Summary: In this paper, we study the model-checking problem of linear-time properties in multi-valued systems. Safety properties, invariant properties, liveness properties, persistence and dual-persistence properties in multi-valued logic systems are introduced. Some algorithms related to the above multi-valued linear-time properties are discussed. The verification of multi-valued regular safety properties and multi-valued $\omega$-regular properties using lattice-valued automata are thoroughly studied. Since the law of non-contradiction (i.e., $a \land \neg a = 0$) and the law of excluded-middle (i.e., $a \lor \neg a = 1$) do not hold in multi-valued logic, the linear-time properties introduced in this paper have new forms compared to those in classical logic. Compared to those classical model-checking methods, our methods to multi-valued model checking are accordingly more direct: We give an algorithm for showing $TS \models P$ for a model $TS$ and a linear-time property $P$, which proceeds by directly checking the inclusion $\text{Traces}(TS) \subseteq P$ instead of $\text{Traces}(TS) \cap \neg P = \emptyset$. A new form of multi-valued model checking with membership degree is also introduced. In particular, we show that multi-valued model checking can be reduced to classical model checking. The related verification algorithms are also presented. Some illustrative examples and a case study are also provided.

MSC:

- 68Q60 Specification and verification (program logics, model checking, etc.)
- 03B50 Many-valued logic
- 68Q45 Formal languages and automata
- 68Q85 Models and methods for concurrent and distributed computing (process algebras, bisimulation, transition nets, etc.)

Keywords:

- model checking; multi-valued transition system; invariant; safety; liveness; lattice-valued finite automaton

Software:

- SPIN

Full Text: DOI

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