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DEIXIS IN SYNCHRONOUS CSCL SYSTEMS

A Collection of Socio-Technical Patterns

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Abstract: There is a growing interest in synchronous CSCL systems that combine a communication space with a task space for supporting knowledge building by distributed or co-located small groups of learners. In that context, in which collaborative learning processes are scattered above two distinct spaces, deictic references to the objects in both spaces, the time of learners' actions, and the identity of participants are very important. This paper describes a structured collection of high-level patterns whose purpose is to catalog and document design knowledge about the mechanisms, resources and practices for deictic referencing.

1 INTRODUCTION

In a classical face-to-face (F2F) collaborative setting participants interact directly, through speech, and indirectly, through shared objects and feedthrough of actions of others. Both kinds of interaction contribute to create a common ground and a shared vision on the ongoing activity (Dix, 1994). Spoken communication includes references to shared objects that are often disambiguated by deictic gestures and gaze movements. Many synchronous CSCL systems are organized in the same way: they follow the Dual Interaction Spaces (DIS) paradigm (Mühlpfordt and Stahl, 2007) in which learners are provided with both a textual communication space and a task space, where learners manipulate one or several artifacts in WYSIWIS mode (possibly relaxed in position and representation). In some cases, the task space is the central location for the joint activity, with written communication playing a supportive role in discussing and disambiguating what happens in the task space. In the other cases, written communication dominates, with the task space serving as a place for clarifying or illustrating things that are hard to articulate in words (Dillenbourg and Traum, 2006). Empirical studies have demonstrated the effectiveness of DIS systems. For example, Baker et al. (2003) have shown that learners manipulating both a chat and a graphical argumentation tool produce more arguments and deeper arguments than learners working only with a chat. Synchronous CSCL systems can be used in a variety of settings, depending on the number of

geographical locations, the way learners are associated with displays (one-to-one or many-to-one), the right for co-located learners to speak to each other, the use of a large shared screen, the presence of a tutor, etc. For dealing with that diversity and complexity it is important *to document, for each major design issue, the possible solutions and their pros and cons*. It can help to better design or configure systems and gain deeper insight.

This paper focuses on deixis, which is a basic pragmatic need of collaboration. In linguistics, deixis is referencing by means of a spoken or written expression whose interpretation is relative to the context. The categories of contextual information referred to by deixis are those of place, time, and person. In a communication event, *spatial deixis* concerns the various relevant places (of the producer, receiver, other people or objects being referred to), *temporal deixis* concerns the various relevant times (like the moment of production), and *personal deixis* concerns all the participants involved in and referred to (producer, receiver, overhearers, other mentioned people). Typically, the point of reference (deictic center) is based on the assumption that the central person is the producer, the central time is the production time, and the central place is the producer's location (Holmes, 1995). In synchronous CSCL settings the degree to which the deictic center is shared and obvious to participants is altered. Elements that are frequently referred to are: the objects located in the task space and the communication space (spatial deixis), the

time of learners' actions (temporal deixis), the identity and role of participants (personal deixis).

Theoretical models of deictic referencing mainly focus on referential ambiguity (e.g., Chastine et al., 2006). In DIS systems, where learners' attention is scattered above multiple activities, *understandability of references over time* is also very important. Usual ways of pointing, like deictic expressions in written language (e.g., "the last component on the right"), can be used in CSCL systems. But there is no guarantee that such a textual description will remain always intelligible. For example, a textual description of the location of a given object becomes unintelligible if that object has been moved in the meantime. Moreover, eye gaze and gestural deixis, like finger pointing, can only be used in settings allowing visual communication between learners.

This paper focuses on the mechanisms and resources that can be included into synchronous CSCL systems for complementing or replacing these usual ways of pointing. Most CSCL systems provide several mechanisms, which play complementary roles. These mechanisms need to be carefully analyzed and documented. For example, Cherubini and Dillenbourg (2007) describe a lab experiment that considers two factors related to spatial and temporal deixis: (un) availability of a support for spatial referencing and (un) availability of a message history. They show that team performance is improved by a spatial referencing mechanism unless its implementation is detrimental to the linearity of the conversation. High-level patterns are used for describing the wide collection of deictic mechanisms and resources. In the field of collaborative systems, the umbrella term "pattern" is used for describing different kinds of specifications (Schümmer, 2005): (1) *Technology patterns* describe technical solutions to recurrent problems and aims at supporting and educating developers. A solution is generally expressed as a class schema in the object-oriented programming style. (2) *Ethnographic patterns* describe existing practices, not necessarily the best ones, and are intended to be used in the discussion between designers and users. (3) *Socio-technical patterns* capture design knowledge in a way that is accessible by both users and developers. Readers can concentrate on the problem and make informed design decisions addressing both the technical and social parts. Patterns in the next sections conform to the socio-technical paradigm. Due to space limitations, the paper can only give an idea of the most important patterns through a simplified description (a longer report is available at www.loria.fr/~jloncham/techdoc/deixisTR.pdf).

2 SPATIAL DEIXIS

2.1 Spatially Indexical Resources

Patterns in that first category describe deictic resources that can be referred to in written messages for designating objects or areas of interest.

P1: AUTOMATIC_OBJECT_IDENTIFICATION

Problem A learner wishes to refer to a previously created object (chat message or artifact component).

Solution The system automatically provides a unique, non-mutable identifier to each object when it is created that can be used for textual referencing.

Discussion Identifiers should be both simple and informative: sequential numbers are often associated to some identification information (see P15).

Sources Many chat tools implement automatic message numbering for cross-message referencing.

P2: PERSISTENT_POINTER

Problem A learner wishes to refer to a specific region of interest into the task space that cannot be reduced to a single element.

Solution A graphical symbol (e.g., an arrow) locates the region of interest and is associated with an identifier (given by the learner or the system) that can be used for textual referencing. A textual description may also be associated to the pointer.

Discussion Persistent pointers favor revisiting old contributions, i.e. grounding activities. Problems arise if the region can move or disappear.

Sources (Lonchamp, 2007), (Oura et al., 2008).

2.2 Virtual Gestural Deixis

Patterns in that second category describe virtual gesturing mechanisms and a "replacement strategy".

P3: TELECURSOR (Telepointer)

Problem Learners simultaneously manipulate artifacts using their input devices. Input devices are private so they cannot be used for gesturing.

Solution Telecursors are visualizations of other learners' input devices that can be distinguished (shape or color) from the local input device. They are shown on remote learners' screens.

Discussion Telecursors are well suited for systems with a single work surface that enforce strict WYSIWIS. They are useful for: (1) Acting as the locus of interest, the other learners directing their gaze at the telecursor position. (2) Becoming an artifact that learners can talk around: "Look at this"

is tied to the place on the screen that is pointed to. (3) Becoming a gesture: circling an area of the screen tells others to attend to all of the items in that area. (4) Providing a cue of someone's intent. Nametags or other mechanisms for identifying the owners can be used (see P15). Telecursors might overwhelm interaction because not all gestures have communicative intents (Tang et al., 2004). They demand high communication bandwidth. It is worse for more sophisticated techniques, like reality-augmenting telepointers (e.g., Bauer et al., 1999), anthropomorphic avatars, or full gaze awareness systems (e.g., Vertegaal, 1999), which cannot be easily deployed in learning settings. **Source** Studied in (Greenberg et al., 1996) and used in many synchronous tools.

P4: OBJECT_HIGHLIGHTING

Problem Observing multiple telecursors on the screen may induce a high cognitive load.

Solution The system highlights remotely the object that is gestured by the local cursor. For avoiding non voluntary gestures by passing over an object, and for enabling the selection of multiple objects some more deliberate action over the object (like double-clicking) can be required.

Discussion The remote representation of the highlighted artifact should be visually modified to differentiate it from artifacts that are not selected and from artifacts locally selected. It may associate a visually distinguishable characteristic to each learner (see P15). Object highlighting exemplifies the class of "semantic pointers" that are mapped to interface objects rather to Cartesian coordinates like telepointers (Greenberg et al., 1996).

Source Discussed in (Suthers et al., 2003).

P5: DIRECT_PROXY_MANIPULATION

Problem Learners are often reluctant to make the efforts required by virtual gestural or written deixis for designating the objects they are working with.

Solution Their "replacement strategy" is to directly create or manipulate the representational proxies in a shared artifact without textual explanations that would require deictic referencing.

Discussion Proxy manipulation will direct partners' attention to that particular element. Thus, participants can collaborate almost entirely through manipulation of representations.

Source Discussed in (Suthers et al., 2003).

2.3 Embedded Communication

Patterns in that third category describe a way to

implement spatial referencing by locating a message or a tool near the element they refer to, thereby providing the context needed to make sense of it. They make also easier to recover the portion of the discussion that is concerned with a given region.

P6: STICKY_NOTE (Post-it note)

Problem A learner wishes to associate some explanation, evaluation, or question to a specific location in a shared artifact or workspace.

Solution The learner can paste a short textual note somewhere by designating the location and opening a simple text editor. An icon and an identifier, provided by the learner or the system (with possibly the author's identification - see P15), are associated with the note. Clicking on the icon shows the message that is overlaid on the artifact. Another solution displays text blurbs on a separate space linked to landmarks with symbols or traits (in the Google maps style).

Discussion A sticky note has a permanent effect that favors revisiting old contributions. Sticky notes can have different labels to serve specific purposes such as a "Question" note or an "Evidence of" note. With sticky notes, it is difficult to get a sense of the whole discussion or to notice relevant relations between discussions about different elements. Artifacts may also become cluttered with comments. Tools have been proposed for switching between parallel and embedded communication (Dimitracopoulou, 2005): for example, inserting at their chronological place in the chat history, the content of sticky notes with the information of the objects they refer to.

Source (Margaritis et al., 2003).

P7: STICKY_ANNOTATED_SNAPSHOT

Problem A learner wishes to associate some complex graphical information to a specific object or region (e.g., sketching the differences between two versions of an artifact displayed side-by-side).

Solution The principle is the same as for sticky notes with a basic drawing tool for graphically gesturing on an automatically created snapshot.

Discussion A graphical sketch over a snapshot is well adapted for complex issues that refer to several elements in different parts of the screen. For the issue of discourse fragmentation, see P6.

Source (Lonchamp, 2007).

P8: OBJECT-BOUND_COMMUNICATION

Problem Sticky elements, notes and snapshots, are individual contributions. When the pedagogical design favors debates and exchanges of views debates and exchanges such isolated contributions

are not well adapted.

Solution A learner can paste a communication tool (asynchronous forum or synchronous chat) at a given location in the task space. This tool is associated with an icon and an identifier provided by the learner. Other learners who share that space can easily access that embedded tool.

Discussion The tool is linked to the targeted object. It keeps all the history attached for possible analysis and continuation. For the issue of discourse fragmentation, see P6.

Sources Embedded chat (Churchill et al., 2000), embedded forum in (Trahasch and Lauer, 2005).

2.4 Explicit Linking

Patterns in that fourth category describe mechanisms and practices implementing spatial referencing through explicit linking of objects.

P9: EXPLICIT_INTERFACE_LINK

Problem A learner wishes to relate a message to one or several previous messages and/or specific regions of a shared artifact.

Solution The system provides a mechanism for defining and automatically drawing a connecting line on the user interface from a message to another message or from a message to a rectangular area in a graphical artifact. As soon as the referencing message is displayed, the accompanying reference arrow is also displayed.

Discussion Explicit linking simplifies both message comprehension and message production. As message comprehension is easier learners are encouraged to revisit old messages. The production cost of repeating or describing parts of related materials can be saved. Explicit linking is restricted to one-to-one and one-to-many relationships. It is organized following the temporal order of emission of messages at the difference of embedded elements. Mühlpfordt and Wessner (2005) have shown that explicit referencing leads to more homogeneous participation and more participation in parallel discussion threads.

Sources (Mühlpfordt and Wessner, 2005), (Hall and Leahy, 2008).

P10: HAND_DRAWN_LINK

Problem A learner wishes to express complex relationships between objects of the same artifact or between objects from different artifacts or spaces.

Solution The system provides a mean for drawing links and more generally any kind of graphical annotation (underscoring, boxing, circling, etc.) on

top of an artifact or of the whole screen. The drawing surface can be a transparent layer provided by a tool or a snapshot (see P7).

Discussion Graphical sketching gives a way for dealing with many-to-many relationships.

Sources (Giordano and Mineo, 2005), (Lonchamp, 2007).

3 TEMPORAL DEIXIS

The aim is to facilitate referencing of actions performed at a specific point of time. They are useful for escaping the implicit temporal orientation that characterizes most communication tools. For example, chat postings are likely to be read in relation to something that recently occurred. Conversely, some artifacts help revisiting and referencing previous ideas and information.

3.1 Temporally Indexical Resources

P11: FADING_POINTER

Problem A learner wishes to draw attention immediately and for a short period of time to a specific element, for example for launching a discussion about that element.

Solution The system provides a gesture object (often arrow-shaped) that fades away over a short period of time. See P15 for the identification issues.

Discussion When the discussion has been established it is assumed that the pointer is no more useful. The fading process contributes to increase the salience of the pointer.

Source (Dongqiu and Gross, 1999).

3.2 Tools for Temporal Referencing

P12: ARTIFACT_HISTORY_BROWSER

Problem Whereas the persistent chat history is the complete sequence of contributions, the same does not hold for artifacts in the task space. Both the ordering and the intermediate results of actions are lost. The necessary context for interpreting messages that reference the artifact can quickly disappear.

Solution An artifact history browser brings a simple solution to some of these issues: (1) It preserves the task space context at all times and can be referred to in messages if some sequence counter is provided (e.g., "at step 87..."). (2) The chronologically ordered developmental steps can be played back.

Discussion Retrospective reflection is facilitated by the fact of being able to review the past developmental stages of an artifact and being able to

point to a particular stage with an explicit reference. **Sources** (Mühlpfordt and Stahl, 2007), (Cherubini and Dillenbourg, 2007).

P13: SESSION_HISTORY_BROWSER

Problem Providing a separate history for the communication space and for each artifact in the task space is unpractical for referring to a given stage of the collaborative process or for reflecting on that global process.

Solution A session history browser better solve the above-mentioned issues.

Discussion As the number of steps may be very large it is important to provide various ways to visit the session history: step-by-step, with a temporal slider, with a textual search facility, etc. For saving the cost for each learner of reaching a given historical stage, a way for synchronizing all browsers at the same point of the history is another important functionality.

Source (Lonchamp, 2007).

3.3 Artifacts for Temporal Referencing

P14: REFERENTIAL_RESOURCE

Problem Learners exchange many ideas during collaborative learning sessions. Revisiting prior contributions is costly if learners cannot benefit from an external representation of all exchanged ideas.

Solution A large category of artifacts, including concept maps, topic maps, mind maps, argument maps, or design sketches, can play that important role of temporal referential resource.

Discussion These artifacts can reduce short-term memory load by providing external items for things that should otherwise be kept in mind. They can also serve as visuo-spatial retrieval cues for long-term memory, evoking relevant information that might not otherwise be retrieved (Suwa and Tverski, 2002). Some artifacts explicitly specify relationships that allow comprehending temporal or causal paths.

Source (Suthers et al., 2003).

4 PERSONAL DEIXIS

The pattern in that last category describes mechanisms that support referencing of participants.

P15: AUTOMATIC_OWNER_IDENTIFICATION

Problem The fact that the creator of an object is made known (or not) to the other participants is an important design choice. Anonymity has both benefits, such as the encouragement to express

truthful opinions, and drawbacks, such as a lack of accountability (Nissenbaum, 1999). When public ownership is the rule, access to the owner (creator) should be made as easy as possible.

Solution The system can automatically associate to objects a direct or indirect indication of who is the owner (e.g., name tags, role tags, distinctive colors or shapes, etc.)

Discussion The notion of ownership is tightly linked to the notion of modification right. Learners often need a clear indication of ownership in order to regulate their activity and avoid conflicts.

Source Many collaborative tools provide automatic owner identification.

5 CONCLUSION

As an empirical science CSCL aims at accumulating empirical knowledge about the efficiency of CSCL practices through controlled experiments and qualitative field studies. As a design science CSCL should similarly accumulate and document knowledge on how to build innovative systems for improving both design and insight. Socio-technical patterns are the basic elements of a “design-oriented language” for communicating between researchers, designers, and educators.

The collection presented in this paper is focused on the limited, albeit important, issue of deixis in synchronous CSCL systems. In the near future, the same approach should be used for analyzing and documenting other important facets of CSCL system design like, for example, “collaboration mining”: search of social bindings, of learners involved in a specific activity or with a specific expertise and so forth. A pattern collection should be adaptive by nature. As the design culture of the community evolves, the “pattern language” is intended to evolve as well. In the collection, which could probably be extended, a few patterns like *TELECURSOR* or *STICKY_NOTE* are known from many years and not specific to the CSCL field. They have both been criticized through experimental studies in the learning field: a telecursor may overwhelm interaction because its activity cannot be always related to the user intention, attention or presence (Tang et al., 2004). A sticky note breaks the temporal order of the discourse and pushes users towards asynchronous forms of communications (Cherubini, 2008). The other patterns reflect more recent advances in the CSCL research field. Some of them result from a kind of “hybridization” between patterns, like P7 that derives from P6 and P10. A pattern collection may also facilitate these geneses.

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