INTELLECTUAL PROPERTY CREATION, PROTECTION AND DISSEMINATION IN UNIVERSITY-INDUSTRY-GOVERNMENT RESEARCH COLLABORATION

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ABSTRACT

There is nothing that can be more contentious, more emotionally charged, and time consuming than resolving intellectual property access and ownership issues in industry-university research collaboration. On the other hand, if approaches with well-defined objectives, with a balanced perspective on approaches that have worked and failed in the past, and if negotiated by parties that understand and represent the objectives and their relative priority, relationships can be established in which all parties benefit significantly. From a university perspective, a key objective must be to *maximize the overall impact of the research*—through the research community, through industry where appropriate, and upon the world. Industry is always concerned about *having access to the research they sponsor* in a way that they can use the results most effectively. Government has a priority to *maximize the effectiveness and the overall benefit of such investments* for the state or nation, and for the public they serve. Note that none of these objectives refers explicitly to financial return! Using examples from my own quarter century of experience at Berkeley and in Silicon Valley, I will suggest approaches that can achieve these respective goals in an open and mutually beneficial way.

INTRODUCTION

I would like to thank the Academy for their invitation, it's a great opportunity to attend this meeting and to speak with you today. It is clearly difficult to speak at the very end of a two day conference, and just after lunch, and on the topic of intellectual property protection! First, just about everything has already been said. There are many, many interesting topics that came up in the last two days and I wish to compliment every one of the presenters—I have certainly learned a lot over the last day and a half!

This morning I snuck in a couple of additional view graphs, to comment on—or at least to add a little bit of food for thought on—one of the topics that came up yesterday, specifically the role and importance of 'disruptive technologies' in the evolution of technology today. I'll begin with that, then I'm going to present what might sound like some bragging about the College of Engineering at Berkeley but the reason for doing that is to try to paint a picture of what I consider to be a very successful operation with respect to technology transfer and intellectual property policy. I'm going to use that as a lead in to the conclusions that we have drawn after twenty five years of interaction and partnership between government, industry and our university campus.

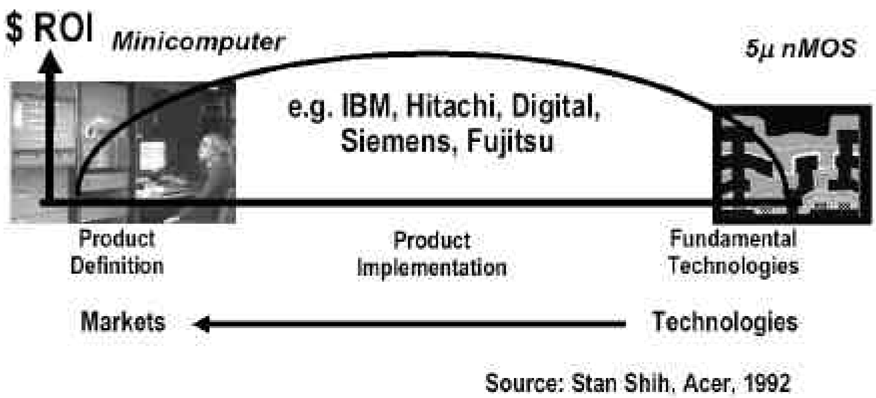

Figure 1: Value Creation in Product Development: 1970's—1980's

Back in 1992 Stan Shih, the founder of Acer and one of the icons of the electronics industry, introduced us to what has come to be known as the 'Stan Shih Smile'. He drew a progression of technology development from fundamental technologies on the far right in Figure 1, all the way across to products and markets on the left, and he said that to a first approximation technologies flow from the right-hand side of this diagram to markets on the left. Stan went on to say that twenty or thirty years ago, if you plotted on that spectrum the return on investment (ROI) you achieved for every dollar you spent in that range of possible investments, it roughly approximated the curve shown in Figure 1 and computer companies like IBM, Hitachi, Data General, Digital and Siemens were the fundamental implementers of that particular curve. On the right-hand side everyone pretty much had the same semiconductor technology—e.g. 5 micron nMOS[1]. And on the left-hand side everyone was pretty much delivering the same product—a minicomputer. Whether it was Digital or Data General or IBM, the value accrued to the company that had a first-class team of scientists and engineers that could take that basic technology and deliver it to the market in the form of a minicomputer most

[1] Or advanced bipolar technology if you were at IBM.

effectively, most reliably, and with the needs of the next generation of customers in mind. The differentiated value was in the design team.

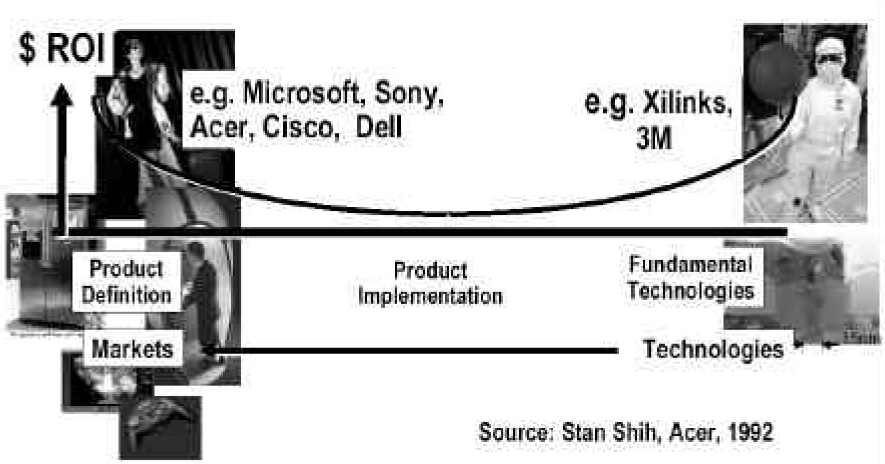

Figure 2: Value Creation in Product Development: 1980's—2000's

Stan then pointed out that somewhere in the last fifteen years or so this curve actually flipped and now looks like the curve shown in Figure 2. He points out that on the far right there, we have companies like Xilinks. 3M and others that accrue a lot of value by creating and protecting basic technologies and who defend those technologies vigorously in commercial challenges. And on the far left we have companies that have been very successful in the marketplace, such as Microsoft, Sony, Cisco, Dell and his own Acer. These companies based their significant success not on a particular proprietary or breakthrough new technology, but on building the right assembly of existing technologies, into the right products at the right time. Their initial success was as much about new models of distribution and support, new approaches to user interaction or perhaps technology-as-fashion. I refer to these successes as pioneering *new business models*—using that term in its broadest possible interpretation.

Yesterday we heard a great deal of discussion about the Clayton Christiensen term, *Disruptive Technology*, popularized in his best-selling book *The Innovators' Dilemma*, that represents a form of contribution made on the far right of the figure above. I use this figure in presentations that I give to Silicon Valley entrepreneurs, to many vice presidents of engineering, where I argue that in today's world I believe we actually have a lot of innovative and potentially disruptive technology on the far right there today. Of course, we need to keep that engine cranking! But what we really *need* today, and where the major short-term opportunities lie, is on the far left—we need new and *disruptive business models*. We need people thinking about markets in innovative and new ways and delivering and supporting the 'right configurations' of technology to those markets in ways that create large amounts of sustained value. We should be thinking a lot harder about how to deliver high-value services via low-cost, reliable, supportable digital communication systems, for example.

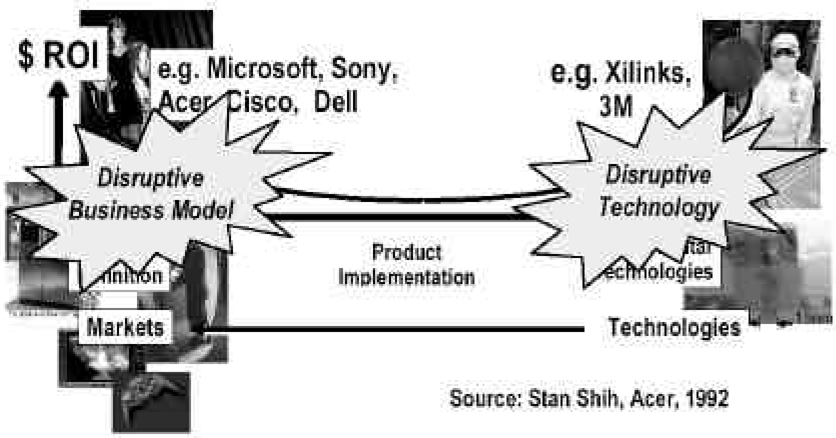

Figure 3: Disruptive Technologies or Disruptive Business Models?

And in fact what I'm going to argue a little later in this presentation is that it's actually the *spectrum between the these two ends* that is critical. Today, the fundamental and new information and communications technologies we develop should be developed and delivered to the market with a *particular business context or application domain in mind* and one that should ideally be represented by a disruptive business model on the far left.

ENGINEERING AT BERKELEY

That is what I added to my presentation this morning and now I'm going to brag about Berkeley Engineering for a few minutes. Berkeley's College of Engineering has always been ranked very highly in national surveys for its contributions in both research and teaching. For example, in the latest survey of engineering colleges from *U.S. News and World Report*, Berkeley's College of Engineering is ranked equal with Stanford and just behind MIT at the top of the national rankings. We have a distinguished faculty, seventy six of whom are members of the prestigious National Academy of Engineering—more members of the NAE than the sum of all other UC campuses in the UC system combined, and more members than any other college of engineering in the United States, including all the privates.

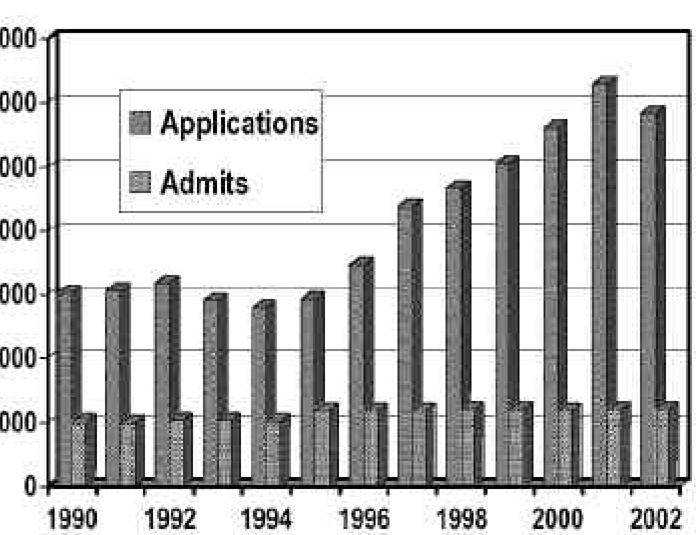

Figure 4: Undergraduate Applications and Admissions in the College of Engineering

What about our students? As an example, the plot above shows qualified undergraduate applications and admissions our college of engineering over the past ten years. As you can see, there is a very strong demand for our programs at Berkeley and there are many students we would love to be able to take that we can't.[2] We often hear about shortages in students applying to engineering and the sciences, but we certainly do not see that at Berkeley and I believe that this has a lot to do with the very strong reputation of the institution—the 'branding' of the institution and the importance that reputation plays today in decision making now for young people.

Our graduate programs see even greater demand, where 38% of the 2002 admissions are foreign students representing 18 countries, and 82 undergraduate institutions worldwide. In fact, at Berkeley we choose to limit the number of qualified foreign applicants admitted because we are a public institution and are supported in part by California tax payers, who fund approximately 30% of our annual operating budget in the College. The remainder of our budget is provided largely by federal grants and contracts and by industrial gifts in support of research. However, the quality of the foreign applicant pool is extremely high, there's no doubt about it, and many of the major private institutions in the United States admit a significantly higher percentage of foreign applicants than we do today.

By any and all measures, Berkeley has without any doubt the most highly-ranked engineering college of any US public university, and is up there with the very best of the privately-funded schools as well.

So why am I telling you so much about Berkeley Engineering's reputation today? I'm saying all this because I will argue later that *the reputation of our institution is critical to its continued success and well being in the long term,* and *how we manage our intellectual property is very strongly related to the creation and preservation of that reputation*. First and foremost, well ahead of any other consideration, the most important element of any policy regarding the dissemination of our research in order to enhance our reputation must be to *maximize the real impact of our work*, the impact that the institution has on the world in terms of its output. Its output in terms of the quality of its students and what they do; its output in terms of the quality of its research and the positive impact that research has in the world; and its output in terms of the service that is performed by the faculty and the students for government agencies and other organizations.

Just to mention a few of the research contributions that have come from Berkeley: **Berkeley Unix**, that led to the workstation generation and helped launch companies like Sun Microsystems, and eventually to Linux; **Relational Database Technology**, invented and developed at IBM, but virtually every other relational database company in the world with the exception of Oracle was founded by, or developed substantially by Berkeley students and faculty; and **Electronic Design Automation** (EDA).

This is my own area of research and I left Australia back in 1975 to go to the PhD program at Berkeley. I just happened to meet an American professor in the computer center at Melbourne University on a Saturday morning in 1971, who had a problem with an early EDA computer program. Not knowing who he was, I walked up to him and said, "Can I help you?" I did help, and he liked my

[2] The dip last year is a direct consequence of the Dot-Com problem—students are wary of computer sciences. We saw an even greater increase in the number of graduate school applications—students are less eager to look for jobs in ICT right now!

contribution to the open-source computer program he was developing at the time called SPICE, today still the most successful, high-impact computer design aid in the electronics industry. Berkeley SPICE or a derivative is still used extensively in virtually every integrated circuit design company on the planet. Last year I counted more than twenty-two text books that have SPICE in their title. A dozen companies have been formed around this technology. Hundreds of millions, if not billions, of dollars of value have been created around the program and from Version 1A, developed in 1969, *SPICE has been completely open source and remains so to this day, available free of charge and without restriction to anyone in the world who wants to use it*—in fact, you can download it from our website any time you want. We only ask two things of our users (but we do not insist):

(1) **Do not charge any third party for the program we give you**.[3] If you modify it, you can charge $1 million for the lines you added if you like, but make sure you tell people you are not charging for the software that you obtained for free from the University of California, Berkeley.
(2) **Please acknowledge that this software was developed initially at the University of California, Berkeley** and give us the credit for the work that we've done and the value we have provided to you.

SPICE was one of the first significant open source programs to be developed and distributed widely, and the chance I had to work with SPICE in Melbourne certainly attracted *me* to the graduate program at Berkeley a few years later. As a faculty member at Berkeley, I have co-founded a number of EDA companies based directly on other Berkeley research in EDA. Two of them—Cadence Design Systems and Synopsys—today represent over US$2 billion in annual software revenues, a market valuation of over US$6 billion, about 9,000 jobs throughout the world, and together these companies own about 60% of the world wide EDA marketplace. *Both of these companies were based on freely available software*, provided free of charge to anyone who asked for it from the University of California, Berkeley and developed by my students and a number of my EDA faculty colleagues.

Other major impact Berkeley ICT developments include **Reduced Instruction Set Computers** (**RISC**—named by Berkeley Professor David Patterson), popularized and co-developed with Stanford; **Redundant Arrays of Inexpensive Disks** (known as **RAID**), a $23 billion industry last year, where the name RAID and the fundamental paper on this topic was coauthored by Berkeley professors Randy Katz, David Patterson, and their students; **Networks of Workstations** (**NOW**), a fundamental contribution in cluster-based computing led by professors David Culler and Eric Brewer and leading directly to companies like Inktomi (Brewer was a founder). Not every high-impact contribution leads to a company—**IEEE Floating Point**, developed by Berkeley CS Professor William Kahan and for which he won the prestigious Turing Award, has been shipped on over US$1 trillion of computers to date. *The priority is always the impact of the work.* **Infopad**, the forerunner to today's wireless WebPad and Tablet PC; we've also invented the **smallest transistor in the world**, **the FINFET**, with a 10nm gate length and our **Micro-Electro Mechanical Systems (MEMS)** research is another area where we've pioneered many, many developments. For example, if you drive a car with an airbag system, the chip that decides when to release the airbag uses a MEMS structure developed at Berkeley and made available to our industrial partners. Today, Boston-based Analog Devices is the company most likely to have built the chip in your car.

[3] SPICE project leader Professor Don Pederson's personal view back in those days was that the program was developed using public funds (originally from an Army Research Office research award) and so we should do our best to maximize the benefit to the public.

Berkeley faculty are *fundamentally motivated by high impact research* and that, I would argue, is why they are at Berkeley and not at not at a private research laboratory like SRI, or a telecom lab, or a start-up and I'll come back to this point later.

A major research initiative being undertaken at Berkeley right now, one that Professor Hume alluded to this morning, is our California Institute for Science and Innovation called **CITRIS**[4]. Started two years ago now as a result of the leadership of State of California legislature, CITRIS stands for the **Centre for Information Technology Research in the Interest of Society.** Along with our university partners at UC Davis, UC Merced, and UC Santa Cruz, the CITRIS goal is to take all of the things we've invented in information technology research and apply them to tough societal problems. Those problems will evolve over time and I'll tell you a little bit about some of the one we are tackling now in a moment. The State of California committed $100 million towards a building for our CITRIS institute. In fact all of that money must be spent on capital projects and, as Professor Hume said, we had to raise an additional pledged match of $200 million to present a viable proposal to the State competition. We were able to do that—in fact, in a five month period we had our friends in industry, our colleagues and others pledge over $200 million of matching money over a four year period. Why were they so generous? Because of the *clear reputation of our College, our faculty and students for impact*, because the s*cale of this research project is one that they themselves could not duplicate*, and because of their gratitude for all of the work we have made available to them in the past. The creation of this institute is a clear consequence of our policies on intellectual property and its wide dissemination.

CITRIS involves over 90 faculty from 21 university departments and more than 30% of these faculty are not in the College of Engineering. We have lawyers interested in privacy and security law, we have sociologists like Manuel Castells, who wrote a very impressive book called *The Rise of the Network Society*, working with us on this. We have people from the business school heavily involved, the Goldman School of Public Policy—all of these people are working on this project because it's about applying technology to improving the quality of people's lives. Frankly you can't only let engineers work on something like this, because all they'll do is make life more complicated for everybody, as we know—more unfathomable remote-controls!

As was mentioned as very important yesterday by Lord May, while the focus of this particular effort is on core technologies like distributed information systems, micro sensors and actuators, human computer interaction and so on, the entire body of work is motivated by applications and for us these applications involve improving the quality of people's lives. Of course, all of that could not happen if it wasn't for a solid foundation—the theory—in areas like security, policy, probabilistic systems, formal techniques and so on. It is the combination and interaction among these three areas: core technologies, applications, and fundamentals.

The applications we are working with initially include such topics as energy efficiency, transportation planning, monitoring health care, lifelong education, land and environment, and disaster mitigation and response—including detection and response to potential large-scale terrorist threats. These are all part of the CITRIS research agenda—applying information and communication technologies to these very difficult problems.

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[4] http://www.citris.berkeley.edu

Each one of our ten Founding Corporate Members (FCMs) of CITRIS committed $6 million over a 4 year period, a total of US$60 million from those companies to work with this Institute. We also received US$120 million of commitments from high net worth Californians, typically people who had benefited personally in the past from the intellectual property that was produced at the university. *I can assure you that if we had attempted to license that intellectual property and draw money from that licensing, we would not have got anywhere near this level of commitment for the CITRIS project.* The commitments we have for this work far outweigh anything we could ever have achieved by licensing our technologies to corporations, unless of course we happened to be incredibly lucky! There is no doubt in my mind, nor in the minds of any of my colleagues in engineering at Berkeley, that our policy of openness in our ICT research—which leads to a demonstrated maximizing of the impact of our research on the US economy and in the world—is also what leads to the *maximum payback to the university* on its private, state, and federal investments in research.

INTELLECTUAL PROPERTY: MAXIMIZING IMPACT

Not one of these partner companies is interested in owning or protecting or taking control of any of the intellectual property generated in this Institute. To the extent that we can possibly do it, all of the intellectual property that will be developed in this particular project will be made available to everyone—anyone who wants it, not just our sponsors—free of charge. In fact, in this activity our FCMs, including Intel and Microsoft, went *out of their way* to ensure the work we develop is open and available to all. Of course, being FCMs they have the ability to have staff on the campus, in the lab, and can benefit directly from early and deep access to the ideas and technologies we generate—CITRIS is designed to be a true and close collaboration with industry and government. Some of our sponsors have referred to our role at Berkeley as creating a 'DMZ of research,' where they can actually collaborate with competitors on these long-range, high-risk (potentially high payoff) research projects, providing critical visibility to potential future directions and possibilities for technology, and so a context for their own long-range planning.

Engineering is a discipline of practice—we simply *must* go out there and work closely with industry. Technology transfer in information and communication technologies almost always occurs via people transfer. It almost never happens effectively in any other way and in fact that transfer is essential to the university to enhance its visibility, its resources, and improve the reputation of the College and the university.

Now, there are of course some challenges; when faculty are involved in these relationships we lose time from instruction and research and there are all sorts of possible conflicts with students as well that we have to deal with and each of these we've dealt with over the twenty five years that we have collaborated with industry. We have developed approaches to these problems from the bottom up, as they have arisen, and at Berkeley Engineering we believe that the techniques we use work quite well in this regard.

Almost all of the sponsored projects we take on in the College of Engineering have multiple sponsors. In all almost all cases, if you wanted to you could find a work-around the specific research artifacts developed in our research programs. In our experience, protecting and limiting access to the intellectual property in ICT is a losing proposition. As you can see from the CITRIS example, many millions of dollars have flowed to the campus following these projects in support of faculty and their research in what we refer to as a "tradition of support" that comes from companies and individuals that have benefited from their open access to what we have provided. For these reasons, our mantra in the College of Engineering at Berkeley is: **"Seed billion-dollar industries, not kilo-dollar licensing."**

In summary, the basic principle that I would like to leave you with in terms of any discussion regarding intellectual property in the context of a university (the arguments might be different for a privately-funded research corporation like SRI or CSIRO), is that one must be clear that the **primary motivation must be the development of a strong institutional reputation and brand by maximizing the impact of research**. The first thing we say is don't *ever mention* the word 'dollars' in IP discussions, because as soon as you do, you're on your way down into a tarry pit that you'll never escape from! *It's about maximizing impact, not about dollars.*

In ICT the impact is usually maximized by making the technology feely and openly available to as many people as you can—we believe we have demonstrated that over the past quarter century of experience, as have others. However, in the biological sciences for example, if I invent a new and potentially beneficial molecule, to take that molecule to the market successfully in the form of a new drug and so maximize its impact on the world might cost an industrial partner over US$200 million. If I made my research widely available, no one would invest the money to take the drug to the market because their competitors could do it as well, and so the impact of the university research would be compromised. So in that particular case it probably does make sense to provide an exclusive license to a particular company (with a strong performance clause, of course!), again to ensure maximum impact for the research. In each case, the choice of how to handle the intellectual property is different but the goal is the same—enhancing the reputation and productivity of the institution by maximizing the impact of the research.

On the corporate sponsor side, want most sponsors want is to maximize access to the results of the work that they're sponsoring. In certain areas maximizing the access for everybody is best achieved by making the work as widely available as possible. And part of the reason for that is that these companies often don't want their own internal intellectual property positions compromised by some protection happening in a context that they don't control, one that might overlap some of their own intellectual property positions later. Therefore, it is *also often better for the sponsor if the work is made open and widely available.* Of course, that access must also include consideration of background rights and all of the other things that are the responsibility of the university, as well as our legal obligations under the tax code, and so on.

What we're talking about here is often not about what you get and what you protect—it's not about *property* and *ownership*—it is better referred to as an *openness agreement*, because what it actually does is it defines the boundaries that protect the rights and responsibilities of both the university, in terms of its tax free status, and on the corporate side, in terms of making sure that there's no reach through from the university. That is, avoiding a situation where the university might be able to get rights to the sponsor's intellectual property. In the end, in information and communication technologies, the best policies all around are ones that encourage openness and fair access for all. Thank you very much.

<u>QUESTION AND ANSWER SESSION</u>

"Dean Newton, what is the proportion of women students in your engineering school and how do you see the role of diversity in maximizing the impact of your work?"

Well, let me say that since we started CITRIS, with its societal goals and improving quality of life, we have more women students in the College of Engineering than we have ever had in the history of our college (over 24% women students today) and we also have more women faculty in the College (as a percentage of the total faculty) than any other major engineering research university in the United States, perhaps with the exception of MIT because they hired a large number of women faculty last year. This result may not be directly related to CITRIS, because we've been working on achieving such a goal for a while, but I have a feeling CITRIS has certainly helped.

We believe at Berkeley that a large part of the reason for our success is our diversity, both in our student body as well as our faculty: cultural diversity, economic diversity, diversity in all its forms—we are a large public university—and we're working very, very hard to sustain and continuing to enhance that diversity. The challenge for us, and it was mentioned earlier, is that it now costs a student (or a parent!) over US$30,000/year for a student to come to Berkeley. That is a very large number! Its not our fees—we are relatively inexpensive in that regard—but just *living* in Berkeley and paying for food and rent and so on, costs about US$30,000. In fact, without securing a large number of means-tested scholarships and fellowships, I believe that cost is a large impediment for us in terms of maintaining that diversity. This is actually a problem I am very concerned about as Dean.

"You speak about maximizing the impact of the research, and of course for the examples you site much of that impact was only visible in hindsight, many years later. How do you feel one should measure impact—quantify the performance of your research programs—in this regard?"

I thin k the gentleman who spoke from the CSIRO yesterday had it right, when he proposed some alternatives in terms of those measures. It's not just about papers published, number of students produced, patents filed, and so on. I think you can look at metrics like *jobs created* (by the creation of companies around the intellectual property), *total market values*, or *revenue* on the business side. We count over a trillion dollars worth of companies that we can tie directly back to the Berkeley College of Engineering in terms of that contribution over the past fifty years, in terms of that form of value that's been created for society.

On the other side, there are the societal return-on-investment issues, which I think are equally important. If you visit the Berkeley College of Engineering web site (www.coe.berkeley.edu) it says our role in the world of higher education, as we see it, is to: **Educate Leaders, Create Knowledge, and Serve Society.** The 'serving society' goal is one that engineering programs often loses sight of, and we should all come back and emphasize this aspect a bit more. There are many non-tangible returns there, through lives saved for example, Many, many years ago at Berkeley, we invented the Ground-Fault-Interrupter (GFI). How many lives have been saved as a result of the fact that the power is shut off automatically when there's a leakage current to ground through a person in contact with a live electric power line? Thousands? Tens of thousands? All of these sorts of measures can be approximated, and when we do that I believe a very compelling case can be made about the tremendous impact that university researchers, working in an open environment, have on the world. The value is there, the investments—from all of us—are truly worth it.

BIOGRAPHY

Richard Newton received the B. Eng. and M.Eng.Sci degrees from the University of Melbourne, Australia, in 1973 and 1975 respectively, and the Ph.D. degree from the University of California at Berkeley in 1978. He is currently Dean of the College of Engineering and the Roy W. Carlson Professor of Engineering at the University of California, Berkeley. He has been a Professor in the Department of Electrical Engineering and Computer Sciences at Berkeley since 1979, where he has been actively involved as a teacher and researcher in the areas of design technology, electronic system architecture, and integrated circuit design.

From 1998-2002, he was the founding director of the MARCO/DARPA Gigascale Silicon Research Center (GSRC) for Design and Test. An industry-university-government public-private research collaboration with an annual budget of US$8M, the GSRC coordinates the research of more than thirty faculty, eighty graduate students, a dozen postdoctoral researchers, and many industrial collaborators to tackle some of the design and test problems for integrated silicon systems that will face chip designers 6-12 years from now.

In addition to his academic role, Professor Newton has helped to found a number of design technology companies, including Cadence Design Systems, Simplex Solutions, Crossbow, and Synopsys, where he has rejoined the Board of Directors. Since 1997, he has also been a member of the Technical Advisory Board of the Microsoft Research Laboratories.

From 1988-2002, he served as a Venture Partner with the Mayfield Fund, a high-technology venture capital partnership, where he has contributed to both the evaluation and early-stage development of over two dozen new companies, including Silicon Light Machines, now a part of Cypress Semiconductor, and where he was the acting President and CEO during 1994 and 1995.

Dean Newton is a member of the ACM and a Fellow of the IEEE.