Towards Mixed-Initiative Discursive Networking

Julean A. Simon

Independent Research
Simmelstr. 33
13409 Berlin
simon@berlin.snafu.de

Abstract

The "mixed-initiative" system-design rationale is explored in the context of networked discourse, in particular in the context of a collaboration model, called DisNet. The frame-based system allows to make contextual relations explicit, but in typical group-projects users can not be expected to formalize the project-context so that it can be used by agents to participate in a collaboration on a higher level. On the level of sub-tasks simple processes can generate a system-behavior that qualifies for collaborative interaction. To achieve model consistency the model of interaction and the communication structure used by peers are used to communicate system behavior.

Introduction

Research in Mixed-Initiative Interaction (MII) studies the coordination of actions, particularly in collaborations where participants take initiative dependent on the situation; i.e. interpreting the situation "at run-time". In computer-supported settings the system, or a component process (agent) has been suggested to be seen as a participant in the collaboration as well (taking the common notion of the interactivity of a system literally). Consequently, mixed-initiative settings specialize the roles of the collaborators and the role of the collaborative environment, affect the working strategies and collaborative logistics and thereby directly, and indirectly influence also contextual aspects of a collaboration.

The mixed-initiative approach has been applied especially in the context of planning (see e.g. (Allen 1994), (Veloso 1996)) and is more or less closely related to fields such as dialog control, decision support, expert systems, etc. These areas usually work with a limited problem-space which allows to formalize contextual knowledge.

In this paper MII will be considered in the context of a collaboration model, called DisNet, that has been developed initially for an educational project. DisNet, which stands for "Discursive Networking", is based on a special communication model and a frame-based knowledge representation. These specifications, but also pedagogical requirements, particularize the formal bases, the functional range and the desired characteristics of system-, or agent behavior.

Before discussing these aspects in more detail features of the DisNet-model, as far as relevant to the subject will be described; for a more detailed description see (Simon, Wohlhart 1996).

DisNet: Model Overview

Pedagogical Considerations

While the mainstream in the development of learning tools targets "information-oriented learning" (supported by declarative type material, such as electronic textbooks, CD-ROM encyclopedia, course-ware), common notions as of the transferability of information and of the traditional student/teacher-roles tend to become obsolete. Studies have shown that in many cases knowledge can be acquired more efficiently and comprehensively by "process-oriented learning" in collaborative learning environments; for an overview see e.g. (Kumar). While the former strategy focuses on the more or less interactive delivery of factual information the latter understands learning as the effect of self-, or group-controlled activity in a problem field. This form of collaborative learning can be typified as an "open discourse": it is a recursive process where an interaction builds upon previous ones (thereby developing a reference structure) and it is self-referential in that its constituents are also made its subject (meta-discourse).

Defining learning as a self-, and group-controlled processes of convergence, condensation and structuring, and especially of the generation and differentiation of knowledge subsequently specializes the connotation of "mixed-initiative interaction" in this paper.

Distributed group-work requires not only to provide access to and support control of a shared workspace but also to offer open structures for maintaining a collaboration: communicative openness implies the maxim, that all participants be equally and fully embedded in the information-flow; operative openness allows the participants to tailor the infrastructure and to devise the logistics of communication and cooperation in a project; strategical openness is secured in that working strategies

may be negotiated and dynamically established in a meta-discourse which should be integrated in the project work.

The (topo-)logical representation of a group-work by current systems often reflects a surface-structure of the collaborative traffic and production, while the structure of argumentation and the knowledge relations remain implicit: especially collaborative learning projects requires the environment to support the explicit representation of knowledge relations.

Communication Model, Context Stratification

Current networked (learning) systems are predominantly based on a pipeline-concept of information transfer; for a review of communication models see e.g. (McQuail & Windahl 1989). Systems organize and represent communication (according to classical information theory) as seen from a super_observer-view and are designed around metaphors feigning "objective" instances of a communication/collaboration.

In fact, from the participant-perspective several aspects of a "communication" are not directly accessible, but rather evaluated on the basis of received feedback: the participant interacts with a black-box (resembling the Turing Test setup). The interpretation of (difference-)relations between communicative acts establishes a context which gives meaning to these acts and to the setting and situation in which they take place. Due to the recursive nature of this process context is continuously differentiated and gradually extended. Thus peers first of all interact with contexts they generate (the social component is one facet of these contexts).

The idea of generating contextual relations by interpreting a new interaction in the context of prior interactions can be found also in mixed-initiative planning, e.g. (Allen & Ferguson 1995). The focus on the difference-relation between interactions, distinguishes the communication model approach from dialog models, usually concerned more with the control of the interaction sequence.

The black-box model characterizes communication as a modulation of the feedback-loop which induces a process of continuous re-generation of context. Interactions with the context are compensatory changes in that they differentiate the current state of the context. Differentiation occurs in different dimensions (specialization, categorization, etc.) and on different levels; thus a context representation system should be capable of making different aspects of interactions and levels of discourse explicit (comp.: specification of sender, receiver, date and subject in email).

In DisNet a contextual object is constituted in terms of a frame (Minsky 1985) that describes the object on the basis of its relations to other objects on different levels and causes a "stratification of context", where the relation between contextual levels should be thought of as modal, rather than hierarchical.

Implementation Aspects

DisNet extends the hypertext-paradigm in that it establishes context as a multi-level relationship between contextual objects. An object is formalized as a frame that consists of any number of slot/value - pairs which make particular aspects of the contextual component explicit. The slots of a frame can easily be deleted or renamed, additional slots may be defined.

The slot-values of a frame (instance frame) are stored as a tuple in a tuple-space (Gelernter 1985); the corresponding slot-names (class frame) are stored as a tuple that is referenced by corresponding instance frames. Thus, a tuple-field may contain a slot-name, a slot-value, a pointer (to another tuple/-field, or tuple-space), or a function. The generic methods applied on tuples/-fields and tuplespaces are matching and differentiation; a composite method is compression that uses referencing; i.e. if a field-value can be inherited from part of another field-value of the same tuple, or from the corresponding field-value of other tuples, it is referenced. This method is used also for the modularization of tuples.

The interface can be built from a family of "domains of interaction" which specialize on different work-strategies; domains can be built from representational/functional primitives that represent and access different aspects of context. The generic interaction domain is FRAMER, a multi-field frame editor and browser, which not only is used to create and browse object frames and edit slot-values (multimedia data), but also to modify the slot-list of object frames and the appearance and functionality of interaction domains (which are treated as contextual objects). Another domain is the STRUCTOR, which allows to structurally represent a context (e.g. as a three-dimensional semantic network which allows 3D-navigation in the context-space). Domains can be combined and are structurally coupled, which supports alternating interaction in e.g. a textual and a graphical domain.

Context Representation and Differentiation

The frame-concept is not used in a strict sense as for logical inference, it has rather been introduced to modularize (encapsulate, reuse, restructure) and stratify (in/externally structure) contextual components.

The slot-list and slot-values of an object may be inherited from a referenced object, or modified at run-time. Thereby aspects and relations of an object which are regarded as essential can be made explicit; thus the internal structure of an object also structures its external relations and allows to localize and distribute collaborative interaction. Making aspects of interactions explicit is a pre-condition for methods such as matching, differentiation and compression. Many sub-tasks in a discourse can be thought of as matching processes on the basis of which relations and references can be established.

If a group-work has clear goals it may be organized on the basis of the deconstruction of these goals (scaffolding

strategy). But usually a discourse, or collaboration starts with an ill-structured, partially defined, problem-specification, which is recursively modified and refined.

In an asynchronous, networked collaboration interactions are (temporally, locally) decoupled which is a good basis for exploratory techniques. This autonomy is balanced by a structural integration: the rule that an object has to be created out of, and thereby linked to a reference object, and "link typing" (Conklin & Begeman 1988) establishes a level that represents local relations between objects as a "contextual network".

Note: when the term "context/contextual" is used in the context of a system, it actually stands for "context representation". Context is a reified pattern from relations; it is implicit, fragmentary (tacitly completed and integrated by interpretation) and dependent on the perspective taken; its components and structures change in the course of the interaction with it.

Collaboration Model

The organization and structuring of a group-project is a continuous process of negotiation as well as implicit control of goals, roles, conventions, strategies and control mechanisms . This meta-discourse establishes the "axiomatic" basis of a project and should - especially in a learning project - neither be fixed, nor shortcutted using predefined settings, or treated as external to the project.

The collaborative basis is essentially established and determined by characteristics of the intercommunication (directness of response, development of a jargon, integrative potential, competition, etc.); the provided (topical, representational, logistic) environment serves as a scaffolding.

The communication model typifies context differentiation as a local interaction, and collaboration as a distribution of tasks. Role-playing, a special type of collaboration can generate higher-level structures and support a coordination of actions in that it introduces meta-tasks (task-oriented roles), and advocates (position-oriented roles).

In a group-work roles often develop naturally; defining roles explicitly can improve the logistics and collaborative dynamics significantly. Analogous to the stratification on the context-level, role-playing can be seen as a stratification of the group-work (or of the work-group); it binds interactions to certain roles, links them according to some meta-task, makes tasks on different levels discernible and supports organizational tasks, such as a participant's decisions to take, or relinquish initiative. The clearer roles and their interfaces are defined the more it allows segmentation of the problem-field and parallel, instead of sequential group-work.

Mixed-Initiative Interaction

The approach taken in this paper is guided by the following basic working theses:

- The work-space of a group-work can become quite complex what the amount of objects and their relations, as well as the options for action concerns. At some point it is desirable and efficient to employ strategies that reduce complexity.
- A system-design that is first of all aimed at supporting human collaboration and representation of "natural" knowledge may as well provide a good basis for machine processes that support group-work and orientation in a project-space, especially if these processes are seen and treated as part of the collaboration.
- Agents can be seen as processes which are (temporally, locally,...) decoupled from direct control. To access data, negotiate options and present results they use the communicative structures established for the human collaboration and are addressed via the same communication structures. Thus humans can also be called agents (it will be avoided here), but agents are not necessarily human.

Implications of the DisNet Model

The specification of the communication/collaboration model along with the pedagogical requirements particularize/restrict the direction, range and character of desired system behavior; the formal and functional constituents of the system more or less define the playfield of cooperative processes (agents):

The proposed communication model does not set an apriori distinction between human and machine feedback; the human/machine-difference is a super-observer distinction. (This is not to say that there is no distinction; e.g. it is a specific human capability to become - by a self-induced reflective process - a super-observer.)

What the structuring of group-work is concerned the communication model, as well as pedagogical considerations, favor a distributed, rather than a centralized organization of the collaborative environment.

Contextual and meta-discursive knowledge is a reification of relations established between communicative actions. It has been pointed out that it is not captured in the context representation directly and therefore is not accessible by machine processes. (Davis, Shrobe & Szolovits 1993) maintain that "a knowledge representation is most fundamentally a surrogate, a substitute for the thing itself... It is a set of ontological commitments". It may be added: for a machine represented knowledge is the "thing itself"; i.e. agents can be expected to collaborate on the level of represented knowledge, which may support peers in the interpretation and forming of context.

Desired Agent Behavior

Early questions such as "Where and how can an agent participate in a group-work?" have to be addressed in the design of a system as well as in setting up, and in the course of a project. The question whether a system process

is acceptable as a collaborator suggests to consider the conditions of a cooperation. A basic condition of group-work is that collaborators trust each other. Trust needs a basis; it needs to be established and continuously confirmed in the collaboration and it depends on the comprehensibility of processes and their results.

It is beyond the scope of the DisNet model to have an agent recognize, "when to lead or otherwise take control of an interaction and when to let others take the initiative" (Haller 1996). This comes close to the ability to moderate a collaboration, in that it requires the agent to have a plan that weighs contextual, procedural, organisatorial and pedagogical knowledge. It is also a question if this would be desirable as the model proposes to distribute moderation among participants and rather structures initiatives (on a meta-level) by role-assignments. The main problem is that high-level tasks require context to be formalized, or provided as domain-knowledge, which can not be expected from participants in a typical group-work, in first place; and as DisNet is an open, multi-purpose system domain-knowledge can only partly be supplied in advance. Note, that this type of system to a certain degree requires the system-designer to provide the users with means so that they make the system collaborate with them.

First Steps Towards MII

Candidates for automatization are processes that operate on available system information, on knowledge that can be provided in advance (e.g. help on system-usage) and on contextual knowledge that has been formalized by the user. It also makes sense to focus on tasks which can be performed better by system processes than by human collaborators. Typically, these are interactions in limited and clearly definable sub-tasks with local goals and which can be bound either to particular actions, or to contextual units (object behavior), e.g.:

Anticipative assistance in system-usage, such as:
- survey available and present relevant options and help
- suggest next step, call for obligatory steps (interaction history)
- recognize and notify of new situations
- give feedback to user-interaction, represent it in context
- ask questions, process user response

Features that concern represented context, such as:
- search for matching expressions
- find and hint at contexually related sites
- observe consistency of input with format, constraints, conventions and rules
- (re-)organize objects, relations and structures, reduce complexity, compress redundancy

In the following, selected features that may be useful especially in a learning context are described in more detail. These simple processes do not directly exhibit characteristics of sophisticated cooperativity (also because the logic of the processes is obvious to the user, or has even been defined by the user), but may generate a system-behavior that qualifies for collaborative interaction.

Semi-/Automatic Editing: supports the creation and structuring of objects. The creation of an object should not be experienced as tedious form-filling. Many slots of a frame actually contain references and get a value assigned automatically in that they inherit it (say, author-name, date); values may also be determined by constraints, or processed by some function. Editing slot-values can be as simple as a drag&drop-operation, or the setting of a reference, in that e.g. the values of a keyword-slot, or a summary-slot may reference regions in a content-slot. The user may define object behavior in terms of rules or constraints that determine not only values, but also the relations of slots of a frame. Note, that a slot-list reflects the local application of a project-definition, of work strategies and of projected goals.

This rationale not primarily attempts to insinuatingly formalize context and make it accessible to automatic processes, but has the didactic end to let the student consider the function of an object in a context and to provide a formal scaffolding for its design. Rather than forcing the student to fill predefined slots, the formal framework should motivate to consider its appropriateness and to adapt it to the needs, if necessary.

Instant Key-Phrase Search: confronts the user with sites that match recent input. New input is searched for project-specific key-phrases (collected in a frame that functions as a project glossary and may contain title-terms, keywords, names, etc.). The process uses idletime to search for matches in the project-space and notifies the user if there are findings. Constraints can be set that filter key-phrases, specify the matching-method and the notification-mode, and determine recently visited, frequent words and obvious matches (explicit reference) to be ignored. If a matching site is confirmed to be relevant a reference is created. The occurrences of key-phrases in related context may be stored also in the link-slot-list of the glossary object which thereby functions as a user-approved cross-reference on the basis of (in this case: identity-) relations. The method may be extended to other types of relation.

The strategy has the effect that during editing the user is given feedback on related material in the project, which significantly influence how an object is built and related to other objects: redundancy may be avoided; if a term occurs in entirely different contexts, the terminology may be re-considered.

Contextualization Test: confronts the student with sentences formed from relations between slot-values. Typically, this process forms sentences on the basis of rules using slot-values of an object, or objects which are connected by typed links. A simple example rule would be:

<author_slot (x) "statesThat" summary_slot (x) link(x,y) summary_slot (y)>, where the slot-name retrieves the corresponding value and x,y refer to the objects.

Rules are stored as frames where the slots determine the values to be chosen, their order and a copula if necessary. Rules are selected randomly, or according to some rationale. The statements may be presented to the student by means of a speech synthesizer, or written in a bubble and serve to check the well-constructedness of objects and their relations. It indicates whether or not the slot-value in question is concisely expressed, whether it represents a logical unit and is directly related to the slot-value it references, whether or not the link-type chosen works as intended, etc.

Provisional Object Creation: uses temporary objects as a process infrastructure. Processes can be established by building task-specific object-templates and by defining their behavior. An instance of a task initializes a temporary object that is used to store and represent its data-structure and its results. These objects can be time-stamped, approved by the user and integrated in the contextual network, or used by other processes. This strategy is used for instance to find redundancies in the tuple-space. Identical values are compressed by exporting the value into a new object and by referencing it from the original site; this strategy can have the effect of a continuous optimization of the tuple-space.

Conclusion

There is certainly no discussion that it is desirable to provide networked group-work with an appropriate environment and knowledge representation, and to support it by processes that help organizing the project-space, and initialize and coordinate actions.

Several reasons can be indicated for extending the traditional collaboration model by considering machine processes (agents) as participants in a collaboration. One reason is based on the assumption that the environment as a representation system is a part of, and co-determines the project-context. It suggests to treat the modalities of the environment as contextual objects. Another reason concerns model consistency: the model of interaction and the communication structure used by peers are used also to communicate system behavior; agents operate in terms of user-suited interactions. Another reason refers particularly to the proposed communication model: the blackbox-situation, as described for the participant-perspective seems to be an appropriate description of the communicative situation of an agent, as well.

Introducing mixed-initiative interaction in collaborative systems faces a specific problem: the access to high level knowledge. Every project establishes its own context and although a formal basis is provided to let the participants make contextual aspects explicit for their particular purposes, in general it can not be expected that this form allows automatic reasoning. Therefore the design of processes has to concentrate on lower-level knowledge and general-type domain knowledge that can be supplied. To increase sophistication and efficiency processes interact with each other and with peers. Another way to go is to couple processes so that they form meta-tasks, that resemble roles humans adopt in a collaboration. This allows to define a role-bound initiative control, which would improve problem-, and situation-specific interaction.

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