Managing Artificial Intelligence and Expert Systems

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Preface

The authors who share their ideas and experiences in this book are eminent practicing professionals in the field of artificial intelligence and expert systems. Their combined expertise extends from the research laboratory to the most hardened bottom-line–oriented business group.

The contributors present their unique perspectives on a new industry as it is taking shape. The research community's efforts to study and create computer intelligence has produced a wealth of new knowledge about the practice of computing: new algorithms, data structures, and hardware configurations. In the last few years, we have seen the emergence of AI from the laboratory into the mainstream of data processing, helped along by a new class of technical entrepreneurs who recognized the power of these new tools and packaged them for commercial use. Their products are being readily accepted into even the most conservative data processing organizations.

A mathematician will happily explain that a system can be either complete or consistent, but not both. This scientific oddity translates into a source of useful tension in the world of management. On the one hand, we struggle to impose clear and ordered policies. On the other, we regularly disrupt policies to gain the advantages of a new tool or technique.

The contributing authors' experiences and expertise in managing these conflicting priorities are reflected in their chapters. Each contributor has been deeply involved in the introduction and acceptance of this new technology; each has been the person responsible within their organization.

Consequently, their writings provide first-hand accounts of successful professionals who have broken ground in an emergent industry. We believe that these unadulterated viewpoints are valuable to anyone interested in how a new technology moves from the laboratory to the shop, and in particular to the reader trying to make sense out of the AI industry at a time when it has not yet—thankfully—spawned any grand theories of management.

Daniel A. De Salvo
Jay Liebowitz

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PART ONE: TEAMWORK

1

Staffing Your New AI Groups

DARYL J. FURNO, Halbrecht Associates, Inc.

To get a better grasp of how to staff an artificial intelligence (AI) group, we must reflect on how it was done in the past. Examples will be presented of the successful—and unsuccessful—ways in which organizations have recruited AI professionals. The types of managers and professionals needed will be detailed. In addition, recruiting and interviewing techniques characteristic of the field will be reviewed.

The subject of staffing new AI groups is tied to the rise to prominence of AI technology from university research laboratories, which began around 1980. This rise to prominence was stimulated by the emergence of manufacturers of hardware dedicated to Lisp, one of the first AI computer languages. The first visions of AI technology with a commercial payoff arose with this hardware.

Originally, the major efforts in AI were located in a few widely spread universities and nearby research labs, the most prominent of which were the Massachusetts Institute

of Technology (MIT) in Cambridge, Carnegie-Mellon University (CMU) in Pittsburgh, and Stanford University in Palo Alto, California. The adjacent private research labs were the Xerox Palo Alto Research Center (PARC), nearby SRI International, and a robotics laboratory at CMU.

With internal funding and some government grants, these initial groups were almost always staffed by professors and their students, mostly Ph.D. candidates. Many of the brightest students were plucked right out of the classroom and offered good salaries and leading-edge projects, which they accepted at the expense of continued formal education.

The tendency to acquire the best talent among computer science students accelerated with the formation of the dedicated AI hardware companies and continued later with the start-ups in expert systems and natural language software. One of the early proponents of AI technology, Marvin Minsky of MIT's AI lab, frequently spoke out in 1982 and 1983 against this drain of students from university research labs. Minsky was one of the few professors of his caliber who did not get involved with some of the early start-ups. However, several years later, he helped form an AI company in which he then participated.

The nature of those working in the universities and quasi-university research labs is pertinent. They were predominantly Ph.D.s dedicated to their own projects. These often were a continuation of earlier thesis work. If they found positions as assistant or associate professors, they tended to stay with the university, teach, and pursue their research. Otherwise, they usually went to the research labs set up in conjunction with the universities that were funded by industry or government.

Examples of the most prominent labs were the Information Science Institute (ISI) in Marine del Rey, which is associated with the University of Southern California, and SRI International in Menlo Park, California. If masters-level students were hired, they were primarily assigned to programming, the most tedious part of projects directed by those with doctoral degrees. The first work in these labs was done on conventional computers. The hardware was usually DEC 10s from Digital Equipment Corp. (DEC) of Maynard, Massachusetts. At that time, there was a need for hardware that was more responsive to the kind of languages these researchers were working in. In the United States, the language was predominantly Lisp.

As university and quasi-university research groups began to develop their own hardware, they realized that there was a market for it. This led to the creation of new computer makers such as Lisp Machine, Inc. (LMI) and Symbolics, both of Cambridge, Massachusetts. In addition, xerox created some of these new machines. LMI and Symbolics were founded by a score of scientists from MIT's AI lab. These scientists tended to be Ph.D. students, their professors, or young, brilliant computer hackers.

As knowledge of these new companies and their products crept into the marketplace, other companies began stepping up their AI efforts. The early AI research labs, such as that of Schlumberger-Doll (Ridgefield, Conn.) and GTE Labs (Waltham, Mass.), bought Xerox machines initially because they were the first available. Later, other labs were able to buy machines from LMI and Symbolics.

Most of these early labs running Xerox hardware were staffed by Ph.D.s from the three major universities devoted to AI (MIT, Stanford, and Carnegie-Mellon). These scientists found comfortable places to continue their research in environments very

similar to the ones they had left. They anticipated that eventually less-expensive delivery vehicles would implement practical applications of their work. The main technology to be commercialized or likely to be was the expert system. A model in an early medical system, called MYCIN, was developed at Stanford University.

One of the first start-ups in Palo Alto was Teknowledge, formed mostly by Stanford professors and their students. They used MYCIN as a model to develop expert systems for customers. They hoped that these prototypes would be developed into larger systems. At the same time, they wanted to develop a shell (a computer-aided design tool for expert systems).

As Teknowledge began to build its dedicated software tools, other groups soon realized that this was the way to go. One of these groups was Inference Corp. (Los Angeles, Calif.), with a founder from the University of Southern California. Another was Intellicorp, founded by former Xerox researchers and others from the Palo Alto area. At the same time, DEC, which had a very strong connection with CMU and its robotics lab, was looking closely at AI, but not for the same reason Xerox sponsored AI work at PARC, which was to augment its product line and provide future leading-edge products.

DEC, on the other hand, chose to use the technology to improve its operations. It did so by means of an expert system called R1, used by the marketing group. R1 is a good example of successful technology transfer. It was created by a team of managers from DEC and top scientists from CMU's robotics lab. The more difficult parts of the expert system were worked out at CMU, but professionals with only masters or bachelor's degrees at DEC did a good part of the knowledge engineering, selected the rules, and carried them through to delivery of the system. Of course, this was under the continual guidance of the group at CMU.

THE BEGINNING OF THE GREAT SHORTAGE

The question can now be asked, When did the shortage of AI professionals first begin? It appears that it was somewhere around 1983 and was based on the activity stimulated by the new hardware companies. In MIT circles, it was no secret that a push toward a new technology was emerging. Some of the consultants from the Cambridge-based Index Group (now called Index Systems), were quick to see the potential commercial possibilities of this new technology. With advice from several MIT professors, who eventually became members of their board of directors, Index Group started a new company called Applied Expert Systems, now known as Apex. Most of the administrative staff and original planners of Apex were former Index employees and principals. They were the first company to try to develop off-the-shelf applications and then sell them to interested American corporations. Because Index originally specialized in the financial-services industry, Apex also aimed its initial applications at that industry. Under great secrecy, they brought in some industrial partners with particular application needs. A major one was selected for the first product. Meanwhile, several prototypes being considered for the liaisons were not with Wall Street, as was first assumed, but with insurance carriers. At first, Apex was served technically by its original university advisers. Early on, it was able to hire the manager of the development group from a nearby research lab. But soon, just as the pressures of product development came into play, hiring qualified staff became more difficult, because more groups were attempting to get into this new technology. To

find Lisp-proficient computer scientists willing to move to a commercial software company, Apex had to seek outside help. In this case, Apex officers followed the example of their previous employer and hired an outside executive search firm. Although at this time no outside firm had the in-house AI technical expertise to assess candidates technically, they were able to employ conventional search methodology for this project. That paid off. Apex was able to attract a young, bright, associate professor who helped to get the project out the door. Apex also attracted one of the few gurus in the field. Because Apex could not have attracted this person without the help of a third party, it is interesting to see the process that was involved in the successful search.

To better understand AI technology, the firm sent representatives to various AI seminars. This was in the early 1980s, so the firm had few representatives to send. Apex also approached a large number of professionals in the field. In all of these places, they left either a verbal or a written description of the opportunity at Apex. As information about this opportunity spread, several AI professionals inquired into these positions. Among them was a senior scientist who, by coincidence, was working at the company from which Apex's hiring manager had originally come. When the name of the hiring company was revealed to the senior scientist, he did not lose interest, although he was quite surprised that there was such a senior-level position open at Apex.

In turn, the hiring manager was amazed that someone who was a former close associate of his, whom he believed was aware of his mission at Apex, would surface as a candidate through a search firm. The senior scientist had been attracted by the generic description of the career opportunity. When the name of the hiring company was revealed, he felt more comfortable with the initial inquiry coming through a third party, because his past relationship with the hiring manager would not become invalid. In this case, the hiring manager welcomed the candidate. They subsequently worked successfully as a team to create the company's first few products.

GROWING COMPETITION FOR PROFESSIONALS

Meanwhile, the other newly formed software companies were finding the personnel marketplace very limited and becoming more so. At this time, the best place to find AI computer scientists was around Stanford. Besides the university itself, there were qualified professionals doing innovative work at research labs such as SRI International, Hewlett Packard Company, and Xerox PARC. This facilitated the easy staffing of the AI start-ups in that area, especially those spun off by professionals from the abovementioned institutions. The northern California software companies were able to bring in the technical talent they needed by means of their network of friends and the qualified professionals in the area. Word also got out to universities throughout the country active hiring was going on in this area. Soon the most qualified Ph.D. students began to apply.

Inference Corporation, located in Los Angeles, had a slightly different problem. One of the two founders of Infererence, Alex Jacobson, was a visionary entrepreneur from the business world who previously had been involved with software development. Early on, he saw the possibility of offering an AI-dedicated tool.

Jacobson teamed up with a very strong technical student working on a Ph.D. thesis leading in the same direction. Unlike its competitors in northern California, this team did not have a national reputation in AI; they were virtually unknown. When it came time to staff their company, they could network into the local universities and the scientists at ISI. However, they discovered that there were not enough qualified professionals available locally.

Inference did not have the kind of reputation that would attract qualified young professionals. Inference solved this problem by forming a technical advisory board made up of the most famous AI researchers. This was not difficult, because its initial product, ART, was very sound. When the product concept was demonstrated, the AI visionaries were impressed with its potential. As soon as Inference unveiled its technical advisory board, the job of attracting Lisp professionals became much easier. Applicants who wanted to know about Inference's plans, its vision, and the long-term potential of its products could contact one of these gurus and ask these questions during the hiring process. This technique proved invaluable during the hiring process. These gurus also served as technical advisors for the company during the first project. Another contribution they made was to give technical credibility to the company in the eyes of venture capital investors.

Inference had another hiring problem. Although many qualified people from other parts of the country were interested in working in AI, they were reluctant to relocate in the Los Angeles area. Living costs were very high. Of greater significance, most AI professionals in California were in the northern part of the state. Inference had to convince applicants from other states that it was blessed with a concentration of AI people and excellent weather. The company was able to attract several excellent people from CMU. This success was partly because of the quality of the company, but also because the weather in Los Angeles was superior to that in Pittsburgh.

One lesson to be learned from this experience and from that of the other companies in the early days of AI is that once a company got one or two leading AI computer scientists on board, it was easier to hire others. Brilliant young professionals who may not have had a reputation would come to work on a team with someone they respected.

THE PROFESSIONALS' WISH LIST

About this time, some invaluable information was developed that was to be of help in recruiting. A group of AI scientists from the Gould Corporation (Amherst, N.H.) ran a workshop on AI. At the workshop, they revealed the results of an informal survey of AI professionals assessing what was important to them in a work situation and what they would look for in a new job. Their priorities, not in any particular order, were

1. a parking spot near the entrance to the workplace and a key to the building;
2. the chance to work in one's lab any time of the day or night, and proper heat and air conditioning;
3. an unlimited supply of free coffee;

4. an informal atmosphere and no unnecessary meetings;
5. more computer memory and better tools;
6. availability of some discretionary funds, especially for hiring;
7. substantial reward for any significant contributions.

The significance of the wish list is that these professionals were not concerned about salaries matching what they considered their worth, but they did want to make sure that when they achieved their objectives, they would be financially rewarded. Based on these revelations, start-up corporations were motivated to give the first cadre of scientists and administrative people a piece of the action in the form of stock. In some instances, vesting in stock options was very quick, sometimes immediate. These perks helped attract staff.

In the early days, salary escalation was inevitable because of the great demand for talent. Hiring corporations that were not located near the major universities specializing in AI found that they could barely compete when offering only the same salaries. If they needed to hire someone, they had to pay a premium. In some cases, they would provide the little extra in the form of stock options or other perks.

A very high salary scale for both experienced and fledgling AI professionals was established in the early 1980s. Since then, AI salaries have stayed at about the same level, mainly because many more qualified people are available, and many more universities are offering graduate studies in AI. In addition, qualified people, especially in expert systems development, have been able to gain needed experience within research labs and in industry. This means that the early salary structure set the salary structure that exists today.

Although salaries for AI specialists have not escalated much from the mid- to late-1980's, they are nevertheless considered very high, especially as compared with those of other computer scientists and analysts. Even today, salaries for AI specialists are higher than those for other professionals with as much education and experience.

In 1983–1984, with the AI start-ups actively recruiting, the established research labs were affected for the first time. With AI catching on, the military and other government agencies began to look into this appealing new technology. Funding from these agencies was growing very rapidly at this time. This was an incentive for the traditional research groups to start AI groups and share in the bonanza. Companies that had the facilities to promote AI research, such as Mitre (Bedford, Mass.), Lockheed (Burbank, Calif.), Boeing (Seattle, Wash.), ITT (Shelton, Conn.), and GTE Labs, were now able to establish small, active AI groups or expand their work in AI. This expansion put a lot of pressure on the supply of available Ph.D. and research scientists in the universities. The universities were losing professionals not only to start-ups but also to these new opportunities in the commercial research labs. In addition, professors with AI expertise either started businesses themselves or were working as consultants. The marketplace for professionals in the established research laboratories became very competitive. Companies committed to AI began to find it more difficult to attract qualified people. At the same time, some of their own employees, such as those who left Xerox PARC to head up several start-ups in the Palo Alto area began to recruit staff from their former employers. This further inflated salary scales for research professionals.

INTERVIEWING TECHNIQUES

The model for interviewing AI candidates came from the early research labs. In general, recent Ph.D. graduates would be invited to come for a day and meet the expert who headed the group for which they were being considered. Perhaps other professionals who specialized in their field would also be brought into the process. Part of the day would always include a presentation, in which candidates would present a synopsis of their Ph.D. thesis. This was similar to the way they defended their dissertations. This procedure revealed the level of their research and their depth of knowledge of the topic, as well as their ability to organize and communicate their ideas. After the presentation, company experts would ask detailed questions about the research and get a chance to do a fairly rigorous technical evaluation of the candidate. The candidates would then sometimes meet with peers. If they were being considered for project management or for other management positions, they might even meet with those who would be on their team and whom they would supervise.

When entrepreneurs left the universities to establish software development companies, they followed the same procedure. They would ask candidates to do a technical presentation as a basis for judgment of their technical depth. The entrepreneurs would do this in addition to (and sometimes instead of) reviewing examples of their work or asking them questions in a personal interview or reading their theses. This evaluation method not only persists, but in many AI groups is applied to applicants for marketing and other nontechnical positions. A candidate for a marketing position could talk about the marketplace for AI. An applicant for a management position might talk about staffing an AI group, the method of developing a team, and the kinds of technologies the group could develop.

FUNDING SHAPES STAFFING

The source of funding for AI research and development has helped to configure the kinds of groups and the staffing of the groups. The Defense Advanced Research Project Agency (DARPA) and other government agencies have always been interested in leading-edge research of value to U.S. defense.

These agencies were some of the earliest funders of the projects at MIT, CMU, and Stanford. They also were very active in supporting early projects at SRI and at Bolt, Beranek & Newman, Inc., in Cambridge, Massachusetts. Those advanced computer-science projects overlapped all through the 1970s and early 1980s and eventually coalesced into what is now called AI. As more and more interest in AI developed, there was in turn more funding from the government. This encouraged the companies long serving the government to realize that they would better establish their own AI facilities. Companies like TRW (Cleveland, Ohio), FMC Corp. (Chicago), Lockheed (Burbank, Calif.), Boeing, and Mitre all began to back some AI effort in their research labs. The staffing of these labs was, in a way, more difficult for them. They did not have stock to offer, and they could not ignore their established salary scales to hire qualified AI experts, much less the top people they really needed. They had to look to

other solutions to staff their labs. Other economic constraints helped them in this effort indirectly. For example, the cost of the new dedicated hardware was very expensive, close to prohibitive. In some of the early work at these labs, there was no need to hire professionals well trained and experienced in Lisp, because no Lisp hardware was available. Thus, they frequently attempted to staff their early efforts with some very bright computer science students working in traditional computer languages.

Some companies, such as Amoco (Tulsa, Okla.) and Lockheed, were able to use professionals already on staff and working in familiar computer languages and techniques. They attempted to build shells that would get them started in AI. The shell developed by Amoco in coordinating with IBM became one of IBM's early non-Lisp expert system shells. Researchers at Lockheed developed a product called LES (Lockheed Expert Systems), which also was a product of its best talent working in a traditional language.

THE BOEING MODEL

Another way these companies were able to staff their labs was by following the Boeing model. The aerospace giant had excellent internal education and training facilities, as did many other large corporations at that time.

While companies like Aetna Life & Casualty (Hartford, Conn.) and General Electric (Bridgeport, Conn.) continued to offer traditional training and executive management courses, Boeing introduced a one-year AI graduate program. Boeing permitted its own employees—managers as well as young programmers—to take time off work to participate in the innovative program. Thus, Boeing trained much of its own staff to lead its AI efforts. At this time, these AI labs were also hiring Ph.D.s out of the universities. They acted as master teachers under which these newly trained people could apprentice.

THE CONSULTANT ALTERNATIVE

Another way these groups were able to afford to bring in good people was not to put them on staff. They were hired instead as consultants. It has always been ironic that American businesses may find it impossible to hire staff professionals at salaries that fall inside the company's existing salary scale, but they are able to pay the same professionals far more as consultants.

One of the early staffing innovations was at Lockheed, which borrowed AI scientists from Inference Corporation and assigned them to work directly on projects as if they were Lockheed employees. This tactic enabled Lockheed to use professionals who were paid substantially more than they would ever be paid on a yearly salary basis. These highly paid consultants worked side by side with Lockheed's people and trained them.

Lockheed also became a major investor in Inference, which gave them favorable access to consulting. This investment also gave Lockheed access to Inference's products and proprietary tools. This strategy helped Lockheed meet its contractual obligations with the National Aeronautics and Space Administration and other governmental agencies.

Lockheed's method of bringing in top talent through consulting assignments and also supporting the source of the talent was soon copied by Framatone in Paris and Detroit-based General Motors Corporation, both of which became major investors in Teknowledge. In the same vein, Ford Motor Company (Detroit) invested in both Inference and Carnegie Group (Pittsburgh).

These liaisons between the software development companies with consulting groups and the giants of industry allowed the latter to bring in top-quality staff. In turn, these arrangements helped the software houses support and maintain their high salary scales. Thus, industrial research groups were perpetuating the high salaries of AI professionals at the same time that these high salaries prevented the labs from hiring the same AI professionals directly. There was one compensating advantage, however: When a research group hired consultants, it did not have to worry about what to do with those highly paid AI professionals if the project had to be aborted.

Not all industrial research labs could afford the luxury of having their parent corporation invest in an AI start-up or consulting group. Nor were they able to afford to hire outside consultants to augment their own AI work. These labs had to either hire young students right out of school at rates within their salary structures and hope that they would become AI superstars, or else they had to attempt to attract more experienced professionals for reasons other than money.

One of the major "other" reasons then, as now, is location. As previously mentioned, if an AI lab was located in a prime territory, such as around Palo Alto, then that lab had an extra means of attracting professionals. Palo Alto is a prime location, not only because of the attractive ambiance and weather, but also because of the heavy concentration of AI professionals and many prestigious companies active in AI.

A close contender to Palo Alto is the Boston area, which also has most of the same attractions plus proximity to sailing and skiing. Pittsburgh, on the other hand, is generally not rated as exciting as Boston, although it has much the same weather and also a major AI-oriented university in CMU.

The more geographic attractions a locality offers, the larger the number of professionals that should be drawn to it. When Martin Marietta Corporation started a large research effort in Denver in early 1980, it hoped to attract professionals through its desirable environment, by providing support, and interesting work in many projects. However, Martin Marietta was limited by the salaries it could offer. It touted Denver as an attraction. Perhaps some candidates who skied and liked the West and its mountains would be interested in the potential in AI.

Could AI affect the bottom line or even become a competitive weapon for these industrial giants? One of the first industries not funded by government to look at AI was the oil industry. One pioneer was Schlumberger-Doll, which was supporting research to help it service the oil industry. In turn, oil companies, such as Standard Oil of Ohio (Cleveland), Exxon (Florham Park, N.J.) and Amoco (Tulsa, Okla.) became interested in this technology and added small AI groups to their research efforts. These oil giants encountered much the same staffing problems as the large defense-related companies. They, too, were burdened by established salary structures that could not accommodate higher priced AI talent.

AI'S APPEAL TO FINANCIAL SERVICES

The financial services industry also began to look at AI for much the same reasons as had other industries. For the former, the bottom line is paramount, closely matched by the need to gain competitive advantage. However, financial services were accustomed to rewarding employees who could affect the business. One hiring obstacle for the financial services was their lack of research facilities. When they needed new technology, they usually bought it off the shelf or in a state almost ready to use. For these companies, an AI research group was out of the question. The notion of selecting a project and then spending six months to two years or more waiting for results was not their way. They might hire one or two professionals to study a technology of interest, and then hire one or two pros to create some protoypes or small systems. Some financial services also dabbled with consultants. In fact, the banking industry supported a very elaborate AI project at Arthur D. Little, Inc. (ADL), (Cambridge, Mass.). In all cases, the AI efforts on behalf of the financial services proceeded haltingly. They did not take off in 1984 and 1985 when larger companies with research labs and the ability to sponsor some long-term projects were really sinking their teeth into AI.

OTHER CONSULTING SERVICES

From the very beginning, Teknowledge and the other AI start-ups (including Inference) who were building tools were also offering consulting services. Sometimes their intent was to sell their tools, but it was also just to show potential customers the value of the technology. These AI companies offering consulting, for whatever reason, soon found this part of their business very lucrative. As a result, the established consultancies, such as ADL and subsequently the "Big Eight" accounting and consulting firms, began to view this new technology as an area of expertise they should be offering to their clients.

Initially at ADL, the head of the AI practice would go out to potential clients and sell the assignment by building a small prototype or at least by outlining a rough design for an expert system. The intent would be to use the staff the partner had in the group, some of whom were not trained AI people or who were fairly new to the technology. When the assignment was sold, ADL would in turn supplement the group with experienced professionals or at least Lisp programmers from nearby universities on a part-time basis, possibly professors or graduate students. Hiring this high-quality part-time help was certainly very efficient for ADL but not inexpensive. One of the early Big Eight accounting firms that established an AI effort was Arthur Andersen in Chicago. Traditionally, Arthur Andersen hires the majority of staff right out of college, trains them in its methodology, and then promotes the most qualified until they achieve partnership. Andersen decided to use the same approach and build an AI group from scratch, despite the fact that there were not many qualified AI graduates in the Chicago area.

After they were given some standard Arthur Andersen in-house training, the trainees were then sent to be trained by the software tool companies in the use of tools. Thus, Andersen slowly started to build an AI capability to serve clients. Some proprietary tools were also developed that could be used with present clients and to acquire new ones.