Modern software systems are increasingly being deployed to the Cloud, leading to the increasing adoption of systems that are predominantly online. An example of these are multi-tenant systems: Cloud-based applications that are shared by and instantiated for a multitude of tenants. Characteristically, such applications are often connected to different heterogeneous clients that are reactively uploading events and data, and are thus required to share the knowledge among the various tenants they support. Rather than hardcoding all this shared knowledge and ontologies in plain code, the knowledge can be easily programmed in the form of rules that orchestrate server-side logic, e.g., as business rules. In such situations, a rule engine is well-suited to accommodate the knowledge for clients of such reactive knowledge-driven applications.

Unfortunately, existing rule engines (and the rule-based languages they implement) were not conceptually designed to support and to cope with the knowledge and rules for multiple tenants at the same time. More specifically, they are unsuitable to support such heterogeneous systems because one has to manually hardcode the modularity and ownership of the knowledge for the various applications and clients, which quickly becomes complex and fallible. They further lack suitable semantics that developers can use to exploit collective or community knowledge that may apply to the data contributed by the various heterogeneous sources.

This dissertation presents Serena, a framework that provides scope-based reasoning in rule-based systems operating in heterogeneous environments. The solution exploits the fact that much of the community knowledge significant when performing reasoning and deductions can be structured in a hierarchy of scopes (that orchestrate which rules should be applicable to which incoming data). Serena augments an event-driven server with a Rete-based rule engine. Serena is distinct from existing rule-based systems due the notion of reentrancy and scoping that are efficiently ingrained at the heart of its inference engine. Serena further eases the encoding of reactive event patterns by clients in the form of scoped rules. Rule designers can utilise scoped rules to detect patterns in real-time data and to realise grouping structures in reactive knowledge-driven applications backed by a common rule-based system.