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Probably the most important lesson we have drawn from our experiences is that it is difficult to overestimate the influence of culture in distinguishing the structure of American and Japanese approaches to teaching and research in computer science. In both Japan and the U.S., the style of teaching and research, the career paths that are taken, the available facilities, and even the topics that are taught and investigated are affected by the culture.

Among the more noticeable differences we observed are:

- The tendency of Japanese faculty to stay in a department, or even a laboratory, from the last year of undergraduate study through retirement differs from the more mobile approach in the U.S.
- The narrow focus of most Japanese computer science research programs, which is balanced at least in part by their greater willingness to accept and use outside ideas, contrasts with generally broader research programs in the U.S.
- The structural leveling of resources in general—computing equipment, laboratory space, and staff support in particular—contrasts with the wide variation across departments in the U.S.
- The marked absence of women and foreigners in the faculty and graduate students ranks contrasts with the more heterogeneous nature of departments in the U.S.
- The small number of faculty and Ph.D. students in top-tier Japanese programs contrasts with the much larger programs found in comparable U.S. universities.

These differences, even when taken together with others in the paper, still do not adequately capture the "feel" of academic computer science in Japan. The influence of Japan on computer science, as in other political, social, and scientific realms, is growing. It is essential for individuals to educate themselves about Japanese computer science in order to benefit from the work that goes on there and to understand how to improve our own efforts.

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Another source of funds is the Ministry of International Trade and Industry (MITI), well-known outside of Japan as the sponsor of such large projects as the Fifth Generation Project and Sigma. Perhaps less appreciated is the fact that relatively little of this money goes to academic researchers, since the primary purpose of MITI's projects is to enhance the industrial sector. What money does flow towards universities is very much tied to a specific project and involves cooperating with industrial partners.

Direct financial support from companies is another source of research funds. In 1990, research contracts and grants totaled 42.6 billion yen (about $300 million). Although this is apparently a significant number, it may be less than expected given the relative wealth of Japanese companies. In 1989, the average contract was for under 5 million yen (about $45,000), which is small relative to industrial grants in the U.S. A common practice is for companies to give money as a "gift" to the professor to ensure access to graduating students in his laboratory. The amounts here are relatively small, on the order of 500,000 yen (about $4500), and can be viewed as somewhat analogous to the industrial affiliates programs found in many U.S. computer science departments. Often this money is used for foreign travel, which is explicitly forbidden under *Monbusho* base funding. Companies with specific goals in mind may also provide money to professors in exchange for performing part or all of a particular project, usually as a contract rather than a grant.

Despite the generally modest level of support from industry, there are a few projects involving significant amounts of university/company cooperation. Perhaps the most noteworthy is TRON (The Realtime Operating system Nucleus), which is an ambitious distributed system project stressing interoperability in systems ranging from embedded controllers to large machines. The project started in 1984 in the laboratory of Dr. Ken Sakamura of The University of Tokyo, and has since grown into a major cooperative effort involving over 145 companies. Currently, the chief coordinating agent is the TRON Association, an organization supported by the membership fees of participating companies.

6 Conclusions

As promised, our discussion of academic computer science in Japan is anecdotal and incomplete. We do believe, however, that it accurately relates our impressions based on sabbatical stays and several return visits. We also find that these impressions are consistent with other colleagues who have visited Japan from time to time.

delays.

Although computing and networking are pretty much on par with the U.S., in other support areas, the situation in Japanese universities is generally worse. Perhaps the two most crucial have been mentioned earlier: space and staff personnel. With space, the biggest problem is quantity, although the quality is also generally below what one would find in the U.S. Lack of technical support staff to manage computer hardware and software is also a serious problem; many of the functions that U.S. university researchers take for granted are performed in Japan by professors or students. Given this lack of professional attention, computing facilities tend to be more disorganized and *ad hoc* than in most U.S. departments. For example, backups are done less systematically in many Japanese laboratories than one might expect in comparable computing facilities in the U.S.

Funding. *Monbusho* is the major source of research money in national universities. This support comes in two forms: base funding and grants. Base funding, as the name implies, is money given to each laboratory to provide a common support foundation for research. The actual amount is based on the number of faculty and students, and is essentially uniform across all public universities and all disciplines.

Monbusho has a number of grant programs, where proposals are submitted by individuals or groups of faculty and selected on merit by a review panel. In 1990 across all disciplines, *Monbusho*'s total research grant budget was 55.8 billion yen, roughly $400 million. For the standard program, proposals can be on any topic. In addition, there is a program for directed research in which proposals are solicited on specific, although widely-drawn, topics.[6] There are usually about 10-15 targeted areas at any one time across all of science and engineering, with perhaps three to five being related in some way to computer science. For example, at the current time, there are five, on such topics as decentralized and autonomous systems, super parallel systems, and concept development and knowledge acquisition. In both programs, there are multiple tiers based on the maximum size of the grant; the higher tiers with larger amounts of money are generally used to fund projects involving multiple faculty and potentially multiple institutions. Grants run for three years, and are used for equipment, supplies, travel, etc., but not for faculty salaries (since they are 12-month salaries) or, as mentioned earlier, to pay graduate students. The concept of additional funds that go to the institution for overhead costs as found in the U.S. is also absent from the Japanese system.

[6] Although theoretically an open competition, in practice, this program directs money to prearranged teams of researchers.

among other things, that the amount of research one would expect to see is proportionally less. In any case, it is our belief that in most areas, the problems being addressed and the solutions being pursued do not differ significantly between the two countries.

Facilities. General-purpose computing facilities devoted to research in Japan are very similar to what one would find in many U.S. universities. For example, use of Sun workstations and X-terminals is widespread; a line of Unix workstations from Sony called NewsStations are also very popular, both because they are generally cheaper than Suns and also because they include hardware support for written Japanese. Various other machines were seen, although less frequently; these include MacIntoshes, NeXTs, DECStations, etc. However, although the amount of general-purpose computing equipment is generally adequate, it still seems to be a notch below that available in many top U.S. computer science departments. This is especially true for those that have received significant external support in the form of DARPA contracts or NSF CER/Institutional Infrastructure grants.

A bigger difference in computing facilities at the current time seems to be in the area of more special-purpose equipment, such as commercial parallel machines or high-end graphics engines. For example, we are aware of only a few hypercube-type machines at universities in Japan. This shortage seems to stem from several factors, including the lack of financial resources needed to purchase this type of equipment in individual laboratories and the relative slowness of universities' central computing facilities to move into these areas. Although we would expect these differences to diminish somewhat in the coming years as the prices of these machines drop, the structure by which Japanese university researchers acquire equipment is unlikely to change quickly.

Network connectivity between sites in Japan, and between Japan and the U.S. has improved greatly in the past decade. JUNET (Japan Unix Network), the main research network within Japan, has been in existence for eight years and now provides sufficient connectivity to link most researchers with electronic mail and sometimes telnet-style service. WIDE (Wide Area Distributed Environment) is another network project started in 1987. It currently supports a backbone network within Japan, and has plans to expand using ISDN technology as it becomes more prevalent. WIDE is also an exceptionally valuable part of the infrastructure for collaborating Japanese and U.S. researchers, since its connection to the Internet via Hawaii has substantially improved the quality of cross-Pacific networking. We found that electronic mail to and from the U.S. was generally all-but-instantaneous; running talk and rlogin rarely showed abnormal

Implicit in this discussion is the fact that, perhaps more than researchers in any other country, Japanese choose to publish in their own outlets *instead* of more international journals or conferences. While it is difficult to determine precisely the reasons for this, several factors seem to come into play. One is simply that it is easier: there is less competition for publication since the submitting community is smaller, plus language is less of a hurdle if the journal is in Japanese, or, if it is in English, if it is refereed by a non-native English speaker. Related, but perhaps even more important, is the fact that there is usually little in the reward structure of Japanese researchers to encourage them to choose international over domestic outlets. For example, as noted above, Japanese professors have tenure upon beginning their careers and pay raises are based on length of service rather than performance. Moreover, given the greater relative importance of personal relationships in Japan, choosing a domestic outlet is actually advantageous since it strengthens ties with others in the field. This is especially important given that the professional societies are in many ways the computer science power structure in Japan.

All these factors mean that the community of Japanese researchers who actively and consistently participate in international conferences and especially journals is relatively small. They are a self-selected group who tend to be more "internationalized" (to use a currently popular Japanese phrase) than the others, and who are willing to make the extra effort necessary to compete in this more competitive arena. Moreover, this effort is usually an *additional* burden since most (but not all) of these individuals also feel it necessary to be active domestically as well to maintain appropriate professional standing within Japan. Thus, the net result is that outside researchers often lack the big picture about computer science in Japan since they tend to see only a small fraction of the results actually generated.

Comparing the quality of computer science research done in Japan versus that in the U.S. is a much trickier and subjective issue. Our own opinion is that, on the whole, computer science is probably stronger in the U.S., but that much of the work underway in Japan is better than many people realize or appreciate. For example, we saw credible efforts underway in such diverse areas as object-oriented systems, document recognition, software engineering, and complexity theory. However, making direct comparisons is a complex matter. One reason is simply the difference in organizational structure between U.S. and Japanese departments; that is, considering a U.S. department of perhaps 30 faculty, plus staff and students, against a Japanese laboratory of about three, plus students, is difficult at best. Additionally, one must also be aware when making any comparison of the fact that the size of the Japan's research community as a whole is much smaller than the U.S., especially within the university system; this means, (IEICE), to those with a more specialized mission like the Robotics Society of Japan (RSJ) and the Japanese Society for Artificial Intelligence (JSAI). In addition to sponsoring publications, these societies regularly hold technical meetings within Japan for their members. As just one example, the IPSJ has approximately 20 SIGs (Special Interest Groups), each of which holds a one-day meeting about four times a year. At these meetings, recent research results are presented, with a proceedings containing (unrefereed) papers being produced and mailed to all SIG members following the meeting. The IPSJ also sponsors more general meetings with refereed papers. The IEICE has a similar system of SIGs and general meetings. Such meetings are more broadly attended in Japan than in the U.S., in part because it is expected and in part because the smaller size of Japan makes it more feasible than in the U.S.

The level of publication activity is also high, although this fact is not widely recognized outside of Japan since many of the papers appear in outlets widely distributed only within that country. Not counting the proceedings mentioned above, a recent informal survey identified more than 20 regular journals and transactions produced by Japanese computer science professional societies and associations[JS91].[4] While most of these are in Japanese and oriented towards the domestic community, at least four are targeted for a more international audience by being entirely in English. Moreover, even those in Japanese often have information such as titles, authors, and abstracts in English that can serve as valuable research leads for non-Japanese speakers.

Despite being a potentially valuable source of information about Japanese research results, the availability of these journals in other countries is limited. As one example, consider the *Journal of Information Processing*, the English-language technical journal published by the IPSJ. As of 1989, only about 25 libraries in the U.S. subscribed to this journal, as compared to hundreds of libraries for a comparable international journal, the *IEEE Transactions on Software Engineering*. As one might expect, the problem is even more severe for Japanese-language technical journals. For example, as far could be determined, the journal *Computer Software*, which is published by the Japan Society for Software Science and Technology, is not received by even a single library in the U.S. Similarly, the *Transactions of the IEICE (D-1)* published by the Japanese Institute of Electronics, Information and Communication Engineers, is received by only one library in the U.S.[5] Improving access to these types of journals within the U.S. and elsewhere seems imperative if scientists are to be able to use Japanese research results to further their own work.

[4]There are also a significant number of periodicals relevant to computer science produced by Japanese companies.

[5]Interestingly enough, this is the library of the U.S. patent office.

can be attributed to the increasing popularity and decreasing price of higher-resolution equipment such as bitmapped monitors and laserwriters that are more suitable for the intricacies of the Japanese written language. Although modified operating systems and other software are required to handle Japanese in such an environment, this represents a significant improvement over the era of standard glass CRTs where different hardware was required as well.

Money to purchase and maintain computing equipment for instructional purposes at national universities is provided by *Monbusho*. (A small amount of equipment is donated by some companies.) A new influx of funds is provided for upgrading equipment about once every 10 years, which lags far enough behind the technology curve that at least some universities have chosen to lease rather than purchase machines outright. Also, this is a case where the "leveling" effect caused by centralized control seems to have had an impact: there seems to be less variation in the quality of computing equipment available for teaching among the different tiers of national universities than would one would find in the U.S. One consequence of this leveling in equipment (as well as in the quantity and quality of space), especially when combined with the strong tendency of students to remain at their home institution throughout their entire life, is that potential students and faculty do not seriously consider equipment (and space) in making career decisions. The group is so important, and the full professor's advice is so compelling, that resources U.S. computer scientists consider as a primary factor in educational and employment decisions are at most tertiary factors to most Japanese computer scientists.

5 Research

As in the U.S., research is an important aspect of academic life in most Japanese universities. Graduate students in Ph.D. programs are expected to produce publishable research to receive a degree, and most faculty pursue research with a fervor similar to most of their American counterparts. Here, we attempt to give an overview of various aspects of Japanese computer science research, and contrast the situation with that elsewhere when appropriate.

Level of Activity and Quality. Many signs point to the fact that Japanese research activity in computer science is significant. For example, there are a large number of professional organizations and associations in Japan related to computer science. These range from general societies like the Information Processing Society of Japan (IPSJ) and the Institute of Electronics, Information, and Communication Engineers

A Japanese undergraduate majoring in computer science becomes a formal member of a laboratory beginning in their senior year. Students apply to join laboratories based on a tour of the laboratories in the department to which they have been admitted. As already noted, if they continue on in graduate school, they will likely not only stay in the same university, but also in the same laboratory. And, if they are first-rate, they will as quickly as possible be appointed as a *joshu* in the laboratory (and then *jyokyōju*, and *kyōju*). In a real sense, then, a student bound for academia makes a lifetime choice about a research topic (and style) in the senior year. The reward for this constraint is that the group, as led by the full professor, feels an unbreakable bond towards mentoring and taking care of each new student. The professor helps arrange jobs, gives advice, and often (literally) helps arrange suitable marriages. Academics in Japan frequently identify their laboratory as well as university and department when giving their personal background.

At the graduate level, small seminars organized within a given laboratory seem the most common form of instruction. Topics of current interest are addressed, with students being required to make presentations based on papers from the literature. Many of these papers are from standard internationally-oriented computer science journals, which has the added virtue of giving students practice reading English-language scientific papers. Occasionally, the seminars themselves are also conducted in English to give students practice in English conversation. In a similar vein, it is worth noting that many computer science Ph.D. dissertations are written in English rather than Japanese, although M.S. theses are usually in Japanese. Unlike most U.S. graduate programs, there is no tradition of a breadth or qualifying exam. However, there are also requirements for publication before being awarded the Ph.D. degree; such publication takes place nearly universally in Japanese-language journals.

Computing equipment used in classes and for other educational purposes is similar to that found in U.S. universities. Unix workstations are popular, but there are also examples of DEC/VMS facilities, Convex mainframes, etc. X-terminals and Apple Macintoshes are also prevalent, although the inroads made by the latter in education seems somewhat less than in the U.S. due to their higher relative cost in Japan. The organization of facilities also seems similar to many places in the U.S., with some equipment operated by university-wide computer centers and other run by the departments specifically for their students and classes.

The fact that the equipment in Japanese universities is roughly comparable to that in the U.S is a significant change over 5 to 10 years ago when this was not generally the case. Much of this improvement right.

This lack of Ph.D. students in computer science could have serious long-term consequences, especially for Japanese universities. It is already evident that there is a significant shortage of faculty in computer science, and we heard many times how difficult it is to recruit given the small Ph.D. production in Japan. This situation is also exacerbated by competition for Ph.D.'s from industry, which can offer positions that are more attractive in terms of equipment support, salary, and surroundings. Also a factor at national universities is personnel policies that mandate faculty retirement at a relatively early age (60-63 depending on the university). Interestingly, this policy actually works to the benefit of private universities, since many professors simply take positions at private universities upon retiring from public institutions.

At the present time, most efforts to alleviate the current shortage of Ph.D.s appear to be driven by individuals rather than institutions, such as cases where professors arrange employment for students so they can stay in school. Another example is a slight loosening in attitudes on hiring foreign faculty, as evidenced by the employment of several non-Japanese at the new JAIST (East) in Kanazawa. There also seems to be some movement towards reducing the time it takes to earn the degree, both to encourage more students to enter doctoral programs and also to speed up production of Ph.D.s. The current nominal time to graduate is two years for an M.S. student and then three additional years for a Ph.D. student; rules have recently been changed at some universities to permit exceptional students to reduce this time by a year at each level, as well as reducing the time for an undergraduate degree from four years to three. Despite these steps, there is no evidence of a concerted effort to increase Ph.D. production by the Japanese government in any way analogous to that seen in the U.S. in the 1980's.

The instructional program in Japanese universities varies substantially from the U.S. model, especially at the undergraduate level. For example, a student takes more courses at a time than would be common in the U.S., which is feasible because classes usually have fewer outside obligations (e.g., homework) associated with it. Indeed, it is commonly accepted that Japanese students put far less effort into academic pursuits during their undergraduate years than U.S. students; this is due in large part to the "difficult entry, easy exit" characteristic of Japanese universities, which leads students to view the undergraduate years of college as a respite between the well-publicized rigors of high-school and corporate life. Also of interest is that, in keeping with the more formal and hierarchical nature of Japanese universities, lectures are less interactive than would be common in the U.S., with professors expounding on the topic with few if any questions or interruptions.

percent of the total student population are graduate students, compared with 15.6 percent in the U.S. The article also notes that natural science and engineering programs at both public and private universities are reporting unfilled positions for graduate students.

The reasons for the lack of graduate students are complex, but there seem to be several factors conspiring to discourage students from entering graduate school. Perhaps the primary reason is financial: there is no tradition or mechanism for awarding financial aid in the form of teaching or research assistantships as in the U.S.; neither are there fellowships from the government, private foundations, or companies. This means that many students must take part-time jobs to finance their graduate education; some find jobs within the laboratory or university acting as lab assistants or performing grading for courses, but outside jobs are common as well. The lack of aid even extends to tuition, which the students—more accurately, their parents—are expected to pay themselves.

Another factor is the labor shortage mentioned above. High-tech industries, as well as banks and insurance companies, are eager to hire students with Bachelors or Masters degrees, and often go to incredible lengths to do so during the annual student recruiting period.[3] Such incentives combine with the financial disincentives of graduate school to siphon away potential graduate students. In addition, many Japanese companies have their own training programs that give employees added education that is roughly equivalent to a Masters degree. As a final motivation for students to move to industry earlier, the added salary that Masters and Ph.D.s receive generally does not come close to compensating for the lost years of earning during graduate school.

Although these appear to be the biggest reasons for the relatively small number of students, there are also a number of other factors. One, mentioned above, is the *Monbusho* guideline limiting the number of graduate students per faculty member. Another is simply the lack of physical space. Many universities are located in the most expensive urban areas, which makes it difficult for them to expand in location to any significant degree. In fact, in the Tokyo area, *Monbusho* currently prohibits the construction of *any* additional university buildings at all due to the extremely high population density of the area. Some universities, such as Hiroshima University and Keio University, are addressing this issue by constructing new campuses outside of urban areas, but this is a time-consuming process and expensive in its own

[3] This recruiting period is intense, with officially agreed upon rules about when it starts. These rules are blatantly disregarded each year, with much hand-wringing in the press. The lengths to which companies go to recruit students from the most prestigious universities is remarkable relative to the U.S.

4 Student Population and Instructional Program

As is the case at the faculty level, the computer science student population is very homogeneous when compared to the U.S. or many other countries. For one thing, it is overwhelmingingly male, especially at the graduate level. Indeed, despite visiting a number of Japanese universities, we encountered fewer than five female graduate students; of these, all or almost all were foreign, primarily non-Japanese Asians. The exclusion of women from such professions as computer science is common in Japan, although there is now a general labor shortage that may eventually force a change in this attitude. For example, during a visit to Toshiba research and development, it was mentioned that they wished to increase the percentage of female software engineers from 10% to 20% in the medium-term future.

In addition to being male, the student population is also almost entirely Japanese, with only a small percentage of the students being from other countries. Of the foreign students, most are from other Asian countries, and it is very unusual (although not unheard of) to find Western students actually enrolled in a degree program, especially those leading to a graduate degree. (There are, of course, more Western students visiting short-term on exchange programs.) Again, however, there are signs pointing to change in this area as well; in addition to the labor shortage, the Japanese government is in the midst of a program to increase the number of foreign students in Japanese universities 20% per year until the year 2000 as part of the "internationalization" of Japanese society. Foreign students face many obstacles in Japan from financial to cultural, so it remains to be see whether this goal will actually be reached.

Another characteristic of the student population in graduate programs is that there are generally fewer students than in the U.S. This is especially true at the Ph.D. level, where a laboratory with two or three faculty may have only five or so Ph.D. students.[2] For example, in the computer science department at one major national university, there are currently 25 Ph.D. students and six *kōza*, giving an average number per laboratory of slightly over four.

Viewed internationally, the small number of graduate students is even more extreme. It was recently reported [Shi92] that only "eight out of every 10,000 citizens enroll in graduate school [in Japan], compared with 71 in the U.S., 29 in France and 22 in Britain." The situation is similar even when viewed within the context of the Japanese university system: the same article reports that only 4.8

[2]We are excluding so-called "paper degree" Ph.D.s, that is, industrial scientists and engineers who are granted a Ph.D. based on papers they have published over the years. These Ph.D.s have little or no interaction with the faculty and thus add no significant load.

“Why do you do that?” The focus on the promotion of the “group,” in this case the home laboratory and university, is so strong in Japan that the potential benefits of exposure to other people and ideas is not considered as important as in the U.S.

Other noticeable differences between American departments and Japanese laboratories include the near total absence of women and foreigners as faculty members. Although we did not conduct a formal survey, it is clear that the percentage of women in faculty positions is far less than the 10% figure commonly cited for U.S. computer science departments. This is not likely to change significantly at least in the short- and medium-range future, in part because there also appear to be very few Japanese women who have received or are about to receive a Ph.D. in computer science in Japan. Also, there are no affirmative action programs and no societal or university pressures to increase the number of women (or minorities), as in the U.S.

With the exception of visitors such as ourselves, there are essentially no foreign faculty in Japanese universities. It was recently reported that, as of 1989, there were seven non-Japanese tenured faculty in any discipline whatsover at all national universities in Japan[Gel90]. Of these seven, several are second or third generation Japanese emigrants who have returned to Japan. Many universities, including prestigious Kyoto University, have a faculty code that prohibits the tenuring of foreign faculty. Kyoto University justifies this in part by stating that the rule increases internationalism by guaranteeing increased turnover among foreign faculty. One indication that these attitudes may be loosening somewhat is the hiring of a number of foreign faculty for the new computer science department at JAIST (East) in Kanazawa.

A final difference between U.S. and Japanese professorships is the pay scale. In Japan, all faculty in all disciplines and at all national universities are paid on the same schedule that takes into account both rank and time in service. Although making comparisons is difficult due to differences in tax laws and benefits, our estimate is that computer science faculty of equivalent rank and seniority get paid perhaps a third less in Japan than in the U.S. In addition, consulting is officially prohibited in Japan, in contrast to the U.S. This might in part account for the weaker ties between industry and academia in Japan, since consulting often leads to grants and contracts in the U.S. The smaller pay is compensated for at least in part by the high prestige of professors in Japan. And prestige cannot be overrated in importance in a country such as Japan where personal interactions and social hierarchies are so critical.

at the same university in a closely related laboratory, it requires the highest personal recommendation from a close colleague at another, preferably more prestigious, university. Although a shift like this away from a person's home university may seem to contradict the basic Japanese notion of lifetime employment in a single job, it is most often viewed as simply a stepping stone for a later return.

Full professor positions open when people retire, die, or move to a full professorship at their home (and usually more prestigious) university. When such a position does open, it is common for the associate professor to be promoted. The other most likely candidates are those originally from the laboratory who hold positions either in other universities or else in other laboratories at the same university.

Full professorships are also created when new laboratories are created. This has happened relatively frequently in the recent past in computer science. The two newly created JAIST universities represent cases where not only laboratories, but entire departments, are created from whole cloth. New laboratories are filled top-down. That is, the full professor is hired first, then the junior positions are filled under the full professor's control. The structure for filling such full professorships is not entirely clear, but the candidates' pedigree is, as usual, of key concern. In the case of the JAIST universities, political issues are also important: in particular, the new faculty is expected to represent a collection of influential universities (and in some cases companies and national laboratories), although perhaps not in an entirely balanced way. Even the fact that there are two JAIST universities represents a political balance between the east and west regions of Japan.

It is not too unusual for a position, especially a full professorship, to be filled with a person from industry. As with the other situations, the person who is hired is almost always a former student from the hiring university. In contrast to the U.S., where movement from university to industry is significantly more common than from industry to university, in Japan movement of faculty from academia to industry is exceptionally rare.

The ramifications of these approaches to appointing and promoting faculty is that inbreeding is significantly higher, in general, in Japan than in the U.S. At the student level as well, the best undergraduates are kept on as graduate students and the best graduate students are kept as *joshu* or sent to other laboratories or universities from which they can later return. Indeed, when one of us gave an informal presentation comparing computer science undergraduate and graduate student life in Japan and America, it was stressed that most U.S. departments and faculty encourage their best students to go elsewhere for both graduate school and also initial faculty positions. One question from the Japanese audience was, faculty member—a previously unheard of situation in Japan—a conflict arises that is difficult to resolve.

3 Faculty Career Paths

As mentioned above, the hierarchical faculty positions in a Japanese university laboratory are the full professor (*kyōju*), the associate professor (*jyokyōju*), the assistant professor (*kōshi*), and the assistant (*joshu*). Each of these is a tenured position, consistent with the lifetime employment structure that is prevalent in Japan.

The way in which faculty positions are filled differs greatly from the American system. In particular, open competition is rare in practice if not in theory. That is, full professors have nearly complete control over who they hire into the other positions in their laboratory. Officially, the appointments and promotions must be approved by the Department, the Faculty, and the President; *Monbusho* must also approve appointments to *kyōju* and *jyokyōju* (but not *kōshi* or *joshu*). It would be extremely rare, however, for the recommendation of a full professor to be overturned. One reason is that each full professor is considered to be autonomous; another is that overturning a decision would cause severe embarrassment to the full professor, an action that is to be avoided at almost all costs in Japan; and a final reason is that, in part to avoid embarassment, the full professor will generally take responsibility to discuss the potential appointment or promotion at great length with other faculty members, who could make any concerns known far earlier than during any formal vote. These last two reasons, of course, hold true in the American system; however, the degree to which they hold differs significantly in the two systems.

In general, professors select their own former students for openings whenever possible. Often, these individuals are already in a more junior position in the laboratory, resulting, for instance, in promotion from *joshu* to *jyokyōju* or from graduate student to *joshu*. In other cases, a full professor might hire a former student who currently holds a position at another university. If such a student is at a lesser university, then they can be kept at the same level; for instance, a *jyokyōju* at any university in the country can be brought into The University of Tokyo as a *jyokyōju*. If such a student is moving to a lesser university, this decrease in prestige must be compensated with a promotion, for instance from *joshu* to *jyokyōju*. Indeed, the *kōshi* position exists largely to add flexibility in this dimension, permitting moves to “lesser” universities with a compensating promotion to *jyokyōju*.

In cases where a person is hired who is not a former student of the full professor or of another professor system. For example, as the head of a *kōza*, a professor has many of the powers and responsibilities usually associated with department chairman elsewhere, including control over financial resources, computing equipment, admissions, etc. (There is a department chairman selected from among the *kyōju*, but the job seems more organizational than administrative and certainly seems to hold less "power" than in the U.S.) This modified role is, of course, a mixed blessing, since along with the increased authority typically goes an increased administrative workload. The prestige associated with the post also means that the individual is also expected to serve on numerous Faculty, University, and government committees and advisory panels, hold posts in Japanese professional organizations, etc. Compared to full professors in U.S. universities, these responsibilities are extraordinarily hard to avoid.

Perhaps a more serious consequence is that the *kōza* system tends to narrow the focus of the laboratory's members to just the activity underway in that laboratory. For example, research collaboration between members of different laboratories is rare at many universities, and even formal social activities tend to be associated with a single laboratory. While this has the positive effect of allowing more time for in-depth investigations of the given subject area, it also means that there is far less collaboration and interaction with other members of the department than is common at U.S. universities. The net result is that there is somewhat less breadth of vision, especially among students, than there would be in the case of a typical U.S. department. It can be argued, however, that this potential problem is lessened because the Japanese seem less plagued by the NIH (Not Invented Here) syndrome. That is, they are perhaps less likely to be aware of a key concept or technology, but when they learn about it, they are far more likely to take full advantage of it.

Monbusho sometimes allows new universities to change the traditional *kōza* structure. A few of the newer universities in Japan are even organized without *kōza* at all. Perhaps the best-known of these is the University of Tsukuba in Japan's "science city" north of Tokyo. There, instruction and research are administratively separate, with the latter being performed in 26 research institutes. The one involving computer science research, the Institute of Information Sciences and Electronics, has approximately 50 faculty members. This program is also of interest because it caters in part to returning students who have been working for a number of years. This notion, which is very common in the U.S., is an entirely new concept in Japan. Returning, older students at the University of Tsukuba present an interesting problem in the Japanese language. Students address professors using a polite form of Japanese; similarly, younger people address older people with the same polite form. When an older student addresses a younger

As far as staff is concerned, the normal complement for a laboratory is quite small, consisting perhaps of a single secretary. The services of this person may even be divided among the personnel of two or more laboratories at some universities. Of particular note is that, unlike many research-oriented computer science departments in the U.S., there are usually no technical support staff, even at the top-tier Japanese universities. The duties that one would associate with such a position elsewhere are handled by the *joshu* and graduate students as a matter of course. The relative lack of staff support has also been noted in Japanese government laboratories doing work in computer science[Kah90].

Each laboratory is associated with a given subject area, which is the formal focus of the research performed by its members. For example, the topic areas for the chairs in the Department of Information and Computer Sciences at Osaka University are

Information Theory and Logics
Computing Mechanisms
Programming Languages
Intelligent Information Processing
Analysis of Information Systems
Information Network Architecture
Computer Aided Engineering
Software Development
Knowledge Bases Engineering
Intelligent Information Systems

Note that this department is unusual in that the number of laboratories is significantly above the usual complement of six. The last laboratory, Intelligent Information Systems, is in fact a gift laboratory for visitors, funded for three years by a company. This and other time-limited laboratories may have different internal structures than conventional laboratories. Notice also that the topic areas are very generally drawn. (Indeed, the correlation between the title and the actual work done in the laboratory is frequently small.) One implication of this is that the degree to which the research within a laboratory is actually coordinated or focused on a more narrow area can vary widely. For example, in some laboratories, all faculty and students work on one project or a collection of closely related projects; in others, a junior faculty member may be more free to pursue his own interests, which may in fact be very different from that of the chair holder. Which of these models is followed seems to depend mostly on the style of the chair holder, with a secondary influence being the tradition at the university.

The prevalence of the *kōza* system within Japanese universities has some interesting ramifications. One is that it enhances the role of the full professor relative to a person of similar seniority in a non-*kōza*

Kōshi, *jyokyōju* and *kyōju* are usually translated as Assistant Professor, Associate Professor and Professor, respectively, although the equivalences to the American ranks are not exact. In practice, the *kōshi* rank is used infrequently in comparison to the other three ranks. Progression through the ranks depends not only on seniority and age, but also the availability of openings at the succeeding rank. This contrasts with most state universities in the U.S., where it is not necessary for a qualified faculty member to "wait for a slot" before promotion is possible. Even at U.S. private universities, which often have a limit on the number of tenured positions, junior faculty do not have to—or are not permitted to—wait arbitrarily long for a promotion.

Unlike the U.S., each department in Japan is further divided into relatively autonomous laboratories or "chairs" known as *kōza*, with six being the standard number of *kōza* per department at top-tier national universities. This additional administrative level, which is based on the German educational model, tends to give a department a much different character than that typically found in the U.S. This difference comes from the laboratory serving as the focus of much of the intellectual and social activity rather than the department, and is magnified by the greater relative importance placed on the group in Japanese culture.

Each laboratory is headed by a full professor. This person acts not only as the administrative head of the unit, performing many of the same functions as a department head in the U.S. system, but also as the leader who sets the tone and style of the laboratory. In this latter capacity, he—and they are virtually, if not literally, all male—serves as a mentor to the other members of the laboratory, which include junior faculty, graduate students, and advanced undergraduate students. This role even extends to the point of being responsible for finding positions for graduating students. Consistent with Japanese culture, this control is exerted to turn the laboratory into a cohesive group in which individual achievements are downplayed and overall productivity is stressed.

The number of people associated with a laboratory varies, but is usually specified to be within a fairly narrow range by *Monbusho* and university rules. Most commonly and traditionally, a laboratory has one *kyōju*, the chair holder, one *jyokyōju* or one *kōshi*, and two *joshu*. The number of students is also proscribed by a formula based on the number of faculty in the laboratory and their rank. For example, a full professor may be restricted to one post-M.S. Ph.D. student per year, for an average of three at any given time; numbers for junior faculty are correspondingly fewer. It is not clear to what degree these guidelines are enforced.

represents a significant departure from the current educational structure in Japan, and a potentially risky move in a country where the tradition is for a student to remain at the same institution from the start of the undergraduate curriculum until the completion of graduate school. JAIST (East) will contain two departments, computer science and materials science; computer science will begin enrolling students starting in April 1993, with the start of the materials science program being one year later. JAIST (West) will also contain two departments, computer science and bioscience; computer science students will matriculate in April 1994.

Japanese universities are generally organized around Faculties, which are analogous to our Colleges. As in the U.S., computer science departments can be found in a variety of Faculties. For example, at Tokyo Institute of Technology, computer science is in the Faculty of Engineering, while at Osaka University, it is in the Faculty of Engineering Science. (Curiously, Osaka University has a Faculty of Science, a Faculty of Engineering, and a Faculty of Engineering Science.) There can sometimes even be multiple departments doing computer science within a single university. For example, at Tokyo Institute of Technology, there is also a Department of Information Science located in the Faculty of Science that focuses on various topics in computer science, operations research, and mathematics. Additionally, to an even stronger degree than in the U.S., individual professors in non-computer science departments may work in computer science; for instance, a professor from a chemical engineering department with expertise in chemical processes will soon move to a computer science department to investigate software processes.

One organizational difference between the Japanese and U.S. system is that the Deans and the university Presidents in Japan are elected by the faculty, in contrast to being appointed as in the U.S. There is reason to believe that this difference makes Japanese universities somewhat more conservative and slow to change relative to U.S. universities[Ros90].

Departments in Japan are, of course, composed of faculty, staff, and students. The primary faculty ranks are, from junior to senior, *joshu*, *kōshi*, *jyokyōju*, and *kyōju*. The literal translation of *joshu* is "assistant", but the position is perhaps more akin to a postdoctoral or research associate position in a U.S. university in its duties rather than an Assistant Professor. For instance, *Monbusho* rules prohibit a *joshu* from teaching a class, although this rule is often honored in the breach. Although a *joshu* is technically not a faculty member, the holder does, in fact, gain tenure upon initial appointment. In general, *joshu* hold Ph.D.s either on appointment or soon after.

engineering disciplines, Tokyo Institute of Technology is often added to this collection to give a group of eight top universities. Of these eight, The University of Tokyo is usually considered the best overall, with Kyoto second, and the rest roughly comparable. Computer science is well-represented at all of these schools, as well as at many other national universities.

The Japanese university system has a number of characteristics that distinguish it from the system in the United States. One, which is consistent with much of Japanese government and culture, is the strong central control exercised by the Ministry of Education (*Monbusho* in Japanese). The primary funding for both teaching and research at national universities comes from *Monbusho*, and the ministry regulates any number of things related to university life, including staffing levels, pay rates, numbers of students, building construction and maintenance, etc. Major programmatic changes, such as the institution of a new degree, must also be approved at this level. The influence and power of *Monbusho* is similar to that of state legislatures over state universities throughout the U.S., but far more extreme. The effects of such centralization are significant. For example, it enforces a uniformity among programs and facilities uncommon in the U.S., even among related universities such as those within the University of California system. The centralization also generally increases the amount of time and effort required to undertake new initiatives.

Surprisingly, *Monbusho* also has significant control over private universities as well. Such universities get a substantial portion of their funding from the central government and are subject to many of the same rules despite their lack of formal government affiliation.

As a discipline, computer science tends to be strongest at the eight top-tier national universities and a few of the private universities, notably Keio. In addition, there are several new and novel programs related to computer science have recently been initiated despite the generally conservative bent of Japanese higher education. One is a new program by Keio University called Environmental Information Engineering, which emphasizes the integration of computers with daily life. Faculty are drawn from such fields as cognitive science, ergonomics, etc., as well as from computer science.

New computer science programs are also being initiated in conjunction with the creation of two new institutes called the Japan Advanced Institutes for Science and Technology (JAIST). One, known as JAIST (East), is located in Kanazawa on the Sea of Japan; the other, JAIST (West), is located in Nara, near Kyoto. These schools, funded from *Monbusho* with significant support from industry and the prefectural governments, are oriented exclusively towards graduate education and research. This months at Osaka University. During that period, he conducted joint research with Japanese colleagues, gave lectures, participated in seminars, etc. He also visited a number of other Japanese universities, as well as such companies as Fujitsu, Hitachi, IBM, Mitsubishi, NEC, NTT, NEC, Sony, SRA, and Toshiba. Funding came in part from sabbatical pay from the University of Washington and in part from endowed positions held at the two Japanese universities; these positions were funded by Toshiba Corporation and SRA, respectively. Richard Schlichting's sabbatical was spent at Tokyo Institute of Technology from December 1989 through July 1990. Like Notkin, Schlichting participated in the ongoing professional life of the university, in his case by conducting joint research, teaching a short undergraduate course in distributed systems, and participating in seminars. He also traveled extensively throughout Japan, visiting approximately 20 companies and universities, ranging from Hokkaido University in the north to Kyushu University in the south.[1] His salary came through the normal sabbatical program at The University of Arizona, with funding for travel and living expenses provided by a grant from the U.S. National Science Foundation.

One final caveat is in order. Given that we were visitors and hence isolated from much of the inner workings of Japanese universities, these views are necessarily those of outsiders. We apologize in advance for any misconceptions we may promulgate, and thank our Japanese colleagues for sharing much of the information contained in this paper.

2 Japanese Universities

Universities in Japan are either public or private. Private universities, as the name implies, are not formally affiliated with a governmental unit, but rather are sponsored by a private organization or foundation. Perhaps the best known in this category are Keio University and Waseda University, both of which have their primary campuses in the Tokyo metropolitan area. Public universities, on the other hand, are associated with a governmental unit. A few are affiliated with prefectures (roughly equivalent to states in the U.S.) or cities, but by far the most important are the universities sponsored by the national government. Within this group, there are multiple quality tiers. The top-tier consists of the seven "Imperial Universities" that were founded prior to World War II: The University of Tokyo, Kyoto University, Osaka University, Nagoya University, Kyushu University, Hokkaido University, and Tohoku University. In the

[1] Trip reports from many of these visits can be found in [Sch91].

1 Introduction

Despite the association of Japan with high technology, most Western scientists know very little about computer science in Japan. Many factors contribute to this phenomenon, including language and cultural differences, a shortage of readily available information, and a degree of technical chauvinism. The problem is aggravated by a general lack of the kind of long-term individual contacts between computer scientists that one often sees, for example, between researchers in Europe and those in the U.S. This remains the case despite concerted efforts both inside and outside of Japan to increase scientific exchange through various government initiatives.

In this paper, we attempt to address part of the problem by presenting some impressions of computer science in Japanese universities. Our goal in doing so is simple: to provide an informal portrait of the discipline as practiced within universities in Japan in the hopes that this will lead to enhanced awareness and increased interaction. In painting this portrait, our focus is primarily on what might be called "structural aspects" of computer science in Japan. That is, rather than describing the specifics of computer science coursework or research projects, we instead attempt to highlight the way in which computer science is organized and pursued in universities. Accordingly, we address such issues as departmental organization, student population, funding, research activity, and computing facilities, with an eye towards contrasting the situation in Japan with that in the U.S. We make no pretense of this being a systematic or complete survey, but rather offer it as a collection of informal, but perhaps still enlightening, observations. This paper can also be viewed as augmenting and updating earlier papers on computer science research in Japan [Kim83, Sto84]; although some of our observations agree with points made in those papers, it is evident that the discipline has evolved in the intervening years.

Two factors influenced our decision to concentrate on computer science in universities at the exclusion of Japanese corporations. One is simply that, as noted below, our personal contacts have been primarily with Japanese university colleagues, so we are most familiar with that arena. The other is that we perceive a greater need for information in this area; computing activities in Japanese companies receive greater attention in both the popular and technical press, and, although corporations undeniably account for a larger share of such activity than in the U.S., the work done in universities in still significant and deserves notice.

The observations in this paper are based primarily on sabbaticals that the authors took in Japan. Starting in June 1990, David Notkin spent three months at Tokyo Institute of Technology, followed by nine

Computer Science in Japanese Universities [1]

David Notkin[2]   Richard D. Schlichting

TR 92-13 [3]

Abstract

This paper presents some impressions of computer science in Japanese universities based on the authors' sabbatical visits. The focus is primarily on such structural aspects of the discipline as departmental organization, faculty and student populations, funding, research activity, and computing facilities. Perhaps the key observation is that Japanese cultural practices influence the way in which computer science is approached in Japanese universities to a larger degree than might be imagined.

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[3]Also available as University of Washington technical report TR 92-04-02.