Report to National Science Foundation: Insightful Understanding of China's Higher Education and Research in Computer Science and Information Technology

U.S. Senior Computer Scientists Delegation Visit to China, May-June 2006

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Executive Summary

Introduction and Purpose of Trip

After continuous and dramatic economic reform for more than 25 years, China is now playing a critical role in the global economy and information technology is a key driver of modern Chinese economic development. China has rapidly developed its college and graduate education and research programs in thousands of existing and newly-established universities and research institutions. In the last 10 years, the number of colleges and universities with degree programs in computer science and technology has grown to over 700, with more than half of these less than 10 years old. In addition, many major and leading U.S. and other international computer software and hardware companies have quickly established research labs in China

Faculty and researchers in U.S. academic research institutions still seriously lack insightful understanding of the rapidly changing trends in Chinese universities and research laboratories, and of the corresponding strong implications for U.S. science, technology, and the economy. Under NSF sponsorship, a delegation of leaders of major U.S. computer science (CS) academic institutions (mostly deans and department chairs) visited China from May 20 to June 3, 2006. The goals of the trip were to establish a dialogue between leaders of major U.S. and Chinese computer science departments, to enable the U.S. leaders to gain insight into current and future trends in information technology (IT) research in China, and lay the groundwork for potential future interactions. This report summarizes the delegation's observations and recommendations and discusses the next steps that the delegation plans to pursue.

Itinerary

The delegation began its visit in Beijing, where it held a one-day U.S.-China Computer Science Leadership Summit with Chinese colleagues to discuss issues of common interest and participated in the opening ceremony for the new NSF Beijing office. The Leadership Summit was held at Beihang University, which also coordinated our local arrangements in Beijing and hosted us for an introductory banquet. In Beijing, we also visited IBM China Research Lab, Microsoft Research Asia, the Institute for Computing Technology (an institute of the Chinese Academy of Sciences), Peking University, and Tsinghua University. A subgroup visited Southeast University and Nanjing University in Nanjing, another visited Northwestern Polytechnical University and Xi'an Jiaotong University in Xi'an, and a third participated in the International Conference on Software Engineering in Shanghai. The entire group visited Shanghai Jiaotong University and took a side trip to Suzhou to Suzhou University.

The Chinese Academic System in Computer Science and Research in Chinese Higher Education

Chinese higher education is changing rapidly, so what we observed may not be the case even in the near future. The People's Republic of China (founded in 1949) did not officially establish academic degrees until 1981, when it began to offer bachelor's, master's, and doctoral degrees to students after their graduation. It has had a short history of graduate studies. In the summer of 1978, for the first time in its history, China started its national entrance exams to recruit graduate students in several established universities. The first accepted graduate students entered graduate programs, including M.S. programs in CS, in the fall of 1978. Entrance into Chinese universities is very competitive and only a small percentage of Chinese young people are admitted to universities. Admission to bachelor's degree programs is based on a national entrance examination. There are complicated quota systems that give priorities at different universities depending on field of interest, minority status, or geographical home. Admission into graduate programs depends on examinations, records, interviews, and student fields of interest. Matching up students to advisors and programs sometimes gives more weight to university and national priorities than to student interest. Once the match between student and advisor is made in a Ph.D. program, it is rare for a student to leave the program prior to completion.

According to the Ministry of Education, China had over one million graduate students in universities and research institutions in 2005 and now has the second highest graduate student population in the world after the U.S. Since graduate programs started very late, and since many older faculty members started research during the Cultural Revolution when research was seriously hampered, many senior faculty members do not have Ph.D. degrees. This, however, is changing rapidly. Chinese professors hold three ranks: associate professor, full professor, and Ph.D. advisor; the fast growth of Chinese universities has created a situation where only a small set of full professors are given this final rank and are thus eligible to supervise Ph.D. students. Our Chinese hosts expressed concern about ensuring and increasing the quality of research by faculty and students. For example, concern with quality of dissertations has led to new procedures at some universities involving anonymous review of M.S. and Ph.D. theses (except in cases where a student has had a paper accepted in an international journal).

Funding sources for Chinese IT researchers include:

- the National Natural Science Foundation of China (NSFC), which supports basic research and some applied basic research in the natural sciences;
- the Hi-Tech Research and Development Program (863 Program), aimed at enhancing China's international competitiveness and improving China's overall capacity of R&D in high tech areas;
- the National Basic Research Priorities Program (973 Program), the national keystone basic research program; and
- the Key Technologies R&D Program**,** which embodies the principle of orienting science and technology towards the main fields of economic development.

Funding from these sources has been dramatically increasing. NSFC's annual budget, for example, has gone from 80 million RMB in 1986 to over 2 billion RMB in 2004. (RMB, or yuan, is the Chinese currency. At present, $1 is approximately 8 RMB.)

The development of high-performance grid computing is very important to academic computer science in China, and there are three national grid projects, China National Grid (CNGrid), ChinaGrid (China Education and Research Grid), and CROWN, all providing applications portals to launch an application.

It is reasonable to say that the Chinese central government plays a much stronger role in setting science and technology research directions than in the U.S., as most research funding is provided by the central government.

Overall Impressions and Observations

We were impressed with what is happening at Chinese universities and research labs, and we hope our observations will help NSF-CISE and the U.S. research community understand what is happening in China and succeed with new collaborations. These observations, however, are based on discussions we had at a limited number of universities and laboratories.

Research at Chinese Universities: Much of CS research in China focuses on systems – the underlying hardware, software, and networking required to support computation and communications. We also saw a number of projects focusing on practical applications of information technology, such as urban traffic management. We saw much less evidence of research in more "fundamental" aspects of computer science, such as algorithms, formal methods, programming languages, architecture, or AI methods. The emphasis in the presentations we saw was on topics involving hardware, grids, and networking. That said, we were not able to observe any of the work in detail. Much of the faculty's research work is strongly mission-oriented, as universities play a key role in the development of technologies of strategic importance to China and, as noted above, in general economic development.

Faculty: Because of the rapid growth in number of Ph.D. students and low number of Ph.D. supervisors, many Ph.D. advisors are supervising more than a dozen Ph.D. students and many more M.S. students through a research group involving other faculty as well. There is no explicit tenure system, though termination of faculty seems rare. Many institutions seem to have a tradition of hiring their own Ph.D. graduates.

Performance Evaluation: Faculty and Universities: China puts great emphasis on ranking universities. Most universities we visited aspire to be in the top tier of international universities. Universities put a lot of weight on statistical measures derived from the Science Citation Index (SCI) and the Engineering Index (EI) in evaluating performance. The universities aspire to have their faculty succeed in publishing in leading international conferences and journals, and there was considerable discussion during our visit about how to increase the number of papers that Chinese faculty and students author in international journals. While emphasis on how to get papers published dominated discussion about research, a number of the faculty we talked to said they were interested in learning about research practices that would make them more internationally competitive.

Students and Academic Programs: We were unable to judge the quality of Ph.D. and M.S. dissertations. However, Chinese universities are paying significant attention to the question of how to enhance academic quality. There is an effort at some universities to modify curricula, inspired by U.S. curricula such as ACM Curriculum 2001.

Diversity: We heard conflicting information about the percentage of women faculty members and students at universities and women researchers at research labs. As in the U.S., the level of participation by women seems low. However, there does not seem to be a priority for achieving gender diversity. At several visits, our hosts said there is a national priority to increase the representation of ethnic minorities through faculty hiring and student acceptance.

Job Market for Chinese Graduates: We heard contradictory comments about the job market for Chinese students with bachelor's degrees. At some schools we heard that it was difficult for all their students to get jobs, and in particular for women with a bachelor's degree. However, the administrators and professors at one teaching-oriented university told us that a high percentage (as high as 95%) of their students with B.S. or M.S. degrees find jobs in local industries after graduation. The M.S. and Ph.D. graduates at the top schools we visited do not seem to have difficulties finding jobs. Although we did not hear it often, our hosts at several universities said they aspire to reaching the point where they can train their Ph.D. students to compete for positions at good foreign universities, including in the U.S.

Foreign Students and Chinese Students Abroad: The Chinese government is encouraging its universities to set up joint research and education programs with foreign universities. Also, U.S. and other foreign universities are setting up campuses in China. At least one university we visited is setting up a "park" for foreign universities. The universities are aspiring to have more foreign students and to provide international experiences for an increasing number of their own students.

Infrastructure: The physical facilities we saw were modern and impressive, including a brand new campus, new buildings everywhere, well-equipped laboratories, and modern student work areas.

Industrial Research Labs and University-Industrial Connections: A growing number of Chinese universities have established "science parks" nearby. The universities and companies located in the science parks often have close relationships and the companies may be owned in part by universities. Industrial laboratories in China have a variety of different arrangements for collaborating with universities, including lab members teaching courses at universities, jointly organized research labs, curriculum development, Ph.D. Fellowships, and support of junior faculty. In some case, the companies are contracting with the universities to do what could be considered advanced development rather than research, e.g., porting a software package to a different platform. Some of the industry-sponsored projects we heard about would not be considered desirable by U.S. research universities.

Obstacles to Future Collaborations: The need for strong English communication skills, both oral and written, among Chinese graduate students is paramount. Many of the graduate students we met spoke reasonably fluent English, many CS textbooks used in classes are in English and some courses are now taught in English. This suggests that communication will be less of a problem as time goes on. Chinese emphasis on publication in journals rather than in conferences – a result of the emphasis on SCI and EI indexing and differences between SCI/EI publication driven research and impact driven research more common in the U.S. – may pose obstacles to collaboration with U.S. researchers working in the major/core computer science fields where publication in highly competitive conferences leads to greater visibility and attention from the community. Many funded projects in Chinese universities are now closely related to the economic development of the country. These would not be defined as basic research projects in the U.S., and that may pose another obstacle to collaboration with U.S. academic researchers.

Recommendations to NSF

Infrastructure for Collaborations: NSF should hold a follow-up Leadership Summit in the U.S. in 2007 and a follow-up activity in China in 2008, set up a joint U.S./China steering committee to develop ideas for future collaborations, and encourage China to put together a delegation similar to ours that would visit U.S. universities.

Multiple Kinds of Collaborations: International experiences are important for U.S. students and faculty. Possible models include internships, summers abroad, semesters abroad, short-term visits, faculty sabbaticals, international REU programs, and joint U.S.-China projects – including capstone projects for undergraduates and research projects. We should consider short courses in China taught by U.S. faculty and develop specialized U.S.-China symposia to deal with issues in CS education. Writing tutorials by successful writers from U.S. faculty, offered in China or prepared for use in China, could help.

Supporting Collaborations: Many scientific exchanges between the U.S. and China are already taking place independent of NSF assistance. However, modest NSF support could help to jump-start many more such exchanges. Availability of such support should be widely publicized. Chinese faculty can often raise the funds to come to the U.S. for visits. Ways to take advantage of this should be explored.

Obstacles to Collaborations: There are a variety of obstacles to collaboration between the U.S. and China. Attention should be paid to ways to break down barriers such as cultural differences, language, the Chinese system of priorities, visa issues, and limitation on availability of travel funding. We need to find ways to overcome obstacles to success of

U.S. student visits to China, including language, longer Chinese semesters, limited course offerings in English, no tradition of summer courses in China, and inconsistent alignment of course content between U.S. and China.

Concluding Comments

The delegation was very impressed with the exciting things that are happening in Chinese universities and international research laboratories based in China, and with the fast pace of progress. There are increasingly many opportunities for interactions with Chinese colleagues and these are to be encouraged.

To facilitate future collaborations, U.S. researchers need more information. NSF should develop ways to gather this. In particular, based on a short visit, we were unable to understand the relative strengths of different research programs. Achieving this understanding will require a more in-depth analysis. Some follow-up, including more in-depth visits, is a good idea. Our trip was limited (with one exception) to top-ranked universities, so we are not able to make an analysis of the situation in and status of CS in the vast majority of Chinese universities. With so many new universities being created in China, future monitoring of the status of newer and up-and-coming universities is necessary. Moreover, with rapid changes in higher education's status, priorities, resources, and its relationships to government and private industry, the situation is fluid. Regular monitoring of the situation is called for and the results of such monitoring should be given widespread dissemination to the U.S. CS community.

Report to National Science Foundation

Section 1: Introduction and Purpose of Trip

After continuous and dramatic economic reform for more than 25 years, China is now playing a very critical role in the global economy with its huge consumers' market, with its high volume of cost-effective supplies ranging from labor-intensive goods to high-tech products, and with its vast human resources of top talents. Meanwhile, sponsored by both government agencies, such as NSF China, and private foundations, such as Hong Kong-based Cheung Kong Scholarship Foundation, China has rapidly developed its college and graduate education and research programs in thousands of existing and newly-established universities and research institutions. Responding to the huge technology and research advancements, almost all the major and leading U.S. computer software and hardware companies (as well as leading companies from other countries) have quickly established research labs in China, including Microsoft Research, Intel, Sun Microsystems, IBM Research, and many others. These research labs in China have been very successful and continue to expand. Information technology is a key driver of modern Chinese economic development. Indeed, technology is driving the country's economic boom and that has important implications for the United States and the rest of the world. Research in Computer Science and Information Technology is burgeoning in China and many important projects are underway.

Faculty and researchers in U.S. academic research institutions still seriously lack insightful understanding of the rapidly changing trends in Chinese universities and research laboratories, and of the strong implications for U.S. science, technology, and the economy from the dramatic economic, educational, and research developments in China. This project was intended to establish a dialogue between leaders of major U.S. computer science (CS) departments in the U.S. and their counterparts in China, identify key areas of information technology (IT) research in China, gain insight into current and future trends in IT research in China, and lay the groundwork for potential future interactions.

A delegation consisting of leaders of major U.S. computer science academic institutions (mostly deans and department chairs) visited China from May 20 to June 3, 2006. This report describes the visit and includes observations and general impressions as well as recommendations to NSF and a description of Next Steps that the delegation plans to pursue to follow up its visit.

Section 2: Members of the Delegation

The delegation members were:

Randal E. Bryant, Carnegie Mellon University, Professor of Computer Science, Dean of School of Computer Science

Jingsheng Jason Cong, University of California, Los Angeles, Professor of Computer Science, Chair of Department of Computer Science

Peter Freeman, National Science Foundation, Assistant Director for the Computer and Information Science and Engineering Directorate

Keith Ansel Marzullo, University of California, San Diego, Professor of Computer Science and Engineering, Chair of Department of Computer Science and Engineering

Martha E. Pollack, University of Michigan, Professor of Computer Science and Engineering, Associate Chair for Computer Science and Engineering (Department of Electrical Engineering and Computer Science)

Debra J. Richardson, University of California, Irvine, Professor of Informatics, Dean of Donald Bren School of Information and Computer Science

Fred S. Roberts, Rutgers University, Professor of Mathematics, Director of Center for Discrete Mathematics and Theoretical Computer Science

Marc Snir, University of Illinois, Urbana Champaign, Professor of Computer Science, Head of Department of Computer Science

Mary Louise Soffa, University of Virginia, Professor of Computer Science, Chair of Department of Computer Science

Gurindar Singh Sohi,, University of Wisconsin, Madison, Professor of Computer Science, Chair of Department of Computer Science

Valerie Elaine Taylor, Texas A&M University, Professor of Computer Science, Head of Department of Computer Science

Bryant W. York, Portland State University, Professor of Computer Science

Xiaodong Zhang, Ohio State University, Professor of Computer Science, Chair of Department of Computer Science and Engineering

Wei Zhao, Texas A&M University, Senior Associate Vice President for Research, on assignment to National Science Foundation as Director of Division of Computer and Network Systems

For biographies of the delegation members, see http://dimacs.rutgers.edu/Workshops/China/member.html.

Section 3: Itinerary

During its visit, the delegation visited several industrial research laboratories and universities. The delegation also held a one-day U.S.-China Computer Science Leadership Summit in Beijing with Chinese colleagues to discuss several issues of common interest and critical importance that deal with research and education in computer science and technology (see Section 8.1). The delegation also participated in the opening ceremony for the new NSF Beijing office.

The delegation visited five cities: Beijing, Nanjing, Xi'an, Shanghai, and Suzhou. In Beijing, we visited IBM China Research Lab, Microsoft Research Asia, and the Institute for Computing Technology (ICT — an institute of the Chinese Academy of Sciences). We participated in the Leadership Summit at Beihang University, which also coordinated our local arrangements in Beijing and hosted us for an introductory banquet. We also visited Peking University and Tsinghua University. The delegation then split up, with a subgroup going to Nanjing, another going to Xi'an, and a third group participating in the International Conference on Software Engineering in Shanghai. In Nanjing, we visited Southeast University and Nanjing University. In Xi'an, we went to Northwestern Polytechnical University and Xi'an Jiaotong University. The group reconvened in Shanghai where we visited Shanghai Jiaotong University and then took a side trip to Suzhou to visit Suzhou University. For some of the visits as well as for the Leadership Summit and Beijing NSF Office opening, we were also joined by Dr. Wei Zhao, Director of The Computer and Network Systems Division of NSF. Peter Freeman, Assistant Director of NSF for CISE, participated in the Leadership Summit and the NSF Beijing Office opening. A detailed description of the itinerary can be found at http://dimacs.rutgers.edu/Workshops/China/itinerary.html. That website also has photos of our trip.

At each of the universities and research laboratories, we met with administrators, faculty, researchers, and students. There were tours of facilities, presentations to the delegation, and in several cases technical talks by members of the delegation. There was also time set aside for question/answer sessions and discussion, which also continued at luncheon and dinner banquets organized by our host institutions. Detailed descriptions of each of our visits are in Section 7.

Section 4: Background on the Chinese Academic System in Computer Science and Research in Chinese Higher Education

4.1. The System of Higher Education

Chinese higher education is changing rapidly, so what we observed may not be the case even in the near future. Many new universities are being established, hundreds in the past decade alone. In the last 10 years, the number of colleges and universities with degree programs in computer science and technology has grown to over 700, with more than half of these less than 10 years old.

China has had a short history of graduate studies. However, the graduate programs have rapidly grown in many universities, including newly established ones. According to the Ministry of Education, China had over one million graduate students in universities and research institutions in 2005. China now has the second highest graduate student population in the world after the United States.

The People’s Republic of China (founded in 1949) did not officially establish academic degrees until 1981, when it began to offer bachelor’s, master’s, and doctoral degrees to students after their graduation. The first bachelor’s degrees were awarded to the college graduates in 1982. In the summer of 1978, for the first time in its history, China started its national entrance exams to recruit graduate students in several established universities. The first accepted graduate students entered graduate programs, including M.S. programs in CS, in the fall of 1978. In 1984, the Ministry of Education started to establish graduate schools among 22 universities in the country. Since the graduate programs started very late and since many older faculty members started research during the Cultural Revolution when research was seriously hampered, many senior faculty members in universities do not have Ph.D. degrees. Recently, the percentage of faculty members holding Ph.D.'s in Chinese universities has increased rapidly, due primarily to the increase in domestically-awarded Ph.D. degrees. The percentage at the universities we visited, which are top universities, varied from about 40% to about 70%, which is a dramatic increase from what it was not long ago.

Faculty positions, in general, have three types of ranks: lecturers, associate professors, and full professors. After graduate programs/schools were established, another faculty rank, called Ph.D. advisor, was created, which is a higher rank than full professor. The fast growth of Chinese universities has created a situation where only a small set of full professors are given this final rank and are thus eligible to supervise Ph.D. students (though at some institutions most of the full professors are Ph.D. advisors). Associate professors may not officially act as Ph.D. supervisors. The qualifications of Ph.D. advisors initially were only approved by the Ministry of Education in 1980s. Since the late 1990’s, the Ph.D. advisors can be approved by each university locally. However, the Establishment of Ph.D. degrees in a university can only be approved by the Ministry of Education. There is no tenure system in Chinese universities. However, by tradition, it is very unusual for a faculty member to lose their (his/her) job.

The Ministry of Education defines a discipline into the Discipline Major (“first class discipline”) and several core subjects (“second class disciplines”) associated with the Major. In other words, a full Discipline Major consists of multiple core subjects of the field. For example, the discipline major for computer science is called Computer Science and Technology, and it consists of three core subjects:
(1) computer systems and architecture,
(2) computer applications and
(3) software and theory.

There are only 15 universities and one research institute that have been authorized by the Ministry of Education to offer Ph.D. degrees in Computer Science and Technology (discipline major, thus being able to supervise Ph.D. in all the three subject areas). The Ministry of Education ranks them as follows:

National Defense University of Science and Technology
Tsinghua University

Peking University
Institute of Computing Technology (Chinese Academy of Sciences)
Harbin Institute of Technology
Beihang University
Zhejiang University
University of Science and Technology of China
Northeast University
Nanjing University
Shanghai Jiaotong University
Huazhong University of Science and Technology
Northwestern Polytechnical University
Xi'an Jiaotong University
Fudan University
Southeast University

Note that the ranking can be interpreted in various ways. The National Defense University of Science and Technology in Changsha, Hunan, has the ability to build large machines (supercomputers), and has a strong foundation in computer systems and architecture. Thus, its computer science and engineering program is ranked #1. However, this is a military school and its ranking does not necessarily reflect its selectivity in terms of students.

In addition, there are another 28 universities who have one or more second-class computer science Ph.D. disciplines. Furthermore, there are another 132 universities that only offer master’s degrees in computer science.

The Chinese Academy of Sciences (CAS) is the top national research organization. It sponsors several dozen research institutes covering various scientific research fields. These research institutes are located all over the country. One of those is the Institute of Computing Technology, located in Beijing. The headquarters of CAS is located in Beijing. Having been established in November 1949, immediately after the People's Republic of China was established, CAS has two missions: addressing the science and technology issues for the country's economic development, and making contributions for scientific advancement in the world. CAS also plays important roles in training graduate students at both M.S. and Ph.D. levels and in fact offers graduate degrees. Currently, there are more than 20,000 graduate students in various fields in CAS.

Entrance into Chinese universities is very competitive and only a small percentage of Chinese young people are admitted to universities. Admission to bachelor’s degree programs is based on a national entrance examination. This is given nationally over a three day period and is an “all or nothing” university entrance examination. There are complicated quota systems that give priorities at different universities depending on field of interest, minority status, or geographical home. In particular, there is higher priority to some regions than others, depending on the university. Thus, for example, a student from Beijing applying to Xi’an Jiaotong University might have a more or less difficult chance of getting admitted than a student from Nanjing, even if both students had equally good scores/records.

Admission into graduate programs is also very competitive, though as the number of graduate programs increases rapidly, the level of competitiveness is not as higher as before. Chinese students are not accepted into Ph.D. programs until after they finish a master's degree. However, sometimes there is a direct line from M.S. to Ph.D. There are also some direct B.S.-M.S. programs. Admission to graduate programs depends on examinations, records, interviews, and student fields of interest. Matching up students to advisors and programs sometimes gives more weight to university and national priorities than to student interest. Once the match between student and advisor is made in a Ph.D. program, it is rare for a student to leave the program prior to completion. However, graduate students are funded by the government for a fixed duration of time and it is expected that they will complete the degree within this time period.

At the Leadership Summit and at many of the universities we visited, our hosts and some speakers expressed concern about ensuring and increasing the quality of research carried out by faculty and students. For example, concern with quality of dissertations has led to new procedures at some universities involving anonymous review of M.S. and Ph.D. theses (except in cases where a student has had a paper accepted in an international journal).

4.2. Funding Higher Education

Based on the presentation by Prof. Xu Cheng from Peking University at the Leadership Summit on May 23, 2006, the funding sources of Chinese researchers in computer science related areas mainly include the following funding agencies and/or national research programs. For more details on this topic, see the Appendix, and in particular the discussion of the Leadership Summit presentations by Professors Xu Cheng and Zhiyong Liu.

- **National Natural Science Foundation of China (NSFC):** The NSFC mainly supports basic research and part of applied basic research in the natural sciences, with emphasis on "scientists in domestic universities and research institutions with good research conditions and strength." (Quotes in this and the following bullets come from Professor Xu Cheng's presentation at the Leadership Summit.)
- **Hi-Tech Research and Development Program (863 Program):** The National High Tech R&D Program (also referred to as 863 Program) was launched in March 1986 with the aim of enhancing China's international competitiveness and improving China's overall capacity of R&D in high tech areas.
- **National Basic Research Priorities Program (973 Program):** The National Basic Research Program (also called 973 Program) is China's on-going national keystone basic research program, which was approved by the Chinese government in June 1997 and is managed by the Ministry of Science and Technology. "The 973 Program is created on the basis of existing research activities and deployments made by the National Natural Science Foundation and major dedicated pre-studies, to organize and implement basic research to meet the nation's major strategic needs."

- **Key Technologies R&D Program:** "Formulated with the purposes of fully carrying out the functions of the central government to meet specific needs in the multiple aspects of capital construction, technical reform, upgrading of industries, development of agriculture, sustainable development of society, etc. in the country. It embodies the principle of orienting science and technology towards the main fields of economic development".
- **Torch Program:** "A guidance program for developing new/high tech industries in China, aims at developing a number of new/high tech enterprises with modernized enterprise systems and famous brand products; promoting the technical and managerial levels of a number of township enterprises that already have necessary conditions; and supporting a batch of private technology enterprises".
- **Spark Program:** "A program to promote the development of rural economy via science and technology. The purpose of the program is to introduce advanced, appropriate technologies into the rural areas and lead the farmers to rely on science and technology in the rural areas, promote rural productivity, and a sustainable, rapid and healthy development of agriculture and rural economy."

In most of the universities that we visited, we heard the faculty and administration acknowledge the support of the NSFC and the 863 Program. At one university (Peking University), there was also mention of the support of the 973 Program. We did not hear acknowledgements to the Key Technologies R&D Program, Torch Program, or Spark Program. In the following, we shall give some more details about the NSFC and the 863 Program based on the information available on the web.

National Natural Science Foundation of China (NSFC):

The National Natural Science Foundation of China (NSFC) was founded in February 1986 with the approval of the State Council. It is an institution for the management of the National Natural Science Fund, aimed at promoting and financing basic research and some applied research in China. At present, NSFC employs 184 staff members, of whom 172 are professionals, 127 (or 73.8% of the total) have senior professional titles (including 48 with full professorship or equivalent), and 39 (or 22.7%) have intermediate professional titles. The average age of its staff is 42. NSFC has enjoyed strong support from the Chinese government. Its annual budget has been dramatically increasing, going from 80 million RMB in 1986 to over 2 billion RMB in 2004. (RMB, or yuan, is the Chinese currency. At present, $1 is approximately 8 RMB.) According to its website, NSFC formulated the evaluation mechanism of "relying on experts and developing democracy to select best proposals for support in a fair and reasonable way". It encourages "fountainhead innovation" and the funding of excellent and creative researchers through fair competition on the basis of scientific and democratic principles. It has "created the categories of General Program, Key Program, Major Program, Major Research Plan, the National Science Fund for Distinguished Young Scholars, a number of other types of funds as well as a whole set of integrated management regulations." The following seven departments are shown under the general program:

Department of Mathematical and Physical Sciences

Department of Chemical Sciences

Department of Life Sciences

Department of Earth Sciences

Department of Engineering and Materials Sciences

Department of Information Sciences

Department of Management Sciences

NSFC also has an international program. As stated on its website, "NSFC strives to facilitate the participation of Chinese scientists in the international cooperation and exchange. Up to now, it has signed cooperative agreements and memoranda of understanding with 60 science funding organizations and national research institutions in 35 countries and regions and raised its budget for international cooperation and exchange from 3 million RMB in 1987 to 82 million RMB at present. NSFC has gradually formed a rather complete funding scenario which includes four project categories and three special funds: joint research projects, international (regional) academic conferences held abroad, international academic conferences held in China, major joint research projects, fund for Chinese scholars abroad returning for short-period of work or lecture (including "two bases" projects), joint fund between NSFC and the Research Grant Council of Hong Kong and fund for international cooperation and exchange of State key laboratories." In particular, the NSFC highlights a joint research program with Germany: "The Sino-German Center for Research Promotion is jointly established by NSFC and DFG. It was put into operation on October 19, 2000. NSFC and DFG invest 10 million RMB each annually to the Center to sponsor the cooperation and exchanges between scientists from the two countries."

Hi-Tech Research and Development Program (863 Program):

The 863 Program is administered by the Ministry of Science and Technology (MOST). According to its 2002 Annual Report (latest available on the website), the total funding under this program is 4.4 billion RMB. In 2002, the 863 Program was implemented in the form of Priority Project, Key Project and Guidance Project.

- Priority projects of the 863 Program in 2002 consist of 2 categories: frontier exploring research (Type A) and applied research (Type B). This led to more participation by industry in the 863 Program. In 2002, 30% of newly approved projects were undertaken mainly by enterprises (industry)..
- With regard to key projects, 26 key projects under the 863 Program were initiated and implemented on a full scale in 2002. Most of them were based on technology integration and targeted to the critical technology demand of economical and social development.

- To support local governments to develop high-tech industry, 43 guidance projects were initiated 2002. These types of projects were mainly funded and managed by local governments with technical support from the 863 Program.

In a recent year (2002), the percentage of funding fom the 863 program by expenditure were 20% for Information, 33% Biotechnology and Advanced Agriculture, 17% Advanced Materials, 10% Advanced Manufacturing and Automation, 14% Energy, and 6% Resources and Environment.

The funding and decision-making process of the 863 Program consists of the following steps:

- Feasibility study of strategy by the Expert Group (which consists of scientists and researchers in the topic area)
- Release of call for projects by the Expert Group
- Evaluation of applications by internal and external experts
- Result of the evaluation reported to the Expert Committee for consulting
- Large projects are submitted to open debate
- Approval by the MOST

This process is quite typical for most funding opportunities, including the selection of ***Key Labs*** or ***Key Institutes***, where an individual or an organization submits an application, which is reviewed by a group of experts (similar to our panel review process), and the funding agencies make the final decision based on the recommendations of the expert group.

4.3. Grid Projects in China

The development of high-performance grid computing is very important to academic computer science in China, both because of the infrastructure it provides and because of its status as a focus of computing research in its own right.

In China, there are three national grid projects, supported by different ministries. First, there is the China National Grid (CNGrid), which is supported by the National High-Tech R&D Program (the 863 Program) of the Ministry of Science and Technology of China. The second grid project is the ChinaGrid (China Education and Research Grid), which was the focus of a presentation we heard at Tsinghua University, and it is supported by the Ministry of Education of China. The third grid project is CROWN, which is supported by NSFC.

CNGrid

The CNGrid is a testbed that integrates high-performance computing with a new generation of information infrastructure. The major tasks undertaken with the China National Grid Project include the following: [1] the development of two high performance computers to equip grid sites; a 5.3 Teraflops one located at CNIC-CAS and a 10 Teraflops one located at SCCAS Shanghai; [2] the development of grid software to support grid applications and grid operation and management; [3] the development of several application grids on production systems for demonstrating the future of grid applications. The CNGrid includes the following application portals: meteorological, resources and environment, aviation manufacturing, scientific data, new drug discovery, biological Information, simulation application, education, urban traffic information service, national geological survey, and forest resources and forestry.

ChinaGrid

The China Grid project is based on CERNET (China Education and Research Network), with a network backbone of 2.5Gbps DWDM and a total outgoing bandwidth outside of China of 800 Mbps. This network covers more than 1300 universities or colleges in about 200 cities. CERNET2 is an IPV6, smaller experimental network. The ChinaGrid is supported by the CGSP (ChinaGrid Support Platform), which is the grid middleware for this grid project. Up to now, the computing power gathered by ChinaGrid has exceeded 15Tflops. And its storage capability also achieves 150TB. ChinaGrid member universities have expanded from the initial 12 in 2003 to 20 in 2005. The application portals for the ChinaGrid are in the following areas: image processing, bioinformatics, on-line courses, computational fluid dynamics, and large-scale information processing.

CROWN

CROWN (China Research and development environment Over Wide-area Network) is a grid testbed that facilitates scientific research in different disciplines. The CROWN environment consists of three parts: [1] resources, including computers, clusters, and storage devices, interconnected via a nation-wide network infrastructure, [2] grid middleware and auxiliary tools to meet the common requirements of different scientific activities in many different areas, and [3] a number of applications to demonstrate the feasibility and robustness of CROWN. The current list of applications portals covers the areas of biology, space telescope science, atmospheric, and a grid of digital museums.

Observations

In all three projects, applications portals are provided to launch an application. It is not the case that a user can develop a new grid application and launch this new application on the grid resources. While having application portals insures that adequate resources are available for the given application, new grid application development may be hindered by the lack of an open testbed for application development.

For more information:

China National Grid
http://www.cngrid.org/

ChinaGrid
http://www.chinagrid.edu.cn/

CROWN
http://www.crown.org.cn/en/

4.4. Closing Comment

It is reasonable to say in closing this section that the Chinese central government plays a much stronger role in setting science and technology research directions than in the U.S. as most research funding is provided by the central government. Chinese academic research is much more "top-down" than the U.S.

Section 5: Overall Impressions and Observations

We were impressed with what is happening at Chinese universities and research labs and we hope that our observations will help NSF-CISE and the U.S. research community understand what is happening in China and succeed with new collaborations. These observations, however, are based on discussions we had at a limited number of universities and laboratories.

5.1. Research at Chinese Universities

1. Much of CS research in China focuses on systems - the underlying hardware, software, and networking required to support computation and communications. We also saw a number of projects focusing on practical applications of information technology, such as urban traffic management. We saw much less evidence of research in more "fundamental" aspects of computer science, such as algorithms, complexity, or formal methods. We also saw little in the way of work on programming languages or architecture, and, with the exception of work on NLP and image processing, little on AI. The emphasis in the presentations we saw was on topics involving hardware, grids, and networking. However, we were not able to observe any of the work in detail.
2. Chinese universities have a stronger emphasis on economic development than U.S. universities. This has pros and cons. Students and faculty have less time for research but students gain practical experience. In particular, we observed many university projects that in the U.S. would be done by industry. The economic development projects, how ever, lead to large-scale testbeds that are excellent for collaborations. Such testbeds include, for example, the wireless sensor transportation test bed at Shanghai Jiaotong University.
3. Much of the faculty's research work is strongly mission-oriented, as universities play a key role in the development of technologies of strategic importance to China and, as noted above, in general economic development. Much of the income of faculty and much of their research funding seem to be tied to such mission-oriented work. It does make it hard to concentrate on basic research.
4. Involvement of universities in national, regional, and local government projects means that some data and information about such projects is more

readily available to researchers than it is in the U.S. This involvement also provides useful insights and experience with industrial-scale development of hardware and software.

5. We were impressed with several projects that were vertically integrated, going all the way from algorithms to chip design. This provides a useful experience for students. Integration of university and corporation research, including company spinoffs from universities, is another aspect of vertical integration.
6. There seems to be little research collaboration among Chinese universities. Grants do not seem to emphasize collaboration except in large infrastructure projects. Grants seem aimed more at funding universities than at funding researchers. Sometimes universities are targeted for grants in particular areas.
7. There appears to be an increasing emphasis on patents in some universities.

5.2. Faculty

1. Only full professors can supervise Ph.D. theses, and even full professors may not be able to do so unless their publication records are adequate. As described in Section 4, the title of Ph.D. Supervisor is beyond full professor. We heard that some universities are finding ways to involve more junior faculty in Ph.D. supervision activities.
2. Because of the rapid growth in number of Ph.D. students and low number of Ph.D. supervisors, many Ph.D. advisors are supervising more than a dozen Ph.D. students and many more M.S. students through a hierarchical system, where each Ph.D. advisor leads a research group and typically has several associate professors and/or lecturers working in the group and assisting him/her for student supervision. (Funding seems to be managed by the senior faculty.)
3. Although there is no explicit tenure system (see Section 4), we heard from some sources that it was difficult to terminate faculty because of poor performance. However, we heard different points of view about this.
4. Many institutions seem to have a tradition of hiring their own Ph.D. graduates.

5.3. How the Chinese Evaluate Performance of Faculty and of Universities

1. China puts great emphasis on ranking universities. Collaborations with top-ranked Chinese universities are likely to be more encouraged by the Chinese government.
2. Most universities we visited aspire to be in the top tier of international universities. Of course, we visited mostly top universities in China.
3. Universities put a lot of weight on statistical measures derived from the Science Citation Index (SCI) and the Engineering Index (EI) in evaluating performance, and in some cases even have fairly complex formulas that specify the number of journal papers, based on where they are indexed, that faculty are expected to produce. The universities aspire to have their faculty succeed in publishing in leading international conferences and journals. The emphasis of SCI and EI indexing, however, may lead to an overemphasis on

journals (versus conferences) when compared to practices amongst U.S. computer scientists.

4. There was considerable discussion about how students and faculty in China can get papers into top international conferences and journals. The Chinese are eager to learn how to do this. We heard that editorial staffs of ACM and IEEE journals have been invited to some Chinese Universities to assist the Chinese in learning about this. There was, however, little discussion of how to step up research programs to generate results worthy of publication.
5. While emphasis on how to get papers published dominated discussion about research, a number of the faculty we talked to said they were interested in learning about research practices that would make them more internationally competitive. Besides paper acceptance, they were interested in problem selection, research supervision, mentoring, etc. When many faculty become well-versed in the practices of leading and running internationally-competitive research groups, the significant pool of talented graduate students could have a multiplicative effect on their efforts.

5.4. Students and Their Evaluation

1. Computer use by students is widespread, not just in Computer Science disciplines. At one university we visited, we were told that 2/3 of the students had their own computers. We were also told that a significant percentage of Chinese homes had computers, although presumably this applies primarily to those living in urban areas.
2. Admission to universities for bachelor's degree study is highly competitive, based on a national examination. A complex system of quotas dictates how many students will be admitted into top institutes from various provinces and from various nationalities. While we were in China, plans to administer the national test were underway. We heard about new high-tech methods to detect IT-based cheating and plans to stop construction projects at early hours so students could study. Competition for spots in the top tier universities is especially intense. This system sometimes results in students studying a discipline not of their own choice.
3. A number of Chinese parents are starting to be able to afford to send their children abroad to study if they cannot get into the top tier Chinese universities. Some universities also have exchange programs where students study a year or more abroad, paying tuition to their hosting institute.
4. Graduate program admissions are also based on exams, and a complex system of quotas, for undergraduates from the same institute, and from other institutes. Admissions into different areas are affected by national priorities.
5. The matching of student to Ph.D. advisor is part of the Admissions process. Changes after admission are rare. In some cases, we heard that students were assigned to research areas according to needs or shortages, not their own priorities.
6. Traditionally, Chinese students who enter a Ph.D. program complete it. Asking a student to leave a program is very rare.

7. We were unable to judge the quality of Ph.D. and M.S. dissertations. However, this is of concern to the Chinese. In the last few years, because of increasing concern with quality control, new procedures requiring anonymous review of Ph.D. and M.S. theses have been instituted at some universities (except for those students with a record of acceptance in international publications).
8. From students we heard that many live in dormitories with as many as 8 or more to a room and the dormitories have strict regulations. For example, one cannot work in a lab after a certain time at night.

5.5. Academic Programs

1. We observed a wide variety of undergraduate majors and graduate degree programs, many typical of U.S. universities and some peculiarly Chinese.
2. There is an effort at some universities to modify curricula, inspired by U.S. curricula such as ACM Curriculum 2001. Time will tell what works in China and what doesn't.

5.6. Diversity

1. We heard conflicting information about the percentage of women faculty members and students at universities and women researchers at research labs. As in the U.S., the level of participation by women seems low. However, there does not seem to be a priority for achieving gender diversity.
2. At several visits our hosts said that there is a national priority to increase the representation of ethnic minorities through faculty hiring and student acceptances.

5.7. The Job Market for University Graduates

1. We heard contradictory comments about the job market for Chinese students with bachelor's degrees. At some schools we heard that it was difficult for all their students to get jobs, and in particular for women with a bachelor's degree, and we heard that one reason so many students from top universities go on to graduate school is because of job placement uncertainty. However, the administrators and professors at one teaching-oriented university told us that a high percentage (as high as 95%) of their students with BS or M.S. degrees find jobs in local industries after graduation. The M.S. and Ph.D. graduates at the top schools we visited do not seem to have difficulties finding jobs, and their placements include work in foreign companies in China such as Microsoft and IBM as well as in national research institutes and universities.
2. Although we did not hear it often, our hosts at several universities said that they aspire to reaching the point where they can train their Ph.D. students to compete for positions at good foreign universities, including in the U.S.

5.8. Foreign Students/Chinese Students Abroad/Collaborations

1. The Chinese government is encouraging Chinese universities to set up joint research and education programs with foreign universities. There are various models for this already in place at universities we visited. One model has a joint program with a foreign university in which students study two years in China, then one year in the U.S., and then one year in China. Another model has one year in China, two in U.S., and then one in China. There are many others.
2. U.S. and other foreign universities are setting up campuses in China. At least one university we visited is setting up a "park" for foreign universities.
3. The universities are aspiring to have more foreign students and an increasing number of their own students to have international experiences.
4. Chinese students are going to study abroad in increasing numbers and at an increasing number of countries. We heard in particular about countries in Europe and about Australia, New Zealand, South Africa and other parts of Asia. While there is still a great deal of interest on the part of Chinese students in studying in the U.S., opportunities in other countries and difficulty getting a visa were mentioned as reasons students in China are looking elsewhere.
5. In a short visit, we could not do an extensive evaluation of the opportunities that seem most promising for future collaboration between U.S. and Chinese researchers. Promising opportunities may be provided by the distinguishing features of CS research in China: The involvement of academic departments in national infrastructure projects may provide opportunities in wide area networks and grid computing; their involvement in large projects could provide opportunities in software engineering and in projects requiring large implementation efforts.

5.9. Infrastructure

1. The physical facilities we saw were modern and impressive, including a brand new campus, new buildings everywhere, well-equipped laboratories, and modern student work areas.
2. We were impressed by the fact that China has three large-scale grid efforts (see Section 4.3). It is unclear, however, if there are collaborations or joint efforts among the three projects.

5.10. The Role of Industrial Research Labs and other University-Industrial Connections

1. A growing number of Chinese universities have established "science parks" nearby. The universities and companies located in the science parks often have close relationships. The may be owned in part by the universities; full time faculty seem to spend significant time with the companies; and research of faculty and students may be closely aligned with the development at the company, and include activities that would be normally considered to be part of industrial development in the U.S.. This has advantages and disadvantages

for the educational enterprise. Some of the companies in these parks are doing R&D while others are basically factories.

2. Industrial laboratories in China have a variety of different arrangements for collaborating with universities, including lab members teaching courses at universities, jointly organized research labs, curriculum development, Ph.D. Fellowships, and support of junior faculty. Some of these are carried out in coordination with the Chinese government, e.g., with the Ministry of Education. Industrial Research labs seem to be more actively involved in promoting academic research and education in China than in the U.S. In some case, the companies are contracting with the universities to do what could be considered advanced development rather than research, e.g., porting a software package to a different platform. Some of the industry-sponsored projects we heard about would not be considered desirable by U.S. research universities.
3. Industrial labs also host students and there are sometimes joint university/laboratory supervisors for the students' work.
4. Some Chinese industrial labs offer post-Ph.D. certificates. We heard at least one person suggest that there is need for more post-Ph.D. certificate programs in China.
5. The industrial research labs are looking to collaborate with U.S. universities,
6. The Chinese industrial research labs have differing arrangements with respect to intellectual property in their shared projects with universities and arrangements with faculty and student collaborators/interns.

5.11. Obstacles to Future Collaborations

1. The need for strong English communication skills, both oral and written, among Chinese graduate students is paramount. Many of the graduate students we met spoke reasonably fluent English, more so than the faculty. Also, English is increasingly present in China, especially on computers, but also on billboards, signs, etc. We were told that many CS textbooks used in classes are in English and that some courses are now taught in English. This suggests that communication will be less and less of a problem as time goes on.
2. Chinese emphasis on publication in journals rather than in conferences seems to result from the emphasis on SCI and EI indexing. The top computer science departments in the U.S. judge the quality of publications mostly on their impact. The differences between SCI/EI publication driven research and impact driven research may pose obstacles to collaboration with U.S. researchers working in the major/core computer science fields where publication in highly competitive conferences leads to greater visibility and attention from the community.
3. Many funded projects in Chinese universities are now closely related to the economic development of the country. These would not be defined as basic research projects in the U.S. In contrast, a large percentage of funded projects in computer science and engineering in U.S. universities are sponsored by the National Science Foundation for basic research. The

differences in terms of objectives, the way of thinking, and the way of management between the domains of mission-oriented and basic research projects may pose another obstacle to collaboration with U.S. academic researchers.

Section 6: Recommendations to NSF

6.1. Infrastructure for Collaborations

1. Hold a follow-up Leadership Summit in the U.S. in 2007 and a follow-up activity in China in 2008. Set up a program committee to carefully develop a program and possibly include some breakout sessions and also technical talks. (Debra Richardson and Bryant York have both offered to host the 2007 Summit.)
2. Set up a joint U.S./China steering committee to develop ideas for future collaborations.
3. NSF should encourage China to put together a delegation similar to ours that would visit U.S. universities, possibly in connection with the 2007 follow-up Summit.

6.2. Multiple Kinds of Collaborations

1. International experiences are important for U.S. students and faculty. There are many possible models for such experiences. Some are: internships, summers abroad, semesters abroad, short-term visits, faculty sabbaticals, international REU programs including some that bring Chinese students to the U.S., and joint U.S.-China projects – including capstone projects for undergraduates and research projects.
2. We should consider short courses in China over the summer, taught by U.S. faculty in English. (The Dragon Star Program (see Appendix discussion of lecture by Professor Yinghua Min) already does this, but only by senior U.S. faculty who can present lectures in Chinese.)
3. Develop specialized U.S.-China symposia to deal with issues of mutual interest in CS education.
4. Chinese students (and faculty) can use help with technical components of writing good papers. During our visit, we were often asked questions about how to achieve good technical writing. Successful .U.S. faculty should consider preparing or presenting tutorials about good technical writing.

6.3. Supporting Collaborations

1. Many scientific exchanges between the U.S. and China are already taking place independent of NSF assistance. However, modest NSF support could help to jump-start many more such exchanges and these are to be encouraged.
2. Ways in which NSF makes available support for assistance with international experiences and international collaborations should be widely publicized.

3. Chinese faculty can often raise the funds to come to the U.S. for visits. Ways to take advantage of this should be explored. U.S. faculty should be encouraged to take advantage of this opportunity. The availability of NSF support to assist with this should be widely publicized.
4. More generally, general information on CS research and education in China, as well as opportunities for collaboration and available support for collaboration, need to be more widely disseminated.

6.4. Obstacles to Collaborations

1. There are a variety of obstacles to collaboration between the U.S. and China. Attention should be paid to ways to break down barriers such as cultural differences (e.g., Chinese students and junior faculty being reluctant to question and challenge senior faculty), communication because of language, the Chinese system of priorities, difficulty for Chinese students and faculty to get a visa to U.S. after 9.11 (the situation has improved recently), and limitation on availability of travel funding (though travel money is more readily available for the Chinese than we had realized).
2. We need to find ways to overcome obstacles to success of U.S. student visits to China, including language, 18 week semesters vs. 14-15 in U.S., not many courses taught in English, no tradition of summer courses in China, and inconsistent alignment of course content between U.S. and China (with implications for transfer credit and prerequisite courses).

Section 7: Discussion of Individual Visits

7.1. IBM China Research Lab (Beijing)

See http://www.research.ibm.com/beijing/

The IBM China Research Lab (CRL) is located on a new campus, which is only about a year old. It is directed by Dr. Thomas Li, who received a B.S. in EE from the National Taiwan University, an M.S. in CS and OR from Penn State University, and Ph.D. in MIS from UT Austin; he has been back in China for 4 years. CRL is one of 8 labs in the Research Division of IBM (Yorktown, Almaden, Austin, Zurich, Haifa, Tokyo, China, and India). It was established in 1995 and its initial focus was on Chinese natural language. The first product derived from this research was the Chinese version of ViaVoice. Since then its focus has broadened considerably.

CRL has about 400 staff: 200 M.S. and PhD level researchers (about 100 of each) and 200 students. Most of their students come from Tsinghua and Peking Universities. Only 3 CRL staff members have PhDs from the USA, but CRL management expressed a desire to acquire more staff from outside China. They believe that there is a lot of competition for research staff in Beijing, with over 700 R&D sites within the city.

Dr. Li stated that every 1% increase in China GDP from IT creates about 1 million jobs, many more than the number generated by a similar growth in manufacturing. The annual GDP increase for China for the past three years has been 9.9%. In 2006 they project a 14 million job gap, i.e. 14 million unfilled jobs. This most likely results from China's fast transformation from an agrarian economy to an urbanized manufacturing economy. A stronger growth in IT and services may reduce unemployment further. China is now developing its 11th five-year plan.

IBM CRL's goal is to build a viable ecosystem in the Service industry. This includes 5 key research areas:

1. Information Management (including search, semantic technology, speech, etc.)
2. Distributed Computing (including autonomic/grid computing, HPC, etc.)
3. Networking Technology (including telecom, BSS/OSS, carrier grade, etc.)
4. Future Systems (including multi-core, digital media, storage systems, and "China unique workload")
5. Next Generation Services (including open collaborative ecosystems for service business and service offerings)

IBM believes that a focus on services will lead to a complete redesign of computer science. CRL has a focus on supply chain and logistics management because of the massive amount of manufacturing going on in China—more than anywhere else in the world. Its logistics costs are 3 times higher than those in the U.S. and 2 times higher than those in Japan. IBM expects much of their business in China to be with small to medium sized businesses which comprise about 98% of all Chinese businesses.

CRL has an active University Relations Program, presented by Maggie Zhang. It has a number of components:

- Joint Research: Joint research labs and joint study have been established at 5 schools (Tsinghua, Peking, Shanghai Jiaotong, Xi'an Jiaotong, and Harbin). For example, at Tsinghua, the joint research focuses on service sciences, and involves 6 professors, 20 students, and about 6-10 IBMers. Note that IBM has a memorandum of understanding with the China Ministry of Education (MOE) to develop a talent pipeline through these joint research projects, as well as through curricular development, described below.

- Visit Exchanges: These include visiting scholars (young professors who do research with senior CRL researchers for a period of 3-6 months), guest professors/adjunct professors/Ph.D. advisors who come from CRL; and faculty awards.

- Curriculum Collaboration: This includes the development of course offerings, particularly on SSME (services science management and engineering). IBM is jointly developing an SSME curriculum with Tsinghua. At Peking University they are working on "On Demand Transformation Technology." CRL also works on faculty training and on jointly developing courseware with faculty.

- Talent Incubation: This includes the worldwide internship program, "Extreme Blue". CRL has a local program called "Deep Research", which is small now (10 people) but growing and open to all students. "Deep Research" is part of Stu Feldman's Exploratory Research Program for long term, pure research. CRL has had 2 proposals accepted in Stu's program, which started in 2006. CRL's goal is to grow from 2 to 10 projects and eventually account for 1/3 of CRL internship activity. They hope to make this a multinational effort. The two current projects are in "Knowledge Management" and "Performance Assistance". CRL also has a PhD Fellowship program and the Young Teachers Funding program which supports young faculty at local universities.

- "Open Innovation" is a concept piloted by IBM in its collaborations with Chinese universities. Under this program, IBM can jointly own IP with a university and each can maintain its own IP as well within the context of a joint project. IBM believes that this approach is very promising.

Descriptions of several IBM CRL University Relations projects were provided:

- SSME (Services Science Management and Engineering). Joint with Tsinghua University; described above.
- Semantic Web. Joint with Shanghai Jiaotong. The staff are 1 PI from IBM and 1 from SJTU, 1 technical coordinator from IBM and 1 from SJTU. Note that SJTU has the ACM Programming Competition winning team, and 2 students from this team are now IBM interns.
- Distributed Computing and Systems Technology. Joint with Peking Univ. This includes multi-document summarization, data mining in data warehouses, and performance modeling and optimization.
- Aging Mechanisms and Rejuvenation Methods. Joint with Xi'an Jiaotong.

The process for establishing funding for such projects involves several steps: First, IBM calls for a proposal, but each university has a fixed set of areas for which proposals are solicited. Then the university writes the proposals. IBM then makes a selection but also makes suggestions to refine the selected proposals. After selection, project reviews are done quarterly or every half-year.

We were told that 30% of the technical staff at IBM/CRL are female, although the representation within the researchers present did not reflect this.

7.2. Microsoft Research Asia (Beijing)

See http://research.microsoft.com/aboutmsr/labs/asia/

Microsoft Research Asia (MSRA) was established in 1998, and is one of 6 MSR labs worldwide, with the others in Redmond (established 1991), San Francisco (1995), Cambridge(1997), Silicon Valley (2000), and India (Bangalore, 2005). Altogether about 700 people work for MSR, with 200 in MSRA. MSR is headed by Senior VP Rick Rashid, who reports directly to Bill Gates.

Of the 200 employees at MSRA, about 50 are researchers from overseas and about 150 are locally trained. They are mainly Ph.D. level, but also many M.S. level researchers; we were told that there's a shortage of senior talent within the lab. Over the years, in excess of 2000 students have worked at MSRA. In steady state they have about 300 students, mostly from China, with about 10-20 from overseas at any time.

MSRA is involved in five major activities: Research, Tech Transfer, University/Public Relations, Incubation, and Tech Licensing. Their research is focused in five areas:

- User Interfaces
- Digital Media
- Networking and Systems
- Digital Entertainment
- Information Search and Mining

Within these areas they have a number of research groups, including speech, NL, internet media, media communication, wireless and networking, graphics, visual communication, web search and mining, etc. They have interests in other areas, but haven't found leaders for those areas yet.

MSRA has had over 1000 papers published in major conference and journals. In 2005 MSRA had 9 SIGGRAPH papers, 11 SIGIR papers, 17 CVPR papers and 200+ tech transfers. Their goal is to publish 5% of all papers in the top 5% of conferences. MSRA has editors who can help refine the English in papers.

MSRA's university relations (UR) effort is coordinated with the Chinese Ministry of Education (MOE). There is a project called "The Great Wall Plan," in which they are working with over 20 universities in China. As part of this project, they participate in research collaborations, do faculty training, help develop curriculum, sponsor M.S. tech clubs, etc.

They want to attract more foreign talent and note that Chinese visas are easy to get, so people can come work at MSRA. Salaries for people who come from the U.S. are comparable to American salaries, as the company "does what it has to" to attract talent, regardless of the cost.

MSRA has a joint funding program with the China National Science Foundation (NSFC). Apparently most Chinese universities are not currently hurting for money, because the Chinese government is aggressively putting money into universities. MSRA noted that Chinese faculty are thus primarily interested in collaboration and training good students; they don't need to scramble for funds.

MSRA has many Japanese and Korean students in their UR effort but fewer Indian students. This may be due to the presence of MSR-India. MSRA finds the Chinese students to be well-prepared in math and computing skills, but lacking in communication skills. When students work at MSRA as interns, MSRA retains the IP rights to their work.

The major criterion for evaluation at MSRA is impact. Impact is measured in terms of research results and tech transfer.

MSRA is a "postdoctoral station" – i.e. a postdoctoral granting institution. In addition, there are several joint Ph.D. programs with universities. One is with Shanghai Jiaotong. Students spend 3 years at SJTU doing all their coursework; then they come to MSRA to do the research for the Ph.D. A similar program exists with Hong Kong Science and Technology University. The students are officially evaluated by the university, but de facto they have joint evaluations since many of the MSRA researchers have guest appointments. In addition, many MSRA researchers are guest professors at Beijing Universities. Rick Rashid's view is that MSR as a whole is a giant CS department.

We were told that where MSRA is doing fundamental research, other labs in Beijing are more focused on advanced development. There is enormous competition for bright young people in Beijing.

The main challenges for MSRA are:

- Retention of talent
- The rapid changes going on in China, which produce a need for new ways to collaborate with professors.
- The need to move towards working on more fundamental issues and on topics with bigger impact.
- A shortage of senior talent

We were told that about 10% of the researchers at MSRA are female and that there are no special programs to help female students.

7.3. The Institute of Computing Technology (Beijing)

See http://www.ict.ac.cn/en/index.htm

The Institute of Computing Technology (ICT) is one of several dozen research institutes under the administration of the Chinese Academy of Sciences (CAS). ICT was founded in 1956, the first academic institute specializing in research in computer science and technology in China. It has played an important role to independently build computer hardware and software in China for the past 50 years. It is one of a small number of research sites emphasizing computer systems and architecture. Over the years it has developed many of the key computing technologies in China, including the first high-performance general-purpose CPU chip. In the process it has spun off 5 institutes and more than 30 companies (including Lenovo (earlier Legend), Dawning, Hope, and Huajian). ICT is the main information technology center for the CAS and its focus is mission-oriented research.

ICT has been offering Ph.D. and M.S. degrees in Computer Science and Technology since 1981. Graduate student applicants to ICT follow the same procedure defined by the

Ministry of Education: to pass both national exams in foundations, such as Mathematics and English and the computer science exams offered by ICT. Graduate students take classes in graduate schools of the Academy of Science in different locations from ICT. ICT faculty supervise graduate students' M.S. and Ph.D. dissertations, but are involved in very limited teaching. In 2006 they had 904 students enrolled of which more than 460 are Ph.D. students, and over 900 research assistants.

Currently it has over 300 non-administrative staff, including 50+ professors (associate and full) and 30+ adjunct professors. Five of the current faculty are members of the Chinese Academy of Sciences/Engineering (CAS/CAE); a total of 19 current and former faculty are members of CAS/CAE.

About 70% of ICT's projects are strategic research projects (large) and 30% are small. ICT's mission includes: (1) Tech Transfer, (2) Public Education, (3) Consulting to Government and Industry, and (5) Academic Services. ICT hosts 4 academic journals, one of them published in English by Springer.

ICT has joint R&D projects with more than 20 universities. Its human resources have grown by about 15% per year for the past three years. This has resulted in the infusion of a lot of new blood, and currently 68% of its staff are less than 35 years of age.

ICT's budget has seen a dramatic increase in the past 5 years, from about 56,160,000 RMB in 1999 to about 240,000,000 RMB (about $30M USD) in 2004. They published 600 papers in 2005 (up from 222 in 2000) and produce about 120 patent applications per year. The 2005 Hudson Institute Report highlighted several major achievements in China, including the facts that: (1) ICT created the Dawning-A 4000 processor used in the Shanghai Supercomputer Center, and (2) ICT designed and implemented the "Godson" CPU chip. Other significant accomplishments include: (a) audio-video encoding standard (AVS), (b) the Open Research Compiler (ORC) which is widely used in the U.S. for the Intel IA-64 architecture, (c) IPV6 next-generation Internet, (d) the Knowledge GRID and VEGA Grid.

ICT is a "networked institute" with remote campuses around China. ICT sees its main challenges between now and 2020 as: (1) recruiting and retaining good people, (2) getting insights into good research topics, (3) execution, (4) cooperation, and (5) funding for sustainable development.

During our visit we got individual project descriptions from project leaders, on the following projects: (a) High Performance Computing, (b) The Godson Processor, (c) Virtualized Storage and On demand Services, (d) AVS - An Audio/Video Coding Standard Towards Low Cost, (e) Knowledge Grid in China, and (f) International Cooperation and Graduate Education at ICT. A brief summary of these presentations follows.

(a) High Performance Computing – Ninghui Sun

This group would like to build a petaflops system by 2010. They expect it to utilize multi-core chips with 32-128 cores per CPU.

(b) Introduction to the Godson Processor – Weiwu Hu

Professor Weiwu Hu gave a fairly detailed introduction to the Godson processor. He briefly described the historical development of the processor family, from the 32-bit Godson-1 released in 2002 to the 64-bit Godson-2 released in 2005. The Godson-1 was developed with funding from the Knowledge Innovation Program of the Chinese Academy of Sciences. It was designed by Professor Hu's team at ICT, was fabricated in .18 micron CMOS technology by Semiconductor Manufacturing International Corp, is clocked at 266 MHz, and has a MIPS-like instruction set with a 32-bit integer core and 64-bit FPU. The Godson-2 64-bit processor implements a MIPS-like instruction set in .18 micron CMOS and can run at 400MHZ – 500 MHZ. The chip has an onboard L1 64KB instruction cache and 8KB data cache (both 4-way associative), with an external interface for an 8MB unified L2 cache. Godson-2 was designed to be used in embedded systems, like set top boxes, as opposed to within PCs.

Next steps include porting the design to a 0.13-micron process as well as beginning work on the Godson-3, which may sprout multiple processor cores and hardware-assisted simultaneous multithreading.

Professor Hu led a large team of graduate students who worked on the design and verification of the chip. For many of these students their work on this project constituted their Ph.D. research. Dr. Hu was particularly proud of the kind of teamwork that his project exemplified and was concerned that a project of this nature and magnitude could not be accomplished in a US university. The manufacture of the chip is handled by a contract chip maker, Shanghai's Semiconductor Manufacturing International Corp. (SMIC).

(c) Virtualized Storage & On Demand Services – Lu Xu

In this project the goal is to build "an information supermarket" by developing new virtualization technology. For this group this means three markets – a data supermarket, a storage supermarket, and a computing supermarket. Key to their approach is the separation of data, computing, and storage. They want to be able to do both static and dynamic binding of data and storage and computing and storage. In support of this effort the group has developed the Blue Whale File System (BWFS), the Virtual Storage and Data System (VSDS), and the notion of Service on Demand. Service on demand allows the construction of computing resources on the fly. This project has 40 professional staff and 30 graduate students. Their goal is to complete the storage-oriented component by 2008, the data-oriented component by 2010, and the service-oriented component by 2012. This research project is being done in the National research Center for High Performance Computing. http://www.nrchpc.ac.cn

It was noted that 10% of the budget comes from dividends from the largest spinoff companies. A company can be spun off and the researcher can get up to 40% of the IP. The NRCHPC has joint projects with Intel, HP, and EMC. These are all "pure research" projects and there are no IP issues. Some projects are done in collaboration with NPOs (non-profit organizations) in coordination with the local government.

(d) AVS – Towards a low cost audio visual coding standard – Xilin Chen

The goal of this project is to develop a low-cost Audio-Visual standard for encoding DVDs. This project has a very practical motivation. In the USA only 3-5 % of the sale price of a DVD is due to the cost of IP. In Japan this number is about 10% and in China about 40%. The goal is to develop a coding standard owned by the Chinese government that would reduce the overall IP cost to about 1 RMB per DVD.

(e) The Knowledge GRID in China – Hai Zhuge

The goal of this project is to develop the technology to support a broad-based knowledge grid. This group has had four significant papers on this topic in the past few years. They have had two papers – one on the discovery of knowledge flow in science and one on the networking and scientific resources needed to support a knowledge grid for science. They have also published on how to evolve an interconnection environment for a knowledge grid and related issues in peer-to-peer networking in a knowledge grid. More recently they have been working on a large application – The Caves of Dunhuang. Dunhuang has over 900 caves containing cave wall paintings recording over 1500 years of history. The project involves the development of the Dunhuang Culture Grid as an online museum in which the paintings and other artifacts are captured for remote exploration by people all over China.

(f) Two Cases of IT Use in Environmental Education – Li Hao

This project was an application described by a person from the Beijing Earthview Environmental Education and Research Center (a non-profit organization). The technology being developed at ICT was used in conjunction with social activism to stop government projects with adverse environmental implications. The most compelling project was the stoppage of the construction of the man-made lakes at Yuanming Park.

Here the government had approved the lining of the excavated areas with materials that would damage the environment. The people from Beijing Earthview were able to discover this problem, videotape the area, and quickly build an online demonstration of the environmental impact. This resulted in a public outcry and the government's rescinding the project.

(g) GRID and Distributed Systems

Although there was no presentation concerning GRID development for EScience, the researchers responded to an inquiry from Professor York. In the response they claimed to have 110 people working on Cyberinfrastructure, E-Science, and GRID development. They claimed a close connection with GLOBUS and OGSA. They will send an ICT person to Chicago during the summer of 2006 to work with the GLOBUS team. They profess to follow the OGSA standard and claim that ICT has software deployed on the China National Grid. The plan is develop and deploy more application grids in China and that the research investment in this area will increase dramatically over the next 5 years.

7.4. Beihang University (Beijing)

See http://scse.buaa.edu.cn/english/

University History: Beihang University (Beijing University of Aeronautics & Astronautics, formerly known as Beijing Institute of Aeronautics), or BUAA for short, was founded in 1952. Beihang University was formed out of the merger of the aeronautical departments of Tsinghua University, Beiyang University, Amoy (Xiamen) University, Sichuan University, Yunnan University, Northwest Institute of Technology, College of Engineering at North China University, and Southwest Aeronautical Institute. Beihang University set up its first computer software major in 1975. In 1978, the Department of Computer Science and Engineering was founded, and was further expanded into the School of Computer Science and Engineering in September 2002. The School of Computer Science and Engineering has five sub-units: [1] Department of Computer Science and Technology, [2] Department of Computer Application Engineering, [3] Department of New Media Art, Computer Teaching Experiment Center, [4] Software Institute, and [5] Network Research Center.

Degrees Offered: The School of Computer Science and Engineering offers baccalaureate, master's, and doctoral degrees in computer science and technology.

Key Labs: The School of Computer Science and Engineering has the national key lab for Software Development Environment, the key lab of Ministry of Education for Education for Advanced Virtual Technology, the key lab of Beijing Municipality for Advanced Computer Technology, and the key lab of Beijing Municipality for Network Technology.

Departments and Labs Visited: The School of Computer Science and Engineering hosted the U.S. – China Computer Science Leadership Summit, which provided an excellent exchange on various research and academic topics between computer science leaders in both countries. We did not specifically visit any departments or labs.

Faculty Size: Total faculty and staff at BUAA number more than 3300, including over 1400 full or associate professors, and 290 supervisors of doctorate programs. The School of Computer Science and Engineering has 23 professors (including 13 doctoral supervisors), 5 part-time doctoral supervisors, and 48 associate professors. The BUAA faculty includes one member of the Chinese Academy of Sciences.

Student Distribution: BUAA has a total enrollment of over 26,000 students including more than 1300 doctorate student, over 5000 master's students, more than 14,000 in 4 or 2 year undergraduate programs, and 300 overseas students.

Industrial Connections: Beihang University is located in Beijing, in which there are many research and development labs, including Microsoft Research Asia and IBM China Research Lab, both described above.

Research Publications: The School of Computer Science and Engineering has published nearly 500 papers in domestic and international journals. Currently, the school is undertaking approximately 100 key projects from the National 973 Program, 863 High-tech Program, the National Natural Science Foundations, Ministry of National Defense, national key engineering projects and international cooperative projects. The school has established long-standing cooperative relationships with the universities or companies in USA, Germany, Brittain, Japan and Hong Kong.

Observations/Recommendations: Beihang University served as our host while we were in Beijing and organized and hosted the Leadership Summit. All of our time at Beihang University was focused on the leadership summit. Hence, we did not have an opporutunity to visit any labs or discuss research with faculty and students. It is for this reason that no observations or recommendations are given.

7.5. Tsinghua University (Beijing)

See http://www.tsinghua.edu.cn/eng/

[Note: Our visit to Tsinghua was very brief, and thus most of the information reported here is taken from their web site.]

University History: Often described as "the MIT of China," Tsinghua is among the top-ranked universities in the country. Located in northwest Beijing, it is situated on a lovely site on the former gardens of the Qing Dynasty. It was founded originally as a prep school in 1911, and first enrolled undergraduate students in a university section in 1925. Four years later, a Research Institute was added. During World War II, the university was forced to move to Kunming, where it joined into a temporary partnership with

Peking University and Nankai University. In 1946, it moved back to its original site and again became an independent university. A few years later, at the time of the founding of the P.R.C., Tsinghua became a polytechnical university. However, since 1978, its education mission has expanded, and it now has 54 departments in 13 schools, spread across the sciences, humanities and social sciences, law, architecture, public policy, and so on; however, it continues to be particularly well-known for its strengths in engineering and technology.

Education and research on computer science at Tsinghua is housed in the School of Information Science and Technology (SIST) at Tsinghua, which has 4 departments (Electronic Engineering, Computer Science and Technology, Automation (i.e., Control Systems and Theory), and Microelectronics and Nanoelectronics), 1 institute (Microelectronics), as well as the Research Institute of Information Technology, Joint Laboratory on Information Science and Technology, Tsinghua University Software College and the National Training Center in IC.

Degrees Offered: Tsinghua offers baccalaureate, master's and Doctoral degrees.

Key Labs: According to its web page, SIST houses the following key labs: State Key Lab on Microwave and Digital Communications, State Key Lab on Intelligent Technology and Systems, State Key Lab on Integrated Optoelectronics, and Key Lab of the Ministry of Education on Bioinformatics.

Departments and Labs Visited: Regrettably, we had only limited time at Tsinghua; our visit consisted of a campus tour and a brief presentation on the computer science department's participation in the China National Grid project, which is supported by China's National High Technology Research and Development Program, "the 863 Program." The China Grid project is developing (a) high-performance hardware to support grid computing (currently between 1 and 2 teraflops with an ultimate goal of 15 teraflops); (b) software to support grid applications as well as grid management; and (c) several grid applications, for example supporting bioinformatics research and e-learning/distance education. Tsinghua has a 128-node high performance computing cluster, which is integrated into the campus grid and the China grid, serving as a Master node for the latter. For more on the China grid, see Section 4.3. While we didn't visit Andy Yao's Center for Advanced Study, we did hear about some of its work during Professor Yao's banquet talk at the Leadership Summit.

Faculty Size: Tsinghua as a whole has 1300 full professors and 1800 associate professors, including 35 members of the Chinese Academy of Science and 31 members of the Chinese Academy of Engineering. The School of Information Science and Technology has 158 full professors and 229 associate professors, including 4 members of the Chinese Academy of Engineering.

Student Distribution: Over 30,000 students, including 13,700 undergraduates, 13,400 Master's students, and 5,000 doctoral students, are enrolled at Tsinghua. The School of Information Science and Technology enrolls almost 4000 undergraduates, about 2500

Master's students, and nearly 1000 doctoral students. Note that it thus constitutes a significant proportion of the overall university. We did not obtain information about the number of foreign students and/or foreign-trained faculty, and this information is not available on the web pages.

Industrial Connections: The web pages report that there are close interactions with industry, but additional details are not provided. We did learn about the SSME (services science management and engineering) curriculum being developed jointly with IBM China Research Lab.

Comments and Observations: Because of the brevity of our visit to Tsinghua, our main observations are based on comments made by people we visited at other sites, who uniformly praised the high quality of work in IT being done at Tsinghua. The two industrial research laboratories we visited, IBM CRL and MSRA, both reported on collaborative programs with Tsinghua, and both reported that they hold Tsinghua graduates in very high regard, and compete to hire them.

7.6. Peking University (Beijing)

See http://www.pku.edu.cn/eindex.html

Peking University (PKU) had its centennial celebration in 1998, and is one of the oldest universities in China. It enjoys the reputation of a Harvard-equivalent in China. PKU consists of 30 colleges and 12 departments, with 93 specialties for undergraduates, 2 specialties for the second bachelor's degree (it is possible for a student to graduate with two B.S. degrees in two majors, which is often considered as an alternative to getting an M.S. degree), 199 specialties for master's candidates and 173 specialties for doctoral candidates. While still laying stress on basic sciences, the university has paid special attention to the development of applied sciences in recent years. At present, PKU has 216 research institutes and research centers, 2 national engineering research centers, 81 key national disciplines, 12 national key laboratories. Currently**,** PKU has 4,574 faculty members, 2,691 of whom are full or associate professors. It has 46,074 students, including 15,001 undergraduates, 8,119 master's candidates, 3,956 doctoral candidates, and 18,998 candidates for correspondence courses or study at the night school. Moreover, it includes 1,776 international students from 62 countries and regions.

Our host at PKU was Prof. Cheng Xu, who is the Chair of the Computer Science Department (CSD), which is part of the School of Electronics Engineering and Computer Sciences (School of EECS). The School has four departments, including Computer Science, Electronics, Microelectronics, and Intelligence Science. The School has 60 Professors (most of them Ph.D. Advisors), 99 Associate Professors, and 79 Assistant Professors. It also includes 15 (Teaching) Assistants and 43 other staff members. A present, the School has 1271 undergraduate students, 771 graduate students, and 285 PhD students. There were no separate statistics given for the Computer Science Department alone.

The School also has 11 research institutes and centers. Four of them are associated with CSD, which are Institute of Computer Architecture, Software Institute, Institute of Computational Linguistics, and Institute of Networks and Information Systems. We had brief visits to the first three institutes/centers, which we shall describe in more detail.

- **Institute of Computer Architecture** (also called Microprocessor Development & Research Center, or MPRC in short): We spent a good amount of time with MPRC and are impressed by its achievements. The center has been developing microprocessors using the approach of system-on-a-chip (SOC). It developed a 32-bit/16-bit microprocessor UniCore32 integrated with many other cores, such as PCI controller, SDRAM controller, Ethernet MAC controller and DMA controller, on a single chip, which can be used as the CPU for low-power and low-cost PCs. The center probably has over 70 students. They have done architecture, circuit, and physical designs all from scratch (with their own instruction set). They also developed all the necessary software environments, such as compiler, debugger, and ISS simulator. The UniCore32 processor seems to be very stable. All the PCs in the center are now powered by the UniCore32 processors (which do not fans for cooling, so their lab is much quieter than others). In fact, they have spun off a company, which is commercializing the UniCore32 processors to build low-cost PCs to serve the rural areas of China. MPRC has 3 PhD supervisors and 2 associated professors.

- **Software Institute**: We had a brief visit to the Software Institute. It includes International Collaboration Labs, Theoretical Computer Science Lab, Human-Interaction & Multimedia Lab, and Software Engineering and Information Security Labs. Research on software engineering has a long history in PKU CSD. The founder and the former director of the institute, Prof. Fuqing Yang, delivered a keynote speech at ICSE'2006 on "*Development of Software Engineering: Co-Operative Efforts from Academia, Government and Industry*". The Institute has 11 professors, 10 associate professors, and 14 lecturers.

- **Institute of Computational Linguistics (ICL)**: The research topics of ICL include language model, language parsing technology, computational lexicography, computational semantics, and application systems. Two of the graduates from ICL were the co-founders of Baidu.com, an Internet search engine company specializing in Chinese language (a Google-equivalent in China). Baidu.com went IPO in the Nasdaq in August 2005 and was the best-performing IPO of the year (with over 300% increase in the same day). Currently Baidu.com has a market cap over $2.5B.

- **Key Labs:** We were also told that the PKU CSD has one national key lab (as part of the Software Institute) and two key labs awarded by MOE (Ministry of Education), one in the Software Institute and another in MPRC.

There are a variety of connections between industry and Peking University. We learned about PKU's connections with research labs such as IBM China Research Lab. As another example, we learned about the PKU project which spunoff a company with facilities in Shanghai and Shenzhen.

7.7. Southeast University (Nanjing)

See http://www.seu.edu.cn/~seue/

On May 26th, the delegation paid a whole day visit to Southeast University, where they met the university president, gave two colloquium talks by Randal Bryant and Xiaodong Zhang in the College of Computer Science and Technology, held meetings with both faculty members and graduate students, and toured the campus and several research labs. During the lunch and dinner times, the four delegation members also discussed with the university administrators and computer science colleagues various topics of common interest.

The delegation was formally welcomed by University President Guanqun Gu, who is also a computer scientist, and a member of the Chinese Academy of Engineering. In his welcome address, he reviewed the history of the Southeast University, state of the university in education and research, and the future plan of the university.

University History: Southeast University is one of the old higher education institutions in China, located in the capital of the national government before 1949. It was established in 1902 as Sanjiang Normal College. The name of the university had been changed several times before 1949: to Nanjing Higher Normal School, National Southeast University, and National Central University. In 1952, the university was renamed to Nanjing Institute of Technology, concentrating on engineering education. In 1988, the university was renamed again to the Southeast University as a comprehensive higher education institution with schools of architecture, humanities, medicine, and business, besides its strong and traditional area of engineering. The university has been supported by several major national grants to upgrade its infrastructure and to establish various research labs. The university is one of the top 10 universities in China, as ranked by external research expenditure. In 2004, the university research expenditure was over RMB 535 million. The university is in the process of building a brand new campus outside downtown Nanjing. This will allow more space to expand its offerings.

Degrees Offered, Faculty Size, Student Distribution: The College of Computer Science and Technology was established in 2006, based in its Department of Computer Science and Technology. The College has a total of 75 faculty members consisting of 27 full professors (15 of them are Ph.D. supervisors), 27 associate professors, and 21 lecturers. The college also has 21 staff members and lab assistants. The total number of undergraduate students is 800. The graduate program hosts 100 Ph.D. students and 330 M.S. students. The College is one of the elite Computer Science academia units that have been approved by the Ministry of Education to offer the Ph.D. in computer science and technology in all the three core subjects. A strong area of research in the College is networking and distributed systems. The faculty and students publish about 300 papers per year (including about 80 in English journals and conferences).

Labs Visited: We only briefly visited two research labs and one networking center in the Southeast University. The first one we visited was a networking research lab where students gave several short presentations on peer-to-peer (P2P) systems. These projects are obviously not national economic development mission related, but are motivated by existing academic papers in P2P and some P2P open source software in U.S. The second lab we visited was a networking application development lab that is nationally funded and supported by a large collaborative grant with multiple universities in the country. The objective of the project is to develop a set of software tools for applications in education, data sharing and business transactions on the Internet. The third site we visited was the networking center sponsored by government grants to build a fast national Internet infrastructure to make remote and fast data access between any sites in the country. The demo presented was high density multimedia content delivery via the Internet infrastructure.

Key Labs: The School of Computer Science and Engineering hosts the following three major research labs: (1) Computer Networks and Information Retrieval Lab sponsored by the Ministry of Education, (2) Jiangsu Province Key Lab of Networking Technology, and (3) China Education Network Center for the East China Region.

Industrial Connections: Sponsored by two large 863 grants, the school has also established two industrial-related labs: the CIMS Technology Center, and the E-Commerence Technology Center. These two labs have joint R&D projects with companies in Jiansu Province.

Comments and Observations: The delegation spent most of its time in several meetings with faculty and graduate students on various topics. The major topics covered in the discussions were (1) research directions in computer and networking systems, (2) research expectations for graduate students, (3) graduate student admissions in U.S. universities, and (4) how to write good papers to compete in good international conferences and journals. One discussion topic worth mentioning was on how to balance family and career as woman researchers. One woman graduate student specifically asked Valerie Taylor about her experience to balance family life and career development. After Valerie presented her experiences, active discussions were started on this topic.

7.8. Nanjing University (Nanjing)

See http://www.nju.edu.cn/cps/site/NJU/njue/profile/index.htm

On May 29th, the delegation paid a whole day visit to Nanjing University, where they met University vice president Tiejun Min, gave two colloquium talks by Gurindar Sohi and Valerie Taylor in the Department of Computer Science and Technology, held meetings with both faculty members and graduate students, and toured the campus.

During the lunch and dinner times, the four delegation members also discussed with the university administrators and computer science colleagues various topics of common interest.

University History: The root of Nanjing University is the same as the Southeast University, which was established in 1902 as Sanjiang Normal College, and was the same university as the Southeast University until 1949. After the People's Republic of China was established in 1949, the university was renamed as Nanjing University. In 1952, Nanjing University are separated into four universities based on disciplines. Merged with Jinling University, Nanjing University kept the humanities and science colleges. Its Engineering College became independent and was renamed as Nanjing Institute of Technology, which is the Southeast University today. Its agriculture college became the Nanjing Institute of Agriculture, and its Education College became Nanjing Normal College.

Degrees Offered: The Department of Computer Science and Technology has a long history in education and research in computer software and distributed systems. It grew out of the Mathematics Department in the early 1960s and became an independent computer science department in 1978. As early as in 1981, the department established the first Ph.D. program in software in China. It carried out some of the early work in compilers and operating systems in China and has maintained a strong presence in software research. Due to the geographical distance from Beijing, has concentrated more on theoretical and scientific work rather than government-defined priority areas in large scale engineering projects.

Faculty Size, Student Distribution: The department has a total number of 59 faculty members consisting of 32 full professors (27 of them are Ph.D. supervisors), 17 associate professors, and 8 research scientists/engineers. The department also has 31 staff members and lab assistants. The total number of undergraduate students is 641. The graduate program hosts about 60 Ph.D. students and more than 100 M.S. students.

Research Labs/Key Labs: The delegation did not visit any research labs. There are about 10 key research labs in the country; such labs receive a funding of RMB 8 millions for 5 years. Nanjing University has such a key lab in the Department of Computer Science and Technology; it is called Novel Software Technology Lab.

Comments and Observations: The most time spent in Nanjing University was in meetings with faculty and graduate students. The meetings were hosted by Professor Daoxu Chen, the department chair. During the discussions with faculty, the delegation mainly asked questions to learn about the department. The faculty briefly reviewed the state of the department in research and education. The department emphasizes more basic research than engineering projects. During the meeting with graduate students, two topics were mainly focused on: (1) how to select M.S. or Ph.D. dissertation topics and (2) how to get admitted in graduate programs in U.S. universities.

During our discussions with faculty and students, we learned about several interesting changes in the department. These include:

- Fewer students are going to US universities. In the past, as many as a third of their students went to the US. Now less than 25% of their master's students go overseas. About 20 undergraduate students (out of a class of 160) go overseas. They thought that about half of them go to the US, and Australia is becoming a popular destination.

- The percentage of women students is dropping significantly (perhaps to about 10% or less).

- A very small percentage of the students are married. This is quite common in other universities in China, because the culture is to finish one's education before getting married. Until recently Chinese universities didn't allow married undergraduate students to enroll in the programs.

- The faculty face several challenges: (i) doing world-class research, (ii) keeping strong students to stay in the graduate program, (iii) recruiting students (they are doing aggressive recruiting), (iv) low salaries (compared to an international standard, though the salaries are good by Chinese standards).

- The faculty spend a lot of time administrative work, e.g., dealing with bureaucracy and getting grants to support their activities.

7.9. Northwestern Polytechnical University (Xi'An)

See http://www.nwpu.edu.cn/en/default.asp

University History: Xi'an Northwestern Polytechnical University (NWPU) grew up from the merger, in 1957, of Northwestern Engineering College and the Xi'an Aeronautical Institute. The later was founded in 1938 (by the Shanghai Jiaotong University, Nanjing Central University, and the Aeronautical department of Zhejiang University) as Chinese universities where moved mainland. In 1970 the Engineering Department of Harbin Engineering College was merged into NWPU. NWPU is strong in aeronautics, astronautics, and seafaring technology, matching the industrial strengths of Xi'An. The University takes an area of 20,000 acres with a floor space of 798,000 square meters. A separate, very modern, Science Park hosts part of the research and education of NWPU. The University is due to move into a new, larger and more modern campus outside the city within a few years.

Degree Offered: The Department of Computer Science and Engineering offers bachelor, master and PhD degrees. It has two doctorate programs, in computer architecture and in computer science & technology – with a focus on aeronautical and astronautical applications. It also has a post-doctoral program in computer application technology. Typically, students complete a master (with thesis) in 2.5 years and a PhD in 4 years.

The teaching is organized in four departments:

Computer Systems and Microelectronics
Computer Science and Software
Computer Information Engineering
Information Security and E-commerce

A separate School of Software and Micro-electronics was recently established as part of a national initiative to create demonstration software colleges, in order to increase the number of trained software personnel in China. This school does not have a doctorate program.

Key Labs: The school has several research laboratories, including

Computer Architecture and Micro-system (ministerial)
Networked Embedded Computing and Sensor Network
Speech and Image Processing (provincial)
Network Security & Intelligent Processing
Virtual Reality and Visualization
High Performance Computing (project 211)

In 2005 it had 18 million RMB of research funds (over $2 million). The research is funded by the central government, the provincial government, local industry and international IT corporations.

Department and Labs Visited: We visited several labs in the school, including Networked Embedded System lab with a sensor network, the VR and Visualization lab that works on visualization using 3D displays. A separate visit took us to the NWPU Center for High Performance Computing (CHPC). The center has a cluster of 42 HP rx2600 Itanium-2 server nodes connected via Myrinet (peak 416 GFlop/s), that is part of China Grid (see Section 4.3). It pursues research in Grid Computing, Parallel Algorithms, and applications such as CFD, structure, material, and electromagnetic; and it is involved in several international collaborations.

Another visit to the Science Park took us to the Aviation Micro-Electronics Center (AMEC). This lab has advanced equipment, including an Agilent 93000 SOC tester, and EDA tools from Synopsys, Cadence and Mentor Graphics. A large team of faculty, PhD students and master’s students work on the development of microprocessors, microcontrollers and DSP chips. This includes the 32 bit Longtium R1 and R2 that are PowerPC compatible (233 MHz), The Longtium S1 and S2 industrial controllers that include an Intel compatible core (133 MHz) and the Longtium T1 color TFT-LCD driver IC for mobile phones. These chips are used in industrial products.

Faculty size: NWPU has 1,400 faculty members, including 200 Ph.D. advisers. The School of Computer Science and Engineering has 21 Professors, 22 Associate Professors and 38 Lecturers. 70% of its academic staff graduated from NWPU.

Student Distribution: NWPU has 26,000 students, including 8,000 master’s and 2,000 doctoral students. The School of Computer Science and Engineering has 1,200 undergraduates, 500 master's and 170 doctorate students. It has graduated 102 PhDs in the last 6 years, and graduates 20-30 PhDs a year.

Industrial Connections: The department has strong collaborations with local industries, and with international IT companies such as IBM, NEC, etc.

Research Publications: The faculty publish about 80 papers a year in international journals and conferences, about half of them in conferences.

Comments/Observation: The Dean, Prof. Xingshe Zhou, and his faculty, were very keen about collaborations with US departments, and were interested in R&D collaborations, scholar exchanges, training programs for young faculty, seminars, short courses, and summer schools. The department already has many international collaborations with UK, Australia, Singapore, Canada, etc.

7.10. Xi'an Jiaotong University (Xi'an)

See http://www.xjtu.edu.cn/welcome.html

Xian Jiaotong University was founded in 1896 in Shanghai as Nanyang College. In the early 20th century, it concentrated on engineering and social science. In 1921, it was renamed Jiaotong ("transportation") University, and in 1955 the State Council moved the university to Xi'an in the center of the country. In 1959 it was renamed Xi'an Jiaotong University. In 2000 it merged with Xi'an Medical University and Shaanxi Institute of Finance and Economy, making it a comprehensive research university. It currently has 76 undergraduate programs and 114 Doctoral degree programs in the areas of science, engineering, medicine, economics, management, humanities, and law. In 2005 there were roughly 19,300 full-time undergraduate students, 8,900 master's students, and 3,900 Ph.D. students. About 800 students are from overseas. It has 2,000 senior level faculty members, which include 1,200 professors and associate professors. Sixteen professors are in either the Chinese Academy of Science or Engineering. The university has 4 state key research laboratories Mechanical Behavior of Materials, Manufacturing Systems Engineering, Multiphase Flow in Power Engineering, and Electrical Insulation for Power Equipment) as well as 4 national laboratories and 2 state engineering research centers. The university has an extensive physical library and a digital library system. The university has exchange programs with approximately 100 universities, and is establishing an international campus, split 50-50, with the University of Nottingham.

The Department of Computer Science and Technology is in the School of Electronics and Information Engineering and is headed by Professor Yong Qi. The department contains 12 full professors (10 being PhD advisors), 25 associate professors, and a total staff of 79. There are approximately 720 undergraduate students, 450 master's students, and 80 PhD students. M.S. students are taken from the top 7% of the undergraduates or are admitted based on their performance in a national examination. The department also has a six-year B.S.-M.S. program. There is an anonymous review process for theses. All students finish in March or retake the exam and finish in May. It is rare for a student to fail both exams.

A Ph.D. student - who has to already have earned an M.S - needs to take only four or five more courses.

There are several institutes associated with the department and the school, including the Institute of Image Professing and Pattern Recognition, the Institute of Artificial Intelligence and Robotics, the Institute of Neocomputers, the Institute of Computer Information Networks, the Institute of Computer System Structure and Networks, the Institute of Computer Applied Techniques, the Institute of Computer Software, and the Institute of Digital Library. Some of these labs are joint with IBM and Microsoft Beijing, and there is also collaboration with Google, Honeywell and Siemens. The president of the university, Professor Nanning Zheng, is from the Automatic Control Department in the same school and has an active institute on image processing.

The Institute of Computer Information Networks is headed by Professor Wei Li. This institute manages both the university network and is the northwest center of CERNET (described elsewhere in this report – see Section 4.3). This kind of laboratory gives researchers more leeway in deploying experimental protocols than in other countries. Some research projects being done on CERNET2 (the ipV6 version of CERNET) include personal address assignment for roaming, spam filtering, security bug detection, and intrusion detection. Professor Li reported that approximately 2/3 of the undergraduate students at the university have their own computers.

We also met with vice president Tianjian Lu. Professor Lu, who works in Material Sciences. He obtained his B.Sc. and M.Eng. degrees from Xi'an Jiaotong, his D.Phil. from the University of Hong Kong, and his Ph.D. from Harvard. Professor Lu was a member of the Cambridge University faculty for many years. Professor Lu stated the goals of the university very clearly: they wish to be considered an international leader within the next ten years. They wish to dramatically increase the number of journal and conference publications that appear in international journals, and they want their Ph.D.s to be actively recruited to join the faculty of universities overseas. He discussed some problems in the way of reaching this goal, such as the English writing quality of the students.

Professor Lu related a recent success story in his own department of Material Sciences. The department had a fairly low success rate in getting papers published in international journals - perhaps 2 a year. Professor Lu invited a managing editor of an international journal to spend two weeks in Xi'an to talk about the process of paper selection and the qualities of a paper that make it publishable. The next year, the department published 20 papers in international journals.

7.11. Shanghai Jiaotong University (Shanghai)

See http://www.sjtu.edu.cn/english/

University History: Shanghai Jiao Tong University (SJTU) was founded in 1896 and is one of the oldest universities in China. SJTU started as an engineering school, and has expanded to become a full university, including schools of medicine and law. Projects

211 and 985 provided the biggest investment and development project to SJTU given by the State and Municipal governments. SJTU has 21 academic schools, for which our visit focused on the School of Electronic, Information, and Electrical Engineering (SEIEE) at the Minhang campus of SJTU (an impressive, new facility of 2.4 km^2 in a suburb of Shanghai).

Degrees Offered: SEIEE includes five departments (Computer Science, Controls, Electrical Engineering, Power, and Instrumentation and Measurement) offering six majors, with undergraduate, master's and doctoral degree programs. The students from the SEIEE Computer Science program, the School of Software Engineering program, the School of Software Engineering and the Network Education College (with CS major) all receive a degree in computer science, as authorized by the Ministry of Education.

Key Labs: SJTU has one state key lab of optical network, one Shanghai municipality key lab of information security, and Ministry of Education key lab of new technology in power transportation and safety.

Departments and Labs Visited: Our visit focused on SEIEE and the Department of Computer Science. We visited labs in the areas of optical communication, automation control (i.e., the autonomous vehicle), robotics (i.e., the autonomous cars traveling along a given path and the tracking robots), and wireless communication (i.e., the sensor-based transportation grid).

Faculty Size: SEIEE includes 360 faculty members, of which 150 are associate professors and 110 are full professors. Most of the full professors are PhD supervisors. In the Department of Computer Science, which was established in 1984, there are 108 staff members, which include 74 faculty members consisting of 25 full professors and 27 associate professors.

Student Distribution: SJTU has 40,000 students, of whom 18,000 are undergraduate students and 4,000 are international students. SEIEE has 4,000 undergraduate students, 2410 full-time master's students, 800 part-time master's students, and 800 doctoral students. SJTU also has a School of Software Engineering, which is separate from SEIEE; many faculty members in Software Engineering have joint appointment in SEIEE. This school has over 1000 students in bachelor's and master's programs. The School of Software Engineering places greater emphasis on hands-on experience and working in industry; this program does not offer a doctoral degree. The Department of Computer Science enrolls the following number of students per year: 150-200 undergraduate students, 150 full-time master's students, 150 part-time master's students, and 50 doctoral students; the average time for a degree is 4 year for the baccalaureate, 2.5 years for the master's, and 3 years for the doctoral degree.

Global Vision: SJTU pays a lot of attention to internationalization. It just announced a University of Michigan – Shanghai Jiao Tong University (UM-SJTU) Joint Institute this April. Given a high degree of freedom and autonomy in terms of faculty hiring, student recruiting, financial management as well as the education mode and assessment procedures, the UM-SJTU JI will serve as a pioneer test bed for how to effectively and painlessly import a world-class education model into China. By build up more strategic collaboration relationships with world-class universities, the UM-SJTU JI will serve as an international education hub. Using English as its official language and UM curriculum as its course structure, the UM-SJTU JI is intended to be a better platform not only for Chinese students toward the world, but also for international student to study and learn about China.

Industrial Connections: The Minhang SJTU campus is located adjacent to an industrial park, focused on the areas of IT, communication, and semiconductors.

Research Publications: Currently, the SEIEE faculty members publish 15 papers per year in IEEE, ACM and similar level transactions. The goal is to reach 80 per year.

Comments/Observations

- SJTU places emphasis on "basic scientific training" and on gaining research prominence through patents and publishing in journals indexed by SCI and EI.
- SEIEE has international programs with the University of Michigan and Georgia Institute of Technology. In the latter case, a few Georgia Tech faculty members go to SJTU each summer to teach courses. With University of Michigan, the goal is to replicate the given curriculum at SJTU.
- SJTU has exchange programs with several U.S. and European universities; approximately 5-6 students per year from each of the U.S. and European universities go to SJTU.

Challenges

- Given that much of the research is mission directed is determined by the funding, it may be hard to reach the goal of 80 ACM/IEEE transactions journal papers per year.
- SJTU has many large-scale development projects, such as the wireless, sensor-based transportation grid, that can provide an excellent testbed for investigating some core research concepts. This may also be an area of fruitful collaborations with well established researchers.

7.12 Suzhou University (Soochow University) (Suzhou)

See http://www.suda.edu.cn/englishweb/

Soochow University is located in the city of Suzhou, midway between Nanjing and Shanghai. It was founded in 1902 by American missionaries and has grown through the merging of multiple institutions and government investment to become a comprehensive university, including agriculture and medical schools. It has 6 campuses, 50,000 students, 10,000 staff (including hospital staff), and 5 hospitals. It is among the 100 of over 1000 universities in China supported by the national Ministry of Education. As a means of calibrating themselves, they noted that they ranked 24th among Chinese universities in terms of publications indexed by SCI.

We met with a delegation of administrators and faculty, including Dr. Xue-Guang Zhang, Vice President of the university, and Prof. Qiaoming Zhu, Dean of the School of Computer Science and Information Technology. We did not meet any students or tour any labs.

Computer science was established as a discipline in 1984. The School of Computer Science and Technology was founded in 2002. It has 3 undergraduate programs: Computer Science and Technology, Information Systems and Management, and Software Engineering (the latter two were inspired by the ACM/IEEE curriculum report of 2002). It has two graduate programs: Computer Applied Technology (M.S. & PhD), and Computer Software and Theory (M.S.). There are 15 PhD students, 283 M.S. students, and 825 undergraduates. There are also 835 continuing education students who attend classes on Saturdays and Sundays, both in degree and nondegree programs. The faculty include 13 full professors (6 have PhDs and 4 are qualified as PhD advisors), 25 associate professors, 33 lecturers and 43 administrative and technical staff. Around 2/3 of the students come from Jiangsu province and 1/3 from outside. The main research areas are Chinese natural language processing and information/network security. They have a provincially-supported key laboratory in computer information processing technology.

Much of the discussion centered on student training and job placement. The university sets a high priority on industry ties and on preparing students to be “very applied personnel.” Suzhou has an industrial park housing international (AMD, Infineon) and domestic (UFIDA, CVIC) computer technology companies. Most of the continuing education students come from these companies, and 90% of the graduates are placed with these companies.

We had a discussion about how to provide students relevant project experience. Several of our delegation described courses they run in which students participate in projects for industrial clients. But, we also emphasized that American research universities view their mission as preparing students with foundations, rather than specific technological skills (e.g. Microsoft .NET). The Chinese delegation expressed a sense that both their students and their industrial contacts put pressure on them to cover these more applied topics.

The university has some undergraduate student exchange programs, but otherwise there was little discussion of international collaborations. It seemed like the main priority of the school was to serve the local industry.

<u>Section 8: Details of Some Other Special Events and Presentations</u>

8.1. Leadership Summit

The delegation organized together with leaders of the Chinese CS community a one day conference that explored major issues of mutual interest to the U.S. and Chinese CS leadership. The issues discussed included state of the art in education and research, Ph.D. training, CS faculty selection and retaining, evaluation of CS research and its impact, and the role of funding agencies and research centers. The meeting concluded with a discussion of cooperation and dialogue and "next steps". For a detailed program as well as copies of presentations at the Summit, see http://dimacs.rutgers.edu/Workshops/China/program.html. A summary of these presentations is included as an Appendix. The Summit concluded with a banquet that included a banquet address by Turing Award winner Professor Andy Yao, formerly at Princeton University and now at Tsinghua University.

8.2. International Conference on Software Engineering (ICSE)

For the first time, the ACM/IEEE Twenty Eighth International Conference on Software Engineering (ICSE) was held in China in May, 2006. Shanghai served as the host city for the conference. Several of our delegates participated in ICSE in Shanghai. Approximately 1300 people attended the conference, with 200 attendees coming from mainland China. The Shanghai Municipal Informatization Commission (SMIC) strongly supported the conference and provided staff, management support, facilities and funding for the conference. SMIC is determined and committed to reach out to the international community in order to make software an important and vital aspect of Shanghai.

From all accounts, Shanghai has a growing and vibrant industry in software engineering. It was clear that the Chinese software industry is booming in Shanghai, with a 35% growth rate on average for the last five years. It is also clear that China's software industry is eager to participate in, and contribute to, the global software engineering community. There was considerable interest from the ICSE Chinese participants in establishing relationships with software engineering researchers and practitioner worldwide. They were particularly interested in efforts to improve their research and papers so they can fully participate in top research conferences and publish in top research journals. Mary Lou Soffa, a participant in the NSF China delegation and also as a Program Co-chair of ICSE, was interviewed by a Shanghai newspaper to provide an understanding of the review process used by the ICSE's technical program committee. The reporters also wanted to know how the Chinese faculty and students can improve their papers and get them accepted in top conferences and journals. Issues, including communication and what constitutes a good research paper, were discussed with the reporters.

Students attending the conference were very interested in discussing how they could be accepted to a leading computer science department in the USA. They wanted to make contacts to improve their chances of getting accepted and indicated that they wanted to study in the USA as they believed this is where the best research in software engineering is being performed.

There were also discussions that indicated the Chinese software engineering community was eager to develop interactions with the academic community in the USA. Programs for having American faculty and students visit and interact with faculty were discussed as well as programs enabling Chinese scholars and students to visit the USA.

In summary, Shanghai's drive to become number one in software engineering was evident from discussions with the Shanghai government and the ICSE Chinese participants.

8.3. Presentations Made by the Delegation

Members of the delegation also gave technical talks at some of the universities visited. Here are titles of talks. Copies of their presentations can be found at http://dimacs.rutgers.edu/Workshops/China/Presentations/slides.html

At Southeast University:

> Randal Bryant, Computer Systems: A Programmer's Perspective
> Xiadong Zhang, Exploiting Idle Communication Power

At Nanjing University:

> Gurindar Sohi, Parallel Execution Models for Future Multicore Architectures
> Valerie Taylor, Prophesy: Analysis and Modeling of Parallel and Distributed Applications

At Northwestern Polytechnical University:

> Marc Snir, Software for High performance Computing
> Jason Cong, Platform-Based Behavior-Level and System-Level Synthesis
> Keith Marzullo, Coping with Dependent Failures in Distributed Systems

At Xi'an Jiaotong University:

> Martha Pollack, Artificial Intelligence in the Design of Assistive Technology
> Fred Roberts, Computer Science and the Socio-economic Sciences

At Shanghai Jiaotong University:

> Marc Snir, Software for High performance Computing
> Jason Cong, Platform-Based Behavior-Level and System-Level Synthesis

Section 9: Next Steps for the Delegation

1. Hold a U.S.-China follow-up Leadership Summit in 2007 and plan one for 2008.
2. Set up a US-China CS collaborations steering committee.
3. Give our report widespread dissemination to U.S. CS community. Identify steps like sessions at appropriate scientific and other meetings; articles such as in CRA News, CACM, Computer Software, Chronicle of Higher Education;

etc. [Marc Snir will help with getting an article we write for CRA News brought to the attention of the Editorial Board.]

4. Disseminate our report widely within NSF, other funding agencies, the U.S. government, and U.S. universities.
5. Encourage ACM, IEEE, AAAI, etc. to help educate our Chinese colleagues on what constitutes a good paper. Invite Chinese researchers to serve as "shadow" members of Program Committees. (First steps along these lines have already been taken with ACM, though the efforts of Keith Marzullo.)
6. Send our report to our Chinese hosts.
7. Prepare a PowerPoint presentation based on our report so that members of the delegation can use it in various venues. (Guri Sohi will prepare this once the report is done.)
8. Work with NSF to arrange that a member of our delegation present a summary of our report to the CISE and OISE Advisory Committees.
9. Create a database of contacts in China, starting with people we met on the trip.
10. Highlight recommendations to the U.S. Higher Education Community. Some preliminary examples:
    a. There are more funds available to Chinese researchers to visit the U.S. than most people in the U.S. realize.
    b. Those thinking about setting up educational exchanges with China should understand that summer courses are not typical in China and that there are differences in length of semester.

Section 10: Concluding Comments

The delegation was very impressed with the exciting things that are happening in Chinese universities and international research laboratories based in China, and with the fast pace of progress. There are increasingly many opportunities for interactions with Chinese colleagues and these are to be encouraged.

The Chinese universities we visited include research in many if not most areas of modern CS research. However, our impression was that there is a particularly strong emphasis on computer architecture, hardware design, and systems-level research, which appeared to dominate theoretical or formal work. Based on a short visit, we were unable to understand the relative strengths of different research programs. Achieving this understanding will require a more in-depth analysis. Some follow up visits of small teams which would spend more time at one or two universities is a good idea.

To facilitate future collaborations, U.S. researchers need more information. NSF should develop ways to gather this as an aid to U.S. researchers.

Our trip was limited (with one exception) to top-ranked universities, so we are not able to make an analysis of the situation in and status of CS in the vast majority of Chinese universities.

With so many new universities being created in China, future monitoring of the status of newer and up-and-coming universities is necessary. Moreover, with rapid changes in higher education's status, priorities, resources, and its relationships to government and private industry, the situation is fluid. Regular monitoring of the situation is called for. Moreover, the results of such monitoring should be given widespread dissemination to the U.S. Computer Science community.

Appendix: **U.S.-China Computer Science Leadership Summit, May 23, 2006**

The summit began with welcomes addresses from the following key leaders:

- Jingpeng Huai, Executive Vice President, Beihang University, Summit host

- Peter Freeman, Assistant Director, National Science Foundation (U.S.), Computer and Information Science and Engineering Directorate

- Yuweng Qin, Deputy Director of Computer Information Directorate, National Science Foundation China.

- Xinli Guo, Deputy Director of Academic Degree Management and Graduate Programs Agency, Chinese Ministry of Education.

- Fred Roberts, Lead CS Senior Leader of the U.S. Delegation

All welcomed the audience and spoke to the importance of continued and expanded collaborations between China and the United States, giving the growing globalization.

Panel 1: State of Art in Education and Research
The first panel painted very broad pictures of the state of computer science education and research in the United States and China, from the point of view of two senior leaders, naturally with their own perspectives.

<u>The State of CS in the U.S.</u>
<u>(Marc Snir, University of Illinois - Urbana Champaign)</u>

Professor Marc Snir described the state of Computer Science research and education as seen from Illinois. Snir began with the bad news, describing declining enrollments nationally in undergraduate CS programs, showing graphs of CS bachelor's degrees granted, which peaked in 2003/04, and newly declared CS majors, which has declined steadily since Fall 2000. He attributed these declines to the .com crash as well as the end of the Y2K scare, which occurred almost simultaneously, followed by the current fear of off-shoring. Another factor is the incorrect image of computer science as an unfashionable, isolated field. (In a subsequent question and answer session, a number of Chinese students commented that CS and IT more generally are not seen as cool and sexy by Chinese students.)

The good news is that the top departments did not see such significant declines, and that IT employment and salaries are both at record highs and growing faster in the U.S. than total employment, implying that much of the bad news can be attributed to misperceptions. The ACM Globalization report documents these trends (http://www.acm.org/globalizationreport).

The story is quite different for CS graduate enrollments, where PhD production is growing, and the fraction of foreign students is relatively stable. The percentage of women enrolling in CS programs has declined significantly in recent years, outpacing the overall enrollment decline, at all levels except the PhD level.

Total federal funding of CS research increased until 2001, but has pretty much leveled off since then. But the funding per faculty member has declined significantly given the growth of the field.

Computer Science as a field has become extremely broad, with research and education done by a variety of differently-named and differently-focused departments and programs, including not only computer science and computer engineering but also information science, informatics, and information technology. CS departments are typically in schools or colleges of science or engineering, but a growing model is the school or college focused entirely on computer science and related fields. Interdisciplinary research and education at the interaction of CS and application areas and with departments across academic disciplines is becoming increasingly important, as is collaborations with industry in this age of globalization.

<u>Just Six Variables - Personal View of Computer Education in China</u>
<u>(Chen Daoxu, Nanjing University)</u>

Professor Chen gave a personal view of computer education and research in China starting with the point that this is a difficult task, given the breadth of the field. He then took a simple approach based upon what he learned from Sir Martin Rees, Astronomer Royal at Cambridge. Rees told us,

> "*Our whole Universe is governed by just six numbers, set at the time of the Big Bang. Alter any one of them at your peril, for stars, planets and humans would then not exist.*"

Chen started his talk by describing the six numbers that define the physical cosmos, and then related them to similar numbers simply defining computer science research and education. By analogy, Chen tried to characterize the community of computer education and research in Chinese universities as a small cosmos and examine what are the crucial factors influencing its future development.

1. **N** = the basic ratio of the force putting things together to that of pulling them apart. In the computing cosmos, the analogy is the ratio between the core of the discipline and the rapidly expanding applications.

2. λ = the basic force resisting the expansion of the cosmos. In computing, there has been rapid expansion in the past few years conflicting with decreasing popularity, due to real and virtual "antigravity".

3. ε = ratio of energy emitting during mass transmutation. The computing analogy is the ratio of high-level research results on educational activities and within China,

the research is addressed with a hierarchical structure in universities and national laboratories, where different universities and laboratories taking on different expertise.

4. **Ω** = the relative importance of gravity and expansion energy in the Universe and leading to either smooth development or turmoil. In the computing field, **Ω** represents research exploration both for publication vs. working for national goals.

5. **G** = identity, ensuring that computing looks different from the other sciences while contributing to them.

6. **D =** the dimension of our universe – science, engineering and service, both broad and narrow.

As a way of tying this analogy/characterization to the reality of computer science education and research, Professor Chen pointed out two primary perspectives on the discipline in China. First, more than 700 institutions of higher education in China offer computer science bachelor's degrees, but more than 50% of those programs have been around less than 10 years. B.S. enrollments in China currently total more than 400,000. Second, Chinese national key discipline units are architecture, software and theory, and application technology. Some of the distribution of expertise include: CAD at Zhejiang University; novel software techniques at Nanjing University; Software Engineering at Wuhan University; SDE at Beihang University; A&V Information Processing at Beijing University; Intelligent Technology and Systems at Tsinghua University; and an emerging discipline of information science and technology at Tsinghua University. These two perspectives point to only some of the various forces on the discipline in China. The "values" we set for the six variables will influence the future development of the field.

Panel 2 PhD Training

This panel presented different views on PhD programs in the U.S. and China as well as ways to assess the quality of PhD students. It generated significant discussion regarding the differences between the U.S. and Chinese systems of mentoring graduate students.

<u>Ph.D. required courses</u>
<u>(Keith Marzullo, University of California - San Diego)</u>

UC San Diego revised the PhD requirements in 2001 to address the tension of a broadening field and recent growth and diversity of both the faculty and student body. One goal was to decrease the time before students started performing real research, and potentially also the time to degree. Professor Marzullo described several considerations taken into account in deciding on the required PhD courses as well as the structure of the program:

- Undergraduate Courses: incoming graduate students are expected to have the following expertise at the undergraduate level (either incoming, taking at UCSD, or testing out): theory of computation, algorithms, architecture, operating systems, programming languages or compilers

- Core Graduate Courses: all students must take the following fundamental courses:
  - Algorithms
  - Architecture
  - Operating Systems: a unique seminar-like course, where students read two papers for each class. Papers are selected as those that are historically important, pivotal, or currently critical to the field, but all loosely structured around operating systems. The course structure is solely a question/answer style followed by an extensive benchmarking project.
  - Complexity must be taken by all Computer Science students
    Computing Circuitry must be taken by all Computer Engineering students
  - Faculty Research Seminar: introduces students to the range of research expertise and specialty areas from which they will take their depth and breadth requirements.

- Depth Requirements: each student takes three courses from a specialty area. Specialty areas are determined by faculty expertise, which obviously can evolve, but currently include:
  - Theoretical Computer Science
  - Programming Languages, Compilers, and Software Engineering
  - Computer Systems
  - Database Systems
  - Computer Engineering
  - Artificial Intelligence
  - Graphics and Vision
  - Bioinformatics

- Breadth requirements: each student takes three non-seminar courses from at least two other specialty areas.

Marzullo's presentation focused on the course requirements in CSE at UCSD, but of course, the PhD also requires the preparation and defense of a top-quality thesis.

<u>Computer Science Foundations for Ph.D. Students The Carnegie Mellon Perspective (Randal E. Bryant, Carnegie Mellon University)</u>

Carnegie Mellon University has a slightly different structure for the PhD program. As usual, the PhD culminates with a significant research commitment in preparing and defending a PhD thesis. Dean Bryant presented the PhD program requirements, which include writing, speaking and programming skills, one year's service as a teaching assistant, as well as eight PhD-level courses, including one each from the following "star" areas (each area with 2-3 options):

  - Algorithms & complexity
  - Programming languages

- o Artificial intelligence
- o Software systems
- o Computer systems

Like the UCSD model, these “star” courses assume students have undergraduate preparation in the subject matter.

The unusual features of the program include that there is no qualifying or comprehensive exams. Students are admitted directly to the PhD program through a very selective process (approximately 25 students are admitted each year out of about 800 applicants). Courses are viewed as more useful than exams, which do not seem to serve the intended role of determining whether the student is qualified to pursue and complete a PhD. Student progress is monitored closely by a mentor, assigned upon “immigration”, and reviewed collectively by the entire faculty twice per year.

In terms of outcomes, about 70% of entering students complete the PhD with average time-to-degree of six to seven years. Most graduates’ CVs include 10-20 research publications; hence they are ready to move into research positions. In fact, most stay in the U.S, moving into faculty positions or the top industrial research laboratories.

By way of summary, Professor Bryant pointed out that CS research programs will be influenced by the decline in undergraduate enrollments; if this trend continues in the U.S., the supply of graduate students will be limited and the need for computer science faculty will decline.

The Dragon Star Program
(Yinghua Min, Institute of Computing Technology)

Professor Min described the Dragon Star Program, sponsored by NSF China, which was initiated to improve computer science and engineering graduate education in the People’s Republic of China through the participation of internationally recognizes scholars, primarily from the United States. The primary goal is to organize graduate-level courses in the field and to increase awareness of the latest progress in IT. Within the program, international scholars teach graduate-level computer science and engineering courses at a range of universities in PRC, meetings are held to enhance education and research as well as to encourage scholarly exchange and research collaboration.

The program is managed by the Dragon Star Committee – a volunteer organization with subcommittees in North America and PRC. It was originally proposed by Professor Wei Zhao in 2000. Since then, 32 courses have been offered by 21 U.S. professors in 17 PRC institutions, with 2637 participants. The Dragon Star Program has become quite popular, and satisfaction with the courses is extremely high. It has resulted in both new research streams and improved teaching styles within China.

Introduction to the PhD Program of the Department of Computer Science and Technology at Tsinghua University
(Chuang Lin, Tsinghua University)

The PhD program in Computer Science and Technology at Tsinghua University emerged from the "Automated Control Department" founded in 1958. Professor Lin began with several statistics. The faculty consists of 41 full professors (of which 36 can serve as PhD supervisors), 35 associate professors, 3 fellows of the Chinese Academy of Science/Engineering, and two chaired professors.

This program was one of the first to be authorized to offer a PhD in computer science, and is ranked first in three of four academic indices in computer science. The program has graduated a total of 307 PhDs, currently producing just over 40 PhDs per year. Students are admitted either on the basis of an entrance exam, including a face-to-face interview, or on the basis of an excellent record in their bachelor's degree.
The time-to-degree is 3-5 years for those entering with a master's degree or 4-6 beyond those entering with a bachelor's. Basic requirements include 18 credits (3-4 courses) beyond the M.S. or 34 credits (9-11 courses) beyond the B.S. Courses are selected from the following:

- Basic theory: 10 courses on basic theory or courses in mathematics;
- Advanced research: over 50 courses covering areas of research expertise in the department.

PhD graduation requirements include publishing at least four papers, with specific constraints on indexing by SCI, EI, or ISI Web of Science, with the intent of encouraging of quality publications before graduation.

Professor Lin recognized that the overall quality needs to be improved in comparison to top international universities. The university is initiating several steps to improve the quality such as setting up a more systematic system of assessment, providing more opportunities for international collaboration, and encouraging publication in the top quality international journals. The future prospective is for the quality of doctoral students to catch up to the top 30 U.S. computer science departments in 5-10 years.

Expectations and Quality Control for Ph.D. Students
(Martha E. Pollack, University of Michigan – Ann Arbor)

Professor Pollock presented the University of Michigan model of quality control for PhD students as a case study representative of most U.S. computer science departments. Quality control begins with admissions, where PhD applications are evaluated by higher standards than M.S. applications. Applications folders are first screened by faculty in the relevant area, who make recommendations to a department-wide committee responsible for making final admissions decisions. Approximately 20-25% of PhD applicants are admitted, 30-35% of these enroll. Upon admission, nearly all admitted students are guaranteed five years of funding assuming adequate progress, and time-to-degree is 5-6 years.

Quality control measures leading up to PhD candidacy include:

1. Breadth of knowledge: grade of B- or better in each of four breadth areas - hardware, software, theory, artificial intelligence;
2. Depth of knowledge: grade of A or A- in two selected courses in a major area;
3. Research potential: independent project with a faculty supervisor and oral preliminary exam by three faculty not including the project supervisor

The "real test" of course is an original research contribution, confirmed by completing and defending a PhD dissertation. It is expected that the dissertation work be also presented to the relevant research community in conferences and journal articles. Upon completion, the PhD graduate is ready for an academic or industrial research position.

Panel 3 Faculty Selection and Retention

This panel presented different stages in the faculty "life cycle" in the U.S. and China and participants discussed different approaches toward development of faculty resources.

<u>Faculty Development in the US: Selection & Retention</u>
<u>(Debra Richardson, University of California - Irvine)</u>

Professor Richardson discussed the recruitment and retention of faculty in U.S.computer science departments. Total faculty sizes are currently continuing to grow at a rate of about 3%, with 85% of hires as new PhDs. Top universities are competing for the best new PhD graduates, and not hiring away from other universities (less than .04% faculty losses are transfers to another university.) New PhD recruits are selected on the basis of the expectation that they will succeed in being promoted to tenure. Further, it is critical to devote significant investment in the hiring of new faculty who will succeed.

There is an increasing emphasis on diversity in the faculty ranks with a focus on equitable hiring and advancement of gender and ethnic minorities. This requires an institutional transformation and cultural change. Richardson described several best practices in transforming culture to achieve diversity and equity, all of which require serious leadership on the part of department chairs and university administrators.

Just as it is critical to devote resources to recruiting the best faculty, faculty retention is critical to the success of the department, as it is much more expensive to bring in new faculty than to ensure that existing faculty succeed. Richardson described several best practices for faculty retention, including mentoring, providing a positive environment and rewarding research accomplishments, providing an environment in which good teaching and research can be accomplished without negatively impacting research, and endorsing faculty awards.

<u>Faculty Development in the U.S.: Faculty Life Cycle</u>
<u>(Valerie Taylor, Texas A&M University)</u>

Professor Taylor went on to discuss the faculty life cycle – the academic ladder from hiring through advancement to full professor and beyond to distinguished scholarly positions such as endowed chairs or administrative tracks. Throughout advancement, the academy rewards scholarship, which consists of three components – research, teaching and service; but there is no question that strategies for success focus on research with peripheral components of teaching and service – that is, research must be outstanding, while teaching must be very good, and service must be present.

Approximately 70% of regular rank faculty in CS PhD granting institutions are tenured. The tenure time-line is usually a 6-7 year clock, with annual evaluations and a mid-cycle review over a seven-year probationary period. Primary criteria for tenure are evidence of scholarly distinction, accomplishments and impact on the field. In particular, evidence of research impact is most important, where quality counts (or should count) more than quantity. There is no substitute for quality, but the relative importance of the basic factors – excellence in research, teaching and service – varies from institution to institution; thus it is important for faculty to understand the local culture and request and accept mentoring from senior colleagues.

Advancement to full professor and beyond is based on international recognition as an established researcher and leader in the relevant field. About 1% of the faculty achieve the status of distinguished or chaired/endowed professor, based upon celebrated research contributions. Other distinguished scholars go the way of administration, becoming deans and higher level administrators and leading their faculty to greater heights.

<u>Organization of Computer Science Faculty in China</u>
<u>(Dianfu Ma, Beihang University)</u>

Professor Ma discussed the organization of computer science faculty in China. He started by laying out several initiatives and national goals for Chinese universities, including an educational development plan in 1998, a postgraduate educational development strategy for 2002-2010, and a long-term science and technology development plan for the country for 2006-2020. There are 1794 Chinese universities in total; by 2004, 505 universities had undergraduate computer science majors with 300,000 students enrolled.

The relevant discipline major ("first-class discipline") in the Chinese university system *is computer science and technology*, while core subjects ("second-class disciplines") include *computer architecture*, *computer software and theory*, and *computer application technology*. Different Chinese universities address different ones of these key disciplines. 25 universities are authorized to confer PhDs in the "first-class discipline" of computer science and technology, while numerous universities are authorized to confer both PhD and M.S. degrees in the "second-class disciplines." This emphasizes the importance of the "first-class discipline."

Professor Ma presented graphs showing recent student enrollment reflecting increasing graduate numbers but decreasing undergraduate numbers, similar to the situation in the United States.

With respect to national plans for faculty development, China has developed several award systems to encourage leaders in the discipline and to bring up elite young academics. China has also initiated several projects to encourage improved academic environments and innovation. The general mix of faculty is $1/3^{rd}$ local (doctorates granted from the institution), $1/3^{rd}$ domestic (Chinese doctorates), and $1/3^{rd}$ abroad (doctorates awarded in other countries). As in the U.S., China values quality; the system emphasizes research impact and funding.

Development and Promotion of the Faculty Teams in the Schools/Departments of Computer Science of the Universities in China
(Xu Xiaofei, Harbin Institute of Technology)

Professor Xu described the development and advancement of faculty, organized in teams, in Chinese CS units, from the perspective of the Harbin Institute of Technology. The School of Computer Science and Technology at HIT is quite large, including 149 faculty and 1842 students. Professor Xu went on to place the development phases of computer science faculty in the perspective of the history of both China and the IT industry. The upshot is that in the current situation, faculty treatment has improved and the current generation of faculty is good quality with PhDs and international study experience.

However, Professor Xu lamented the challenges of faculty teams and development, including the extreme pressures of R&D and teaching, difficulty of recruiting high-quality faculty members, lack of outstanding academic leaders, and the lack of communication with world-class universities and professors. He discussed their approach to developing and promoting faculty teams, highlights include:

- Regular and increased review of research and teaching;
- Improved treatment and more careful recruitment;
- “Four one” requirement for professors – one international journal paper per year, one NSF project in hand, one international partner, and one office of service;
- Increased international collaboration – e.g., visiting international scholars as part time or visiting professors and role models and emphasis of international R&D projects.

Chinese universities are developing several “software” schools, which have a distinctly industrial focus, preparing students to become software professionals through a practice-oriented education by faculty with industrial experience.

Professor Xu concluded by emphasizing international collaboration and collaboration with the IT industrial sector as critical to enhancing the competency of CS faculty in Chinese universities.

Junior Faculty Recruitment and Development at HKUST
(Lionel M. Ni, Hong Kong University of Science and Technology)

Professor Ni described the university system in Hong Kong. There are eight universities sponsored by the Hong Kong government, with the Hong Kong University of Science and Technology (HKUST) established in 1991. The Hong Kong tertiary educational system consists of a University Grant Committee, which is the major source of university budgets, supplemented by student tuition, and the Research Grant Council, which provides major research funding.

Computer Science and Engineering at HKUST is very similar to the U.S. system. The department is within the School of Engineering. It is one of the two largest departments at HKUST, with about 40 faculty members, including three chaired professors, seven full professors, 18 associate professors, and 11 assistant professors. The student body consists of approximately 100 doctoral, 40 master's and 320 undergraduate students.

Faculty are recruited from a worldwide pool, mainly from the U.S. Criteria include a strong research and publication record as well as some China/HK connection. For promotion, considerations are top-rated journals and conferences, funding record, PhD student production, external letters, quality teaching, professional and university service. The promotion process includes a department level review, a school level/dean's evaluation, a university-wide review committee recommendation, and the president's final decision.

Panel 4 Evaluation of Research

Evaluating Research and Impact
(Guri Sohi, University of Wisconsin - Madison)

Professor Sohi discussed the metrics and mechanisms for evaluating research and its impact. There are a diversity of metrics depending on the research area – basically including funding, publications, artifacts, and impact. Funding is necessary but not sufficient. The tension in evaluating publications is quantity vs. quality; there is a temptation to rely on quantity because it is more easily measured, especially by outsiders, but the community must assess quality, which is often measured by the selectivity of publication venues. Impact is a difficult metric but critical – the conflict is short-term vs. long-term; short-term impact is biased toward today's hot topics. Impact can be measured by citations, adoption of artifacts, and success of former research team members (i.e., PhD graduates.) Several citation indices help with measuring impact, but relevance is highly dependent on the area.

Comments on Development-Oriented vs. Basic Research
(Jason Cong, University of California - Los Angeles)

Professor Cong considered the question as to whether there is basic research in computer science or whether all CS research was applied and development-oriented. He defined basic research as understanding nature and discovering ultimate truth, without consideration of practical implications. This led to the conclusion that most CS research is applied, and mostly just theoretical computer science conducts basic research. However, there is much to leverage from basic research in development-oriented research through strong collaborations.

Interdisciplinary research is crucial to leveraging basic research as is broadly educating students so that they not only can innovate but also understand and appreciate basic research.

For the advancement of computer science, it is important to focus on long-term applied research – that is, pre-competitive research that will have a long-term impact when fully developed. Accomplishing long-term impact requires vision and good taste, sufficient funding, and rewards for taking risks.

Multi-Dimensional Factors in Academic Research Evaluation
(Xiaodong Zhang, Ohio State University)

Professor Zhang also discussed academic research evaluations, considering multiple dimensions. He started by emphasizing how research impacts education – that is, strong research within universities improves both undergraduate and graduate programs by updating course content in a timely fashion as well as providing research opportunities for students of all levels. Further, strong university research and education makes the university more competitive with higher recognition, attracting the strongest students and new faculty, which fuels the future.

Research productivity is typically measured by publications in refereed conferences and journals, artifacts and their adoption, patents, invited lectures, and research awards and honors. Research input is also important and is measured by proposals and project planning, grants awarded, and recruiting students and forming teams.

Research impact, on the other hand, is measured by a variety of metrics, including citations, technology transfer, patents, and useful artifacts, influence and leadership in the research community. The importance of publishing in top-tier, flagship conference and leading journals is without question. In experimental computer science it is widely acknowledged that conference papers are more prestigious, visible, and selective than most journal alternatives. Each field has is own top tier conferences and journals, with reputation defined by the research community. Evaluation by records such as the Science Citation Index should not be used as metrics guiding merit awards and promotions, as a SCI entry does not necessarily reflect the best quality in each individual research field.

Although indirectly related, research impact is more important than productivity – quality over quantity.

Professors (especially assistant professors) must establish their own identity and reputation by conducting research on focused topics in depth rather than spreading themselves too thin. A strong department will develop strong reputations in many areas/identities.

Both universities and departments or programs are ranked by a number of agencies or societies; these rankings are a reference and not an absolute indicator of quality, since rankings have in part been based on pre-existing (and sometimes dated) reputations. These rankings cannot be ignored, because university rankings affect parents of students in their decisions about where to attend college, and department/program rankings affect student and faculty recruitment.

The foundations of academic excellence include excellent educational programs and a broad research agenda conducted by excellent faculty, an excellent research and educational infrastructure along with high standards in education and research, and ambitious students who will take on future leadership roles.

Professor Zhang closed by describing some of the obstacles to establishing world-class universities in China and what would need to be changed to do so. The obstacles included:

- The limitations of the current student selection process, which is too narrowly focused on exams and knowledge rather than innovation and ambition;
- The economic development focus of research, which emphasizes mission-oriented projects with low research value rather than basic research;
- The lack of rigor in the faculty selection system, which is not very selective and does not lead to building life term scholars;
- The poor evaluation of research by currently focusing on SCI papers rather than impact as the foundation of scholarship;
- The centralized, governmental control, which limits university vision and lacking competitiveness, and does not lean toward selecting university leaders and administrators from the strong world-wide pool.

<u>An Introduction to China's Science and Technology Programs</u>
<u>(Xu Cheng, Peking University)</u>

Professor Xu presented China's main science and technology programs. While he focused on the 863 program, he first discussed a few other programs:

- The Key Technologies R&D program is formulated to carry out the central government-directed principle of sustainable economic and societal development.
- The Torch program is a guidance program for developing new high tech industries in China
- The Spark program is to promote the development of rural economy via science and technology.

The National High Tech R&D program, which is referred to as the 863 program, was launched in March 1986 to enhance China's international competitiveness and to improve China's overall capacity of R&D in high tech areas. In the area of Information Technology, topics include computer hardware and software, telecommunication, information acquisition and processing, and information security. The 863 program also covers several other areas not related to computer science. The structural organization of the 863 program was described, which consists of three government agencies, which set target, task, and make decisions, and three expert groups consulting, evaluating, monitoring and managing the areas and topics.

The 863 Program has a focus on international collaboration, which supports projects with the EU, with joint funding and researcher exchange. Some achievements through such collaborations include the development of GSM, and TDS-CDMA.

Basic Research vs. Development-Oriented Research
(Bryant W. York, Portland State University)

Professor York compared and contrasted the funding models for basic and development research between the U.S. and China. In both countries there is a pressure for social relevance of the research, which impacts how much basic research vs. applied research is funded, but research in theoretical computer science, for instance, is critical because it underlies much of the applied research that follows. Often it is difficult to decide whether a given research project or result is basic or applied, until long after its impact is felt.

The linear model of USA research and funding was sketched, showing universities doing the basic research and some portion of the applied research, with funding from NSF and indirectly form other federal agencies through programs like STTR. Industry also conducts a fair amount of applied research, and then does virtually all of the advanced developmental research and development. Industrial research is often funded by federal agencies through programs such as SBIR and STTR. Professor York provided a list of NSF Computing Discoveries in computer science and information technology (see http://www.nsf.gov/discoveries/index.jsp?prio_area=5) from being able to see the earth's biodiversity on your laptop to the grid community pulling together to battle SARS in Taiwan to improving barcode scanners leading to widespread use.

The distribution of participants in Chinese research and its funding were also sketched, with the principal funding agencies being the Ministry of Science and Technology and the Ministry of Education, the Chinese Academy of Sciences, and NSF-China. Several research institutes perform both basic and applied research, and again industry conducts applied research through development. R&D projects are one of priority, key, demonstration or guidance projects. Professor York also provided a list of information technology achievements by Chinese researchers.

Professor York ended his talk by posing several questions focused on how we could improve the funding situation for both basic and applied research. These questions included

- How can we make government leaders and funding agents understand better the importance of basic research in CS/IT?
- Can we lay out a coherent, long-range program of research that can be understood by the general public and make them aware of the significance of CS research?
- Can we develop new models of worldwide, collaborative research?
- What proportion of research funding should be devoted to basic vs. applied?
- Is CS/IT getting a sufficient share of science funding?

Panel 5: Funding Agencies

This panel focused on describing the major funding agencies for computer science research in both China and the U.S. – namely, the U.S. National Science Foundation (NSF) and the National Science Foundation China (NSFC).

Basic Research on Information Sciences Supported by NSFC
(Zhiyong Liu, National Science Foundation China)

Profess Liu described NSFC as well as the basic information sciences research supported by NSFC. NSFC was established in 1986, with an annual budget of approximately 100 Million Yuan. The budget has increased steadily to a current budget of approximately 3.5 Billion Yuan. NSFC supports international cooperation around the world through coordinated research projects as well as international conferences, science policy and academic exchange.

The Division of Information Sciences supports the following research areas: electronics and information systems, computer science, automation, micro- and nano-electronic devices, and optics and optoelectronics. Approximately $1/5^{th}$ of submitted projects receive awards. Priority areas reflect the government focus on economic development: including next generation communication, networked computation, high performance computing, advanced information processing, and new technologies and devices.

Professor Liu concluded by presenting high-level organizational charts of several large projects, including NSFCNet, CROWN Testbed, CSGrid, HEP Grid, and Bio-Informatics GRID.

Overview of U.S.A. National Science Foundation
(Wei Zhao, Texas A&M University and U.S. National Science Foundation)

Professor Zhao described NSF, which was founded in 1950 as an independent federal agency reporting to the executive branch "to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense." The NSF budget increased rapidly in the beginning (beginning with a budget of 100,000 USD in 1950), but the rate of increase slowed down markedly around 1968 (when the budget had risen to about 800 Million USD); the current budget is approximately 8 Billion USD.

CISE – Computer and Information Science and Engineering – is one NSF directorate, with an associate director and currently three divisions: Computing and Communication Foundation (CCF), Computer and Network Systems (CNS), and Information and Intelligent Systems (IIS). CISE was founded in 1986 with an approximate budget of 100 Million USD, the budget increased steadily but slowly until around 1990, when the budget increase grew dramatically between 1990 and 2001 (when the dot com boom crashed). The current CISE budget, whose increase has leveled off, is slightly more than 600 Million USD.

NSF takes a leadership role in the U.S. by focusing on long term, big impact projects, such as revolutionary infrastructure, and engaging with the basic research community.

Professor Zhao presented the GENI project, a new revolutionary infrastructure project whose goal is to reinvent the Internet.

NSF has three international offices – in Paris, Tokyo, and now Beijing – reflecting the importance placed on international collaboration with the EU and Asia.

Research Centers in Computer Science: A New Way of Doing Science
(Fred Roberts, Rutgers University)

Professor Roberts spoke about the importance of research centers as a new, very productive, way of doing research. Today's research challenges often require teams of researchers with many different backgrounds, often coming from multiple universities and often also industry and government – centers facilitate this engagement. Centers also facilitate the integration of research and education by supporting both undergraduate and graduate student participation as well as post-doctoral scholars, and also outreach activities that introduce people to the excitement of modern computer science.

Professor Roberts described DIMACS (the Center for Discrete Mathematics and Theoretical Computer Science, based at Rutgers University) and its partners and affiliates as an example, which consist of multiple universities and industrial research labs,

There are numerous major U.S. programs that encourage ambitious centers, including NSF Science and Technology Centers, Engineering Research Centers, and Mathematical Sciences Research Institutes.

Centers primarily do research on projects that would be difficult for an individual investigator or small team to accomplish. The research is often interdisciplinary and usually high risk but with high potential impact and reward. Computer science is especially relevant for interdisciplinary centers as computing is now so pervasive and affects virtually all disciplines – for instance, computational biology and epidemiology; security, privacy and digital government; and even the social sciences.

Centers also often organize conferences, workshops, tutorials, and short courses based on the expertise of the center and its members. They often have visitor programs and international partnerships and exchanges. Finally, centers are critical in dissemination of results and technology transfer.

R&D Orientation of Computer Science and Technology in Chinese R&D Organizations
(Wang Huaimin, National University of Defence Technology)

Professor Wang described the changing orientation of computer science and technology in Chinese R&D organizations. He started with two challenges – of the post CS&T era and of the CS&T revolution. In the post CS&T era, what will be critical is transitioning from technique-driven to application-driven R&D, where consumer factors will influence the technology itself and rational investment will be considered. In the CS&T revolution, the challenges are new mathematical and physical theories; mainstream CS&T education, which must be less mechanical and more exciting so that it will give birth to revolutionary CS&T.

China is currently trying to emphasize “indigenous innovation” and “leapfrogging” in research. Yet, science and technology R&D are expected to support and lead future economic growth.

The priority fields for CS&T R&D include integrated circuits, large-scale software, high performance computing, broadband wireless mobile communication, next generation networks, and network information security. The key state projects are clearly poised to lead economic development rather than basic research.

Finally, Professor Wang described the changing orientation in CS&T R&D with R&D organizations taking on more innovation in core technologies, standards, and top-end R&D and companies moving into innovation as well but continuing to emphasize product services, and production. The Chinese R&D community must face the challenges of CS&T and meet the country’s goals of cultivating competitive talents and innovative research teams.

Panel 6: Cooperation and Dialogues

<u>How to understand and cooperate between U.S.-China in CS</u>
<u>(Jinpeng Huai, Beihang University)</u>

Professor Huai spoke about how understanding and cooperation between the U.S. and China is critical for computer science in China. There is a huge demand from IT and its applications, such as e-government, e-commerce, and e-learning, on basic research. There is increasing revenue from software products in China resulting from an increasingly large industry. Taking e-government as an example, this is a huge space with 2861 counties in Mainland China with 1 Billion people, and a GDP amounting to 500.4 Billion USD.

The main R&D resources in China are NSFC for basic research and the Ministry of Science and Technology for more applied research. The industry sector is also taking on an increasing importance in funding and producing R&D, but the universities still play the leading role in China.

More than 770 Chinese universities have computer science departments, and in the past ten years, over 200,000 students are majoring in CS. With the rapid development of IT, China faces many challenges including providing better educational programs, especially improved PhD programs; playing a crucial role in innovation; and improving and evaluating abilities.

With respect to cooperation between China and the U.S., Professor Huai suggests an annual joint workshop to promote collaboration and successful cooperative innovation; a virtual U.S.-China CS Forum for Leadership through the Internet; more exchange programs; and a joint R&D program by NSF and NSFC supporting collaborative R&D.

Banquet

The Summit concluded with a banquet, where Turing Award winner Professor Andy Yao of Tsinghua University (recruited to China from Princeton) spoke about the need for Chinese role models. Professor Yao concisely summarized his experiences of returning to China by making three points: (1) There are a lot of exciting economic developments and investments in higher education and research in China. (2) The young talent pool in China for pursuing science and engineering careers is large compared with what he had observed in top US universities, such as Stanford and Princeton. (3) Many things in higher education and research management need to be improved; however, China has a promising future. The banquet also included wonderful performances by Chinese actors and acrobats.