



Notes on Human Resource Issues in the Software Industry and Their Implications for Business and Government¹

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We have prepared this issues outline to facilitate our discussion of the implications of the software talent shortage for the software industry, which includes the software publishing sector, software services firms, corporate and government Information Systems (IS) departments, and the software that is embedded in gadgets, devices, equipment, machines, instruments, toys, and other products. Since there is general agreement that finding qualified software people has become problematic throughout the industry, we will briefly review our position on the scope and nature of the shortage and then focus primarily on the impact this situation will have on the different sectors of the software industry and on the public policy implications we see.

I. The Importance of Software

- The economic impact of software has grown dramatically in recent years..
 - Software publishing is now a \$106B industry worldwide, growing at 12-15% annually. This sector is currently dominated by US firms (77% of worldwide sales), although an increasing amount of product development is done abroad.
 - Software services are about \$185B, growing at 10-12%. Combined with internal projects in corporate and government IS organizations, these activities represents an annual global expense of \$1 Trillion.
 - These “information systems” projects are no longer motivated simply by cost savings or productivity. Information systems are being used strategically to differentiate an organization based on, for example, product customization, speed of response, service quality, and customer loyalty (e.g., frequent flyer programs). As computing evolves into a universal digital communications network, software applications will take an even more strategic role in linking workers, companies and customers.
 - The functionality and market appeal of products of all sorts is increasingly dependent on software, indeed, on increasingly sophisticated software: microwave ovens, cellular telephones, Tickle-Me-Elmo, airbags, anti-lock brakes, and the Boeing 777, to name a few.

1. Presented to the NSTC Presidential Advisory Committee on High-Performance Computing and Communications, Information Technology, and the Next Generation Internet, Washington, D.C., October 30, 1997.

2. All SCIP papers are all available at <http://www-scip.stanford.edu/scip/>

II. Is There a Shortage in the Workforce for the Software Industry?

- Evidence for the shortage
 - Delays in projects caused by movement of personnel
 - Delays in filling open positions with qualified personnel
 - Wage increases
 - Silicon Valley start-ups having more difficulty finding key talent — the last to feel the pinch
 - Project failures and systems malfunctions caused by gradual loss of qualified people in some sectors. This is not a labor shortage, it is a talent shortage.
- Arguments against this evidence
 - There was a surplus of IT professionals 5 years ago
 - There have been dire predictions before: telephone operators and physicists
 - All labor shortages are cyclical and will disappear with rising wages
 - There are plenty of programmers, employers are too picky
 - No shortage exists -- employers are conspiring to be allowed increased access to cheaper immigrant labor
- Some common misconceptions about the software talent shortage
 - This shortage is global, not local to Silicon Valley or to the US
 - It is not limited to Java, SAP, HTML or any other technical specialty and not caused by a crisis like the Year 2000 problem or the Euro conversion.
 - The shortage was masked in the early 90's because of massive relocation of workers from large IT firms (IBM, Digital Equipment, AT&T), corporate IS departments and the defense/aerospace sector
 - The simultaneous appearance of Indian talent, often cited as a reason for labor displacement, even now accounts for less than 0.1% of the world's SW services
 - The shortage is not likely to be very sensitive to future economic cycles because it is driven by demand for software across all industries. It is likely to get worse for a decade or more before it gets better.

III. Causes of the Shortage

- This is a demand vs. supply problem
 - Computing technology continues to become more powerful and more accessible
 - Every new idea of how to use computer technology must be realized in software
 - The trend is for more software of greater complexity & importance
Complexity of the task increases with additional functionality, integration with more and more existing systems, and repairs and patches over the years

- Demand for SW of all sorts is growing
 - Publishing: applications, tools, games
 - Enterprise information systems
Competitive weapon, not just “productivity”
Intranets, Internet and e-commerce.
 - Infrastructure in developing countries
 - Embedded code in products of all types
Creators of embedded systems are often not counted as “programmers”
- Productivity of software developers is constant
 - We still cannot mass-produce software -- we depend on craftsmen
 - SW development is still a tedious process; tools have not kept up with complexity
E.g. GUI tools increase productivity, but now GUI’s are required!
CASE, Knowledge-based programming, automatic programming, etc.
 - New technologies for improving programmer productivity are not likely to have a broad impact on software development during the next decade.
- The supply of software talent has natural limitations
 - Software talent is multi-dimensional and poorly understood (see Appendix I)
Aptitudes and skills for different tasks/jobs should be studied (see Section XIV)
Complexity of programming task, tools and operational environment, deadline pressure, and consequences of errors preclude “entry-level” involvement
Most projects require experienced architects and designers, in very short supply
 - Talented people have many alternatives
Interest in computing careers has declined
Prestige of career still has not recovered from layoffs in early ‘90s
The Dilbert Syndrome: only nerds go into computing
 - Not an attractive working environment, especially in IS departments
Time pressure, working conditions, “Death Marches”
Good work is not appreciated, and errors are not tolerated
 - Schools have a limited capacity
Graduates down 40% from 1986-1994
Enrollments up in recent years, but growth of teaching capacity of university departments is constrained
College and junior college capacity is limited
Competent teachers have alternative careers
 - Immigration and offshore outsourcing are inconsequential compared to increasing demand
India was a special case
No large, untapped pockets of SW talent will become available soon. Russia and China, for example, are not likely to become major exporters of software.
 - Demographics are working against us
The first generation of programmers and analysts is beginning to retire
Women & minorities are not entering the field

IV. General Consequences of the Talent Shortage (across all sectors of the industry)

- Migration of talent to start-ups, publishers, boutique services firms and “software-aware” firms (see Figure 1)
- Project delays, cost overruns, and abandoned projects (now at 40% in corporate IS, see Figure 2)
 - Key people leaving projects for better jobs
 - Shifting resources between projects slows all projects down
 - Delays in replacing talented people and in filling “growth” positions
 - Bringing less-qualified people up to speed on technology
 - Bring qualified new hires up to speed on projects
 - Current workers are less productive while working on their resumes
- Escalating wages and competition for top talent
 - Predatory recruiting practices including signing bonuses and hiring away entire project teams
 - New hires from top schools are being wooed like basketball stars
 - Current employees will demand higher wages or leave
 - The resulting wage spiral will, naturally, increase the cost of software
- Product quality deterioration
 - QA people, entry level jobs, are pulled into development and replaced by less-experienced staff
 - Delays caused by staffing shortages force compromise in testing and quality in order to hit market windows
 - Increased failure rate for software products and software-intensive devices
 - New tradeoffs and liabilities in product design
- Slowing the overall pace of technology innovation
 - Production and adoption of new developments must result in business value
 - America’s high-tech advantage is fundamentally tied to rapid technology change

V. Recruiting, in general (see Section X for specifics about enterprise recruiting)

- Recruiting is becoming a high-priority at software-aware firms
 - At Oracle, every manager has been asked to spend 15 minutes a day interviewing, persuading, etc.
- Recruiting strategies are changing
 - More money is being spent on all aspects of recruiting
 - One firm uses local TV advertising to “prep” market for recruiting efforts
 - Recruiters can no longer just “fill vacancies,” must be part of project planning
 - Recruiting college students from outside traditional disciplines is now common
 - Less-experienced recruits implies more training by employers

- What attracts top software talent? It's not just salaries:
 - Challenging, exciting projects
 - “Toys:” high-tech development environment
 - Top-tier colleagues
 - Tangible results of work
 - Contribution to what matters in the corporate culture, e.g., bottom line
 - Appreciation, recognition and respect

VI. Impact on the SW Publishing Sector

- Consolidation in some publishing categories
 - Publishers acquire companies, vs. build competitive products
 - Greater need to partner or merge firms to acquire needed skills
 - “Musical chairs” implies having the most chairs is a winning situation
 - Talent shortage can be a barrier to entry for new competitors
- Errors, bugs, poor user experience
 - Product liability could become a major issue in the software publishing sector
- Intellectual property
 - IP disputes starting to arise as people move from company to company

VII. Impact on Enterprise Software Publishing — A Special Case

- Customers must integrate new technology offerings into their business to create value for their companies
 - Their best talent is now working for the publishers and services firms
 - Shortages of talent will lead to inability to integrate new offerings, and slowdown of purchases of new products and upgrades
- Trend toward increased customer support from enterprise SW publishers
 - SAP, Oracle & Microsoft are staffing up services offerings
 - Migration services for new releases
- Slower technology adoption by corporate IS will slow down the IT industry
 - Poor quality and abandoned projects may sour CEOs on new systems adventures
 - Which, in turn, makes product innovation relatively less valuable than, e.g., quality or service
- Some good news for applications publishers
 - Corporate IS departments, unable to build their own applications, will be more inclined to purchase off-the-shelf applications in this sector

VIII. Impact on the Software Services Sector

- More competition for talent
 - Some major services firms are reporting 40% annual turnover
 - Contractors are an increasingly large part of the work force
 - Training investment, already significant, will increase
- Stratification and niche specialization of services firms
 - Boutique and regional firms can supply critical talent
 - Offshore services providers are viable, but neither easy nor cheap
- Partnerships vs. vendors: new relationships with outsourcers
 - Services firms as long-term strategic partners
 - Shared risk — completing projects in a timely fashion will reap bigger rewards
 - Proprietary projects will preclude current “re-sale” strategy
- Good news: more business
 - As strategic use of IT grows, and the SW development capability of IS departments shrinks, non-proprietary applications will be increasingly outsourced
 - However, working with understaffed and talent-shy corporate IS groups will be more difficult, involve increased liability exposure, and require souped-up project management capabilities

IX. Impact on Corporate and Government IS Departments

- In many industries, e.g. banking, insurance, securities and telecommunications, some firms will gain competitive advantage and create barriers to entry because competitors will not be able to hire the talent they require in order to offer competitive products and services
- Improved status of corporate IS groups, which is long overdue
- Outsourcers, once viewed by internal IS groups as threats, will become allies
 - Mundane work will be outsourced — internal projects will be more important
- As recruiting top talent becomes more difficult, corporations must cooperate with local colleges, junior colleges and trade schools to produce the talent they need
 - Computer Associates’ deal with SUNY Stony Brook
 - Enterprise investments in training, now relatively low, will increase substantially
- Increased appreciation at the executive level of the importance of IT to competitiveness in many industries
 - Strategic vs. productivity applications
 - Business value of software may be clearer after December 31, 1999
 - The cumulative value current systems have created over time
 - Replacement cost of current systems — suppose they were gone tomorrow

- Know-how of the systems staff
- Technology vendors can enter your business — can you compete with Bill Gates? (who has already entered the banking, travel, entertainment, classified ads, and news businesses)

X. Strategies for Corporate IS Departments

- Audit current software expense (products, services, IS projects, embedded systems) and establish true worth & strategic importance
 - Many firms are still trying to shrink IT budgets to “industry average”
 - Budget freezes and layoffs have a devastating effect, long term
- Recruit as if the success of the organization depends on it
 - The needed talent is no longer coming to the door -- recruit from Microsoft and Oracle
 - Have HR recruiters get more familiar with the technology & development needs. Work with engineering managers to help them recruit
 - Plumbing isn't glamorous, but it does attract certain types of software people — know the target recruit
- Retain the talent already in-house
 - The current staff is the best you will get -- can't hire better
 - Buy technology to attract top talent and make them happy
 - Esprit de corps is the only weapon against aggressive recruiters
 - Reduce pressure, “death marches,” abandoned projects
 - Measure managers on recruiting and retention (employee satisfaction)
 - Free pizza works for some Silicon Valley firms, others offer concierge services
- Reorganize
 - Segregate programmers in a meaningful way to keep the best talent happy
 - Focus on support talent too
- Standardize where appropriate and use off-the-shelf software
 - If it's not a competitive weapon, buy, don't build
 - If it's not on the market, form an industry consortium
- Nurture alliances with outsourcing partners and contractors
 - Contractors are an growing part of the software labor pool
 - New relationships with services providers (see Section VIII, above)
- Find a way to make better decisions about IT investments
 - Determine which systems have top priority
 - Invest limited talent where it will have the greatest impact in the long term
 - Build vs. buy decisions
 - Recognize new tradeoffs and liabilities in product design
 - Understand true impact of software errors and delays (e.g., YR 2000)

- Invest in a software infrastructure over the next 10-20 years
 - Based on 3 technologies: software reuse, distributed computing, and components
 - On-going investment required, just like the organization's database infrastructure
 - Architected by experts, not random reuse
 - Administration & maintenance are costly
 - Establish procedures, training required
 - Multiple levels of access permitted
 - Layered architecture
 - Building blocks at every layer – coordinate change
 - Move some layers closer to customers
 - Some innovations require new substrates
 - Architecture implies principles of design
 - Reduce integration complexity
 - Make it easier for developers to do it right

XI. Impact on Government IS Departments

- Budgets are unable to keep up with salaries and demands for software (ex. USAF projected to double need for SW in 2-3 years with only a 10% increase in budget)
- Major difficulties recruiting and retaining qualified people
 - Not able to attract top half of graduating class, or experienced talent
 - Many government agencies have under-funded IS for years (decades), are running archaic systems and infrastructure, and have created impenetrable relationships with entrenched services firms
- Major shift to off-the-shelf with perhaps a loss in unique functionality needs
- Huge project failures, cost overruns, and poorly designed, poorly running systems
 - Possible security consequences in not being as agile and up-to-date in SW in such areas as warfare, network security, encryption
 - Already taking huge losses on abandoned systems, such as IRS, Medicare
 - Work on important welfare systems like Social Security is out of control, with potentially serious civil consequences
 - Important, but archaic, safety systems like FAA are increasingly less reliable
 - Loss of credibility and faith of citizens and other countries
 - State and local governments are in similarly dire straits

XII. Possible Government Actions

- “Manhattan Project” type of effort for renovation of critical government systems
- Certification of services providers to the government and tracking of their performance, with the possibility of de-certification, of course
- Research funding
 - Real numbers on the commercial impact of software
 - Detailed information about the labor pool, skills shortages, and future needs
 - New software development technologies — another Manhattan Project

XIII. Some Possible Actions by the Software Industry

- Industry-funded “trade school” training programs
 - Beyond existing vendor certification programs
 - And in addition to partnerships with and gifts to schools
 - Project management is as important as coding
 - Making these programs international would be smart
- Maximize productivity of current workforce
 - Retraining and retooling
- A rational approach to the training of the software labor force
 - Rethink the way we satisfy the demand for software products and applications
 - SAP and the off-the-shelf movement
 - Assembly of software components: investment in architecture & infrastructure
 - Synchronize with customer technology adoption constraints, changing needs
 - Help customers avoid “build and scrap” cycles
 - Redefine skills and job classifications
 - Reinvent the way we train the labor force
 - E.g., start young, everyone gets basic training
 - Breakdown programming projects for different types of labor

XIV. SCIP Research Questions for 1997-98

- In order to make better decisions about software projects in a resource-limited world, how can companies determine what is the total amount spent on software -- purchased, outsourced, developed internally, and embedded into products?
 - Develop and field test an audit methodology
 - Measure true % of expenditures devoted to software
 - Look at how various types of systems contribute to competitive advantage (besides reducing cost)
 - Extending market reach, exploiting new channels
 - Increasing product variety
 - Enhancing customer service
 - Enabling competitive product features
- In an environment of limited SW development resources, how best can companies link decision making about systems development to overall corporate strategy?
- How will trends toward increased strategic use of software be affected by the talent shortage?
 - Look across industries to see pattern of strategic use of IT in 5 or 10 “software aware” industries
 - Planned collaboration with other Sloan industry studies
- What is the mix of software skills needed by industry — which are in short supply?
 - Develop an up-to-date list of skills needed in various parts of the software industry (see Appendix)
 - Analyze job classifications based on skill sets
 - Collaborate with private and public organizations to count software professionals and job openings based on skill sets
- How can firms identify and recruit the talent they need?
 - Identify best practices in recruiting
 - Follow-up research on success on job, turnover, additional training needs
 - Research best practices in retention
 - compensation structures
 - working conditions
 - organizational practices (like parallel career tracks)
 - effects of outsourcing
 - Role of independent contractors
- How can relationships with software development firms and outsourcers best be structured, maintained and utilized when it's a sellers' market for software systems.
 - Look at alliances motivated by need for people resources rather than for technology or channel access

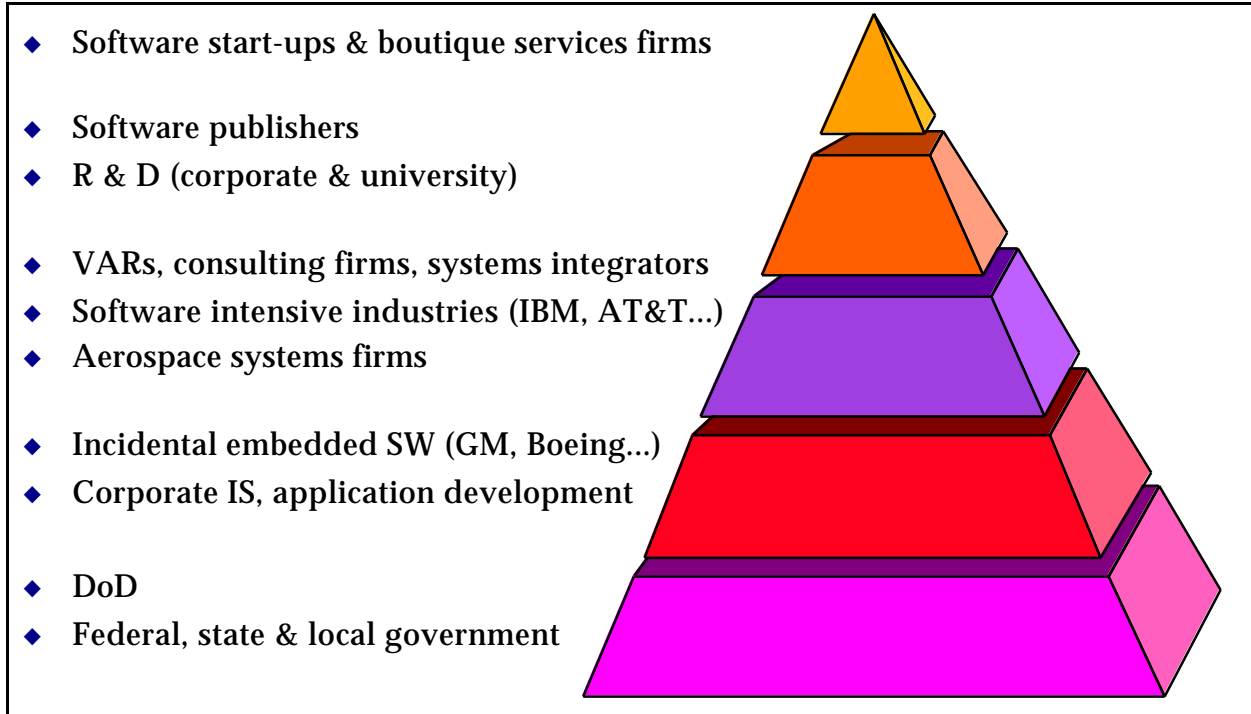


Figure 1. Top talent migrates to prestigious jobs for many reasons, not just salaries and stock options (see Sections V, X and XIV).. Executives of “software aware” firms, roughly the upper half of the picture, are cognizant of the strategic importance of software.

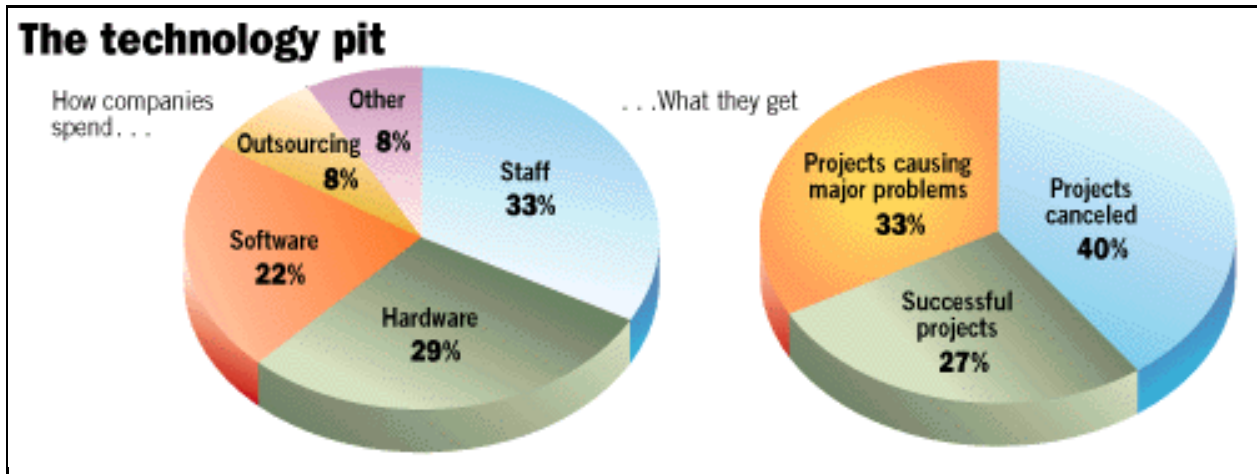


Figure 2. From Forbes, December 30, 1996. Sources: Computer Economics, Inc.; based on a survey of 300 managers; The Standish Group International, Inc.; based on a survey of 365 companies

Appendix 1: What is Software Talent?

Software talent is not a well-understood set of abilities, although it has been studied since the 60's. At the very beginning of the data processing industry, IBM had to develop an "aptitude test" to identify workers who could become the world's first programmers.

However, the process of developing software has become more complex in many ways since those early days, and there are many more skills needed to staff successful projects (not all are unique to software projects, of course). Here's a list to start from:

- Systems analysis – needs and vision, business process design
- Architecture – form and function, space of technical alternatives
- Design – usability, constructability, testability, reliability and maintainability
- Development – still craftsmanship
- Debugging – skill and temperament
- Testing – still undervalued
- Documentation, training and support — facilitating effective use
- Project management – the key to success