Governance of Services: A Natural Function for Agents[1]

F.M. Brazier [a] F. Dignum [b] V. Dignum [a] M.H. Huhns [c] T. Lessner [d]
J. Padget[e] T. Quillinan [f] M. P. Singh [g]

[a] *Delft University of Technology, The Netherlands*
[b] *Utrecht University, The Netherlands*
[c] *University of South Carolina, USA*
[d] *University of the West of Scotland – Paisley, UK*
[e] *University of Bath, UK*
[f] *Thales Nederland, The Netherlands*
[g] *North Carolina State University, USA*

1 Introduction

The deployment of systems based on service-oriented architectures (SOA) is becoming widespread and successful in many application domains. However, SOA-based systems currently being constructed are *static*, in that the services are known and fixed at design time, and their possible interactions are defined and characterized completely in advance. The use of *dynamically* discovered, configured, deployed, engaged, and maintained services has not been successful yet The problem is that current service standards, which are necessary for widespread usage of services, are unable to describe anything other than the simple syntax and formatting of service invocations; they are thus insufficient for characterizing the rich usage and interactions required throughout the *lifetimes* of service-based applications, from discovery through maintenance

In particular, service-oriented computing is intended to enable services to be discovered and enacted across enterprise boundaries If an organization bases its success on services provided by others, then it must be able to trust that the services will perform as promised, whenever needed. This entails having descriptions of the *behaviours* of the services, not just their functionality, so that their run-time interactions are predictable, observable, and controllable. Moreover, they must be predictable and controllable over a lifetime of interactions. Thus there is a need for what we call *service governance*.

The features of service governance are well beyond what was originally envisioned for service-oriented architectures. These features include quality-of-service (QoS) and contracts, i.e., service-level agreements (SLAs) among the participants. To make this governance dynamically and autonomously configurable, the participants will need the ability to negotiate at run-time to establish the SLAs, to monitor compliance with them, and to take actions to maintain them. These are *software agent* capabilities. However, if the introduction of agents increases the flexibility of service interactions, it also introduces a new set of vulnerabilities, due to uncertainty and complexity that characterize multi-agent systems. That is, agents may exacerbate the problems, while—surprisingly—also providing the only reasonable solutions to them. The autonomy of agent-based services makes them less predictable, but also enables them to self recover and to avoid deadlocks and livelocks, thereby making them more reliable. Their ability to learn can increase their robustness by being able to adapt to changing interaction environments, but also can increase their unpredictability. Their abilities to negotiate and reconcile semantics can enable them to re-establish connections and relationships among services and ameliorate uncertain execution environments. The peer-to-peer interactions

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	Knowledge (ontology)	Process
(Virtual) Organization (Representative)	**S:** control structure, roles, values, type **F:** norms, purpose **B:** quality of ethos	Business model defining normative relationships
Agent (Owner)	**S:** communication, decision making strategies, level of autonomy **F:** goals, mores/values, BDI **B:** Quality of Character	Coordination model
Service (Provider)	**S:** data types, syntax, interfaces **F:** declarative semantic description **B:** Actual QoS	Enactment

Table 1: Model overview

of agents can improve the efficiency of agent-based services, particularly when they are deployed in clouds. Finally, agents can exploit the redundancy provided by multiple alternative services.

In this paper, we present initial work towards a model for dynamic SOA, using agent-based technology, that provides different levels of abstraction for the specification of governance, expectations and behaviour.

2 Governance Model

We propose a governance model for virtual organisations that comprises three levels: (1) organisations, (2) agents and (3) services. Organisations describe real-life engagements, their context, expectations and norms. The relationships between agents are defined by the organisations to which they belong, but agents are lead by their own reasoning abilities, desires and beliefs. Agents activate services in order to achieve their goals. Services, or compositions of services, are encapsulated in the agents that make them available to others. This governance model distinguishes for each of the three levels (1) the knowledge (ontologies) and (2) the processes involved. In the ontology (per level) the concepts that are used to define the three components *structure* (**S**), *function* (**F**) and *behaviour* (**B**) are described.

(Virtual) organisations have a *Representative*. The *structure* of an organization is described in terms of roles, values, etc. Organisations have their own norms and purpose: goals and ethical *function*. The Quality of Ethos determines the way organisations are perceived (their *behaviour* is seen).

Agents have *Owners*. Agents have their own level of autonomy, communicate with other agents, and make individual or collective decisions. They have their own individual goals, mores and values, beliefs, desires and intentions. Quality of Character defines the way they are perceived, determines their reputation.

Services are provided by *Service Providers*. Agents activate services using the syntax, data types and interfaces published. Services are often chosen on the basis of their declarative semantic descriptions. SLAs define the expected quality of service and the conditions. A service is best described by the actual Quality of Service it provides.

3 Discussion & Conclusion

In this paper, we identify (i) dynamic behaviour, (ii) formalization of business roles and rules, (iii) response to change (over short and long term) and (iv) formalization of agreements (in the physical and the virtual world), as the key challenges to be met to achieve the next level of aspirations in electronic service provision. We believe it is clear from this necessarily partial view of a broad range of research, that good foundations exist on which to build the next steps in delivering service-oriented architectures — as long as we are prepared to borrow, extend and collaborate, rather than re-invent.

We propose that the combination of software agents and organizational modelling are well-suited to the task of providing an agile management layer whose function is directed by the dynamic interpretation of formal models of governance. In so doing, we seek to build on a broad range of research in service, workflow, semantic web and grid computing, each of which brings its strengths to a complex, layered, architecture.