Temporal Plan Interdependencies

Katharina Kaiser and **Silvia Miksch**[1]

Abstract. *Asbru* is a complex formal language developed to represent clinical guidelines and protocols which are time- and process-oriented. To facilitate and support the modeling in *Asbru* methods and tools are required. In this paper, we provide a systematic analysis of the various plan components and their temporal interdependences (written in *Asbru*) to infer heuristics for our methods and tools. We develop different forms of representations to display flows in Asbru to simplify the modeling process.

1 INTRODUCTION

Asbru [3] is a complex guideline-representation language that represents clinical guidelines and protocols (CGPs) in a computer-supported way for execution in decision support systems. A comprehensive overview about various guideline-representation languages can be found in [6]. CGPs are "systematically developed statements to assist practitioners and patient decisions about appropriate health care for specific circumstances" [2] that can improve patient care.

The strong point of Asbru is the modeling of CGPs that are *process-oriented*. Our aim is to facilitate the generation of computer-supported protocols and in series to support the creation of parts of protocols in Asbru. At present there exist two different tools that supports the creation of Asbru protocols, *AsbruView* [4] and the *Guideline Markup Tool (GMT)* [5], whereby the plan developer has to have at least process modeling and medical knowledge or even the knowledge about Asbru.

Thus, the demand for a tool is arising that supports the creation of Asbru protocols as automated as possible. Resulting we want to offer support for modeling these processes without having to know the syntax of Asbru in detail. As part of a preprocessing we need a systematic analysis and description of Asbru elements and process components to describe the whole value facet.

2 TEMPORAL INFORMATION IN ASBRU

For the formal definition of complex flows a powerful representation is needed, which is provided by Asbru. For ideally representing flows and processes that have a strong temporal context a special form of representation of intervals was defined that can also represent uncertainties in respect of the begin, the end, and the duration of the interval. Furthermore, no time points for the begin and the end are defined, but shifts (earliest/latest starting shift (ESS/LSS), earliest/latest finishing shift (EFS/LFS)) from an arbitrary definable reference point. This point can individually be assigned for any interval. Additionally, the duration can be represented by a minimum and maximum (MinDur and MaxDur) – which are not 100 % dependent on the start and end points, but are constrained by them.

Furthermore, we can differentiate between seven plan states in Asbru: *considered, possible, ready, activated, suspended, completed,* and *aborted*. For our model we will only deal with simplified plan states named *selected, active,* and *finished*.

For representing different relations between plans, Asbru provides several *plan types* that describe the behavior concerning the execution of the plans and their synchronization [3]: *sequential plans*, *any-order plans* (only one plan can be active; the ordering of the plans is established during execution), *unordered plans* (all plans are executed without any synchronization), and *subplans* (plans can be nested, i.e., a plan can invoke subplans, which are again subject of a particular ordering by assigning one of the above plan types; subplans can be activated during their parent's *activated* or *suspended* state and can last during their parent's *completed* or *aborted* state).

3 REPRESENTING PLANS IN ASBRU

Connecting intervals in Asbru with a relation based on Allen's calculus of time [1] is a hard venture. As mentioned in the preceding section, Asbru intervals have an area of uncertainty regarding the starting and finishing point as well as the duration.

When activating a plan the interval is instantiated and a starting time is defined. After finishing of the plan the finishing time of the interval is defined as well as the duration, which is computed by the difference between the finishing time and the starting time.

In Asbru three methods are provided for representing relations between intervals, which will be described in the next subsections: (1) representations based on plan states and state transitions, (2) representations based on plan types, and (3) representations based on time points.

3.1 Representing relations based on plan states and plan state transitions

Fig. 1 gives a detailed description about the relationships of the plan states and Allen's interval relations. The first two columns represent Allen's 13 mutually exclusive interval relations. The third column describes the referring limiting point of interval B and the last three columns show the resulting plan state or plan state transition of of interval A. We can see that relations with at least one limiting point of an interval equal to a limiting point of the other interval, the plan state transition (depicted by an arrow) is matter and not the plan state.

3.2 Representing relations based on plan types

We can part Allen's 13 mutually exclusive interval relations [1] in two categories: *sequential relations* (before, after, meets, met-by),

[1] Institute of Software Technology & Interactive Systems, Vienna University of Technology, Vienna, Austria email: kaiser@asgaard.tuwien.ac.at

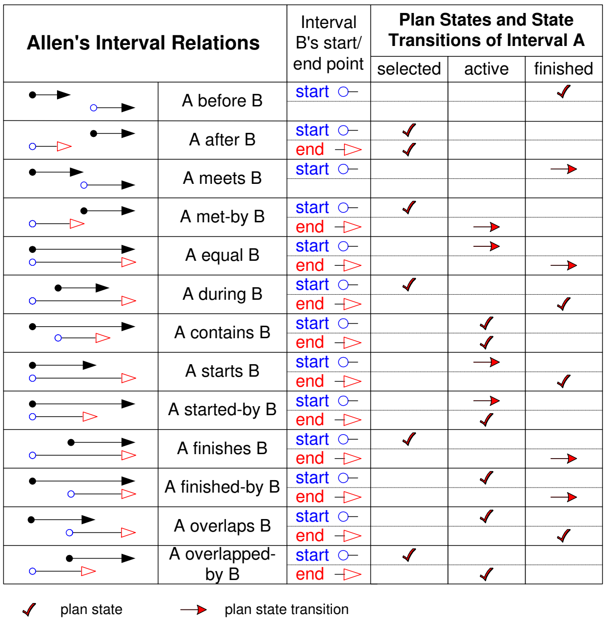

Figure 1. Interval relations represented by means of plan states and plan state transitions.

which can be modeled by sequential, any-order, and unordered plan types [3], and *overlapping relations* (equal, starts, started-by, finishes, finished-by, during, contains, overlaps, overlapped-by). We can look at the latter category by different aspects like the position of the various starting (see Figure 2) and finishing points. The types

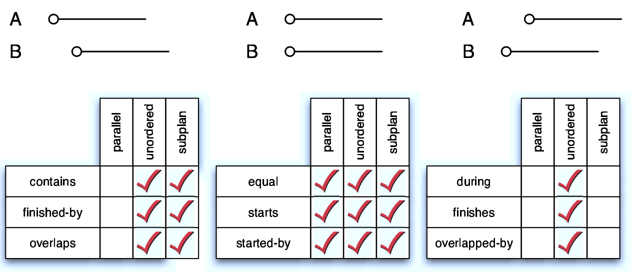

Figure 2. Plan types by whose means the several interval relations can be modeled. This array is resulting from considerations regarding the starting points.

of synchronization that define the different plan types in Asbru are oriented by the start of the particular plans - and not by the finishing of the plans (cp. [3]).

3.3 Representing relations based on time points

Intervals can have uncertainties regarding the start and end time points as well as the duration. Therefore, it is very difficult to define relations by time points. For example, the *before* relation:

A before B:

The reference point of B ($\mathtt{ref}_B$) is set to the time point, when plan state of interval A passes from *active* into *finished* ($\mathtt{FP}_A$) and B's earliest starting shift has to be greater 0.

$$\mathtt{ref}_B = \mathtt{FP}_A,\ \mathtt{ESS}_B > 0$$

Thereby, we can see, that we can only define conditional relations by time points. This is more apparent for relations like the *overlaps* relation:

A overlaps B:

Although, B's reference point is set to the time point when A is *activated*, both the starting and the finishing shift of B cannot be set exactly.

$$\mathtt{ref}_B = \mathtt{SP}_A,\ 0 < \mathtt{ESS}_B < \mathtt{MinDur}_A,\ \mathtt{EFS}_B > \mathtt{MinDur}_A$$

4 CONCLUSION

We have shown how information about events and actions can be used and methods to represent them in formal representation Asbru (more detailed given in [3]). Nevertheless, it can be difficult for the human plan designer having a consistent image of all plans and detecting coherences, because of the potentially varying available temporal information regarding events and actions. The systematic analysis presented is applicable

- to give an overview about plans and show interdependencies among them to the plan designer.
- to support the transformation process from text to a formal representation by means of an intermediate representation. This intermediate representation contains a representation of special aspects (e.g., temporal information about processes) and can provide tailored functions that support the sequential processing of the information.
- to capture the process information about different available temporal expressions, like point or interval relations and metric and qualitative information, and how to represent them in Asbru.
- to save developing time and thereby costs by simplifying the process of transforming the CGPs to the guideline-representation language Asbru.

ACKNOWLEDGEMENTS

This project is supported by "Fonds zur Förderung der wissenschaftlichen Forschung FWF" (Austrian Science Fund), grant P15467-INF. We greatly appreciate the travel grant by ECCAI.

REFERENCES

[1] James F. Allen, 'Maintaining knowledge about temporal intervals.', *Communications of the ACM*, **26**(11), (November 1983).

[2] *Clinical Practice Guidelines: Directions for a New Program.*, eds., M.J. Field and K.H. Lohr, National Academy Press, Institute of Medicine, Washington DC, 1990.

[3] Katharina Kaiser and Silvia Miksch, 'Treating temporal information in plan and process modeling', Technical Report Asgaard-TR-2004-1, Institute of Software Technology & Interactive Systems, Vienna University of Technology, (2004).

[4] Robert Kosara and Silvia Miksch, 'Metaphors of movement: A visualization and user interface for time-oriented, skeletal plans.', *Artificial Intelligence in Medicine, Special Issue: Information Visualization in Medicine*, **22**(2), 111–131, (May 2001).

[5] Robert Kosara, Silvia Miksch, Andreas Seyfang, and Peter Votruba, 'Tools for acquiring clinical guidelines in Asbru.', in *Proceedings of the Sixth World Conference on Integrate Design and Process Technology (IDPT'02)*, (2002).

[6] Mor Peleg, Samson W. Tu, Jonathan Bury, Paolo Ciccarese, John Fox, Robert A. Greenes, Richard Hall, Peter D. Johnson, Neill Jones, Anand Kumar, Silvia Miksch, Silvana Quaglini, Andreas Seyfang, Edward H. Shortliffe, and Mario Stefanelli, 'Comparing computer-interpretable guideline models: A case-study approach', *Journal of the American Medical Informatics Association (JAMIA)*, **10**(1), 52–68, (Jan-Feb 2002).