# Future Intelligent Information Systems: AI and Database Technologies Working Together

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## Abstract

The effective application of AI Technology and the development of future computing systems require the integration of AI and Database Technologies. The integration will benefit both AI and Databases and will substantially advance the state of computing.

Information Systems are among the greatest potential beneficiaries of AI Technology. What if advanced reasoning capabilities could be added to any Information System? What if intelligent interfaces could replace unfriendly interfaces? What if AI techniques were used to extend Database Management functionality? At the same time, AI Technology will benefit dramatically from Database Technology. What if knowledge could be shared concurrently by existing and unanticipated applications (*Knowledge Independence*)? What if AI systems could contain hundreds of thousands of rules and access millions of facts? What if new reasoning techniques could be directly applied to existing knowledge bases? What if knowledge could be reorganized, independently of applications, to optimize for current usage (*Representation Independence*)? What if AI systems development involved simply incremental augmentation of existing knowledge bases? What if AI systems were as robust as On-Line Transaction Processing Systems?

Future computing systems will require AI and Database Technology to work together with other technologies. These systems will consist of large numbers of heterogeneous,distributed agents with varying abilities to work cooperatively. Each will have its own knowledge and reasoning schemes, languages, and capabilities. Data, procedures, knowledge, and objects in these systems may be shared, incomplete, and inconsistent with those of other agents; but will certainly persist and will together form a massive distributed information base. The current trend to *Interconnectivity* -- one system accessing another via standard interfaces -- will evolve into *Interoperability* -- intelligent cooperation amongst systems to best achieve specified goals.

Such future computing systems pose major challenges for both AI and Database Technologies. Many of these challenges (e.g., managing, structuring, searching, sharing, and modifying objects; reasoning about tasks and specific domains) are present in simpler forms in current AI and Database Systems. Extending existing solutions to new contexts requires a deep understanding of both technologies, their requirements, their capabilities, and their limitations.

Difficulties with current research and commercial AI systems, let alone future systems, are due, in part, to the lack of such a deep understanding. Integration of AI into conventional Information Systems requires resolution of knowledge/object management and access issues addressed by Database Technology for simple tabular and structured data. Basic systems issues underlying this resolution include the appropriate use of secondary storage and effective architectures.

Database Technology currently solves the above problems for about 5% of existing corporate and scientific data. Exciting database research is extending these solutions to new application domains such as AI. Much of this work utilizes the object paradigm. It is hoped that the use of this evolving paradigm in AI, Databases, Programming Languages, Operating Systems, and other areas will provide a common ground for technology integration. For example, combining the object paradigm with that of heterogeneous, distributed databases could provide network wide object management regardless of the systems in which objects reside. This interoperability would permit systems to cooperate with less need to know exact details of foreign systems and objects. Open problems here include the appropriate partitioning of functionality amongst, and the nature of interfaces between Database, Object Management, AI, and other systems. These issues must be addressed at the Knowledge, Symbol, and Architectural/ Organizational Levels.

This talk presents a vision of future computing that provides a framework and goals for the AI-Database Integration. Short and long term benefits are illustrated and the critical nature of this progress is emphasized. Progress over the past ten years is illustrated. The applicability of existing Database Techniques to AI systems and of AI Techniques to Database Systems is described. Open problems are identified together with promising research directions.