

DRAFT

UNIVERSITY-INDUSTRY COOPERATION; Examples from the US

INTRODUCTION

This report will attempt to review a small part of the University-Industry cooperation in the United States. It will be limited to the cooperation in the Information Technology area, not because this is the more important economic growth area in the US, although it currently is, but due to the limitations of knowledge of the reviewer. There are large and productive relations between the US Research University, the Life Sciences and the Pharmaceutical Industry. In 1995, it was reported that “ninety percent of companies with significant biomedical research interest had relations with academic institutions”. (NRC 1999) The University-Industry cooperation in IT considered here are but a small subset of the many cooperative efforts at nearly every major university in the US.

No review of University-Industry cooperation can be done without considering the role of the government funding of curiosity driven research. (Here I will use the categories of curiosity driven and need driven research as first described by Don Stokes (Stokes 1995) rather than the usual fundamental and applied research. It is a much better description and with over 40 years of experience in R&D, I am unable to tell the difference between applied and fundamental research). In the US, the bulk of the longer range or curiosity driven research is supported by the federal government, although in some states like California and New York, a larger role is being played by local governments. The R&D budget in the US in 2005 was about \$350 billion. One third of this funding is from the Federal Government and the bulk of the remainder is funded by industry. Since the late twentieth century, nearly all of the longer range research is government funded. Industry, meanwhile, has moved more of its funding into product development. (Rosenbloom and Spencer) This is due, in part, to global competition and the disappearance of US companies with dominant market

share. This also makes the cooperation with the university more attractive to industry and often results in additional industry funding to the university. Industrial research funding in universities has dramatically increased in the last two decades and today represents about ten percent of the total academic research base, in the US.

The area of government-university-industry cooperation has been extensively studied by the US National Academies. There is a group, Government, University, Industry Research Roundtable (GUIRR) that has conducted a number of meetings and written numerous reports on this activity, their web site is with the National Academies web site.

<http://www7.nationalacademies.org/guirr/>

The federal government funding of research is dispersed among many agencies. While the National Science Foundation plays a major role in physical science and engineering research funding, the Department of Energy, the Department of Defense and the Department of Commerce through the National Institute of Standards and Technology all play a role in research funding. This diversified base makes the funding a complex process but tends to keep any single agency from being dominant and generally leads to more stability in funding. However, there has been a concern over the last decade that government funding is focusing more on short term results and less on longer range research and that there has been a decline in funding for the physical sciences and engineering. This has been especially true in the Defense spending and the long term role that DARPA has played in university funding.

While the US universities are playing an increasing role in R&D, it is broadly believed by industry and government that the principal role of the university is the supply of well trained graduates. This is an area that the US universities have done exceptionally well in the last fifty years. Students from around the world are attracted to the US schools. Today nearly fifty percent of the graduate degrees from US universities are granted to foreign born students. Taiwan has benefited by having some of its key scientists and engineers obtain their training in the US and some spent several years in US industries before returning to Taiwan. This has been true for many nations and has resulted in a positive transfer of learning and capability worldwide. It is the strong belief of the author that the primary role of the university remains the production of qualified graduates and research, funded either by the government or private industry, should support that mission.

The fundamental work done in industry has led to the transistor, the integrated circuit, the laser, magnetic memories, liquid crystal devices, software programming environments, the graphical user interface, Ethernet and other key discoveries and developments that are the foundation of the information technology industry of today. With the decline in the great industrial laboratories of the US (Rosenbloom and Spencer), that responsibility for new inventions and innovations will, I believe, move to a cooperative effort between universities and corporations with the help of governments in funding this research.

EXAMPLES FROM INFORMATION TECHNOLOGY

Information technology (IT) is a major global industry today. Here I will include semiconductors, communications, computers and software. Even with this focus, it will be possible to consider only a small subset of the university-industry cooperation that has contributed to this large industry. IT is close to a two trillion dollar industry world wide. The first section covers Network Systems and Communications. The second, the semiconductor industry which is the technology underlying most of the productive gains in communications and computers, then the Berkeley Wireless Research Center, a more traditional cooperation between Industry and the University with some innovative ideas on intellectual property (IP) and finally a short section on University start-ups.

NETWORK SYSTEMS AND COMMUNICATIONS.

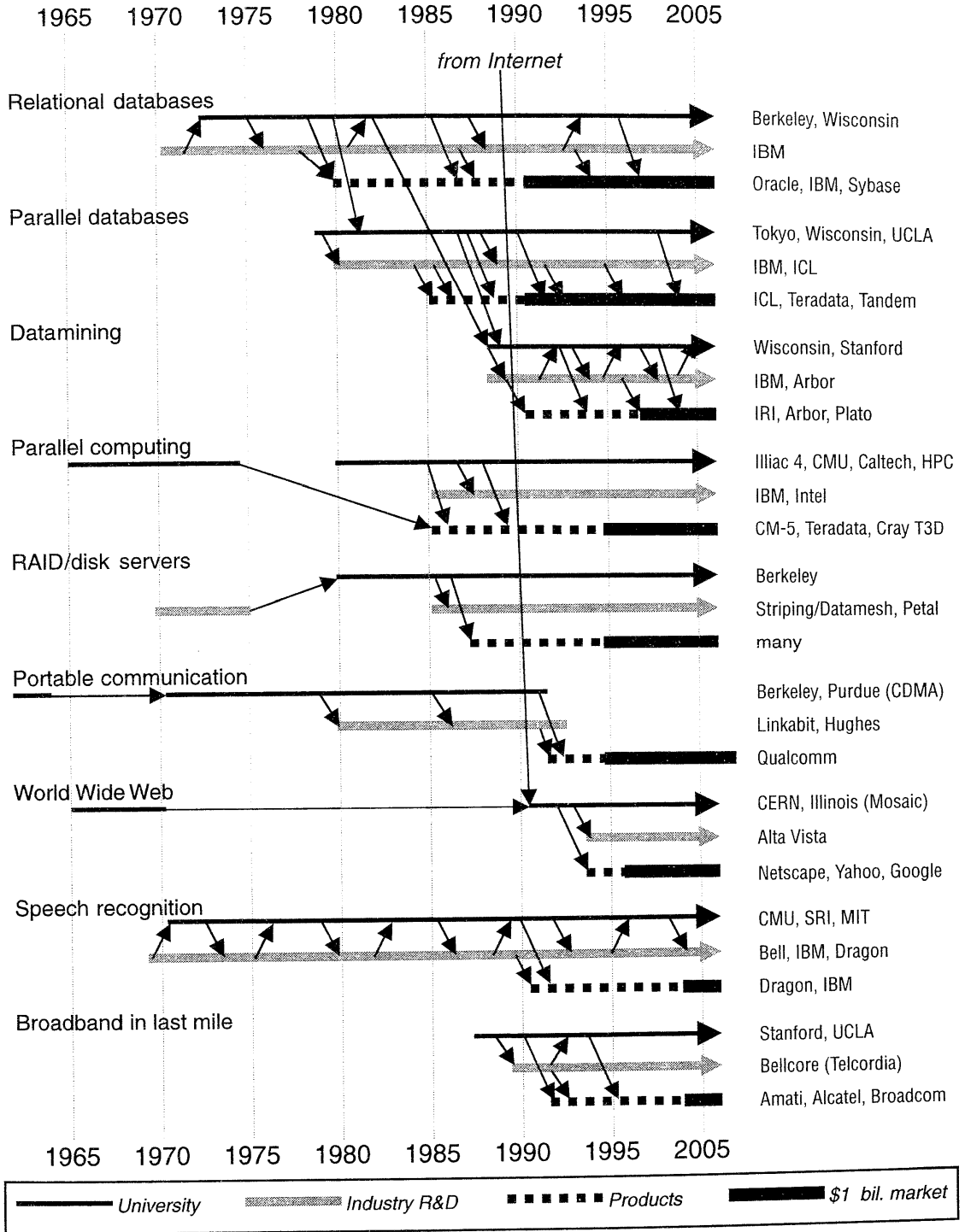
The bulk of this section is based on a 2003 study by the National Research Council (NRC) titled “The Impact of Academic Research on Industrial Performance”. (National Academy Press, 2003) The study covers four other industrial areas in addition to Network Systems. These include Aerospace, Financial Systems, Medical Devices and Transportation. Network Systems and Communications is a broad area covering telephony, the Internet, communication equipment and the associated services to these technologies. The prior two decades have seen substantial growth, over 15%

per year, in this industrial sector. The deregulation of the telephone system in the US and other economic regions has led to the rise of a number of new companies as well as substantial growth in the more established areas.

The innovation in the area of network systems, and often in other high technology areas, does not follow a linear path from research to development to manufacture and then to the market (Spencer 1989). The process is often complex and may involve several organizations before becoming a market product. The next figure follows several of the key technologies for over forty years from the earliest demonstration to a one billion market product (NRC 2003). The narrow lines represent research in universities, the next broader lines that done in industry and the final dotted and heavy lines when a technology becomes a product. The lines and arrows illustrate the progress of various technologies that are part of the network systems and communications market today. In some cases, such as speech recognition and relational databases, the initial research occurred in industry and was then picked up in universities. In other cases, the initial work was in universities and later moved to industry and then to product. The chart shows only those ideas that became billion dollar business, there were many that resulted in smaller markets and of course many failed to reach the market at all.

Although it is not explicitly shown, the government played a large role in the development of many of these technologies. Funding from DARPA, the DoE, and other parts of the DoD were key to the early and in some cases the later development of these products. This was especially true in the development of internet protocols and the early networks themselves.

The principal point here is that the interplay between the three areas, the university, the government and industry was key to the success of the network systems and communications area. Where early development was almost entirely in the Bell System, much of the later work was done in universities and new companies. The other point is that this type of innovation takes many years to provide a product return. Often it is more than a decade between a new idea or invention and any product to be marketed.



SEMICONDUCTOR INDUSTRY.

The semiconductor industry was born at Bell labs almost 60 years ago. It was the result of need driven research to replace the vacuum tube in telecommunications. The industry got another boost in the late 1950's when the integrated circuit was demonstrated independently at Texas Instruments and Fairchild Semiconductor Labs. While the early research was done in industrial labs, the early markets were supplied by the federal government and especially the US Department of Defense. Universities also played a key role, especially the Electrical Engineering and Computer Science (EECS) Department at the University of California at Berkeley in the development of computer modeling and design. An important point in the Berkeley development was the open nature of the work leading to the results being widely available and a new industry, computer aided design (CAD) developed.

The worldwide sales of semiconductors reached \$168 billion by 2000 and has continued to expand at double digit growth since then. The industry is very cyclical and suffers times of depression as well as rapid growth. This has not kept the industry leaders from funding university research for several decades. The US Semiconductor Industry Association (SIA) founded the Semiconductor Research Center (SRC) in 1982 to fund university research and to provide a source of well trained graduates for the industry. The funding for SRC has grown to over \$30 million by the 21st century. In addition, the SIA has expanded the research to include specific technologies since the late 90's. The first of the MARCO centers were focused on design at Berkeley and interconnect at Georgia Tech in Atlanta. The centers are expected to be expanded further to include other key semiconductor manufacturing technologies. The MARCO centers are jointly funded by the semiconductor industry, the semiconductor equipment industry and the federal government. The final budget is expected to be over \$50 million per year.

SEMATECH was founded in 1987 with an initial budget of \$200 million, half from the US semiconductor industry and half from the federal government. The government funding included an agreement that \$10 million would be spent at universities. This resulted in ten centers called SEMATECH centers of excellence (SCOES) being established at leading US universities. This provided some additional research effort, but more importantly, it lead to industry-university cooperation and the exchange of faculty, students and industrial scientists and engineers. Several faculty

spent sabbaticals at SEMATECH and there were summer and Post Doc jobs for students.

The semiconductor industry, in the US and other economic regions, has been a leader in university-industry cooperation. Often the cooperation included the federal and state governments as partners in funding. An example of state funding is in the SEMATECH center for lithography at the State University at Albany in New York. Often the local governments play an important role in providing tax benefits or support for the local industry to cooperate with the local university. This was an one aspect of SEMATECH moving to Austin Texas. Close relations have existed between SEMATECH and the University of Texas in lithography and personnel exchange.

BERKELEY WIRELESS RESEARCH CENTER.

This industry-university cooperative research center is located near the University of California at Berkeley Campus in downtown Berkeley. Information is available at bwrc.eecs.berkeley.edu. It was started in 1999 and has currently about 60 graduate students, eleven faculty and funding from Industry and the Federal Government. The full members include Intel, ST_Microelectronics, Infineon, Hitachi, Sun, Cisco, Agilent and Conexant. There are also nine associate members and the government funding comes from DoD/DARPA, National Science Foundation, Office of Naval Research and MARCO (a semiconductor industry research consortium).

One of the aspects of the cooperation is the open intellectual property (IP). Research results are quickly published. There are few patents and those that are granted are available to all members. This has removed one of the major stumbling blocks to industry university cooperation in the past.

The research is wide ranging and covers many aspects of wireless communication and the products, software and technology associated with the wireless industry. Industry engineers spend time at Berkeley and many of the faculty have consulting arrangements with member companies. Recent publications, meetings and current research activities are available at the center's web site.

UNIVERSITY START-UPS.

No discussion of university-industry cooperation would be complete without some mention of new companies that might grow out of cooperative

research usually with the bulk of the employees coming from the university faculty and students. Here, I will limit my brief comments to two schools, Berkeley and Stanford. This is not to exclude the effort in many other parts of the US, but only because that is where my limited knowledge lies.

The Xerox Research Center in Palo Alto (PARC) had close ties to several departments at Stanford after its inception in 1970. Many faculty worked part time at PARC and there was a broad exchange of students as well. In fact, one start-up, Silicon Graphics, did the development of their first silicon chips in the fabrication center at PARC and did the testing there as well. Several PARC employees also left the company in the late 70's to take some of their ideas to start-ups and other companies.

Some of the notable start-ups from Stanford include Google, Silicon Graphics, Sun, MIPS and many others. Some of these companies were later bought by existing companies and many went on to become large employers and develop major market share.

The University of California at Berkeley, as earlier mentioned, played a major role in the development of computer aided design of integrated circuits. This led to start-up companies like Cadence and Ingress. In addition, there were many other new companies. These included Chiron, Inktomi, NanoSystems and others.

The ownership of IP was often a major issue when the research was partially funded by industry. This has led to difficult negotiations of research contracts and is perhaps the biggest stumbling block to university-industry cooperative research efforts. Each university and industry has its own policies for IP. This further complicates the issue. The government role was clarified with the Bayh-Dole Act, which awarded the IP to the federally funded research organization.

CONCLUSIONS

The examples chosen to illustrate cooperation between universities and industries, often in partnership with the federal and/or state governments offer several lessons that might be useful in Taiwan. Again, these examples come from the information technology industry and lessons from the life sciences cooperation may well be different.

First, the principal role of the university is the training of graduates. Any research cooperation must be in support of that mission. Fortunately, most government or industry funded research is in areas where jobs are available and support the education of graduates. The semiconductor industry has

been an excellent example of funding university research in support of well trained graduates.

One of the major barriers to university-industry cooperation is the ownership of IP. In every negotiation that I have witnessed, be it by a single company or a group of companies, the ownership of IP has taken the most time and often leads to the most controversy. The Bayh-Dole act has made ownership of research results clear for federally funded research. I believe the process established by the BWRC is an example of how this problem can be resolved to the benefit of both industry and the university. Patents are rare and when granted are freely licensed and research results are published quickly.

Often cultural changes in both the university and the industry are important in any cooperative effort. The industrial changes are more profound in my experience than those in universities. Industrial employees often do not see the benefit to their career to spending time at a university. This exchange of people is the better way for any technology developed to be taken to the market. Today's university faculty and students are more closely aligned with industrial culture than those of the past.

The Berkeley Wireless Research Center brings many of the requirements necessary for productive cooperation together. Industrial employees spend time in Berkeley. Students and faculty in the center work at industry during summers or on sabbaticals or as Post Docs. IP is freely available and the advantage the center industrial participants get is access to the technology early and to students and faculty.

Another approach to improving the university-industry cooperation in Taiwan is to form partnerships with US universities. In 2005, 14 junior year students from NCTU spent a semester at the University of California at Berkeley's College of Engineering. The program was considered a success at Berkeley. The involvement of President Chang of NCTU and Berkeley's Dean Peter Wu made this experiment possible. Secondly, having Taiwanese companies participate in US university-industry programs, is another way to gain experience with cooperation and bring these lessons to local universities. It is important to remember that the government plays a key role in funding these types of experiments. There have also been discussions between Berkeley and NTU on possible cooperative efforts as well.

The example established at ITRI is another model of industry working with a research laboratory. The research here has resulted in many new companies in Taiwan and provided employees and IP to existing companies. ITIC played a role in funding some of these new companies.

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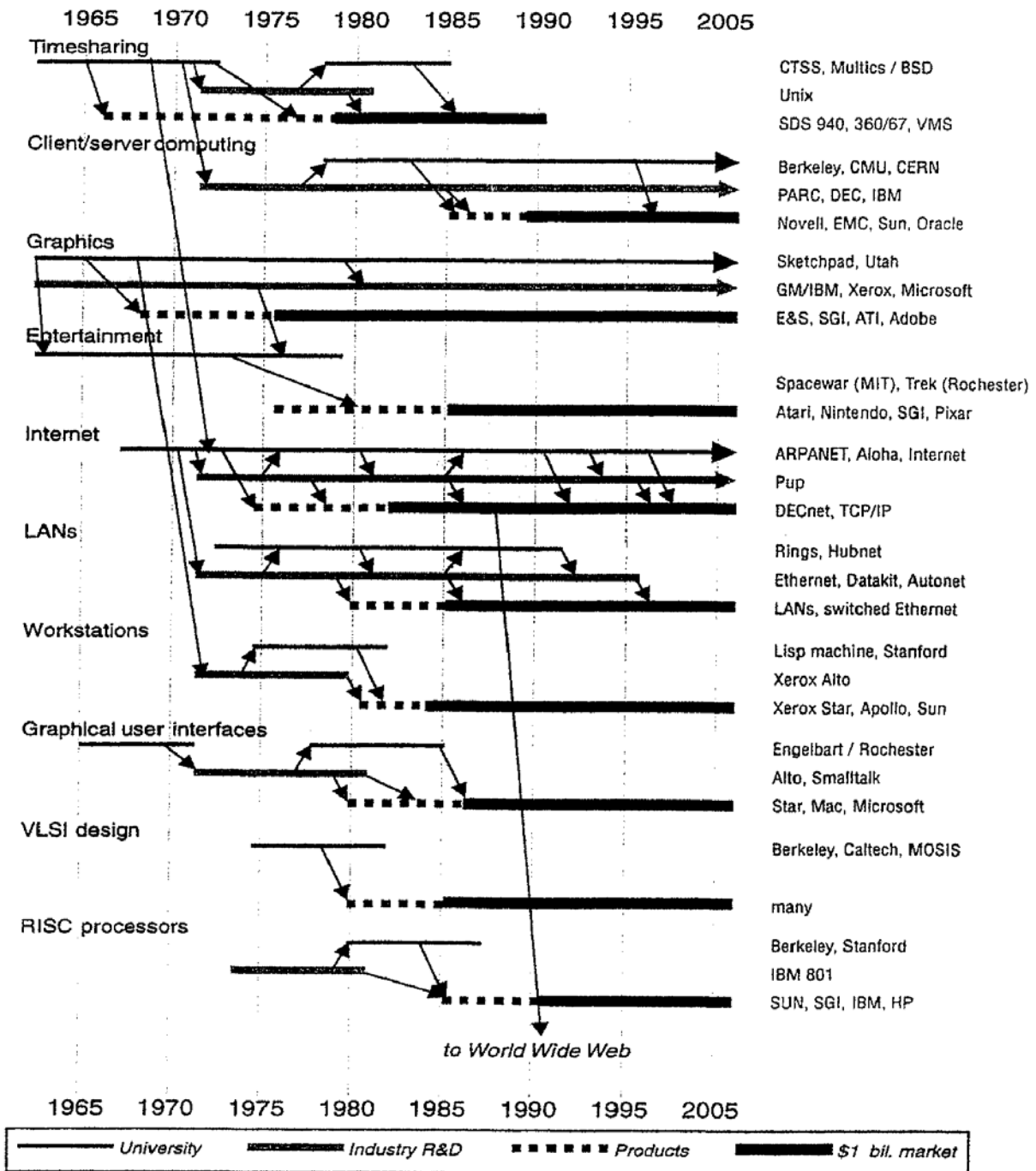


FIGURE 2-1 Examples of academic government-sponsored (and some industry-sponsored) IT research and development in the creation of commercial products and industries. Source: NRC, 2003.

