Introduction to Software Verification

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— *Models and Properties* —

Example of abstract models

Give examples:

- Finite Automata.
- Turing Machine.
- Pushdown Automata.
- Counter Systems.
- Vector Addition Systems

Interesting Properties

Explain and put examples:

- Reachability.
- Model-checking.
- Liveness.
- Fairness.
- etc.

Reachability

Input: A graph $\mathcal{G}$ and two vertices x, y.

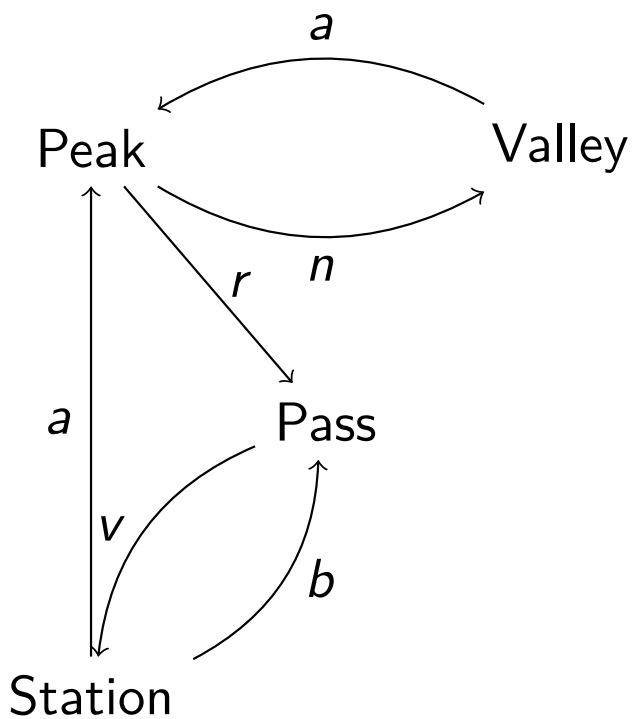
Output: If there exists a path between x and y.

Reachability

Input: A graph $\mathcal{G}$ and two vertices x, y.

Output: If there exists a path between x and y.

Example: Is it possible to go from the valley to the station?

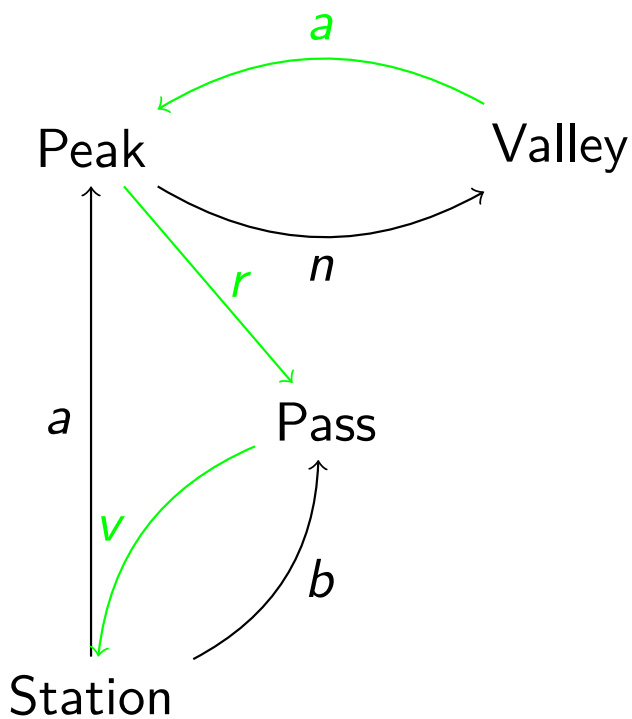


Reachability

Input: A graph $\mathcal{G}$ and two vertices x, y.

Output: If there exists a path between x and y.

Example: Is it possible to go from the valley to the station? Yes.



Model-checking

Input: A graph $\mathcal{G}$ and a logic formula ϕ.

Output: If $\mathcal{G} \models \phi$.

- First Order: $x \xrightarrow{a} y$, $\exists x$, $\forall x$
- First Order with reachability: $x \xrightarrow{*} y$
- Monadic Second Order: $x \in X$, $\exists X$, $\forall X$

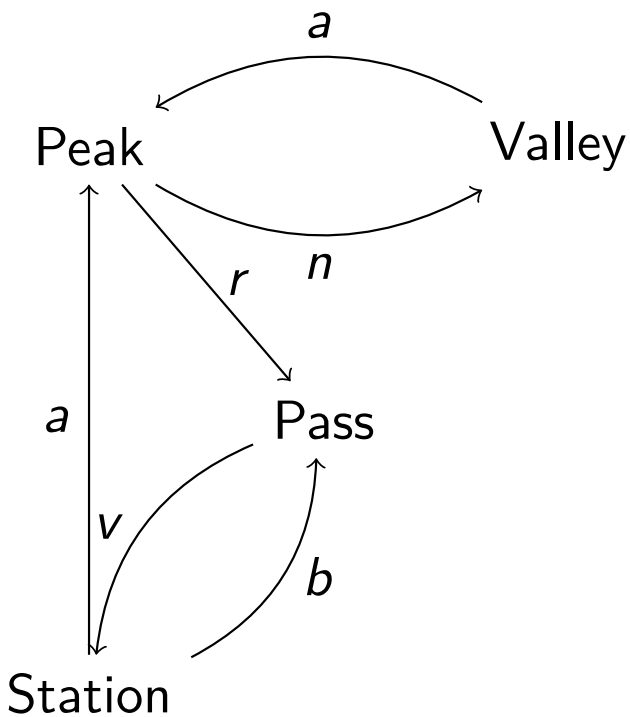
Model-checking

Input: A graph $\mathcal{G}$ and a logic formula ϕ.

Output: If $\mathcal{G} \models \phi$.

Example: Is it possible to leave the valley without taking any ski lift?

$$\phi = \exists x, (\text{Valley} \xrightarrow{v} x \vee \text{Valley} \xrightarrow{n} x \vee \text{Valley} \xrightarrow{r} x) \wedge x \neq \text{Valley}$$



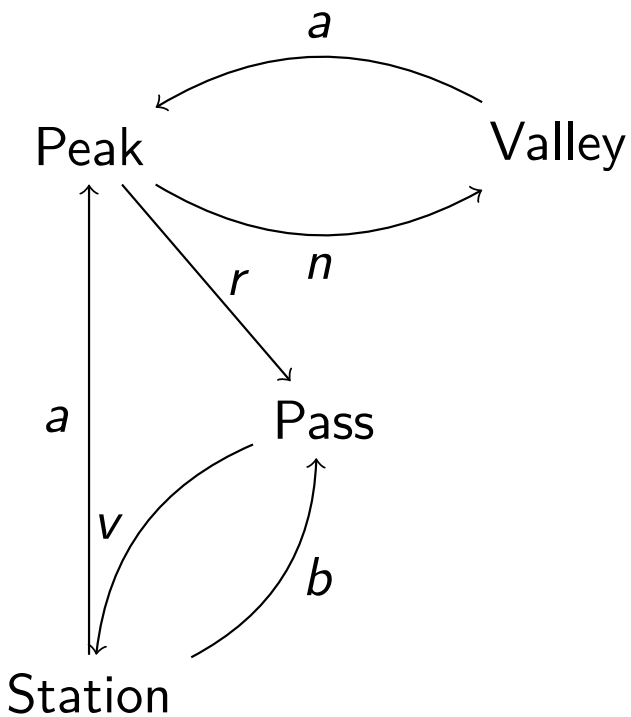
Model-checking

Input: A graph $\mathcal{G}$ and a logic formula ϕ.

Output: If $\mathcal{G} \models \phi$.

Example: Is it possible to leave the valley without taking any ski lift? No.

$$\phi = \exists x, (\text{Valley} \xrightarrow{v} x \vee \text{Valley} \xrightarrow{n} x \vee \text{Valley} \xrightarrow{r} x) \wedge x \neq \text{Valley}$$



Safety

Nothing bad happens (bad states not accessible).

Liveness (concurrent programs)

Something good eventually happens. What to show ?