disciplines**
- **Developers Work Together**



And The Customer Is King

It's object oriented, incorporating the latest AI research

I don't like the color



If the customer is not satisfied, it doesn't matter how slick the technology is or how "leading edge" the work is

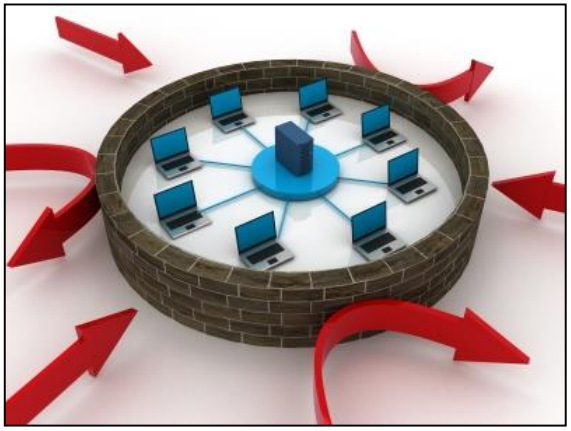
Skills All Employers Want
(1 of 2)

Most of our computer and software engineering effort is spent communicating via viewgraphs and documents

- Reports
- Presentations
- Proposals
- Plans
- …

Skills All Employers Want
(2 of 2)

- **Ethics and security issues are becoming critical to business success**
  - Computers present new ethical and security dilemmas
  - Software Engineering Code of Ethics



Sobering Thoughts From USA Today - 2/21/95

Student grades count little with employers

Employers say schools and colleges are not preparing students for the workplace, and grades are seldom considered# in hiring, says a Census Bureau study out today. ...

Managers at 3,000 locations nationwide say what's important to them on a five-point scale are an applicant's:

- **Attitude, 4.6**
- **Communication skills, 4.2**
- **Work experience, 4.0**
- **Recommendations from previous employers, 3.4**

 # Except for the first job out of school

The Nine Things that Matter More to Employers than Grades

Becky Johns, PR Daily, March, 2013

1. **Knowing How to Learn**
2. **Applying Theory to Real-Life Situations**
3. **Time Management**
4. **Relevant Professional Experience**
5. **A Portfolio Showing You Can Produce**
6. **Ability to Give and Receive Feedback**
7. **Presentation Skills**
8. **Writing Skills**
9. **Your network**

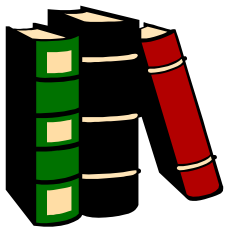
www.prdaily.com

Ultimately, What Do Employers Look For?

People Who Add Value to the Company

How Top Employers Evaluate Candidates

Did they come from a sound program in their discipline?

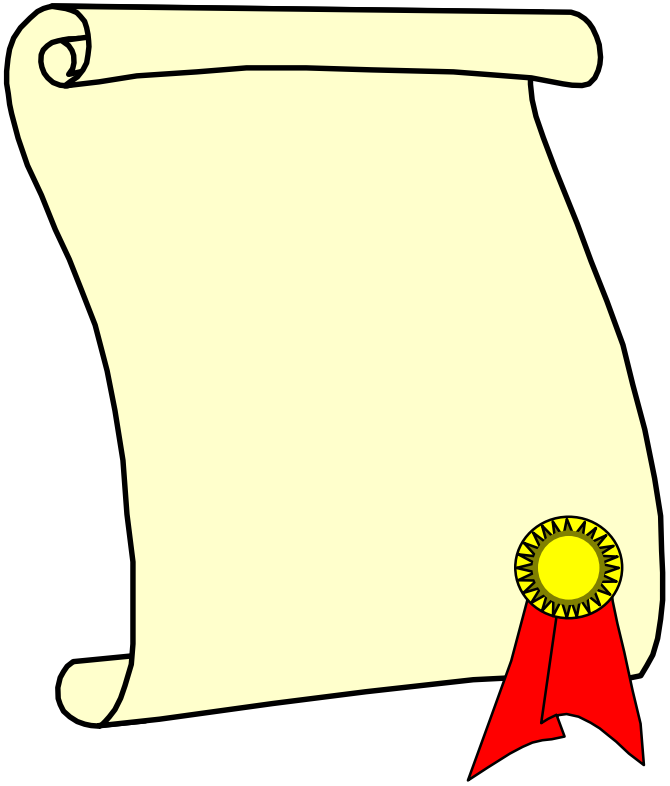


- ***Academic reputation*** of school, department, and program
- ***Prior experience*** with graduates from their school
- ***Specialized accreditation*** [engineering or computer science (ABET)]

More of How Employers Evaluate

What does the transcript show?

- Individual degree contents vary greatly
- Employers look for ***evidence of accomplishments***, especially in technical areas
  - Team Projects
  - Difficult Courses



And More

What does the resume show?

- Internships, projects, jobs and co-op work
- Building ***real products for real customers***
- ***Well rounded*** individuals who have a life

And Still More

What does the job interview show?

- Ability to write and express self well
- Ability to ask good questions – and answer them too!

➢ **Tip: Research the company and ask well informed questions about their business and products**

The Ultimate Basis for a Hiring Decision

1. **Does this person know what their resume claims they know?**
2. **Can this person add more value to my company than I am paying him or her?**
3. **Can this person be useful right away, without a lot of additional training?**
4. **Will this person grow and mature into a responsible technical leader?**

Tips for Your Job Interviews (1 of 2)

from Madeline Plesac, Executive Recruiter

1. **It's OK to not know what you want to do with your life.**
2. **Don't be afraid to start something new – a new city and a new life**
3. **Utilize LinkedIn (www.linkedin.com)**
4. **Have a professional looking headshot photo**
5. **Use correct spelling and grammar**
   - And ***avoid use of acronyms***, especially text acronyms

Tips for Your Job Interviews (2 of 2)

from Madeline Plesac, Executive Recruiter

6. **Customize cover letters and resumes**

7. **Learn what other people do. Find out about different jobs.**

8. **Find companies that do something you are interested in**

9. **Use your network – friends, relatives, professors, classmates, etc.**

10. **Send thank you notes to interviewers and those who have helped you**
    - Hand written is best

Commu-nication Skills

In Summary

Computing Skills

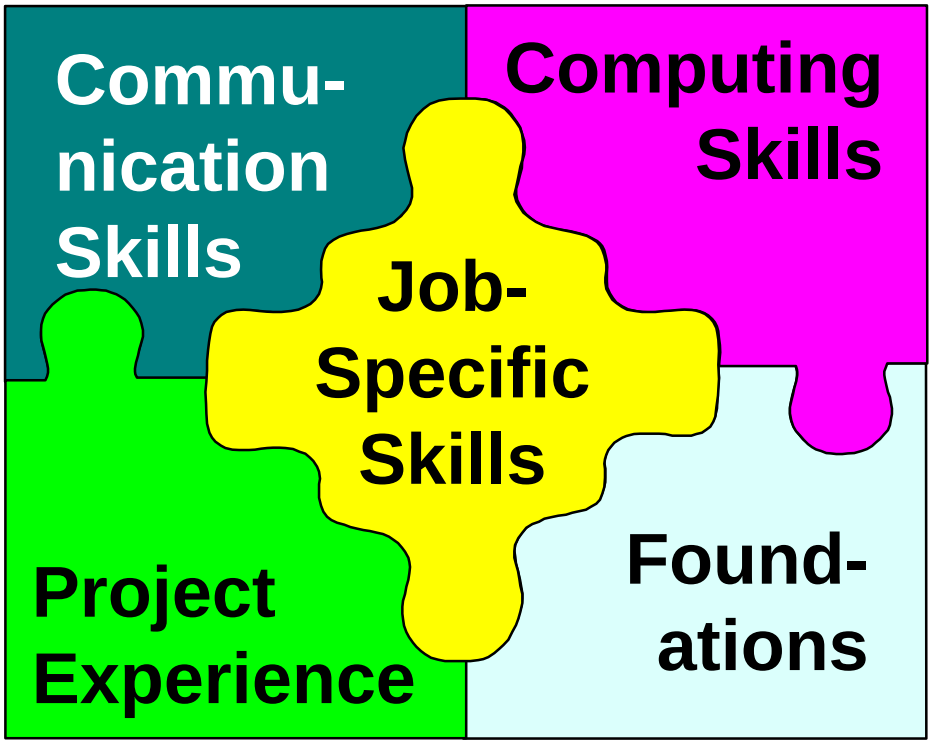
- **Technical skills are only the beginning of what you need to know**
- **Most of the opportunities involve applications of computers**
- **Plan for a career, not just a job**
  - Today's languages, operating systems, computers, tools and buzzwords will be gone in ten years
  - Fundamental knowledge lasts for a career

Job Specific Skills

Project Experience

Found-ations

Preparation for a Successful Computing Career



Questions?