

Software Agents for Assessing Environmental Quality: Advantages and Limitations

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Extended abstract

The last decades, there has been a remarkable change in modern societies. Environmental values are appreciated to a greater extent, as it has become evident that they are highly correlated with our quality of life. The aftermath of the growing societal interest in the environment and sustainable development was the emerging need for providing environmental information to the public. The challenge for Environmental Management and Assessment Information Systems is to provide efficient, accurate and timely electronic services to the public.

In this work, we examine the applicability of software agent technology for automating the environmental quality assessment process. Software agents are best suited in systems that are *modular, decentralized, changeable, ill-structured and complex*, according to Van Dyke Parunak (1999). Environmental management and assessment systems are of this kind, and employing software agents to realize them makes possible the provision of advanced features. However, certain limitations may arise. Both advantages and limitations of agent-based applications for environmental monitoring and assessment systems are connected with real-world functionality.

Environmental Management and Assessment Information Systems is a generic term that covers software systems responsible for

1. gathering environmental information from dissimilar data sources,
2. managing environmental data for supporting the decision making process involved in environmental assessment, and
3. post-processing data and facts for supplying citizens, industry, public institutions and government with information services related to the natural environment.

Developing such systems is a demanding task, which requires interdisciplinary efforts originated from natural and environmental sciences, social and economic sciences, and informatics and computer science. In a schematic representation, we con-

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sider Environmental Management and Assessment Information Systems to be built upon the junction of environmental informatics, integrated assessment and decision support systems, shown in Figure 1. For such systems the challenge is to take advantage of the information technology tools, and integrate them seamlessly in the current procedures for providing services to all peers, including the government, the industry, public institutions and the society.

Advances in the Information Technology sector seem capable to meet the demanding requirements for building environmental information services. Current developments in software engineering have brought forth software agent technology. The key abstraction used is that of an agent, i.e. a software entity characterized by autonomy, reactivity, pro-activity, and social ability. Certain types of software agents have abilities to infer rationally and support the decision making process. Agent-based systems may rely on a single agent, but the advantages of this initiative are revealed in the case of Multi-Agent Systems, which consist of a community of co-operating agents. Several agents, structured in groups, can share perceptions and operate synergistically to achieve overall goals (Jennings, Sycara and Wooldridge 1999). In this background, software agents could be considered in three distinct, yet concurrent ways:

- a. Agents as information carriers, i.e. as autonomous entities capable for processing information.
- b. Agents as decision-makers that comprehend their environment and respond to it, taking advantage of their abilities to reason rationally and behave proactively.
- c. Agents as societal illustrators, capable to achieve common goals synergistically, through the collaboration of autonomous individual actions.

This triple view on software agents is illustrated in Figure 1. In our recent developments, we have combined these three approaches for building intelligent software applications for environmental management and assessment (Athanasiadis and Mitkas 2004, Athanasiadis et al. 2003, 2004).

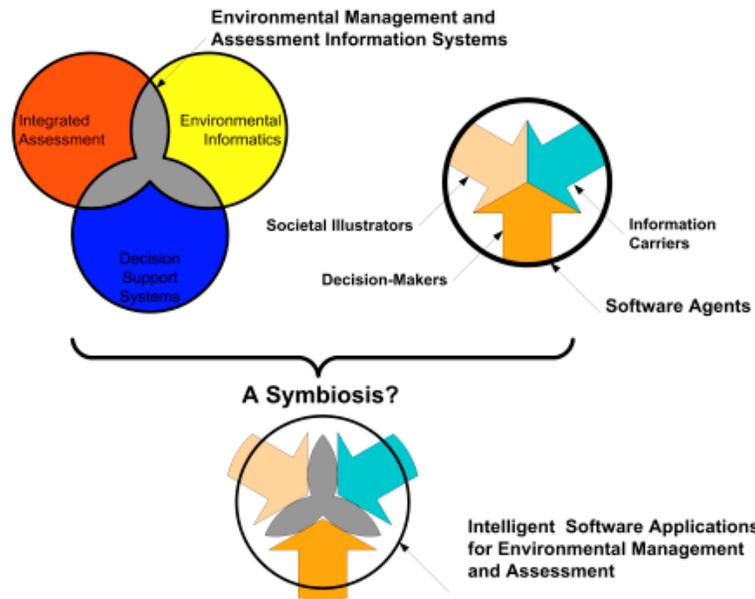


Figure 1: Software agent technology can be used for building modern environmental management and assessment information systems

Developing intelligent software applications for environmental management and assessment with agents is beneficial for all involved parties as the notion of an agent is easily comprehensible by natural scientists, environmentalists, economists, social scientists and software engineers. In this way, value conflict problems can be tackled efficiently. Also, agent technology benefits for rapid prototyping and software reusability can be also considered in the advantages of such an approach. However, the problem of lack of standardization in agent-based software engineering methods and tools still remains. Even so, agents acting as mediators seem suitable for delivering preprocessed information in distributed environments able to support new, efficient, modern information services to the public.

References

- Athanasiadis, I. N., Mitkas P.A. (2004a): An agent-based intelligent environmental monitoring system, in: *Management of Environmental Quality*, 15(3):238-249, Emerald.
- Athanasiadis, I. N., Mitkas P.A. (2004b): Supporting the decision-making process in environmental monitoring systems with knowledge discovery techniques, in: *Knowledge-based Services for the Public Sector Symposium (Workshop III: Knowledge Discovery for Environmental Management)*, pg. 1-12. KDnet.

- Athanasiadis, I. N., Mitkas P.A. (2004c): Applying agent technology in environmental management systems under real-time constraints, in C. Pahl , S. Schmidt, A. Jakeman (editors): International Environmental Modelling and Software Society 2004 International Congress "Complexity and Integrated Resources Management", pg. 46. iEMSs.
- Athanasiadis, I. N., Vartalas P., Mitkas P.A. (2004): DAWN: A platform for evaluating water-pricing policies using a software agent society, in: C. Pahl , S. Schmidt, A. Jakeman (editors): International Environmental Modelling and Software Society 2004 International Congress "Complexity and Integrated Resources Management", pg. 42. iEMSs.
- Athanasiadis, I. N.(et al) (2003): Applying machine learning techniques on air quality data for real-time decision support, in: First International Symposium on Information Technologies in Environmental Engineering (ITEE-2003), pg. 51, Gdansk, Poland. ICSC-NAISO Publishers.
- Athanasiadis, I. N. (et al) (2004): Embedding data-driven decision strategies on software agents: The case of a multi-agent system for monitoring air-quality indexes, in: R. Jardim-Goncalves et al. (editors), Concurrent Engineering: The Vision for the Future Generation in Research and Applications, vol. 1, pg. 23-30: Balkema.
- Jennings, N. R., Sycara, K., Wooldridge M. J. (1998): A roadmap of agent research and development, in: Autonomous Agents and Multi-Agent Systems,1: 7-38, Kluwer.
- Van Dyke Parunak, H (1999): Blue-collar agents: Experience and issues in the development and deployment of industrial agent-based systems, in: Fourth International Conference on the Practical Application of Intelligent Agents and Multi-Agent Technology (PAAM'99), pg. 3-9.