Games for Co-Evolution of Digital Resources and Knowledge Tools

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Abstract. Successful digital resources have resulted from effective partnerships among content experts and tool builders, but such relationships are difficult to establish. Collaboratory testbeds were originally conceived as a response to that difficulty, but have been largely unsuccessful. We contend that effective testbed partnerships are as essential for knowledge-tool advancement as that advancement is to the support of effective partnerships, since knowledge tools must evolve to augment rather than merely to replicate human inference. We are building a game framework as a method for instituting testbed partnerships and an architecture for modular knowledge-tool integration, as essential steps in the co-evolution of knowledge tools and digital resource testbeds.

Collaboratory Testbeds Reconsidered

Many promising knowledge tools are stranded at the end of their research and development cycles, waiting to be found by user communities. Meanwhile, digital resource developers struggle to find tools powerful enough and customizable enough to augment their development work and to support the evolution of research applications that rely on their resources. The collaboratory-testbed method of technology customization and transfer would be an appropriate solution, if it could be realized as originally conceived for evolving scientific resources. (see Lederberg & Uncapher, 1989 : 14).

Testbeds were to support partnerships between users and technologists in exploring the utility of various technical approaches by which a scientist user-community could take advantage of emerging technology. In the virtual context of testbeds, scientist users could remotely collaborate to examine, calibrate, validate, and interpret some particular data content, while their technologist partners observed their work and introduced coordination technologies in experimental versions integrated for use in actual working contexts. The appropriate components of systems architecture and an array of tools for data access and communication would be designed and developed within a program of prototyping, testing, and evaluation that could support continuous improvement. Testbed participants were to be a sample group from the user community for whom collaboration support technology would be developed, and they were to be committed to work in partnerships with technologists who would be committed to work with them.

Partners collaborating in testbeds were conceived to be geographically distributed, to represent a range of disciplines, and to be dedicated to a continuing study of what might improve the quality of both data content and testbed context. Testbed partners must be able to correlate and coordinate three basic realms of concern: the specific nature and uses of the content data, the computing context for collaboratively manipulating that content, and the continuing improvement of that collaborative context for that content manipulation. Based on game theoretical studies of how cooperation and coordination capabilities can evolve, our game framework aims to institute the self-critical conduct required to engage testbed partners.

Testbed Games for Resource and Tool Improvement

Within the game framework (see Axelrod, 1984; Keeler, 2004; Keeler & Pfeiffer, 2005), tool users engaged in game-playing, while tool developers engage in tournaments to capture the variety of possible tool strategies that might improve the users' game. The users' game involves their particular content knowledge and the collaborative evolution of its concepts. We use Robert Brandom's *model of discursive practice,* because it treats concepts as norms, or nodes in an evolving inferential network of related concepts that determines "what counts as a reason for particular beliefs, claims, and intentions," in the same way that rules determine the correctness of moves in a game (Brandom, 2000 : 243; Keeler, 2004 : 25). Brandom's model identifies conceptual content in an expression by whether it can play a role in the inferential game of "making claims and giving and asking for reasons." Players give their beliefs, desires, and intentions conceptual content when they answer such pragmatic questions as "under what circumstances would that belief, desire, or intention be true?"— by expressing their answers in the form of conditional propositions (Brandom, 2000 : 158). The collaborative meaning of these propositions emerges in the social structure of their *inferential articulations* during the game (see Brandom, 2000 : 183). Conceptual content in this game is essentially collaborative.

When players in a testbed game report their claims (or hypotheses) in conditional form, they make explicit what is otherwise implicit in their ordinary discourse concerning whatever they consider significant in their ongoing work. Each player, using this propositional form in natural language (which need not be constrained to strict "if-then" statements), contributes hypotheses

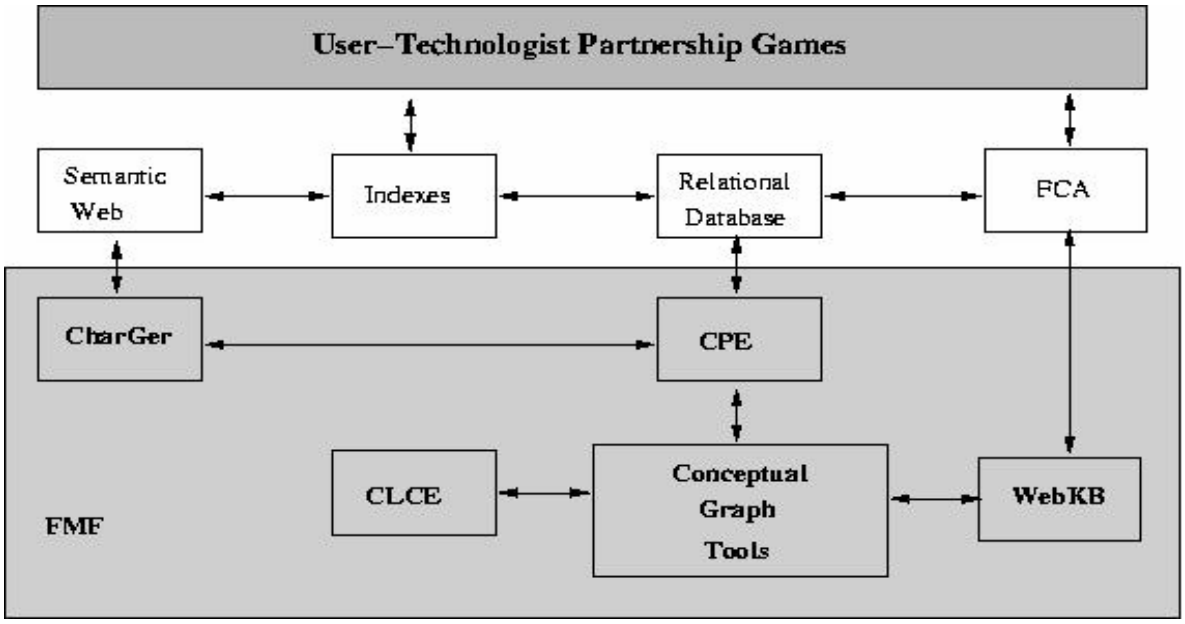

Figure 1: Tool Integration Architecture For Testbeds

to engage in collaborative discourse. By means of knowledge processing techniques in the game framework, valid collaborative hypotheses can be formulated from the contributions (see Keeler & Pfeiffer, 2005, for detailed scenario of scholars playing a digital manuscript game).

Using what Brandom calls the *normative fine structure of rationality*, NFS, the players can rely on the mechanism of the game to help them focus on and clarify the complexities of conceptual content and inference that emerge in their work's collaborative evolution. Incompatibilities that emerge mark possibly missing hypothetical inferences that should direct further inquiry. Compatible inferences trace the implications of validly related claims, and their reasons record the testable reliability of claims with respect to any data under their collaborative investigation (see Brandom, 2000). While each player attempts to maximize individual scores (the count of legitimate claims), all players must minimize the score of incompatibilities to improve their collaborative hypotheses, as the ultimate objective of the game. The "harmonizing" effect is similar to that of judges formulating principles of common law by codifying prior practice as represented in precedent, to express explicitly as a rule what was implicit in that precedent, as regulative authority in subsequent practice (see Brandom, 2000 : 75-76). Good standards-making in technology development also has this effect.

While users play the game to test (deductively and inductively) their claims and reasons concerning resource content development, they can also engage with their technologist partners in the game to specify and maintain consistency in requirements for augmentative technology. All conditional statements "played" are expressed in controlled natural language, such as Sowa's Controlled English Common Logic, CECL, and translated into formal "if-then" statements for processing as content requirements or tools specifications (see Sowa, 2002). An NFS mapping reveals incompatibilities among tool specifications to aid in developing standardization that is directed *de jure* by tool usage, rather than *de facto* by tool developers, for the many tools needed in the evolving work of digital resource-building: database, document, and knowledge-based management, search and retrieval, knowledge acquisition, interlingua for both natural language translation and system integration, knowledge-based communication services support and discourse management. These tools are modularly integratable for testing, as components to be customized for the needs of testbed game-players, by means of the “integration architecture,” Conceptual Programming Environment, CPE (see Pfeiffer, 2004). Figure 1, shows several knowledge tools integrated under Sowa's Flexible Modular Framework, FMF (see Sowa, 2004) and using CPE to communicate with each other and with outside systems.

Conclusions

The testbed method of user-developer partnerships can respond to evolving and diverse digital resource requirements. In testbeds, tool users and technology developers can participate in critically refining and validating both the functionality of the tools and their own habits of conduct. Tool developers can carefully consider how their systems actually work in particular contexts of operation, while resource builders have the chance to become comfortable with new versions of tool systems gradually by participating in their development. Testbed games can be used to evolve the partnerships and the knowledge tools needed for effective digital-resource collaboratories. In collaboratory testbed games, with knowledge tools as integratable components, resource-builders and technologists can explicitly modify their habits along with tool improvements, in co-evolution.

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