APPENDIX F

Model Checker

The $\mathcal{R}$ operator in a model checker can be used either in a Boolean-valued query: $\boldsymbol{\mathcal{R}}\ bound\ [rewardprop]$ or a real-valued query: $\mathcal{R}\ query\ [\ rewardprop\ ]$. Where bound takes the form $< r$, $<= r$, $> r$ or $>= r$ for an expression r and query is $=?$, $min =?$ or $max =?$.

rewardprop represents the reward property. There are various different types of reward properties:

Reachability reward $\mathcal{F}$: Reward accumulated along a path until a certain point is reached;

Cumulative reward $C <= k$: Expected state reward cumulated after k steps;

Instantaneous reward $I = k$: Expected state reward to be gained in the state entered at step k;

Steady-state reward S.

For example, in order to consider the reward value of all the states up to the state labeled as "news", following property can be used:

$$\{\}\,\mathcal{R} =_{?}\ [\mathcal{F}\ news]$$

Inside the bracket {}, the web-application development or operations team can also specify the scope of the property for a defined user class (e.g. a user agent) or simply leave it empty (no limit).

The Merging Approach Used In The Model Checker

In order to build a single DTMC by merging selected DTMCs (if there are multiple DTMCs) we used the merging approach suggested in [1] as follows. It is used in the property analysis step of this study.

- The set of states in the new DTMC consists of the union of the states of the DTMCs required to be merged.
- The transition probabilities in the new DTMC are calculated using the law of total probability:

$$P_T(s_i, s_j) = \sum_{1 \le k \le n} P_k(s_i, s_j) \times P_i(u_k)$$

  where, $P_i(u_k)$ is the probability of belonging to the user-class u_k when transitioning from s_i to s_j.
- Labels of the states in the new DTMC are the same as labels in their corresponding input DTMC.
- Reward values of the states in the new DTMC are the same as reward values in their corresponding input DTMC

REFRENCES

[1] C. Ghezzi, M. Pezz, M. Sama, and G. Tamburrelli, "Mining behavior models from user-intensive web applications," presented at the Proceedings of the 36th International Conference on Software Engineering, Hyderabad, India, 2014.