Chapter XIV
Specifying Artificial Institutions
in the Event Calculus

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ABSTRACT

The specification of open interaction systems is widely recognized to be a crucial issue, which involves the problem of finding a standard way of specifying: a communication language for the interacting agents, the entities that constitute the context of the interaction, and rules that regulate interactions. An approach to solve these problems consists in modelling open interaction systems as a set of artificial institutions. In this chapter we address this issue by formally defining, in the Event Calculus, a repertoire of abstract concepts (like commitment, institutional power, role, and norm) that can be used to specify every artificial institution. We then show how, starting from the formal definition of these concepts and of application-dependent concepts, it is possible to obtain a formal specification of a system. By using a suitable tool, it is then possible to simulate and monitor the system’s evolution through automatic deduction.

INTRODUCTION

The specification of open interaction systems, which can be dynamically entered and left by heterogeneous, autonomous, and self-interested agents, is widely recognized to be a crucial issue in the development of distributed applications on the Internet. The interacting agents may be heterogeneous because...
they may be developed by different designers; as a consequence, no assumptions can be made on their internal architecture and it is impossible to access their internal states. Agents may be self-interested because they act on behalf of different human counterparts that, in general, do not share a common goal. Finally, agents are autonomous because they are not centrally controlled, but act on the basis of private strategies.

The specification of such systems involves two main problems: the first is the definition of a standard way of specifying a communication language for the interacting agents and of the context of the interaction; the second, which derives from the assumption of the agents autonomy, is finding a way to regulate interactions so that agents may have reliable expectations on the future development of the system. A possible approach to solve those problems consists in modelling the interaction systems as a set of artificial institutions. By this term we mean the digital counterpart or extension of a human institution, like for example the institution of language, the institution of property, or the institution of auctions.

In our view the definition of a specific artificial institution (Fornara et al., 2008) consists of: (i) a component, called meta-model, which includes the definition of basic entities common to the specification of every institution, like the concepts of commitment, institutional power, role, and norm, and the actions necessary for exchanging messages; (ii) a component specific to the institution in question, which includes the specification of the powers and norms that apply to the agents playing roles in the institution, and the definition of the concepts pertaining to the domain of the interaction (for example the actions of paying or delivering a product, bidding in an auction, etc.). The aim of this chapter is to give a formal definition of the domain-independent component and to illustrate the domain-dependent component through a meaningful example.

In the literature on multi-agent systems, various concepts that have some similarities or analogies with our idea of an artificial institution have been proposed. In the Nineteen-eighties, Carl Hewitt introduced the concept of open systems (Hewitt, 1986); in (Artikis et al., 2002) Artikis and colleagues give a detailed definition of the term open societies and use the term institution as a synonym, without distinguishing, as we do, an open system from an artificial institution; Noriega, Sierra and colleagues use the term electronic institution (Noriega, 1997, Esteva et al., 2001) to indicate “the rules of the game—a set of conventions that articulate agents’ interactions”. According to Arcos and colleagues (2005) “The essential roles (electronic institutions) play are both descriptive and prescriptive: the institution makes the conventions explicit to participants, and it warrants their compliance.” (p. 193); therefore electronic institutions are very similar to our artificial institutions, even if usually they do not allow for the violation of rules and thus do not address the management of sanctions. In (Vázquez-Salceda et al., 2005) Vázquez-Salceda and colleagues concentrate their attention on the organizational perspective of an open system. There are moreover works that are mainly focused on the normative component of a system, usually called Normative Framework (López y López et al., 2005) or Normative System (Boella et al., 2007). In this chapter we formalize OCeAN (Ontology, CommitmEnts, Authorizations, Norms) (Fornara et al., 2007, Fornara et al., 2008), a meta-model for the specification of artificial institutions, using a variant of the Event Calculus, the Discrete Event Calculus (DEC) introduced by Mueller (Mueller, 2006). Based on many-sorted first order logic, DEC is suited for reasoning about action and change: by means of axioms it is possible to describe how certain properties of a domain change according to the occurrence of events or actions at different time points. The DEC formalization of OCeAN consists of a set of events, fluents, and axioms that describe the entities, and their evolution in time, that can be used in the specification of a wide range of artificial institutions. The specification of an interaction