Temporal Dependence Networks for the Design of Convivial Multiagent Systems

(Extended Abstract)

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ABSTRACT

We show how to use TROPOS as a design methodology for *convivial* multi-agent systems. We introduce temporal dependence networks to measure the evolution of conviviality over time, and we compare them to dynamic dependence networks introduced for conviviality masks and internal dynamics.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems; D.2.1 [**Software Engineering**]: Requirements/Specifications—*Methodologies*; K.4.3 [**Computers and Society**]: Organizational Impacts—*Computer-supported collaborative work*

General Terms

Theory, Design

Keywords

Dependence Networks, Conviviality, TROPOS, Multiagent Systems

1. DEPENDENCE NETWORKS IN TROPOS

In the TROPOS methodology [2], agents are endowed with intentionality from early requirements to implementation. Very early phases of requirement analysis allow for a profound understanding of the environment and of the interactions for the software to be built. This methodology guides a designer through an incremental process, from the initial model of stakeholders, to refined intermediate models that, at the end, become the code. TROPOS uses dependence networks, a kind of social networks where the relations among agents are labelled by goals, representing that an agent depends on other agents to satisfy its goals. Abstracting away from the actions or plans of the agents, we [3] define dependence networks as in Def. 1.

DEFINITION 1 (DEPENDENCE NETWORK). *A dependence network is a tuple $\langle A, G, dep\rangle$, where A and G are two disjoint sets (of agents and goals), and $dep : A \times 2^A \rightarrow 2^{2^G}$ is a function that relates with each pair of an agent and a set of agents, all the sets of goals on which the agent depends on the set of agents.*

Boella *et al.* [1] show how dependence networks can be used to determine which reciprocity based coalitions can be formed, and we [3] argue that such reciprocity based coalitions are an indication of conviviality, because reciprocity plays a central role in conviviality. More precisely, Illich defines conviviality as "individual freedom realized in personal interdependence" [5], and dependence networks model this interdependence [4, 6]. Conviviality can be measured by the number of reciprocity based coalitions that can be formed, because if this number is high, then the agents have a lot of freedom in choosing with whom to cooperate to see to their goals.

Moreover, we [3] define a conviviality mask as "a transformation of social dependencies by hiding power relations and social structures to facilitate social interactions", and for the internal dynamics of such transformations we introduce dynamic dependence networks by replacing *dep* by *dyndep* : $A \times 2^A \times 2^A \rightarrow 2^{2^G}$, a function that relates with each triple of an agent and two sets of agents, all the sets of goals on which the first depends on the second, if the third creates the dependency. However, it is very difficult to measure the evolution of conviviality over time, and we therefore introduce temporal dependence networks.

2. TEMPORAL DEPENDENCE NETWORK

Temporal dependence networks are sequences of networks.

DEFINITION 2 (TEMPORAL DEPENDENCE NETWORK). *A temporal dependence network is a tuple $DP = \langle A, G, T, dep\rangle$ where A and G are sets (of agents and goals), T is the set of natural numbers, and tdep : $T \times A \times 2^A \rightarrow 2^{2^G}$ is a function that relates with each triple of a sequence number, an agent and a set of agents, all the sets of goals on which the agent depends on the set of agents.*

We illustrate the evolution of dependence networks and conviviality over time using a virtual adoption example. The procedure involves parents listing themselves to advertise their profile to prospective children who, if they like the parents, can select them. The agency matches children and parents and organizes a try-out period. Once parents and children have made their decision, they come back to the agency to cancel the adoption if unhappy or otherwise to confirm it and get their adoption certificate and a ceremony.

The TROPOS methodology starts by informally listing critical stakeholders together with their goals and dependencies. In particular, the parent is associated with the goal 'adopt child', while the actor child is associated with the goal 'get adopted' and virtual

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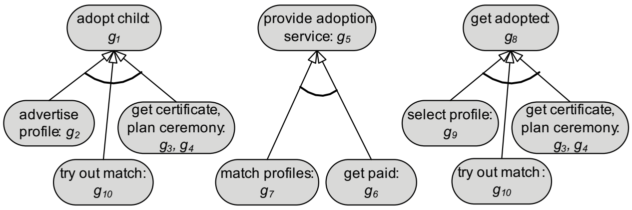

Figure 1: Goal diagram.

agency with the goal 'provide adoption service'. In Fig. 1, the decomposition of goals is visualized by a so-called goal diagram. For instance, the child goal 'get adopted' is decomposed into 'select profile', 'try out match' and 'get certificate - plan ceremony.'

Thereafter, TROPOS builds a dependence network to represent the dependencies among the agents. We, however, propose to build a UML sequence diagram first, as visualized in Fig. 2, illustrating

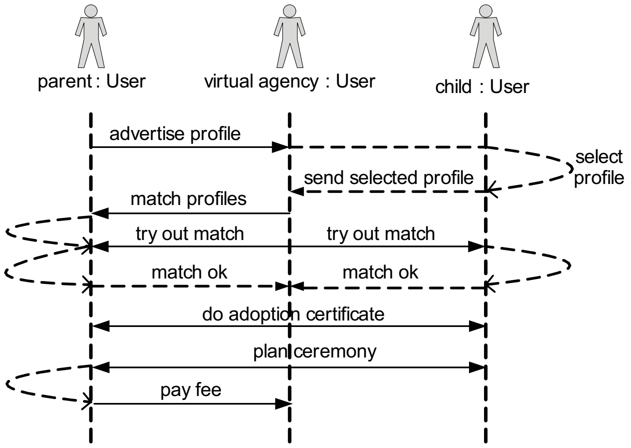

Figure 2: Sequence diagram.

the interactions among the stakeholders and how operations are carried out. The diagram shows time incrementing vertically. The interaction starts with the 'advertise profile request' by the parent to the agency and ends with 'pay fee' by the parent to the agency. Moreover, the agency sends the adoption certificate and the plan ceremony to both child and parent.

We use the UML sequence diagram to build the sequence of six dependence networks visualized in Fig. 3. This figure must be read

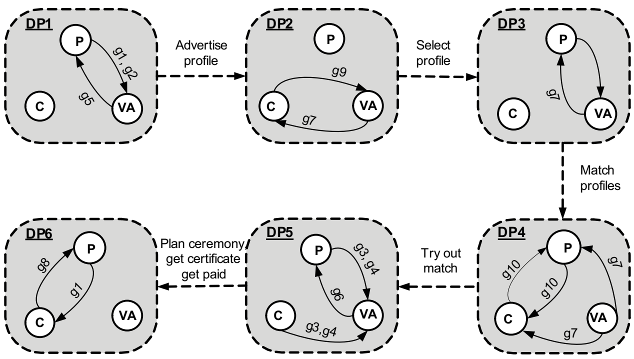

Figure 3: Temporal dependence network

as follows. First note that the set of agents $A = \{P, C, VA\}$ does not change, the only elements that change are the dependencies among them. Then, dependence network DP1 is the network before the profile is advertised, representing the dependencies among the parent and the agency, and so on. For example, in DP4, agency *VA* depends on parent P and child C to achieve goal g_7 (to match parent-child profiles), parent P depends on child C to achieve goal g_{10} (try out match), and vice versa. Most steps of the sequence diagram are represented by a dependence network. "Match ok" is not depicted as a dependence network, but needs to be indicated in the sequence diagram as a trigger for next events, and the three last goals are merged in the dependence network.

3. COMPARISON

It is much easier to model a state of the sequence diagram as a dependence network, than to model all dependencies in a single dependence network. For example, if we simply combine all six dependence networks in a single dependence network by putting all dependencies in, then there are many reciprocity cycles which do not make sense. For example, $\{g_1, g_6\}$ is a set of reciprocal dependencies between parent and virtual agency of DP2 and DP5, which could be joined together.

More refined conviviality measures can be defined. The conviviality measure is roughly the number of possible exchanges in the network, represented by the number of cycles. Such a rough measure can be made more precise by taking into account the number of agents in the network, and how dependencies are distributed over the agents. For example, it is more convivial if all agents have some freedom in selecting their partners, than if most agents do not have any choice, and one agents has a large choice. With temporal dependence networks, we can also take the evolution of conviviality into account. For example, it is more convivial if the agents have freedom in all phases of the interaction.

4. CONCLUDING REMARK

Besides a more detailed description of the conviviality measures, temporal dependence networks allow for a more modular and local approach. For example, as on one hand, every moment in time is not necessary relevant enough to be modeled on its own, and on the other hand, some sequences may depend on each other and therefore gained in being combined together, several sequential steps can be modeled as a single dependence network.

5. REFERENCES

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