Report on the SCIP Software Labor Roundtable:
Discussions Regarding the Global Software Labor Supply

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In February 1997, the Stanford Computer Industry Project hosted a roundtable to discuss the continued adequacy of the supply of software professionals in the face of continued robust growth in demand. Participants included members of the business community, government, and academia. While the majority of participants believed that the software industry is experiencing a growing labor shortage, some felt that any "tightness" in the labor supply was local, temporary or limited to certain specific technical areas. There was even less agreement on the seriousness of the shortfall, on the reasons for it, or on proposed solutions to the problem. Discussions encompassed both industry and public policy issues related to software labor, in three general areas:

1. Education -- encouraging more students to enter software-related courses of study, retraining older workers in new technologies, and ensuring that training for both groups is as relevant as possible to the needs of industry;
2. Technology -- promoting public and private funding for research on new software tools and methodologies to increase the productivity of software developers;
3. Immigration / outsourcing abroad -- understanding the role of non-US citizens in the US software industry, and examining foreign trade and immigration policies to ensure that they will continue to contribute to the country's success in the worldwide software industry.

Debates on the above issues prompted more general discussions revealing a need to clarify such basic concepts as:

- Who is considered a software professional?

  The BLS defines only two categories: computer engineers, scientists and systems analysts is one category; computer programmers is the other. If we define a software professional as anyone involved in the design, development, testing, documentation or maintenance of software programs, then we need to also consider other jobs such as project manager, documentation writer, quality assurance engineer, and webmaster, as well as a number of non-computer science engineering jobs in which writing software constitutes a significant percentage of the job requirements.

- How do we properly measure both the demand and supply of software professionals?

  Currently, demand forecasts are based on a combination of anecdotal evidence, BLS estimates (1994 estimate of 198,000 job openings per year through 2005 to meet growth and replacement needs), and relatively small-scale surveys such as the February 1997 ITAA study. More comprehensive analysis of the demand for software labor is needed, including a better understanding of the possibly differing labor demands across business sectors. On the supply side too, more research is needed to ascertain whether and how people from other fields might be attracted into these jobs and used effectively. While rising software salaries might attract some trainable new graduates from related engineering fields, it is unclear that the migration will be large enough to substantially meet the rapidly growing demand.

- Is there a broad shortage of software people, or can we characterize some part of the shortage as a mismatch of worker skills and industry requirements?

  Better information is needed on what skill sets and aptitudes are basic requirements for which jobs, and what kind of training would best equip workers to meet those industry requirements.

All agreed that more study of these questions is imperative to ensure that any industry and government initiatives undertaken would be effective in meeting industry's needs.

Education

Cyclic need for SW professionals? Discussions about the recruiting of more students into CS programs inevitably turn to the question of whether the current need for software professionals is likely to be a long-term need. Participants recalled the boom/bust cycle in other science and engineering disciplines, such as physics, in which thousands were enticed into a lengthy course of study, and could not find desirable positions upon completing their degrees. Unfortunately, physicist employment was highly dependent on continued government project support in universities and national laboratories.

In contrast to the experience of physicists in the ’70’s, the demand for software talent is spread broadly across the economy rather than concentrated in relatively few government-funded projects in industry and academic research. This broad-based need should dampen the effects of downturns in any particular industries, keeping overall demand at a stable or growing rate. Still, the drop in enrollments in CS programs during the period 1986 to 1994, presumably in reaction to the well-publicized downsizing in corporate IS departments and downturns in several high-tech sectors of the economy (defense, aerospace, telecommunications and computer hardware), may indicate that students must be convinced that jobs will be available for them before they will enter the field in large numbers. A study to determine what

drives the variability in enrollments in computer science programs would be desirable to confirm whether the primary motivator is student lack of interest, a perceived lack of jobs in computer science, strong demand for talent in other fields, or student migration into related technology areas, such as engineering.

K-12. There was general agreement that training students for future participation in a high-tech economy should begin early. Students must be trained in problem solving and logical thinking, and should be encouraged to be creators of technology, not just users. Moreover, teachers must be trained to provide students with the proper instruction.

University programs. The consensus from both educators and industry participants was that universities and community colleges were not keeping their training current with the rapidly-changing requirements of industry. Many university computer science and information science programs emphasize mainframe technologies, and don't offer training in project management or "business awareness." The top-tier schools are even more likely to stick to traditional curricula that emphasize the theoretical underpinnings of computer science, believing that such a approach will offer students a strong base that will allow them to better adapt to new technologies as they appear during their careers.

At least in the short-term, training oriented toward the immediate needs of industry is more likely to come from junior colleges and university extension programs. Their contribution to the supply of adequately trained software professionals may prove to be key, as their mandate is to train both beginning students and to offer lifelong learning to professionals already in the field. These programs hire instructors from industry, quickly offer courses in the currently popular tools and languages, and work more closely with companies and industry associations to provide customized training. Still, they may need do more to upgrade and change their curricula as major changes in technology appear and begin to be adopted widely.

Graduate education. At the 1986 peak year for CS and IS graduates, about 16% of graduates were masters level and 1% were PhD's. In the period 1987 through 1994, undergraduate degrees awarded dropped 40% while masters degrees awarded grew slightly, and the number of those receiving PhD degrees tripled. By 1994, those trends produced a situation in which 30% of all new graduates received masters degrees and 3% received PhD's. In contrast, industry respondents of the ITAA study reported that approximately 82% of their staffs held undergraduate degrees, and only about 18% were advanced degree holders, about equally split between masters and PhD level.

These data are occasionally used to argue that the US is producing more people with graduate degrees than the country can accommodate. However, several factors make the issue more complex, including the significant presence of foreign graduate students (about 40% of CS graduate students overall), at least half of whom return to their home countries after graduation; the strong industry demand for software professionals of all educational levels; and the choice of some practicing software

professionals to seek an advanced degree as a retraining alternative to certificate programs.

Industry Training

Industry recognizes that it must play a substantive role in the training of software people because technologies change much quicker than university programs can. Beyond that basic acknowledgment, there is significant diversity in approaches. Some large companies, like Motorola, have extensive in-house training programs. Other companies, like Intel and Computer Associates, train and retrain their software professionals through close partnerships with universities. Still others provide funding and flexible schedules to allow their employees to pursue whatever retraining programs that they choose. This last alternative puts more of the responsibility for retraining on the employee. Industry associations also assist in retraining technical professionals. The Massachusetts Software Council, for example, offers a multi-week software training program for laid-off engineers from the hardware and electronics industries.

Industry participants from large companies voiced their concerns that they expend considerable moneys to recruit and train people, only to have them leave for a better-paying position elsewhere when their training program is completed. They are therefore motivated to recruit people already possessing the right skills. Smaller companies asserted that they cannot afford the training costs or the time to train, so they too believe that they must demand applicants with certain specific skills. Companies of all sizes also see the speed of business change as another reason for preferring to hire rather than train for the skills they need. Thus, while companies acknowledge that they must train and retrain people to meet their needs for software, they also point to substantial competitive pressures as the reason for trying to hire people that already have the right training and experience.

Government Involvement

The Canadian Department of Industry has taken an active role in evaluating the shortage of software professionals in Canada, and in developing programs and policies to ameliorate the situation. For example, the government-backed Software Human Resources Council administered a nationwide study of businesses to determine the number and type of software professionals that were in short supply. It then promulgated a number of new policies, including easy entry for software professionals who want to immigrate to Canada.

In the US there is much less government attention to the larger issue of software labor, and a more politics involved in the few issues that are debated. The most prominent of these issues concerns the legal entry of foreign skilled professionals. The H1B visa process for temporary employment in the US is an expensive, complex and lengthy process that most agree needs to be reformed. With reform proposals,

however, come calls to reduce the number of skilled professionals that may enter to country yearly, and to make it more difficult for non-US citizens graduating from US universities to stay and work in this country. After vocal lobbying efforts from the high-tech industry and other groups, the H1B visa program and its current limit of 65,000 people per year was left intact. Any efforts to reopen the debate could result in the reduction of that annual number. With perhaps 12-15,000 software professionals entering the US yearly under this program, further reductions might well harm the competitiveness of international firms that use the H1B visa program to train and coordinate projects with their non-US employees, as well as to obtain expertise that is scarce locally.

Measurement of supply and demand. All agree that much more data about high-tech employment must be collected. Neither the Bureau of Labor Statistics nor the Bureau of Economic Analysis has undertaken any reasonably thorough look at the professionals working in this sector. While it is admittedly difficult to keep up with such a rapidly changing field, only a large-scale data collection effort can truly illuminate the importance of software professionals to the economy, and the shortage of those professionals throughout both the manufacturing and services sectors.

Small-scale surveys, combined with large doses of anecdotal evidence, currently serve as the primary sources of information on the high-tech labor force. For example, the ITAA survey estimates that 190,000 IT positions remain unfilled in the US, not including federal, state and local governments, small companies, or non-profit organizations. The organization predicts exponential growth in IT occupations, and maintains that not enough graduates will be available in CS or in related engineering fields to fill the gap. Another small survey, this one from the Massachusetts Software Council, reports that approximately 10-15% of jobs are open in its member companies because they cannot find the right people.

A number of other surveys, such as the EETimes annual salary survey and the Coopers Lybrand study of salaries in the software industry, indicate double-digit increases in compensation levels in a number of software job classifications. The increases in pay rates are higher than in other engineering and scientific disciplines. In addition, anecdotes of people-pirating through six- and seven-digit signing bonuses have begun appearing in the press as well as in Stanford researcher interviews with executives in the software and finance industries.

The favorable salary situation may well draw more people into the software industry. The CRA reports, for example, that enrollments in CS programs are up 5% in 1995 and 40% in 1996 after a 9-year decline. As for people already in the workforce, their ability to move into the software field to take advantage of the higher salaries may be impeded by substantial retraining and experience requirements. Studies are needed to determine how to facilitate such migration.

Quantity Versus Quality

Much unresolved discussion revolved around the issue of how companies can hire the "right" people. Participants described various approaches to identifying qualified people for different jobs. Many companies use degree and course of study to judge whether an applicant is likely to have the right skills for a particular job. In the context of that discussion, several comments indicated that demand for software professionals is much more intense for bachelors and masters degree applicants in CS than for those with a two-year degree. Additional discussion focused on understanding the differences in training among all software-related degrees, including computer science, information systems, software engineering, and electrical engineering. Other participants expressed interest in viable approaches for identifying candidates with the appropriate aptitude (and non-software-related degrees) and training them for the job.

This interest in aptitude led to a discussion of what general skills, specialized knowledge, and personality traits are most appropriate for a software professional. Some discussants felt that the demands of the complex and rapidly changing high-tech business require versatile individuals with broad knowledge of business and technology. Small startups especially require versatile employees because these companies cannot hire one person for every specialty required. An equal number felt that this same rapidly moving business context required specialists with deep knowledge of a few areas, and that companies could not expect their software people to keep up with so many technology or market changes.

All agreed that special attention must be paid to the top 20% of software professionals — those that are on the cutting edge of technology and design, and those who are most productive in software development. We need to identify those students (or workers in other fields) with the aptitude to be superior performers in software, and to reward those already in that group of top talent.

Technology

While new tools and methodologies have made today's programmers more productive than their predecessors, they have not kept up with the growth in demand for software. The complexity of new software has also increased dramatically, dampening the affect of any tool-based productivity gains. Ironically, in spite of the rapid pace of change in high-tech industries, the pace of adoption of new development methods has historically been very slow. Still, those in the high-tech industry, including many of the roundtable participants, have faith that current tools and techniques, like object-oriented programming, will eventually be adopted more broadly by software professionals, and that additional improvements will be made and will contribute substantially to future productivity improvements.

Future Outlook

Some consensus about the future emerged from the discussions: the lack of skilled software professionals is likely to be a barrier to future growth in a broad range of industries, both manufacturing and service industries. Managers who cannot find the right talent today will be faced with tough choices. Hiring less qualified people or remaining understaffed may make certain types of software development projects impractical to undertake. Staying competitive with wage increases may bring in more people, but may not be political feasible unless all levels of management understand the central position of software in their business strategies. All agreed that more data collection is needed to determine the depth and breadth of the gap between the demand and supply of software talent; and more collaboration is needed between industry and academia to train and retrain this key component of the labor force.

Notes from the Chair

Since the Roundtable meeting in February, our research on the cause and extent of the shortage and on its impact has continued. We now expect that the situation will worsen for at least a decade, and that it will cause fundamental changes in both the publishing and services segments of the software industry. Perhaps the most serious impact on the software industry and on computing in general is the potential that labor-related problems will slow down the purchase of new technology, as firms realize they no longer have available the skills to turn IT into competitive advantage.

But the impact is not limited to the technology sector. In many industries, those firms with executive-level awareness of the competitive importance of software development, and who therefore are better able to cope with the changing realities of recruiting and retaining talent, will gradually gain strategic advantage over those who still view software as a non-core competency or even as a clerical skill. Looking back in 20 years, it may be hard to isolate specific events or systems, but we will see that decisions about software capabilities will have reshaped many industries.

Roundtable Attendees

Stephen Barley, Stanford, Industrial Engineering
Avron Barr, Stanford Computer Industry Project
Paul Bartlett, President, Hall Kinion
Ron Borzekowski, Stanford Computer Industry Project
Tim Bresnahan, Stanford Computer Industry Project
Norman Brown, Executive Director, Software Program Managers Ntwk.
Richard Dasher, Director, Stanford, US-Japan Tech. Center
Teresa Engelhard, Partner, Mohr, Davidow Ventures
Hiroyuki Furukawa, Senior Vice President, Toshiba America, Inc.
David Gilmour, Manager, Giga Information Corp.
Sy Goodman, Stanford, CISAC
Brenda Hall, CEO, Hall Kinion
Mark B. Hoffberg, Consulting Scientist, Philips
Rod Hsiao, SRI International
Margaret L. Johnson, Stanford Computer Science
Leda Karabela, Development Officer, Stanford Computer Industry Project
John C. Lafrance, Economist, US Department of Commerce
Peter Leyden, Features Editor, Wired Magazine
Paul Lorton, University of San Francisco
Norman Matloff, Universtiy of California at Davis
Frank Mayadas, Program Officer, Alfred P. Sloan Foundation
Marianne K. McGee, Senior Editor, Information Week
Frank McGrath, DoD Consultant
Harris Miller, President, Information Tech. Assoc. of America
William Miller, Director, Stanford Computer Industry Project
John Moran, SW Industry Coalition
Glen Mueller, CIO, Stanford, ITSS
Kathleen O'Toole, Writer, Stanford University
Joyce Plotkin, Executive Director, Massachusetts Software Council
Judy Powers, Manager of Technology, Santa Clara County, Education
Marisa Quinn, Research Associate, Stanford Computer Industry Project
Sharat Rastogi, Regional Manager, Tata Consultancy Services
Charles Roller, Network Coordinator, Software Program Managers Ntwk.
Harry Saal, Chairman, Network General
Pete Sinclair, President and CEO, Smart Valley, Inc.
Michael Teitelbaum, Program Officer, Alfred P. Sloan Foundation
Shirley Tessler, Stanford Computer Industry Project
Tony Vickers, Exec. Director, Information Tech. Assoc. of America
Ken Virnig, CEO, Devine & Virnig
Timo Wadhawan, Senior Vice President, Argos Adriatic Corporation
Anthony Wasserman, Software Methods and Tools
Fred W. Weingarten, Dir. of Public Policy, Computing Research Association
Charles Weiss, President, Global Tech. Management, Inc.