Preserving Liveness: Comments on "Safety and Liveness from a Methodological Point of View"

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January 9, 1991
revised June 26, 1991

Dederichs and Weber [4] define what it means for a property to be a liveness property with respect to a safety property. They argue that a specification should be written in the form $P \cap Q$, where Q is a liveness property with respect to the safety property P. They also criticize Alpern and Schneider's general definitions of safety and liveness [2]:

> Alpern and Schneider's characterizations are problematic, since they permit a certain kind of anomaly.

The anomaly is that a liveness property, which should constrain only infinite behavior, can implicitly rule out some finite behaviors.

Dederichs and Weber's definition is not new. Such a pair P, Q of properties was called *machine closed* by Abadi and Lamport [1], who explained that one tries to write liveness properties that "[do] not rule out any finite behavior." The same idea was introduced independently by Apt, Francez, and Katz [3], who defined a fairness condition for a programming language to be *feasible* if it produces machine-closed specifications for all programs. Apt, Francez, and Katz discussed the same anomaly as Dederichs and Weber, pointing out that feasibility is necessary to "prevent a scheduler from 'painting itself into a corner'".

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While machine-closure/feasibility is necessary for a practical programming language, it is not clear that it is necessary or even desirable for an abstract specification. For example, the general specification of serializability given by Lamport [5] achieves its simplicity by not being machine closed. Moreover, Abadi and Lamport's completeness result [1] requires that only the lower-level implementation be machine closed, suggesting that there is no need for high-level specifications to be machine closed.

Even if one tried to forbid non-machine-closed specifications, they would arise in proofs that one specification implements another. A state-based proof that a lower-level specification Z implements a higher-level specification X is usually done in two steps. One first adds history and prophecy variables to Z to obtain an equivalent specification Y [1], and then one proves $Y \Rightarrow \overline{X}$, where $\overline{X}$ is obtained from X by substituting concrete realizations for abstract variables [5]. Surprisingly, it turns out that each of these steps can destroy machine-closure, so Y and $\overline{X}$ need not be machine-closed even if Z and X are. Although there are alternatives to using history and prophecy variables, substitution of concrete entities for abstract ones is fundamental, and it is likely that non-machine-closed specifications will arise in any approach that handles liveness.

We agree with Dederichs and Weber that machine closure is a useful requirement that will be satisfied by most reasonable specifications. Arbitrary liveness properties are "problematic". However, the problem lies in the nature of liveness, not in its definition.

One cannot avoid complexity by definition.
Stephen Jay Gould

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