Composing Features and Resolving Interactions

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ABSTRACT

One of the accepted techniques for developing and maintaining feature-rich applications is to treat each feature as a separate concern. However, most features are not separate concerns because they override and extend the same basic service. That is, "independent" features are coupled to one another through the system's basic service. As a result, seemingly unrelated features subtly interfere with each other when trying to override the system behaviour in different directions. The problem is how to coordinate features' access to the service's shared variables.

This paper proposes coordinating features via feature composition. We model each feature as a separate labelled-transition system and define a conflict-free (CF) composition operator that prevents enabled transitions from synchronizing if they interact: if several features' transitions are simultaneously enabled but have conflicting actions, a non-conflicting subset of the enabled transitions are synchronized in the composition. We also define a conflict-and violation-free (CVF) composition operator that prevents enabled transitions from executing if they violate features' invariants. Both composition operators use priorities among features to decide whether to synchronize transitions.

Categories and Subject Descriptors

F3.1 [**Logics and Meanings of Programs**]: Specifying and Verifying and Reasoning about Programs—*Specification techniques, Assertions, Invariants*; F3.2 [**Logics and Meanings of Programs**]: Semantics of Programming Languages—*process models*; D.2.12 [**Software Engineering**]: Interoperability; D.2.11 [**Software Engineering**]: Software Architecture—*domain-specific architectures*

General Terms

Design

Keywords

Modularity, incremental programming, feature interaction, conflict resolution

1. INTRODUCTION

Software engineering techniques such as separation of concerns and incremental programming help software developers to build feature-rich applications by allowing them to consider new features as independent increments of the application's basic service. However, separately developed features can subtly interfere with each other because they enhance the same basic service and manipulate the same service variables. In general, a *feature interaction* occurs whenever one feature affects the behaviour of another [11].

Not all interactions are bad. Many are planned. For example, features are designed to interact with the basic service and any features that they override and extend. Conflicts occur when seemingly unrelated features trip over each other while trying to simultaneously override system behaviour. The problem is that while features are treated as separate concerns, they are coupled to one another through the service that they extend and their access to the shared service is not well coordinated.

The *feature interaction problem* is how to rapidly develop and deploy new features without disrupting the functionality of existing features. Approaches to this problem include the following

Eliminating interactions during design. The idea is to formally specify features as separate entities, compose the specifications, search the composition for interactions, and resolve interactions by modifying the feature specifications [1, 3, 6, 8, 15, 24]. However, features cannot be re-designed independently to eliminate interactions. Also, if the system is evolving, many of the features under consideration may already be implemented and not open to re-design [30]. Instead, most design-time resolutions specify how groups of features behave together, either by adding exception clauses to features [3, 29], adding supervisors that explicitly interleave the actions of feature combinations [2, 26], adding rules or features that explicitly define the behaviour of feature combinations [5, 29], etc. The problem with such resolution techniques is that they don't scale to systems that have hundreds or thousands of features because the number of feature combinations to consider grows exponentially. Worse, by specifying the behaviour of feature combinations, they counteract the benefits of separation of concerns, making it difficult to resolve interactions with future features or to customize resolutions to an individual user's needs.

Preventing interactions via architectural constraints. An architecture can help avoid interactions by constraining and coordinating the features' access to the service's variables and resources. Distributed Feature Coordination (DFC) [20] organizes features in a pipe-and-filter architecture where the messages that are passed among the features act as tokens that

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