

Slicing State-based Models

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With thanks to Kelly Androutsopoulos and David Clark

2011/1/25

What is a state-based model?

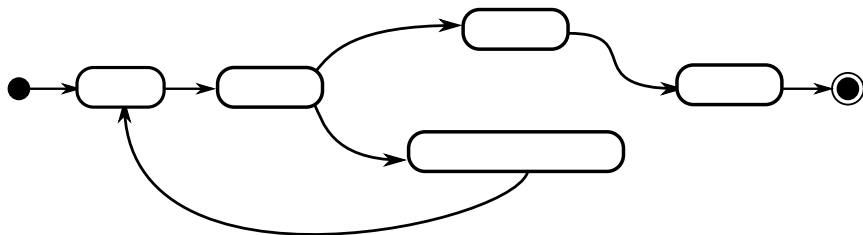
- Generic term for many languages: statecharts, statemachines, EFSMs etc.
- Fundamentally: a system is in one state until it transitions to another.

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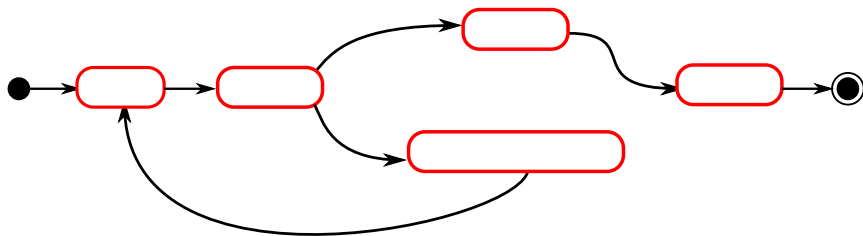
- Generic term for many languages: statecharts, statemachines, EFSMs etc.
- Fundamentally: a system is in one state until it transitions to another.
- Conventionally represented graphically.

A state-based model

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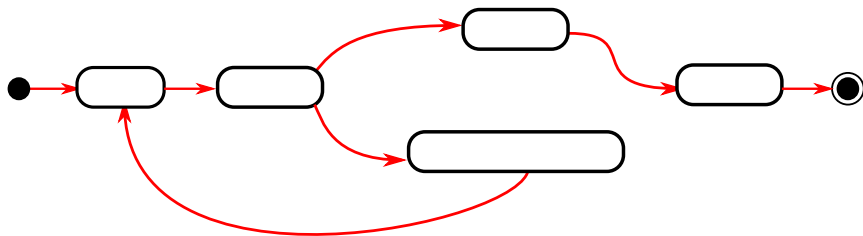


A state-based model



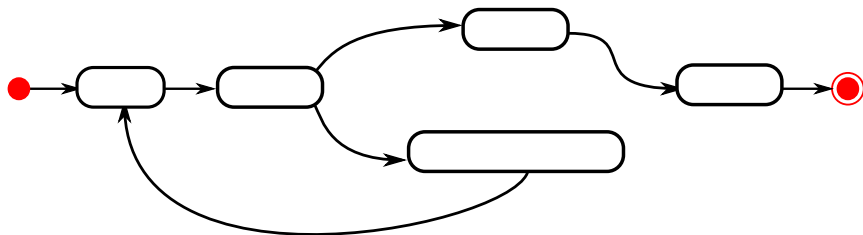
States (every language)

A state-based model



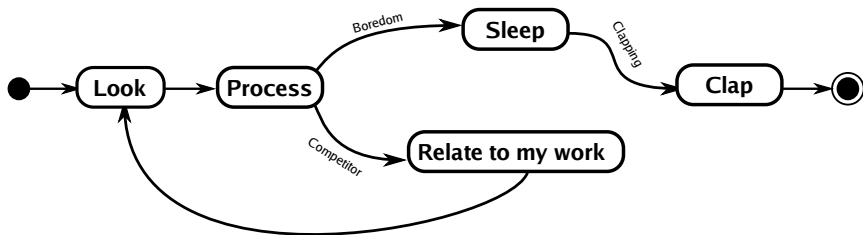
Transitions (every language): *event*[*guard*]/*action* (most languages)

A state-based model



Other bits: start / end states (varies language to language)

A state-based model



Where are state-based models used?

- Generally not an end in themselves.
- Typically used for modelling systems i.e. used as an abstraction.
- Used for computing and non-computing systems (e.g. business processes).
- Most common form probably UML statemachines.
- Short version: lots of them in the wild.

Why slice state-based models?

- Program slice: the subset of a program relevant to a slicing criterion.
- In English: 'the minimalish parts of the program relevant to a specific point of interest.'

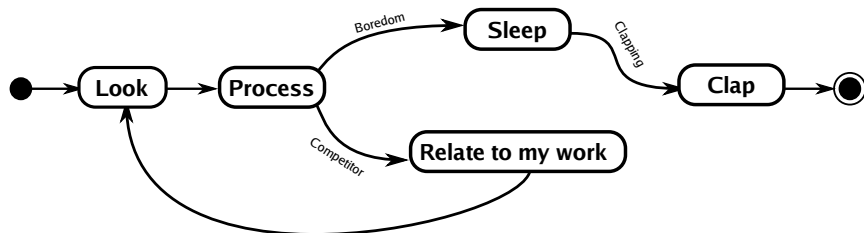
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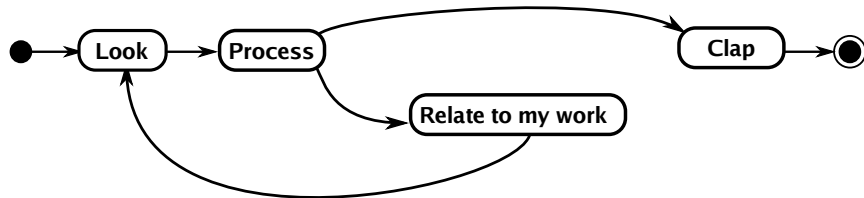
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- Same motivation for state-based models.
- State-based models can also be huge (e.g. mobile phone models).

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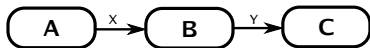
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- Intuition: transitions are just `gotos`.
- Question: why not translate SBMs to programs and slice those?

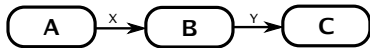
Why SBM slicing is different (1)

- Input SBM:

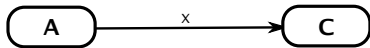


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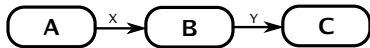


- What we hope for:

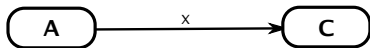


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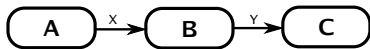
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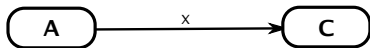
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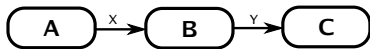
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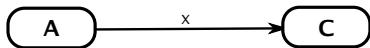
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- Slicing `goto` programs is hard and difficult.
- SBM slicing has to acknowledge (and make use of) graph structures.

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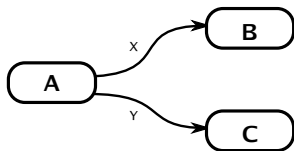
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state := A
B: if (next_event() == Y) goto C;
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```
- What SBM does that map back to?
- Fundamentally: we need an isomorphism between $A \rightarrow B$ and $B \rightarrow A'$, but program slicing can't provide that.

Why SBM slicing is different (3)

- SBM features map nicely onto PL features and vice versa.

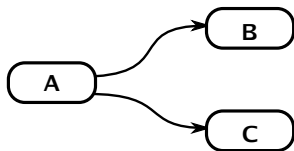
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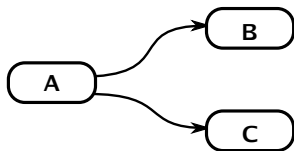
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- Not many programming languages with non-determinism...
- So we have to encode that. Two problems:
 - 1 What non-determinism to encode? SBM formalisms rarely define how to resolve non-determinism; irrelevant for specifications.
 - 2 Translating back has problems (#2 in disguise).

Applications

- As program slicing, many potential applications.

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- etc.

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- EPSRC funded project, first at King's and now at UCL (and a few hangers on like me).
- Building upon previous work (e.g. Korel et al.) and advancing the art w.r.t. SBM slicing.

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- Underlying question: should CD be sensitive or insensitive to non-termination?
- Dealing with non-terminating SBMs is non-trivial.
- No existing definition ideal.
- New CD definition *UNTICD* (FASE 2009) subsumes Korel et al.'s CD definition; and has neat correspondences with NTICD and NTSCD.

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- Realisation: 'best' dependency depends on your application.
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- Adapted WOD (Amtoft et al.) for SBMs.
- Differs significantly from UNTICD when no data dependency; subtly different in other ways.

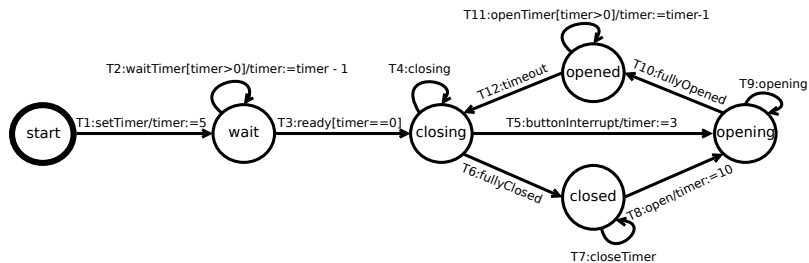
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- Adapted WOD (Amtoft et al.) for SBMs.
- Differs significantly from UNTICD when no data dependency; subtly different in other ways.
- Several empirical studies done (under review) to help determine which CD is best.
- Perhaps work to do: both UNTICD and WOD can introduce new non-determinism.

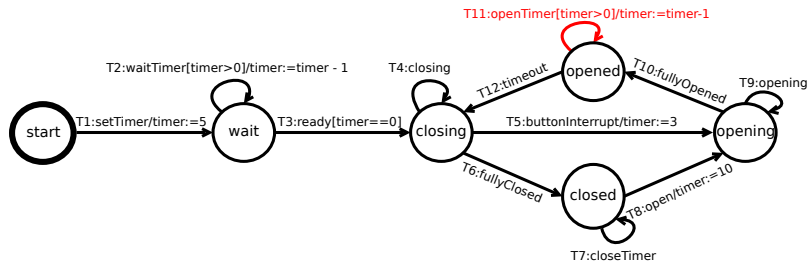
Problem #2: slicing

- Korel et al.'s algorithms (¹ and ²) the only amorphous SBM slicers.
- Tends to produce large slices, but not easy to improve upon.

Lift example



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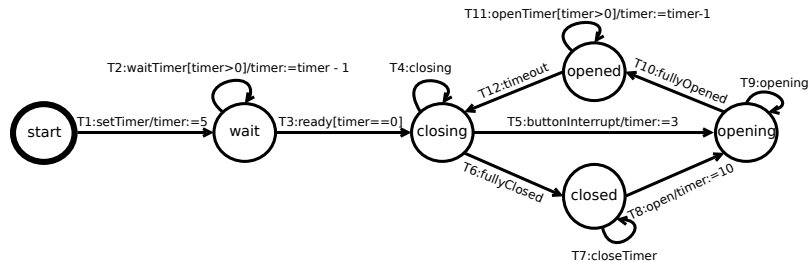


Amorphous slicing algorithm

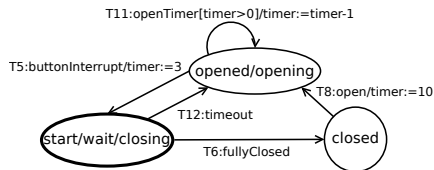
Essentials:

1. $M_{post} \leftarrow M_{pre}$
2. $DG \leftarrow \text{compute_dependence_graph}(CD_{def}, M_{pre})$
3. $M_{post} \leftarrow \text{traverse_backwards_marking}(t_{sc}, V_{sc}, DG)$
4. $M_{post} \leftarrow \text{anonymise_unmarked_transitions}(M_{post})$
5. **while** $\text{apply_rule1}(M_{post})$ **or** $\text{apply_rule2}(M_{post})$
 or $\text{apply_rule3}(M_{post})$ **do**
- 6: **end while**
- 7: $\text{apply_epsilon_elimination}(M_{post})$
- 8: $\text{garbage_collect}(M_{post})$
9. $S_{toMerge} \leftarrow \text{right_invariant_equivalence}(M_{post})$
10. $\text{merge_states}(S_{toMerge}, M_{post})$
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12. $\text{merge_states}(S_{toMerge}, M_{post})$
13. **return** M_{post}

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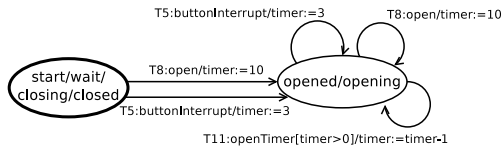


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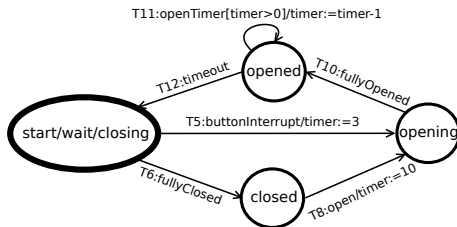
Korel et al.'s slicing algorithm² with NTICD

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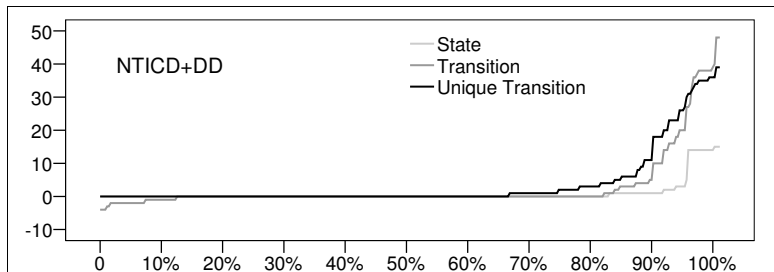
SLIM(NTICD)

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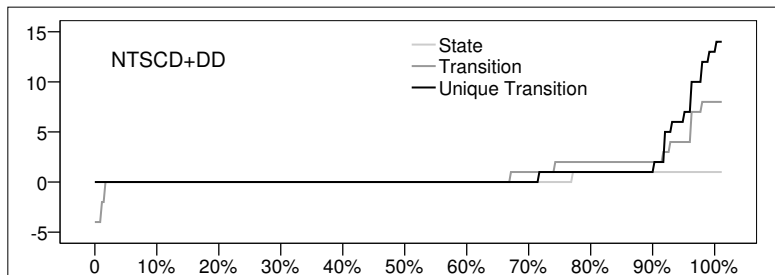
SLIM(UNTICD)

Relative slice sizes



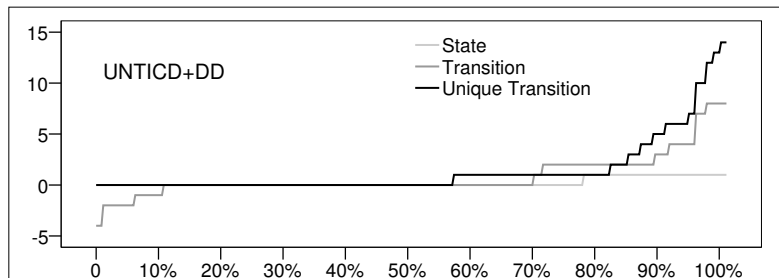
SLIM & Korel et. al's algorithm² with NTICD

Relative slice sizes



SLIM & Korel et. al's algorithm² with NTSCD

Relative slice sizes



SLIM & Korel et. al's algorithm² with UNTICD

- The CREST slicing tool.
- Python tool which can slice SBMs in several different ways.
- Pluggable control dependency etc.
- Able to visualize huge SBMs with Graphviz.
- To appear soonish.

Summary

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- SLIM has pushed the state of the art forward considerably.
- Ready for real-world in some parts; in others, important questions to be answered.

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Thanks for listening