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# Specifying and Verifying Contract-driven Service Compositions using Commitments and Model Checking

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## Abstract

The paper proposes a novel model checking-based approach towards verifying the compliance of intelligent agent-based web services with contracts regulating their compositions specified in the Business Process Execution Language (BPEL). Unlike the existing approaches in the literature, the main contribution and impact of the introduced approach is the ability to verify intelligent and autonomous composite web services by capturing and describing in details both compliance and violation behaviors, how the system can distinguish between them, and how the system reacts and can be recovered after each violation. The approach encompasses three contributing parts, namely: 1) the marking process of an extended BPEL; 2) the transformation of the extended and marked BPEL to an automata model; and 3) the encoding of the resulting automata model into the Interpreted Systems Programming Language (ISPL), the input language of the MCMAS model checker for intelligent and autonomous multi-agent systems. In the first part, we extend BPEL that specifies the business process of the composition by creating custom activities called labels. We use those labels as means to represent the specifications and mark the points the developer aims to verify. A significant advantage of this labeling is the ability to highlight specific points in the design to be verified and to distinguish compliance behaviors from violations, which makes this verification focused and highly efficient. In the second part, we introduce new transformation rules to transform the extended and marked BPEL to an automata model. This transformation requires a prior modeling of agent-based web services composition using automata definitions. In the third part, we introduce algorithmic translation rules encoding the resulting automata model into ISPL. This translation makes model checking the behavior of our contract-driven compositions possible. A novel characteristic of the proposed approach is the automatic generation of the properties against which the system is verified from the composition's implementation, which is technically challenging. The verification properties are expressed in the Computation Tree Logic of Commitments (CTLC). Technically, CTLC provides a powerful representation to formally model 1) interactions among multi-agent based web services and 2) compliance and violation behaviors

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