

Lawrence Rabiner

Leadership—Some Random Thoughts

I have been fortunate to have had a seven-year association with the Massachusetts Institute of Technology (MIT) (as both an undergraduate and graduate student), a 40-year association with AT&T (first at Bell Labs and subsequently at AT&T Labs Research), and am only now embarking on what I hope will be a long and successful career in academia at Rutgers University and at the University of California at Santa Barbara. During this tenure, I have learned a few things about how to succeed in engineering and how to be an effective manager and leader, and it is my goal to share some of what I have learned with you.

A brief description of some of the key parts of my career will lend context to my subsequent discussion on personal work programs and leadership. I went to MIT in the fall of 1960 without the slightest indication of what field I would choose for my career. I was most interested in mathematics (like virtually every freshman accepted into MIT) and was hoping for a career in this field. That was before I met people who really knew mathematics and could grasp concepts that were well beyond my capabilities. It was then I learned the difference between loving mathematics as a tool that enabled you to solve problems and loving mathematics as a way of life. The former became engineers, and the latter were the true mathematicians of the world. I, of course, was the former.

Hence I joined MIT's electrical engineering program in my sophomore year and applied for the cooperative program to gain some practical experience. I applied to several companies and was accepted in the Bell Labs Cooperative Program where I spent four assignments learning about designing computer interface circuits for Telstar, doing simulation studies on Nike-X reentry vehicles to see if we could distinguish warheads from dummies that were sent up as diversionary tactics, and working on experimental verification of a theory of binaural hearing that explained why two ears were much better than one in being able to perceive speech in the presence of interfering speech and noise. Ultimately this last assignment became my master's thesis under Dr. Nat Durlach at MIT and the supervision of Dr. James Flanagan at Bell Labs.

I continued graduate school at MIT, working with Prof. Ken Stevens on problems relating to machine synthesis of speech. My Bell Labs advisor, Jim Flanagan, remained a coadvisor on my doctoral research and provided me with summer jobs at Bell Labs. I finished my Ph.D. dissertation in May of 1967 and immediately began work at Bell Labs on a permanent basis—again working for Jim Flanagan on problems in speech analysis, synthesis, and coding.

My earliest work at Bell Labs was in the area of digital signal processing (DSP), a field that was evolving and growing rapidly. I became involved

with virtually every aspect of the field from filter design, to spectrum analysis, to system implementation.

The next phase of my career involved using DSP to develop advanced speech processing systems

The author of this article has had long leadership roles in creating signal processing research as we know it today, as well as our Society, from their early stages. Larry Rabiner writes that engineering leadership has two necessary conditions—namely a sense of how to achieve excellence in individual contributions and how to create strong teams that can work together and get things done. He describes his thoughts about leadership based on what he has learned in a 40-year technical career at AT&T and most recently in academia. His article is presented in three sections, the first outlining individual achievements in his own career, the second discussing some important things he has learned about individual excellence and achievement, and the third discussing some key factors for success as a manager. In his view, the most important attributes for successful leadership are individual excellence and strong managerial talents.

—Arye Nehorai
Leadership Reflections Editor

including those based on temporal representations, spectral representations, and model representations, such as linear-predictive coding methods. A wide body of theory as to design and analysis of these systems evolved.

The last phase of my original research at Bell Labs was in the area of speech recognition systems. By the late 1970s, methods for processing speech signals had become both extremely sophisticated and easy to implement in either hardware or array processing software. Thus it became practical to look at ways of representing speech so that it could be reliably and efficiently recognized by machine. This work, which initially utilized simple pattern recognition technology, evolved to statistical methods based on hidden Markov modeling. Ultimately the performance of these speech recognition methods became good enough that they began to be used in services, often with millions of daily users. In particular, AT&T utilized simple speech recognition in a service called voice recognition call processing (VRCP), which automated so-called operator-assisted calls and enabled machines to reliably handle collect calls, person-to-person calls, third-party billing calls, reversed billing calls, and operator-assisted calls. This application was introduced into AT&T services in March 1992 and very rapidly grew to handle 1.2 billion calls each year with word accuracies of close to 100% (actually about 99.8%) and with less than 1% rejection of input speech. The VRCP system ultimately saved AT&T close to US\$360 million a year in displaced operator and supervisor costs.

As a result of the successes in my technical career, I assumed a number of management positions in AT&T. In 1972 I became a group supervisor, responsible for the work of five technical support staff, programmers and people who assisted

with various experiments. In 1985 I became a department head in charge of the small, but growing, speech recognition group. I expanded the group from an initial size of about 12 highly talented individuals to close to 35 permanent and visiting staff. This group made a number of significant contributions to speech recognition technology over the five years that I led the team. In 1990 I was appointed director of the Information Principles Research Lab with responsibility for supervising all research in the area of acoustics and speech processing including a small but highly focused group in image and video processing. The lab grew from about 75 people initially to about 110 people at the time of the split between AT&T and Lucent Technologies. At the split, I chose to join the newly created Research Lab at AT&T as vice president of the Speech and Image Processing Services Lab (a group of about 50 people) since I foresaw the value of rapidly moving speech technology to services that would benefit the company. In 1998 I was made vice president of Research, with responsibility for about 550 people working in virtually every area of telecom from access, to the network, to operations, to services. I remained in this position until my retirement in March 2002.

During my career I have learned a great deal about how to do research, how to be effective in various positions, how to lead and manage highly talented groups of individuals, and how to succeed in whatever you endeavor to do. I'd like to outline just a few of these key observations.

How to Succeed in Your Work Program

The following are some key thoughts about how to succeed in whatever occupation you choose. Like almost all generalizations, these observations are meant to stimulate

thought more than to effect lifestyle changes, but I truly believe that they are fairly canonic across almost any field of endeavor.

▲ 1) *Be enthusiastic and passionate about your work.* Life is just too short to be working on dull or uninspiring projects. Your creativity is directly proportional to the time that you think about your work, and this just happens naturally when you love what you do and can't wait to get to work each day. The adventure of discovery and invention awaits those who are passionate about their jobs, and almost all new ideas come from people who own every aspect of their working lives.

▲ 2) *Sweat the details of what you do.* Almost everyone gets good ideas about the work they are doing, and many of these good ideas make significant differences to the success of a project. Without carrying each good idea to a stage where it can be evaluated in some prototype or test-bed system, however, you never know whether the idea is a great one only in theory (but doesn't work well in practice) or is one of those ideas that change the way a technology plays out in the marketplace and in the world of technology.

▲ 3) *Neatness counts in everything you do.* No matter how caught up you get in the day-to-day details, it is essential that you develop habits related to good organization and management of your resources, your work projects, and your life. At some point you will have to access past results, prior data records, and stored records of experimental results. Without an organized process to rely on, you will spend most of your time looking for information that should be at your fingertips. Although the messy desk is often the cinematic characterization of the "mad but brilliant engineer," it is generally the real-life characterization of the "sloppy and disorganized" individual who doesn't have his priorities straight

and tends to pay most attention to things at the top of the pile. Although people often function without having any sense of neatness or organization, eventually this bad habit has a way of catching up and causing major problems, generally at times of extreme stress. So it is best to avoid the problem initially by realizing the importance of neatness and organization.

▲ 4) *Present your work and your ideas early and often.* Communication skills are probably the most important thing an engineer can develop once he or she has learned the fundamentals of the field of endeavor. Both oral and written communication skills are essential for success, since if you can't share your ideas and your thoughts with your colleagues, your managers, and outside audiences, you will never get the feedback and criticism that enable you to progress more rapidly and get your work accepted. A corollary of this principle is the old adage "You never get a second chance to make a good first impression." This means that it is incumbent on you, the communicator, to be prepared for every presentation that you make. That means knowing your material as well as possible so that you could present it in your sleep, if necessary. It means thinking about what parts of your presentation might confuse your audience (which might be your boss or higher management) and being prepared for questions and explanations that help explain your work better. It means making sure that when you show off your work, you show it at its best, not just the first time it works.

▲ 5) *Write up your work on every project you do.* Various managers have told me throughout my career that no job is really complete until you describe the work in print. I have personally found this to be the case for virtually every project in my career. Writing about your work

forces you to be precise, exact, and correct. It forces you to learn things about your work that you didn't completely understand. Finally the process of organizing and writing up work leads to many new ideas about things that were either bypassed or never thought about because of lack of time during the course of the project.

▲ 6) *Teach what you have learned.* If writing and presenting talks about your work are good, carrying this forward to the next level is even better. That means thinking globally about a body of work and converting those ideas to a tutorial lecture or tutorial paper, a short course or book chapter, and ultimately to a long course or a book. Once most individuals have worked in an area for a number of years, they have learned far more about the area than they think, and converting that knowledge to a broad publication or presentation vehicle is probably one of the most satisfying and rewarding things you can do in your career. What seems almost daunting and undoable, such as writing a full-length textbook for publication, is merely a step-at-a-time exercise in self-discipline and time management. The payoff from this level of publication or presentation far exceeds the effort required to take your work to this level, and I highly recommend it for everyone with something important to say or share.

▲ 7) *Strive for the highest goals you can set your sights on.* The most amazing thing about most exceptional work done in almost every field is that the individuals achieving the success were usually not the ones most people would have pointed to early on. Thus the people voted "most likely to succeed" are rarely the ones that have dared to dream beyond their capabilities and succeeded in changing the world by following their dreams to the logical conclusions. People who succeed

beyond their wildest dreams have generally set their sights high and are willing to take risk and even fail. The down side of failing is the feeling that you didn't accomplish much. The upside of failing is that you learn from your mistakes and then can grow to even greater heights in future ventures. Perhaps the greatest risk taker and biggest failure in the history of invention (prior to a pretty good success that ultimately ensued) was Thomas Alva Edison, who ran thousands of failed experiments trying to find a suitable filament for the electric light bulb, before finally discovering the carbonized thread (which later was replaced by the tungsten filament) that enabled the light bulb to shine brightly for the last 100 or so years.

▲ 8) *Pay attention to the gurus but not the forecasters.* The gurus are people who have continually learned from a combination of success and failures and on balance have had a lot more successes than failures. The forecasters are generally individuals who try to stand on the shoulders of those who have succeeded and look forward at technology without ever having dirtied their hands in finding the paths through the technology maze. As such, the gurus teach us about the past and give us guidance for the most likely paths to pursue in the future. The forecasters merely try to extrapolate from what they perceive are the technological successes, without the benefit of knowledge gleaned from the failures and the abortive attempts at progress. Perhaps the only valuable forecaster tool is the famous Moore's law of semiconductors which states that VLSI technology will double in density and halve in price every 18 months. Even that law is more of a guiding principle than a scientific law as there is no basis in theory for this law, but the practice certainly follows the law, and thus the forecasters know that

they can rely on this for guidance as to future capabilities of technology.

▲ 9) *Show respect for everyone with whom you come into contact.* We all lead busy lives with far too much to do in a mere 24-hour day. Since the laws of nature prevent us from getting additional time each day, we tend to prioritize work according to value received and potential impact. That often means we disregard requests for help, don't answer e-mail messages, avoid returning calls, and generally choose who we will talk to and whom we will avoid. Unfortunately this prevents many of us from getting to know students and colleagues who ask for help but find no responses to their messages or phone calls. We should all consider this a form of pro bono work and payback for the opportunities we have to contribute to society, by making a commitment to interact and help out anyone in need, especially students and lower level colleagues. The extra effort will be well rewarded over time.

How to Succeed as a Manager

There are perhaps thousands of books that purport to explain how to be a good manager. Some books have virtually unlimited suggestions as to how to succeed in making the people you manage both respect and enjoy working for you. Although many of these suggestions are appropriate and reasonable for technical managers, there are a few suggestions I can make based on my 30 years of managerial experience.

▲ 1) *Always hire people who are smarter than you.* One of the major responsibilities of most managers is hiring new people, both to replace losses and for growth of an organization. Once you begin interviewing and hiring people, it should become immediately clear that among the many goals of hiring new people, first and foremost

should be raising the intellectual level of the organization with each new hire. Bright, highly motivated new hires energize an organization by challenging traditional thinking about problems and by bringing in new ideas that can often be rapidly integrated into the working environment. New hires that are well respected have the ability to effect change almost immediately, and that is basically good in almost all cases.

▲ 2) *Be a good listener.* As a manager, you will spend a great deal of your time listening to your group, presentations, your managers, and higher management, all with views on how you can best do your job or support them on doing theirs. It is essential that you listen to everyone who comes to talk to you. First of all, you will often get good ideas for your own work or for others in your group. You might learn a great deal about technical and business aspects of the work going on in your group, outside the company, or in other parts of the company. At the very least you will expand your horizons of knowledge, and finally you will gain the respect of your group, your colleagues, and your bosses.

▲ 3) *Recognize excellence early and often.* People are motivated by having someone pay attention to them and their work. Whenever someone in your group does a good job the payoff from something as simple as an "atta-boy" note is remarkable. Small tokens of recognition go a long way to having happy and contented employees. As head of Research at AT&T Labs I instituted a Research Excellence award that was given to people who had both done a superb job with technology and succeeded in getting it into deployment within AT&T. For this effort they were rewarded with a shirt with the term "Research Excellence" embroidered into the shirt pocket, a presentation in front of the vice president of research

(who talked about their work and its significance to AT&T), and an article about them and their work in the internal publication *Research News*. Over the course of about four years I awarded about 60 such shirts to about 50 individuals (some won the award more than once), and I found that even such a small token of appreciation was highly respected both internally and externally, as outside people learned about the award by seeing awardees wearing the shirts at various technical conferences. Another, and more highly rewarding, form of recognition is nominating colleagues and group members for external recognition awards such as Fellowship in relevant technical societies, technical field awards of various organizations, and even membership in national academies such as the National Academy of Engineering. Such recognition requires more work than awarding a shirt, but this activity is most appropriate for managers in the technical community who can judge achievements in unbiased ways and make the decisions as to when individuals are deemed ready for recognition in this most prestigious manner.

▲ 4) *Don't ever compete with your team.* As a manager it is your job to motivate, inspire, and lead your team. As such you have to avoid competing with the team for resources that should naturally go to the team, including attendance at technical meetings, putting your own name in publication of results of the work, taking credit for doing the work, and making presentations of the work to various levels of management. Of course, as group manager, it is often appropriate and fitting that you present the work of your team, but then it is essential that the team members be fully recognized so they understand that you are presenting the results of their work. It is essential that in all

activities you put your team above yourself and make sure that the reward structure for the team recognizes both individual achievement and team achievement, as appropriate. It is essential for the manager to create a strong team spirit, and things that tear apart the team must be avoided at all costs.

▲ 5) *Maintain the highest standards of integrity.* As a manager it is essential for people at all levels to know they can trust you in word and deed. If you make a promise to an individual, your word should be your bond, and people should be able to leave knowing that you will do what you say. It is essential that you be open and honest in all your dealings with people, including the option to say no to requests with an explanation of the reasons why you made this negative decision. Although it often seems impossible to avoid, it is essential that you avoid politics in your decision making and leadership, since politics confuse most people and make you look like you lack the integrity that people crave in their leaders. The bottom line is that if your integrity is in doubt, you will have failed as a manager—independent of what you accomplish in your career or in other parts of the job.

▲ 6) *Love your work.* No one has to be a manager; it is a conscious choice of most individuals. Leadership is something that you work at and get better at with experience. Most managerial aspects of the job can be learned. However, passion for the job is innate—you either feel it or you don't. Without passion for the work, it is just a job, not a great opportunity to change the world. Once you have passion for your work, the tasks of being a great coach, mentor, and cheerleader come naturally with the territory, as you cheer success, encourage your people to strive for excellence, and provide resources to

maximize opportunities in the work program. Great managers have passion for the job and then they do whatever it takes to succeed. There just is no substitute for passion about your work.

There are undoubtedly about a dozen more good ideas for management and leadership, not to mention vision, excellence, rewards, and all the other standards of management, but I will close with one last thought. Success in engineering builds on a firm foundation in mathematics, computer science, signal processing and physics, and an innate desire to NSL (never stop learning) and growing. The most successful engineers and managers are those who acquire new knowledge, skills, and expertise each year and who push themselves to do things they know they can't possibly do. Great managers have an attitude of trying virtually anything once and seeing if it works, changes the world, creates a new paradigm for doing things, or just is valuable in its own right.



Lawrence Rabiner received the S.B. and S.M. degrees in 1964 and the Ph.D. degree in electrical engineering in 1967, all from the Massa-

chusetts Institute of Technology, Cambridge. From 1962 through 1964, he was in the cooperative program in electrical engineering at AT&T Bell Laboratories, Whippany and Murray Hill, New Jersey. He joined AT&T Bell Labs in 1967 as a Member of the Technical Staff. He was promoted to supervisor in 1972, department head in 1985, director in 1990, and functional vice president in 1995. He joined the newly created AT&T Labs in 1996 as director of the Speech and Image Processing Services Research Lab

and was promoted to vice president of Research in 1998. Dr. Rabiner retired from AT&T in March 2002 and is now a professor of electrical and computer engineering at Rutgers University and the associate director of the Center for Advanced Information Processing (CAIP) at Rutgers. He also has a joint appointment as a professor of electrical and computer engineering at the University of California at Santa Barbara. He is coauthor of the books *Theory and Application of Digital Signal Processing* (Prentice-Hall, 1975), *Digital Processing of Speech Signals* (Prentice-Hall, 1978), *Multirate Digital Signal Processing* (Prentice-Hall, 1983), and *Fundamentals of Speech Recognition* (Prentice-Hall, 1993). He is a member of Eta Kappa Nu, Sigma Xi, Tau Beta Pi, the National Academy of Engineering, and the National Academy of Sciences and a Fellow of IEEE, the Acoustical Society of America, Bell Laboratories, and AT&T. He is a former president of the IEEE Acoustics, Speech, and Signal Processing Society, a former vice president of the Acoustical Society of America, a former editor of *IEEE Transactions on Acoustics, Speech, and Signal Processing*, and a former editorial board member of the *Proceedings of the IEEE*.

Erratum

There was an error in the September 2003 issue of *IEEE Signal Processing Magazine*. On page 39, the correct title of the article by A. Dogandzic and A. Nehorai is "Generalized Multivariate Analysis of Variance." The title was correct on the table of contents.