Panel Description: DoD's Software Technology Plans: What Do They Mean for KBSE, and What Does It Mean for Them?

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Barry Boehm, Department of Defense, Panelist
Morton Hirschberg, Army Ballistics Research Laboratory, Panelist
Richard Jullig, Kestrel Institute, Panelist
Randy Shumaker, Naval Research Laboratory, Panelist
Douglas White, Rome Laboratory, Panelist

Introduction

The objectives of this panel are (1) to identify and discuss the major implications of the Department of Defense's software technology planning for research and development in the area of Knowledge-Based Software Engineering (KBSE), and (2) to offer the KBSE research community an opportunity to comment constructively on that planning.

The most recent and comprehensive presentation of DoD's software technology intentions is the DoD Software Technology Strategy (SWTS). SWTS has been presented and discussed extensively by representatives of military and defense contractor organizations. It identifies five major strategic themes, including the integration of Artificial Intelligence (AI) and Software Engineering (SE) technologies: "Integrating the two technologies in the right ways can provide the new functionality and flexibility advantages of AI along with the scalability and verifiability advantages of 'conventional' software technology." [p. ES-7]

Panelists have been asked to address a specific question regarding this SWTS theme: "To what extent is KBSA (as a proxy for KBSE) one of these right ways (and where does it fall short of being the perfect way)?

The Knowledge-Based Software Assistant (KBSA) research program, initiated by the USAF's Rome Laboratory in the early 1980s, was one of the first Government-sponsored research efforts directed at the application of AI to support the SE process. KBSA, and more generally KBSE, appear well-positioned to address this integration of AI and SE. This panel will explore how KBSE research efforts and DoD software technology planning can influence and support each other.

Position Statements

Dr. Barry Boehm is Director of the Department of Defense's DDR&E Software and Computer Technology Office, the organization responsible for the development and collaborative implementation of the DoD Software Technology Plan. He has also served as Director of DARPA's Software and Intelligent Systems Technology Office, and as Chief Scientist of the TRW Defense Systems Group.

The DoD SWTS strongly emphasizes automated aids for improving software engineering. It therefore presents many opportunities and challenges for KBSE technology. Examples can be derived from the primary SWTS themes:

1. **Reuse and Megaprogramming** (component-oriented software engineering) present challenges concerning the ability to use knowledge about software components to automate or expedite their assessment and assembly into software products. The use of domain knowledge and domain specific software architectures appears to be an attractive approach.

2. **High-Level Reengineering and Post-Deployment Support** require good KBSE capabilities. Support is already becoming available for some aspects of software restructuring, design recovery, and incremental analysis. Here also, domain knowledge may provide a strong boost for these capabilities.

3. **Process Support and Technology/Management Synergy** imply KBSE challenges involving knowledge capture and knowledge application to process management. These capabilities must be scalable and relevant to large software projects.

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1 Department of Defense, Software Technology Strategy (Draft), DDR&E: December, 1991.

2 The Panel Chair has edited these to achieve space limitations and consistency of presentation.
4. Commercial Technology Leverage and 5. Integrating AI and SE require the transition of experimental KBSE tools into commercial practice and the interoperability of KBSE technology with mainstream CASE tools and environments. This latter approach appears highly attractive, in that it combines the flexibility and expertise of knowledge-based tools with the performance and scalability of mainstream CASE tools.

Mr. Douglas White is Program Manager of Rome Laboratory's Knowledge-Based Software Assistant (KBSA) research program. Mr. White has been at the Rome Laboratory since 1971, and was initially involved in research and development related to programming languages, compilers, and environments. In the early 1980s he joined the AI technology branch and thereafter joined the KBSA effort.

The year 2000 objectives of the SWTS are to reduce equivalent software life-cycle costs by a factor of two, reduce software problem rates by a factor of ten, and achieve new levels of mission capability and interoperability via software. In 1983, the KBSA paradigm was offered as an alternative with the potential for achieving orders of magnitude improvements in productivity as well as elimination of clerical errors, increased optimization, better documentation, and increased reusability. This enhanced system development process would also contribute to improved system quality and longer system lifetimes. The belief that KBSA can achieve these large gains in productivity and quality has not diminished since 1983, but has been strengthened by recent reports concerning the use of CASE and object-oriented programming technologies. The original KBSA strategy embraces all five of the SWTS strategic themes in a unified and effective manner that will demonstrate that "the whole is greater than the sum of the parts." Likewise, the KBSA program has addressed — to some extent — all six of the SWTS' specific technology areas. The SWTS has presented estimates of returns on investment for both current and achievable programs to exceed 15:1. In light of the limited resources that have been expended, KBSA should greatly exceed that rate of return.

Mr. Morton Hirschberg is Chief of the Computer Science and Mathematics Branch of the US Army's Ballistic Research Laboratory, which he joined in 1973. Prior to that, he held technical positions at the General Research Corporation and at North American Aviation. He has authored or co-authored over 50 research papers, and played an active role in the development of the SWTS.

The most important problem facing the military is the formulation of knowledge: the fusion of information and the production of new data and information from that knowledge. Software answers this problem, but presents us with new problems. We have seen a large proliferation of specialized languages and tools, and now need to build interface capabilities between them. For example, we might need to run a factor analysis and then determine the probabilities of various results via Monte Carlo simulations. We need the ability to select and merge appropriate tools based on the user's requirements.

I support KBSE as a step in the right direction, especially to the extent that it supports the user. KBSE's drawback is that it will take a long time to migrate into everyday use. Further, high-level KBSE tools will require considerable training. They need greater exposure in the everyday working community so that they can be refined and extended to meet additional requirements as they are identified. We ought to be open to several ways of integrating AI and SE — given sufficient funding we can be. Economics being what they are, however, one right way is a good start.

Dr. Randall Shumaker is the Superintendent of the Information Technology Division of the Naval Research Laboratory in Washington, DC. This Division conducts research in applied AI, human computer interaction, assured computation, massively parallel computation, networks, formal methods, software engineering, hard real-time computation, simulation, and rapid prototyping techniques. He participated in the development of the SWTS.

The field of computation has made outstanding progress in providing computing power in the past four decades. By comparison, progress in software development has been surprisingly poor. While raw power has improved by perhaps seven orders of magnitude in forty years, software development efficiency has improved by perhaps a factor of seven. Part of this difference may have to do with the differing cultures in hardware and software development. Computer hardware engineering has undergone substantial automation and revolutionary changes in implementation techniques since the first computer; it has benefited from a long legacy of engineering practice in building things. Software engineering is still in its infancy, with software development largely practiced as an art form, complete with picturesque practitioners using the computer equivalent of hand tools. As in any domain relying primarily on skilled craftsmen, while there is more to producing a quality product than amassing a fine toolset, progress is inevitably limited without the toolset. KBSE, by helping create the needed toolset, represents an important step towards an engineering discipline for
software. KBSE is thus an important element of the overall DoD SWTS, but must be understood as only one part of the progress toward true engineering of software.

**Dr. Richard Jullig** is the Associate Director of the Kestrel Institute, which has undertaken several of the KBSA research projects, including the Project Management Assistant and the Development Assistant. His major research interests are in the areas of automated software synthesis, formalisms for the structural modeling of systems and the construction of systems from their components, and the compilation of declarative knowledge representation into pragmatically useful forms.

The notion of a knowledge-based software assistant conjures up many of the connotations associated with AI technology: competent but in need of guidance, able to reason about the domain of discourse based on an explicit domain model, and capable of reactive as well as proactive behavior. Thus KBSA is "right on" in the sense that it attempts to complement conventional SE technology with AI technology. Much of the existing technology has not yet reached full maturity, and much remains to be invented. In recent years it has become evident that knowledge representation in the software domain tends to require a good dose of formal methods, leading to the meeting of two communities reluctant to sail under each other's flag.

Perhaps more controversial is the way that the KBSA requirements were derived, and its organization as a research and development program. The SWTS does not claim to be a plan, but — in addition to an astonishingly comprehensive compendium of software technology topics — it outlines a technology production and transfer schedule. In sharp contrast to KBSA, SWTS implies an approach based on incremental improvement of the status quo, with return on investment as the dominant principle of prioritization. The original KBSA planning document postulates a new paradigm of software development together with a new kind of technology, where process and technology are mutually reinforcing. The KBSA process requires the KBSA technology to become practically viable; the KBSA technology redefines the roles of software developers and so reshapes the process.

It has become clear during the execution of the KBSA program that the "revolutionary" KBSA approach needs a modicum of the "evolutionary" SWTS approach to survive. The introductions of KBSA into software practice cannot be accomplished in a completely painless, incremental way; every paradigm shift requires upsetting changes in the prevailing infrastructure. On the other hand, support for KBSA will dry up unless there is evidence that the expected big bang will be more than a mere fizzle. Developers of KBSA technology must recognize and exploit the numerous but often unexpected opportunities for technology transfer of KBSA components. At the same time, they must not lose sight of the strategic goal. SWTS research program management will do well to emulate the patience with which the KBSA sponsors have nurtured the KBSA community.

**Dr. William Sasso** is an Associate Scientist in the Software Engineering Laboratory of Andersen Consulting's Center for Strategic Technology Research. Since 1988, he has participated in Andersen's knowledge-based software engineering research, including the KBSA Concept Demonstration System project. His responsibilities include KBSE technology transfer, empirical evaluation, and process modeling.

Written between the lines of the SWTS is the DoD's recognition that there is no silver bullet that will end the difficulties of software development. The process of improving software engineering practice and technology via the five strategic themes will be an arduous one. Our experience to date with KBSE should give us valuable insights in the types of AI/SE integration with the greatest practical value in the short- and mid-terms, as well as help us set priorities for basic research in the KBSE area. DoD must recognize, address, and support the requirements of both aspects of current KBSE research as well as advanced development work to build robust, transferable KBSE tools. We need to build a coalition of supporting organizations, including Government research agencies, academic researchers, commercial research centers, KBSA and CASE tool developers, and KBSE and CASE tool users working in a collaborative framework to realize the KBSE vision presented in SWTS. No one organization — not even DoD — can conduct or fund the vast amount of basic and applied KBSE work that remains to be done.