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variED: An Editor for Collaborative, Real-Time Feature Modeling

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Abstract: This work was published in *Empirical Software Engineering* (EMSE) 26, 2 (2021) [Ku21].

Feature models are a helpful means to document, manage, maintain, and configure the variability of a software system. Various stakeholders in an organization may get involved in modeling the features in such a software system. Currently, collaboration in such a scenario can only be done with face-to-face meetings or by combining single-user feature-model editors with additional communication and version-control systems. While face-to-face meetings are often costly and impractical, using version-control systems can cause merge conflicts and inconsistency within a model. Advanced tools that solve these problems by enabling collaborative, real-time feature modeling, analogous to Google Docs or Overleaf for text editing, are missing. We describe the formal foundations of collaborative, real-time feature modeling; a conflict resolution algorithm; proofs that our formalization converges and preserves causality as well as user intentions; a prototype; and the results of an empirical evaluation to assess the prototype's usability. Our contributions provide the basis for advancing existing feature-modeling practices to support collaborative feature modeling. Our prototype is considered helpful and valuable by 17 users, also indicating opportunities for new research directions.

Keywords: Feature Modeling; Collaboration; Consistency Maintenance

Modeling the variability of a software product line in a feature model is essential for an organization to document and manage all implemented features, and also to derive valid configurations that are tailored to different customer requirements. To create a meaningful feature model, all relevant stakeholders must work collaboratively—however, there is neither a tool nor a technique that supports *collaborative, real-time editing* of the same feature model, similar to the text editors *Google Docs* and *Overleaf*. Nonetheless, such a tool promises advantages in several use cases, for instance when (a) working simultaneously on different or coordinated tasks, (b) sharing the model with domain experts for real-time feedback and evolution, or (c) teaching feature-modeling concepts and performing hands-on exercises. In particular, the COVID-19 pandemic highlighted the value of remote collaboration.

To support these use cases, we describe the conceptual foundations of collaborative, real-time feature modeling [Ku19, Ku21]. We define requirements that our technique aims to fulfill, derive formal specifications for the operations that we need to develop, extend

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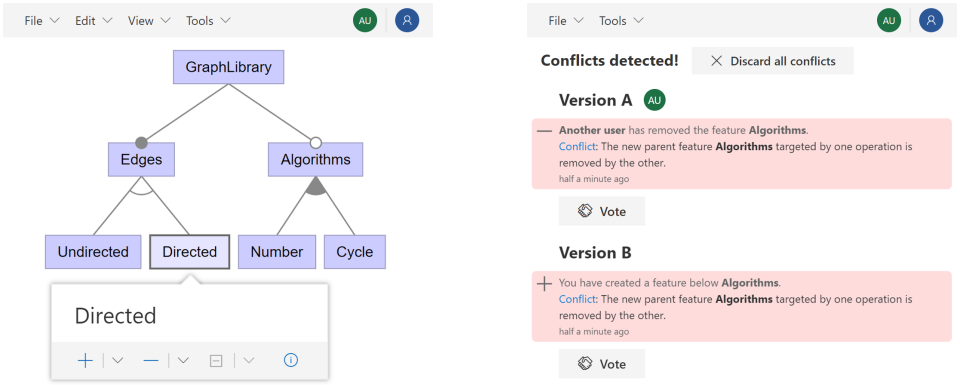

Fig. 1: Editing a feature model (left) and resolving a conflict (right) in variED.

the concurrency-control technique MVMD [SC02] to detect and resolve conflicts, and implement variED, an editor for collaborative, real-time feature modeling (cf. Figure 1).

We further prove that our technique is correct and evaluate it empirically in a user study with 17 participants. The results of our empirical user study show that our tool supports the defined use cases well and is a helpful means to extend current collaboration strategies (e.g., versioning via Git). More precisely, the results show that our tool facilitates important use cases that are not covered by currently employed strategies and it received far more positive feedback compared to these strategies, despite its technical limitations.

Data Availability We provide Zenodo records for the open-source implementation of our tool[6] as well as our questionnaire and anonymized responses.[7]

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