Preface

The leading edge of computer science research is notoriously fickle. New trends come and go with alarming and unfailing regularity. In such a rapidly changing field, the fact that research interest in a subject lasts more than a year is worthy of note. The fact that, after *five* years, interest not only remains, but actually continues to *grow* is highly unusual. As 1998 marked the fifth birthday of the International Workshop on Agent Theories, Architectures, and Languages (ATAL), it seemed appropriate for the organizers of the original workshop to comment on this remarkable growth, and reflect on how the field has developed and matured.

The first ATAL workshop was co-located with the Eleventh European Conference on Artificial Intelligence (ECAI-94), which was held in Amsterdam. The fact that we chose an AI conference to co-locate with is telling: at that time, we expected most researchers with an interest in agents to come from the AI community. The workshop, which was planned over the summer of 1993, attracted 32 submissions, and was attended by 55 people. ATAL was the largest workshop at ECAI-94, and the clear enthusiasm on behalf of the community made the decision to hold another ATAL workshop simple. The ATAL-94 proceedings were formally published in January 1995 under the title *Intelligent Agents*, and included an extensive review article, a glossary, a list of key agent systems, and — unusually for the proceedings of an academic workshop — a full subject index. The high scientific and production values embodied by the ATAL-94 proceedings appear to have been recognized by the community, and resulted in ATAL proceedings being the most successful sequence of books published in Springer-Verlag's *Lecture Notes in Artificial Intelligence* series.

ATAL-95 was held at the International Joint Conference on AI, which in 1995 was held in Montreal, Canada. The number of submissions leapt to 55, and the workshop was attended by 70 people. Since many international conferences fail to attract this many submissions and delegates, it was decided at this point to make ATAL an annual event. It was also decided to hold ATAL-96 in Europe, following the successful model of ATAL-94 by co-locating with ECAI-96, which was held in Budapest, Hungary. We received 56 submissions, and the workshop was attended by about 60 delegates. For ATAL-97, it was felt that the workshop was sufficiently mature that it merited its own event, and so the conference was located immediately before the AAAI-97 conference in Providence, Rhode Island. It was attended by about 75 delegates. ATAL-98 was co-located with the "Agents World" series of events, held in Paris in July 1998. 90 submissions were received, and 139 delegates registered for ATAL.

In the five years since ATAL-94, the landscape of the computing world has changed almost beyond recognition. Even seasoned veterans of the historically fast-moving IT environment have been surprised by the current rate of change. Perhaps the simplest way we can sum up these changes is by noting that the first ATAL was also the last not to have a World Wide Web (WWW) page. In 1999, on the eve of the new millennium, it would be unthinkable for a serious academic conference or workshop not to have a dedicated WWW site. The changes brought about by the explosion of the Internet into worldwide public and corporate awareness are well documented, and it is not appropriate for us to add to the mountain of comment (and hyperbole). However, it is important to note that the rise of the Internet had a significant impact on the development of the agent field

itself. By the summer of 1994 it was becoming clear that the Internet would be a major proving ground for agent technology (perhaps even the "killer application"), although the full extent of this interest was not yet apparent.

The emergence of agents on and for the Internet gave rise to a new, associated software technology, somewhat distinct from the "mainstream" of agent research and development. In the summer of 1994, a California-based company called General Magic was creating intense interest in the idea of *mobile agents* — programs that could transmit themselves across an electronic network and recommence execution at a remote site. At the time, General Magic were distributing a widely-read white paper that described "Telescript" — a programming language intended to realize the vision of mobile agents. In the event, it was not Telescript, but another programming language that caught the imagination of the Internet community: Java. When Netscape incorporated a Java virtual machine into their Navigator browser, and hence brought the idea of applets into the mainstream, they gave Java an enormous impetus, both as a way of animating the Internet, but also as a powerful, well-designed object-oriented programming language in its own right. A number of mobile agent frameworks were rapidly developed and released as Java packages, and interest in Telescript rapidly waned. As we write this preface in late 1998, Java is the programming language of choice not just for agent systems, but also, it seems, for most other applications in computing.

Mobile agent technology was not the only other agent technology beginning to make its presence felt at the time of the first ATAL. The summer of 1994 saw the publication of a special issue of *Communications of the ACM* with the title "intelligent agents". Many of the articles in this special issue described a new type of agent system, that acted as a kind of "expert assistant" to a user working with a particular class of application. The vision of agents as intelligent assistants was perhaps articulated most clearly by Pattie Maes from MIT Media Lab, who described a number of prototype systems to realize the vision. Such user interface agents rapidly caught the imagination of a wider community, and in particular, the commercial possibilities of such technologies was self-evident. A number of agent startup companies were founded to commercialize this technology (many of which have by now either been sold or gone bust). Current interest in such agents comes, to a great extent, from the possibility of using them in electronic commerce scenarios, where they negotiate on behalf of their "owner".

The commercial interest in agents in the latter half of the 1990s has not been limited to venture capitalists and "small scale" agent systems. Perhaps one of the most encouraging long-term trends for agent technology is the idea of agents as a software engineering paradigm. The level of interest in this concept has been evidenced in several ways. For example, the number of large-scale industrial-strength agent systems being developed and deployed is an obvious indicator. However, the degree of interest is perhaps best illustrated by the attempts currently underway to develop international standards for agent communication. Although some tentative steps towards standard agent communication languages were taken by the KQML/KIF community in the USA in the early 1990s, it is the FIPA initiative, started in 1995, which currently appears to be the best candidate for a standard agent communication framework.

Turning more specifically to the ATAL workshops, a number of smaller scale trends have emerged, echoing to some extent the more visible changes in the computing world

itself. One obvious indicator that agent technology is beginning to mature is that far fewer *new* agent architectures are being developed. It seems that authors are taking architectures off the shelf, rather than developing their own. In this vein, the belief-desire-intention (BDI) class of architectures has become particularly prominent. This work represents a paradigm example of the ATAL ethos — there is a well-defined theory, which relates more or less directly to specific architectures or programming languages. On the theoretical side, there has been an increasing trend towards more integrated models; that is, theories which cover a wider proportion of an agent's decision making and acting capabilities.

We noted above that five years sometimes seems like a long time for an academic workshop. Incredibly, when ATAL began, there were no conferences dedicated to agent technology. In contrast, the agent research community is now served by at least two major international scientific conferences (the *International Conference on Multi-Agent Systems* and the *International Conference on Autonomous Agents*), as well as a dedicated journal (*Autonomous Agents and Multi-Agent Systems*). That agent technology is able to comfortably support this degree of interest tells us that agents have a good chance of succeeding as a technology. We hope that ATAL will continue to play its part in this development, maintaining its current high level of scientific and production values, and serving a vibrant, rich research and development community.

To close, we would like to take this opportunity to thank those who have made ATAL the success we sincerely believe it is today. In particular, our thanks go to Jörg Müller, Munindar Singh, Anand Rao, and Milind Tambe, who have all acted as organizers for ATAL, and helped to shape it through their dedication and vision. In addition, we would like to thank those who have played various other special roles throughout the first five years, including Klaus Fischer, Michael Fisher, Mike Georgeff, Piotr Gmytrasiewicz, David Kinny, John-Jules Ch. Meyer, and Jan Treur. Also thanks to the program committee members, and finally, to Alfred Hofmann, our editor at Springer-Verlag, whose support and genuine enthusiasm for a well-produced volume has helped establish ATAL as a premier forum for publishing agent research.

November 1998   Michael Wooldridge
                                                              Nicholas R. Jennings

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Foreword

It is a particular pleasure for me to contribute, from the publisher's point of view, a few paragraphs as foreword and acknowledgement on the occasion of this fifth volume of the Intelligent Agents subline within the LNCS/LNAI series. One might object that the fifth anniversary of a workshop series is nothing special. In the fast moving area of agent technology, however, the continued success of a highly reputed workshop series deserves the attention usually reserved for achievements of longer duration. To my knowledge, there is no other series of workshops or conferences explicitly devoted to agents from its very beginning that has such a long and well-established tradition. We are proud to have been the publishers of ATAL, from its inception and in its entirety (vols. 890, 1037, 1193, 1365, and 1555 in LNAI), and we look forward to continuing this successful cooperative effort into the future.

When in October/November 1994, the initiators of the ATAL workshop series and editors of the first ATAL volume (LNAI 890), Michael J. Wooldridge and Nicholas R. Jennings, prepared their manuscript for publication, Mike gave me a call during which he impressed me by stating that they were ready to invest time and effort "to make this a book that is really useful to the community". This attitude seemed remarkable to me since I had rarely experienced LNCS/LNAI volume editors who volunteered to do extra work to make post-workshop proceedings more than just a collection of papers. We went on to discuss various options for increasing the value of their book; the resulting volume features a unique survey article by Mike and Nick with a comprehensive bibliography, a glossary of key terms, an annotated list of systems, and a subject index. These added-value components and the careful selection of thoroughly reviewed and revised full papers made the volume an excellent state-of-the-art survey, designed for use by scientists active in the area as a standard source of reference and by newcomers to agents research and development as an ideal starting platform. As a consequence, the volume quickly exceeded all expectations: I had expected the initial print run of 1000 copies to cover demand for the volume's entire life cycle (of about 10 years), but already in October 1995, after only 10 months on the market, LNAI 890 had sold out and it has been reprinted twice since. Such an unexpected sales success had hardly ever happened before in the history of LNCS/LNAI.

Mike and Nick were later joined in the co-editing of subsequent ATAL volumes by (chronologically) Jörg P. Müller, Milind Tambe, Anand Rao, and Munindar P. Singh. Here too, cooperation was excellent and successful, and it went beyond ATAL. In all of the volumes published so far, the editors have improved their workshop documentations by adding special features to the high-quality papers selected in increasingly competitive reviewing processes. From ATAL II onward, the Intelligent Agents volumes have appeared with the new blue-and-yellow jacket cover that distinguishes high-profile titles on hot topics from the

many proceedings in the series. In a certain sense, it's a pity that LNAI 890, which is a state-of-the-art survey volume par excellence, was not released with the distinctive jacket cover, as an LNCS/LNAI de luxe. However, this first ATAL book was instrumental in the introduction of the LNCS/LNAI jacket cover concept, and there is certainly greater merit in the establishment of quality standards reflected in a new concept line than in being just one volume in such a line. While recently evaluating a new LNAI publication proposal, I became aware that also the scientific community shares this appreciation of the special nature of the publication concept introduced by ATAL: as an argument of trying to convince us to accept the project, the proposers assured us that they "would do the book in the Wooldridge-Jennings style, like LNAI 890".

Fortunately, the success of ATAL in LNAI has helped attract quite a number of other agent-related projects. Over the years we have succeeded in building a whole publication line around ATAL; with about 15 volumes released annually, LNCS/LNAI seems to be understood by the agents community as one of its premier publication forums. For me personally, agent technology is presently, perhaps along with cryptology, the most exciting subfield of computer science and artificial intelligence, with great promise for the future both as a computing paradigm and a software technology. I am very happy to see that people from distributed AI, who popularized the concept of agents and have been the driving force behind agent technology for years, are now actively seeking the cooperation of the core computer-science community — notably of researchers in traditional distributed computing, networking, programming, software engineering, information systems, multimedia, cryptology, electronic commerce, telecommunications, and human-computer interaction — in order to cope with the problems that emerge in the context of large-scale intelligent applications. This cooperation will undoubtedly advance the state of the art in theory, and both the development community and practitioners interested in everyday private and professional applications will certainly benefit from the results of these efforts.

On the occasion of the fifth anniversary of the ATAL success story, I would like to convey my congratulations to the ATAL community in general and to the aforementioned persons and friends in particular. The devoted and professional cooperation that Springer-Verlag has enjoyed is very much appreciated on our end, and I personally would like to express sincere thanks to all "ATALians" who have shared their visions, thoughts, ideas and publication plans with me and, in doing so, have taught me a bit about a fascinating new technology.

ATAL ad multos annos!

Heidelberg, January 1999   Alfred Hofmann