The role of an information analysis center in software engineering technology transfer*

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THE PREDICAMENT

As software engineering advances into its second decade, the ideas, principles and practices conceived in its first decade need to be assimilated into a workable set of tools and techniques that can be dispersed to software developers for their use in the production of software. The need for this technology transfer is clear and immediate. Without the proper transfer of software engineering technology from software engineering researcher to developer, the software world will be unable to extricate itself from its present predicament. This predicament has been characterized by Meyers as follows:

"The general character of the software predicament can be seen clearly, although consistent numbers with which to characterize it more precisely are hard to come by. Because less expensive hardware is bringing more applications within economic reach, the amount of software to be developed is increasing. Also because more software is already in existence, there is more to be maintained. But the productivity of programmers is improving rather slowly, especially by the standards of hardware price/ performance, with the result that the overall cost of software development is tending to increase."1

The predicament presents a rather ominous picture to be sure. Essentially, the problems of today in the software world are more difficult, but the solutions to the problems do not seem to be effective. The result is a losing battle if things continue as they have. One reason for the losing battle may be that the software world is trying to solve today's problems with yesterday's solution techniques. For example, several recent surveys have shown that the transfer of software engineering is at a standstill and that people are still developing software as they were five years ago.2

A POSSIBLE SOLUTION

"I firmly believe that technology transfer is the primary means we have to combat the software problems the industry has been experiencing."4

Reifer's statement points a way to the beginning of a solution to the software predicament that exists today. Technology transfer needs to bring new and effective solutions from the software engineering researcher to the software developer. Unfortunately, the process is not quite as easy as it sounds. Setting up direct communication links between researcher and developer will not insure that technology is transferred over these links. The wholesale importation of the latest software engineering techniques, in fact, just invites disaster. The developer needs to understand the techniques so they can be evaluated within the context of the development environment. This is essential. Another way of stating this is by citing Reifer's Technology Risk Principle.

"Technology should only be used when the risk associated with it is acceptable."3

Some of the technologies may indeed be acceptable in terms of risk; however, the developer needs to understand the technology and all of its myriad applications before any consideration can be made to its transfer to the development environment. This technology transfer business is more than giving lectures or writing journal articles about the latest technologies. It involves a certain amount of information synthesis and analysis so that the ultimate receiver can evaluate the technology's worth. If no benefit is perceived by the developer, no transfer of technology is going to occur. Of that we can be certain.

SOME SOLUTION MECHANISMS

Although the technology transfer process is a difficult one, there are mechanisms in place today within the software engineering community to effect the transfer of technology. Wasserman, for example, cites four major mechanisms (and their attendant shortcomings).6

1. University graduates go to work in software development settings.

Problem: New graduates generally have positions of low visibility and responsibility and have not received any

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development experience within the university environment.

2. University faculty serve as consultants to industry.
   
   Problem: Consultants often opt for more “interesting”
   (i.e. more research-oriented) situations as they come
   about and have little continuity within one company.
   They also lack the same software development expertise
   that their students lack.

3. Industry people go to the university.
   
   Problem: Sabbaticals are not open to many people and,
   besides, they are rarely taken by people with major project responsibilities.

4. Industry people attend short professional development courses.
   
   Problem: The direct application of the techniques
   learned in these courses is often difficult to transfer to
   a typical work situation.

These four techniques all involve some level of inter-personal dealings in an environment different than one the person is used to. Because the performance of individuals in such a situation has such a wide variance, it is difficult to obtain a consistent level of technology transfer. The crucial process of transferring the context of ideas generated in a researcher environment to a developer environment is a difficult achievement when attacked on a one-to-one basis. Nevertheless, these techniques should be effective if the “right” person for the job can be identified.

Studies in scientific and technical information dissemination have identified such a person. This person has the important technology transfer ability to interface the outside world (i.e. the research community) to the inner realm of the development organization. Much of the time, however, these people tend to be senior technical staff and not high level managers who could influence the company to adapt a new software engineering technology.

The professional societies and the journal literature serve as an aid to technology transfer in a more formal manner than the inter-personal techniques. For example, many of the societies arrange and conduct tutorials to disseminate information about software engineering technologies. Along the same lines, the journals of the professional societies publish articles about the latest techniques. Although these techniques are formal, their effectiveness is limited by the very structure of the professional groups and journals.

Professional groups, by their nature, are essentially special interest groups created to advance the interest and ideas of a relatively narrow area of interest. For this reason, the societies and their journals are more for the purpose of intra-group rather than inter-group communication. Both researcher and developer have their own societies, and both sides recognize the need and importance of the technology transfer issue. But the very structure of any society is not designed to facilitate a process such as technology transfer. The required interface mechanism between developer and researcher are not strong for the societies or the journal literature.

INFORMATION ANALYSIS CENTER AS TECHNOLOGY TRANSFER AGENT

A formal mechanism that can perform the interfacing role between researcher and developer for the purpose of technology transfer in the software world does exist. The mechanism is the information analysis center. Specifically, the information analysis center for software engineering is named the Data and Analysis Center for Software, hereafter referred to as DACS.

The purpose and objective of an information analysis center transcend those of a technical information center or library. The technical information center and library provide bibliographic services as their main commodity. Information analysis centers, as their name may imply, provide information analysis and synthesis services as their primary commodity. It is these analysis and synthesis services that serve as the core of the technology transfer mechanism within the information analysis center. As has been previously discussed, a precondition for the transfer of software engineering technology from the researcher to the software developer is a thorough understanding of the technology and its attendant implications in terms of risks and benefits within the developer’s environment. It is this essential precondition to the technology transfer process that can be provided by the synthesis and analysis of information within the information analysis center. Although the previously discussed mechanisms are all useful to some extent, they do not possess the match of capability and task that exists between the information analysis center and the technology transfer task. In software engineering, the requisite synthesis and analysis skill are provided by the DACS as the software engineering information analysis center.

THE INFORMATION ANALYSIS CENTER CONCEPT

The formal concept of the information analysis center was expressed in 1963 by the nuclear physicist Alvin Weinberg. Weinberg had prepared a report at this time which was to serve as somewhat of a landmark document in the field of national scientific and technical information policy. The information analysis center concept did not originate in the report; in fact, the report listed over 400 organizations in the nation it considered as meeting the criteria of an information analysis center. Highlighting the contribution information analysis centers could have in managing the nation’s technical information was one of the major concerns of the report. An excerpt from the report explains the worth of the information analysis center concept.

"The activities of the most successful (information analysis) centers are an intrinsic part of science and technology. The centers not only disseminate and retrieve information, they create new information. . . . In short, knowledgeable scientific interpreters who can collect relevant data, review a field and distill information in a manner that goes to the heart of a technical situation are more help to the overburdened specialist than a mere pile of relevant documents."
Although this excerpt does not explicitly mention technology transfer, that process of "... distilling information in a manner that goes to the heart of a technical situation" is certainly central to the process of technology transfer. The receiver of the technology must be able to understand and evaluate the technology on his own terms. The analysis and synthesis of information about a technology by the information analysis center matches the need and is the driving force behind the center's ability to act as an effective technology transfer agent. The fit between technology transfer and the information analysis center is a natural one; the statement Weinberg made about the value of the synthesis and analysis process is as valid and crucial today in the area of software engineering as it was in 1963 when the statement was made. By synthesizing and analyzing software engineering information into a form that is comprehensible and relevant to the software developer, the DACS has an important role as technology transfer agent in the field of software engineering. This task of synthesizing information in software engineering is more difficult than it might be with other fields because of the breadth and dynamic state of software engineering at the present time. But these very characteristics of software engineering may result in bigger payoffs when the technologies are transferred than may be the case with a narrower or more static discipline. The task is harder, but the potential benefits resulting from software engineering technology transfer may be greater.

A TWO-WAY STREET

Technology transfer is generally thought of as a one-way street from researcher to developer. Simply, technology, which originates with the researcher, is transferred to the software developer who is the ultimate user of the technology. In its broadest sense, however, technology transfer is a two-way street. It is a two-way street because the researcher needs the experience of the developer for guidance in future research efforts. Both good and bad experiences with technology provide the researcher with valuable information to improve the technology.

Information analysis centers are good places for the developer to transfer software experience information. Just as the information analysis center interfaces between the transfer of technology from researcher to developer, it can provide the interface for the flow of experience data from developer to researcher. The synthesis and analysis skills of the information analysis center are just as useful and relevant for both directions of information flow. A large part of the DACS effort is expended in this regard, particularly in the organization of software experience data into databases that can be used for the evaluation and analysis of software engineering technologies.

DACS—A SOFTWARE ENGINEERING INFORMATION ANALYSIS CENTER

In June of 1975, the Rome Air Development Center (RADC) contracted with IIT Research Institute (IITRI) to design a center that would acquire, analyze, and disseminate information on software engineering technology. The Air Force recognized the need for such a center to serve the government, industrial, and university community as a focal point for software development and experience data.

DoD has traditionally recognized the worth of information analysis centers. Several organizations within DoD sponsor a number of centers. For example, nine DoD Information Analysis Centers are managed and funded by the Defense Logistics Agency (DLA). In keeping with the nature of all information analysis centers, the centers are responsible for the acquisition, analysis, evaluation, and dissemination of scientific and technical information to the managers, scientists, engineers, and technicians they support. Among the specialized areas the centers deal with are electronic hardware reliability, metals and ceramics, and machinability. As part of its responsibilities, each center serves as an information and technology transfer agent within its own area of technical expertise.

A contract to establish the DACS was awarded to IIT Research Institute (IITRI) by RADC in August 1978. When fully implemented and operational, the DACS will provide a centralized source for current, readily usable data and information concerning software technology. This software information resource will: (1) aid the program manager in planning and monitoring software projects; (2) supply experience data to software research projects; (3) provide baselines for software development methods comparisons; (4) foster the use of uniform terminology; (5) aid in establishing data collection guidelines and standards; and (6) distill and disseminate information on software projects.

The benefits expected to be accrued by members of the software engineering community, both developers and researchers, are: (1) valuable savings of scientific and engineering manhours in locating data and information; (2) rapid application of the latest technologies via technology transfer; (3) elimination or minimization of duplication of effort; (4) reduction of software costs and improved performance; (5) minimization of program delays and schedule stretchouts.

All of the objectives of the DACS are related to the process of technology transfer. Through the first objective, the DACS will aid the technology transfer process by supplying information about software technologies to the developer in an understandable format. The second objective deals with the feedback from developer to researcher, as discussed earlier, that is required for refinement of technologies. Objective Number 3 will facilitate technology transfer by providing a basis for the evaluation of technologies in developer-related terms. Objectives 4 and 5 are objectives that will streamline the technology transfer mechanism. Uniform terminology (objective 4) and data collection guidelines (objective 5) are essential to aid communication between researchers and developers. Objective 6 is, in itself, the essence of the information analysis center technology transfer process—the ability to synthesize and distill information about the technology.

The benefits of the DACS, when they are realized, will result in efficient and effective technology transfer (benefits

From the collection of the Computer History Museum (www.computerhistory.org)
1-3) and a start at escaping from the software predicament which the Air Force, the Department of Defense, and the entire software community are facing (benefits 4 and 5). Although these benefits are ambitious, the framework of the information analysis center provides an excellent mechanism for achieving these goals.

HOW DACS OPERATES

Objectives cannot be fulfilled or benefits realized unless a methodology to achieve these ends is established and followed. Information analysis centers serve technology transfer by synthesizing, distilling, analyzing and repackaging information. The DACS, as an information analysis center technique, provides a mechanism for synthesizing and analyzing the information concerning software engineering technology. Since the DACS is currently a pilot facility, the techniques are just being formatted, utilized, and tested. Although these techniques are still in a test mode, they should be adequate as they follow the techniques used for other technical IAC's with a fair amount of success. A functional model of the techniques is shown in Figure 1.11,12

DACS ACTIVITIES AND PRODUCTS

Two major components make up the technique represented in Figure 1: (1) building an information base about software engineering technology and, (2) transferring information about the technology in a form that can readily be understood, evaluated, and used to the advantage of the software developer by the processes of information analysis and synthesis. Each of the major components consists of several sequential processing steps with each processing step resulting in the output of a particular information type. As a pilot facility, the DACS has more experience with the earlier steps, but all steps have been utilized to some extent.

Building the technology information base has been a major effort and concern of the DACS to date. This process consists of (1) information collection and, (2) information organization. From a technology transfer viewpoint, the purpose of these two steps is to prepare the information base so that it can later be synthesized into a form more suitable for technology transfer.

Information collection is being actively pursued by the DACS. The professional society publications are reviewed, as are conference proceedings: reports on new research projects, trade journals, and technical reports from universities, government, and industry. Information on new and previous software engineering research is the primary result of this review and collection procedure. Software experience data is also being collected by the DACS. At the present time, seven major datasets have been assembled and two are currently being assembled. Collection of all this information is, of course, necessary prior to any synthesis or analysis of the data that is required for technology transfer.

Information organization is the next step in the process of building a technology information base. Information man-
management skills, such as indexing, abstracting, and information storage and retrieval, are used in this phase. The information collected in the first step is indexed, abstracted, and entered into a computerized information retrieval system. Custom bibliographies can then be produced by the retrieval system by specifying subject keywords or by qualifications on other fields such as author or title. These bibliographies are of use to the research community and developers in locating results of research. At this point in the process, the information is organized as final preparation for the steps of information synthesis and analysis that are so important to the information analysis center's contribution to technology transfer. These first two steps (information collection and organization) are performed by most technical libraries. The next two steps, however, separate the information analysis center from the technical library.

Information synthesis, the next step, is the core of the technology transfer process. Information generated by the researcher must be digested and made palatable for the developer. If at all possible, the information must be presented in a format to allow cost-benefit assessment by the developer. Depending on the novelty and age of the technology, this may not always be possible. At the very least, however, the information must be distilled so the basic concepts and principles are explained in a language that the developer can comprehend. This is not an easy task. Considerable skills in communications and expertise in the technology are required to produce the handbooks and state-of-the-art reports that are the outputs of this technology transfer process.

DACS has produced a state-of-the-art report on quantitative software models. Research in this area has been extensive and has the potential for being used by developers, so this subject area was a prime candidate for this initial effort. With these thoughts in mind, the state-of-the-art report was produced with two major features to facilitate technology transfer. The first feature was a description of the salient characteristics of the model, such as data parameters, key equations and relationships, and experiences in using the model. This feature enables the developer to understand the model's concepts and capabilities.

Synthesis of information was carried one step further to produce the second feature of the report. A matrix was prepared to correlate model with data parameters. By using this matrix, a developer can quickly determine what models could be used with the data parameters available to the developer. If data parameters were unavailable, the cost of collecting them could be weighed against the benefits of the model as presented in the description.

Additionally, DACS has published a glossary of software engineering terms. This glossary should aid the technology transfer process by providing a reference point for uniform terminology.

One last step is included in the technology transfer process: information analysis. Analysis goes one step beyond synthesis by providing an evaluation of the technology. As the center makes the transfer from pilot to full-scale operation, this analysis effort will be pursued. One target of analysis that DACS would like to examine is the effectiveness of modern programming practices. At the present time, data sources for such an effort are being collected and organized.

USER PERCEPTIONS

A recent survey mailed with the DACS Newsletter is currently being analyzed. One interesting result in the light of the role of the DACS as technology transfer agent, is the interest of the respondents in state-of-the-art reports. These reports, as previously mentioned, are one of the primary products of the DACS.

Questionnaire respondents were given a list of the seven types of information processed and/or generated by an information analysis center and were asked the following:

"For your job, please rate the value of the following types of information (1 = most valuable)"

Table I summarizes the results. Although these results are preliminary, the results point to a definite preference for surveys of current technologies. The final results of the survey will be used to plan future DACS services and products.

CONCLUSION

The need for technology transfer in software engineering is clear and essential if the software world is to escape from

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<td>Information value:</td>
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<td>Percent of respondents ranking an information type as 1, 2, or 3 on a scale of 1 (most valuable) to 7 (least valuable).</td>
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<td>Information Type</td>
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<td>Information on new software research</td>
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its present predicament. Various methodologies and mechanisms exist for this transfer process. One process, using an information analysis center as a transfer agent, is appealing because the capability of the information analysis center as synthesizer of technology fits the task of transferring technology in such a way that the software developer and user can understand and evaluate the technology. As a software engineering information analysis center, the DACS is fulfilling the role of transfer agent. Mechanisms are in place to synthesize the software engineering technology and disseminate it to software developers. During its operation, DACS has built an information base of software engineering and used that base to synthesize the technology into several handbooks and state-of-the-art reports. Response to the reports has been encouraging, and the DACS plans to issue more in its role as a software engineering technology transfer agent.

REFERENCES


