Slicing State-based Models

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With thanks to Kelly Androutsopoulos and David Clark

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What is a state-based model?

- Generic term for many languages: statecharts, statemachines, EFSMs etc.
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- Conventionally represented graphically.

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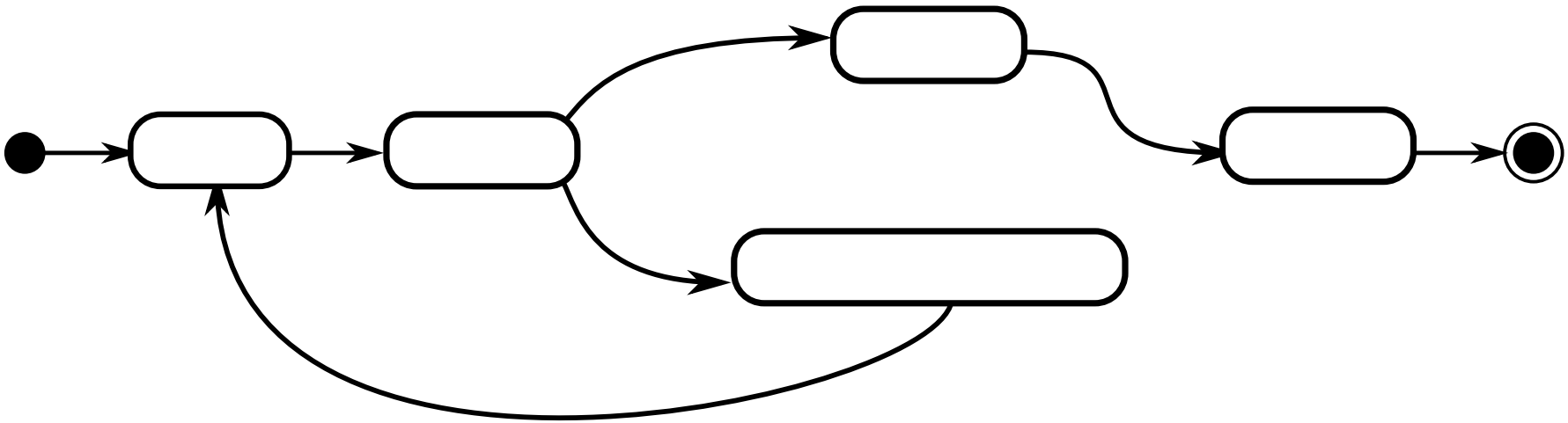

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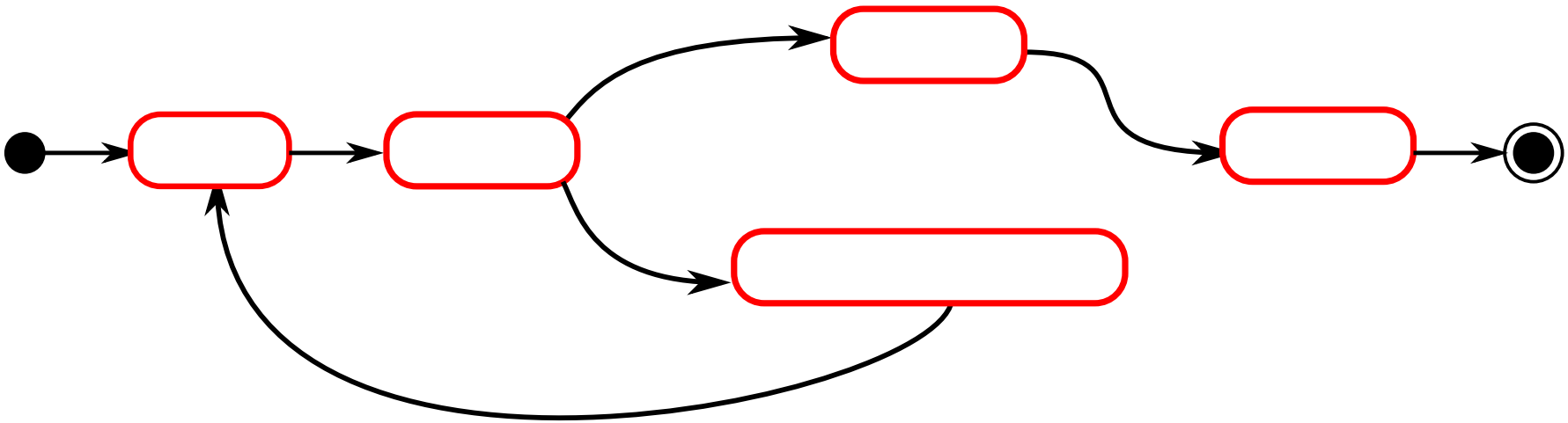
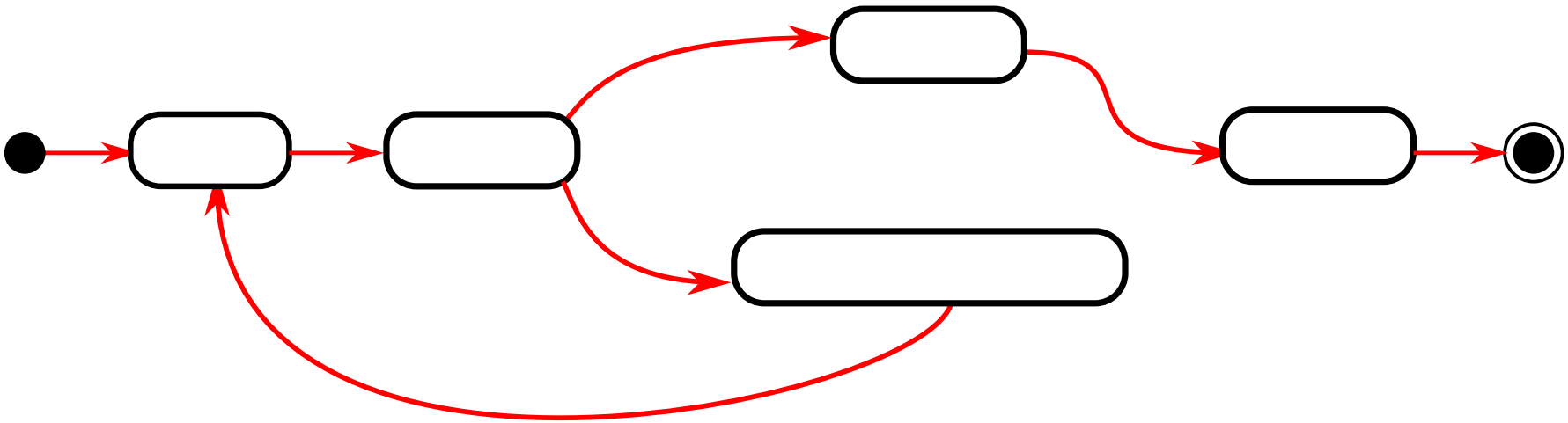


States (every language)

A state-based model



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

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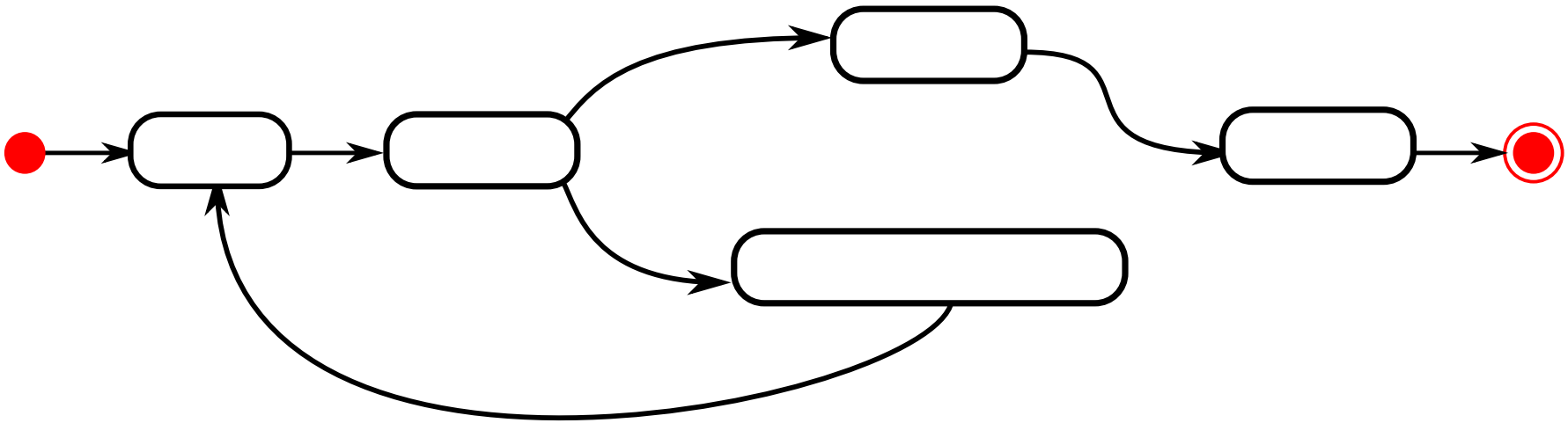
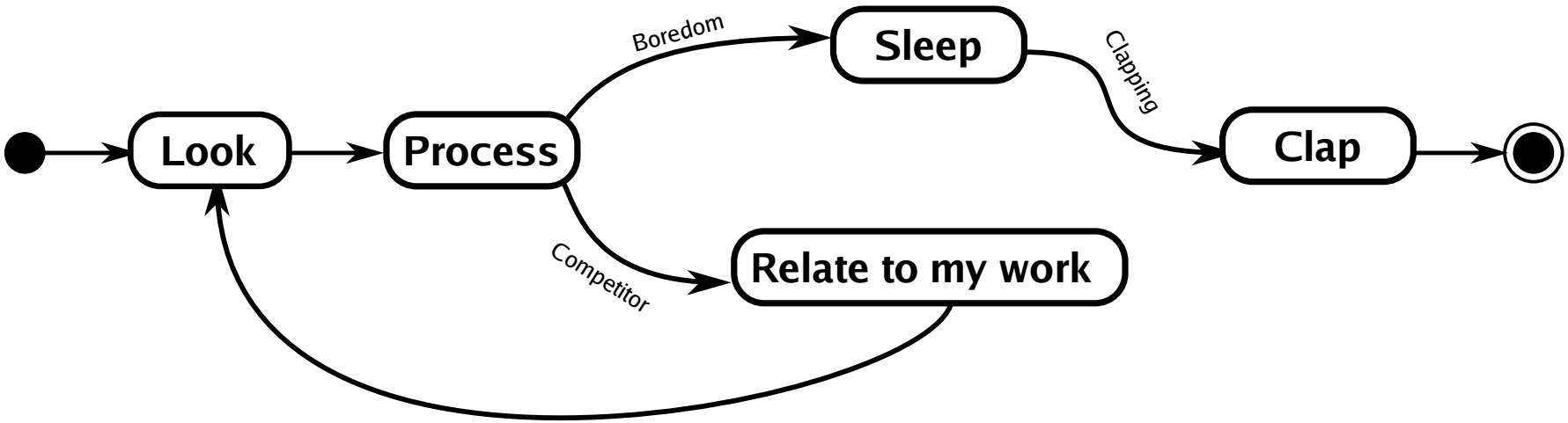


Other bits: start / end states (varies language to language)

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.

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- Motivation? Programs are big; slice them to a manageable size.
- Same motivation for state-based models.
- State-based models can also be huge (e.g. mobile phone models).

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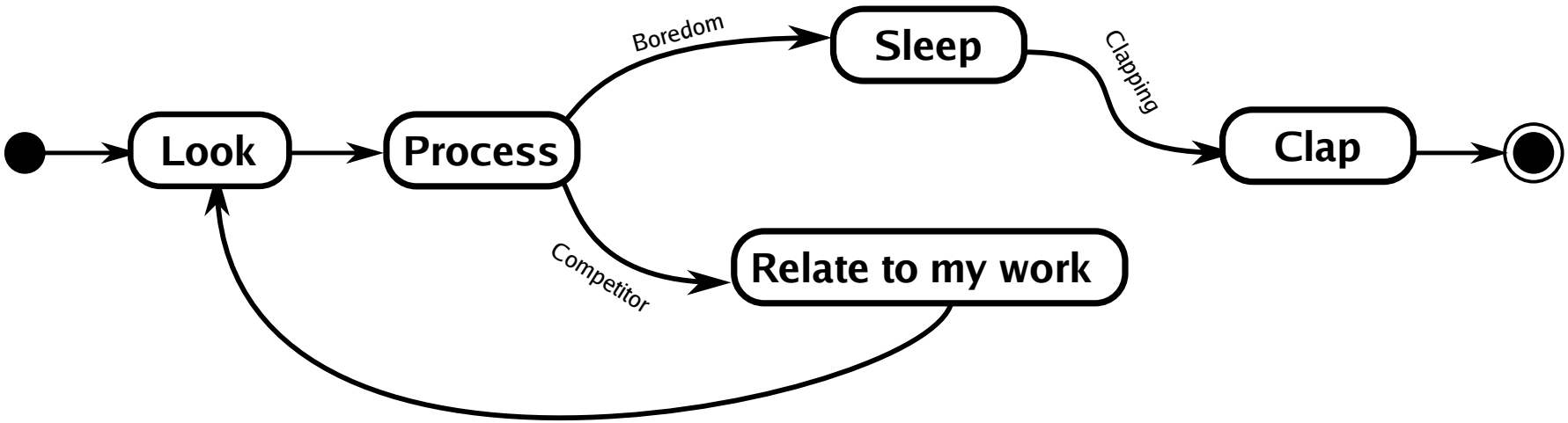

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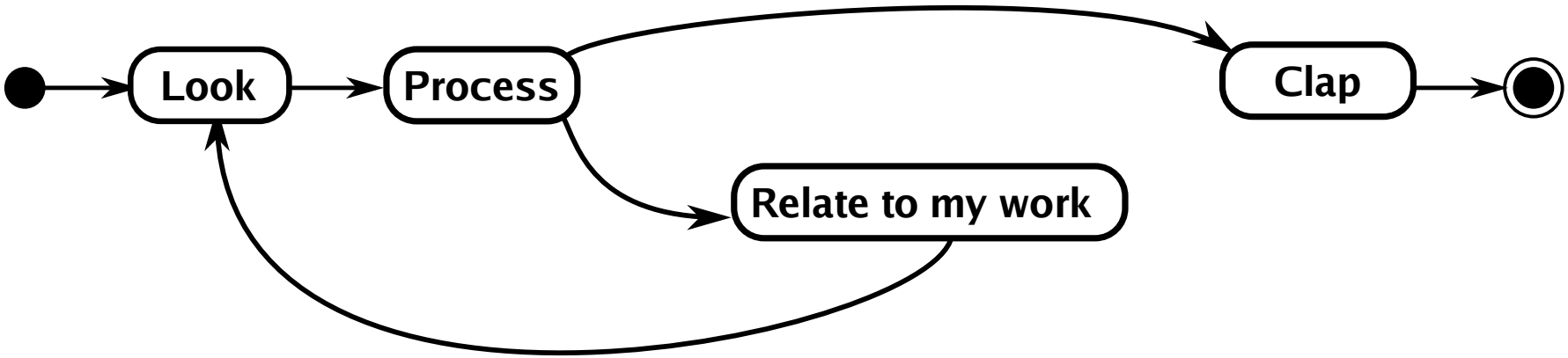

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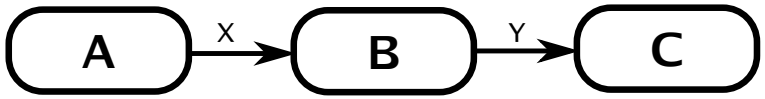
- Intuition: transitions are just `goto`s.
- Question: why not translate SBMs to programs and slice those?

Why SBM slicing is different (1)

- Input SBM:



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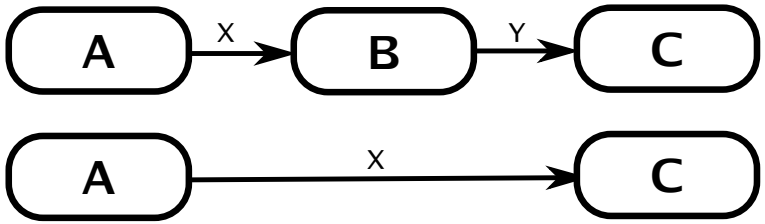

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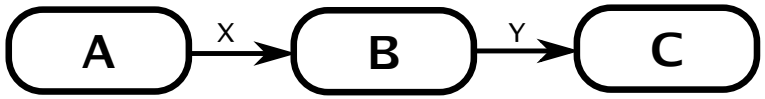

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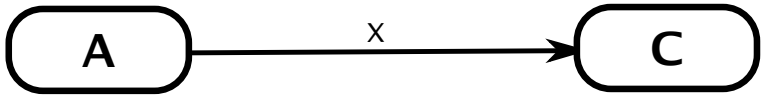

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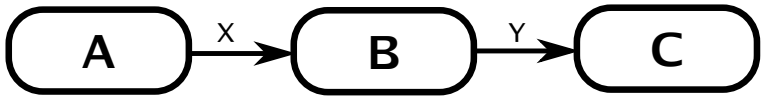

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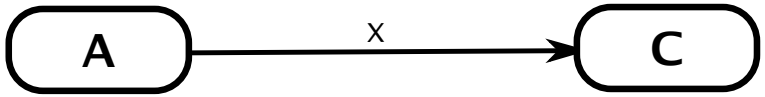

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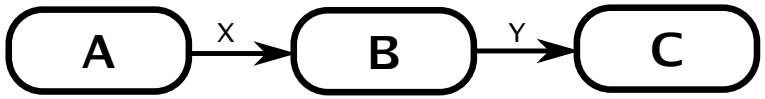

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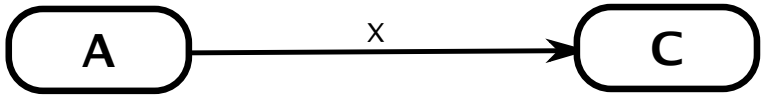

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- Slicing `goto` programs is hard and difficult.
- SBM slicing has to acknowledge (and make use of) graph structures.

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- 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.

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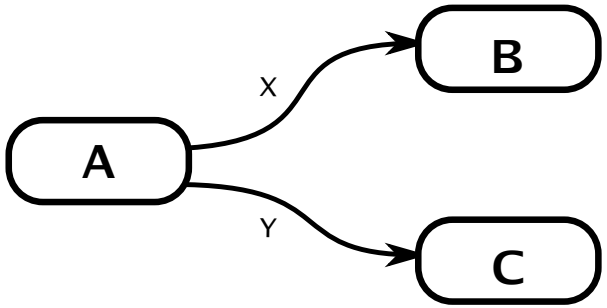

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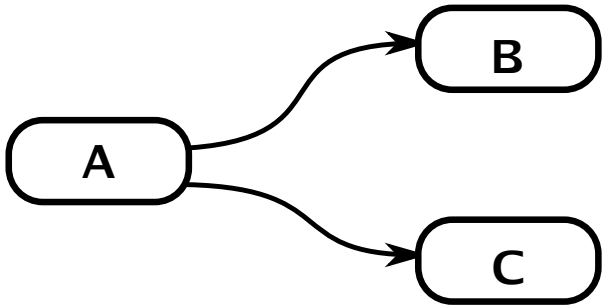

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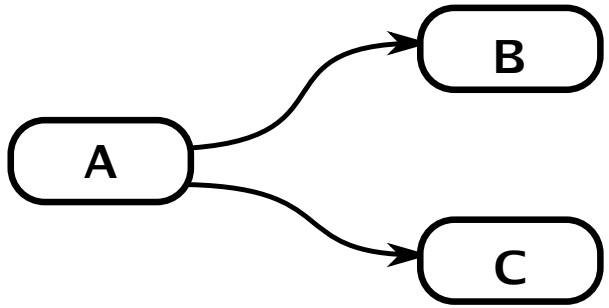

- Not many programming languages with non-determinism...
- So we have to encode that. Two problems:
  1. What non-determinism to encode? SBM formalisms rarely define how to resolve non-determinism; irrelevant for specifications.
  2. Translating back has problems (#2 in disguise).

Applications

- As program slicing, many potential applications.

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- 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.

Problem #1: dependency

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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.

Problem #1: dependency (2)

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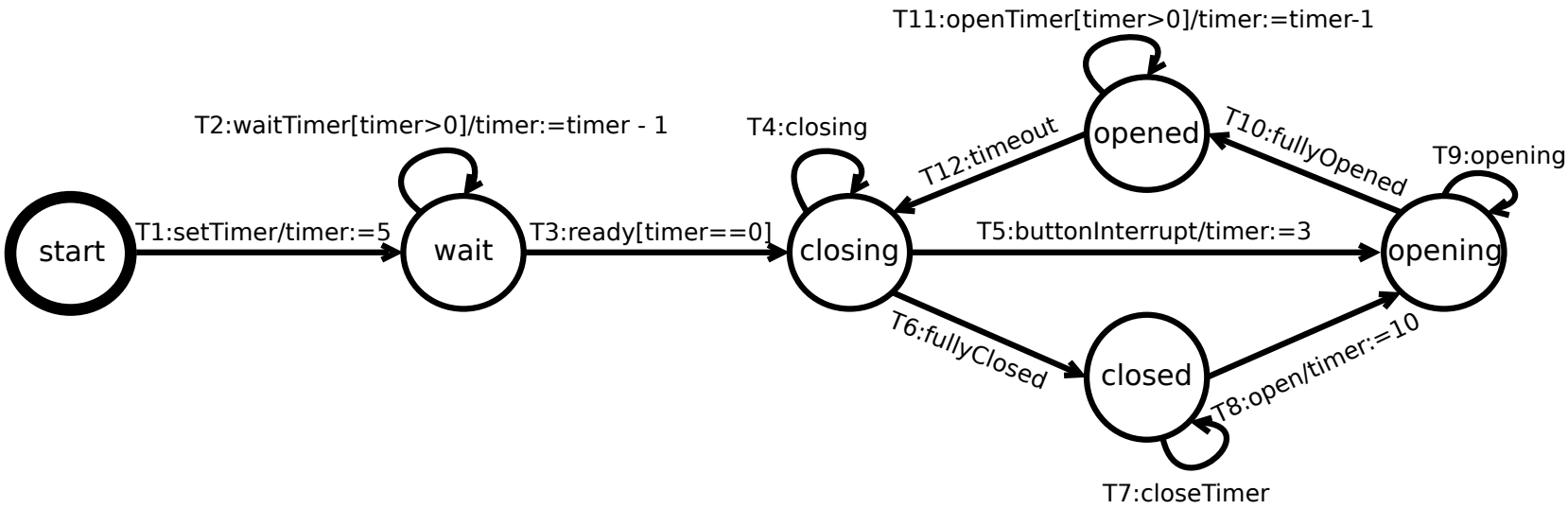
- Adapted WOD (Amtoft et al.) for SBMs.
- Differs significantly from UNTICD when no data dependency; subtly different in other ways.
- Several empirical studies done (under review) to help determine which CD is best.
- Perhaps work to do: both UNTICD and WOD can introduce new non-determinism.

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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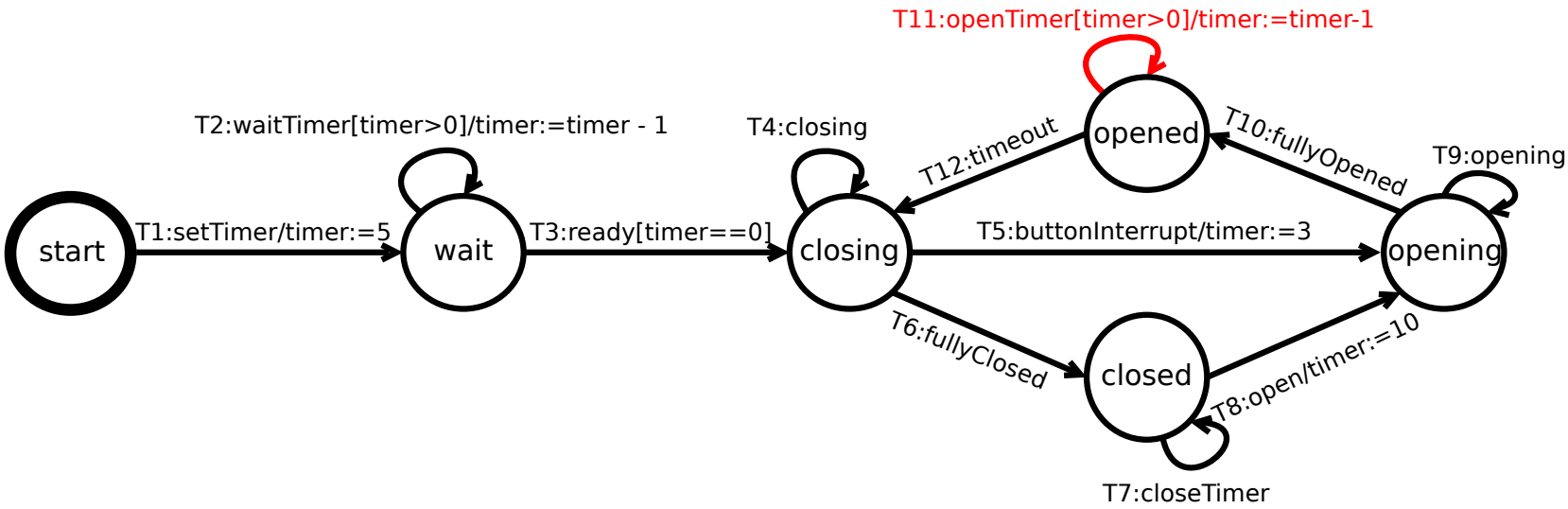

Amorphous slicing algorithm

Essentials:

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

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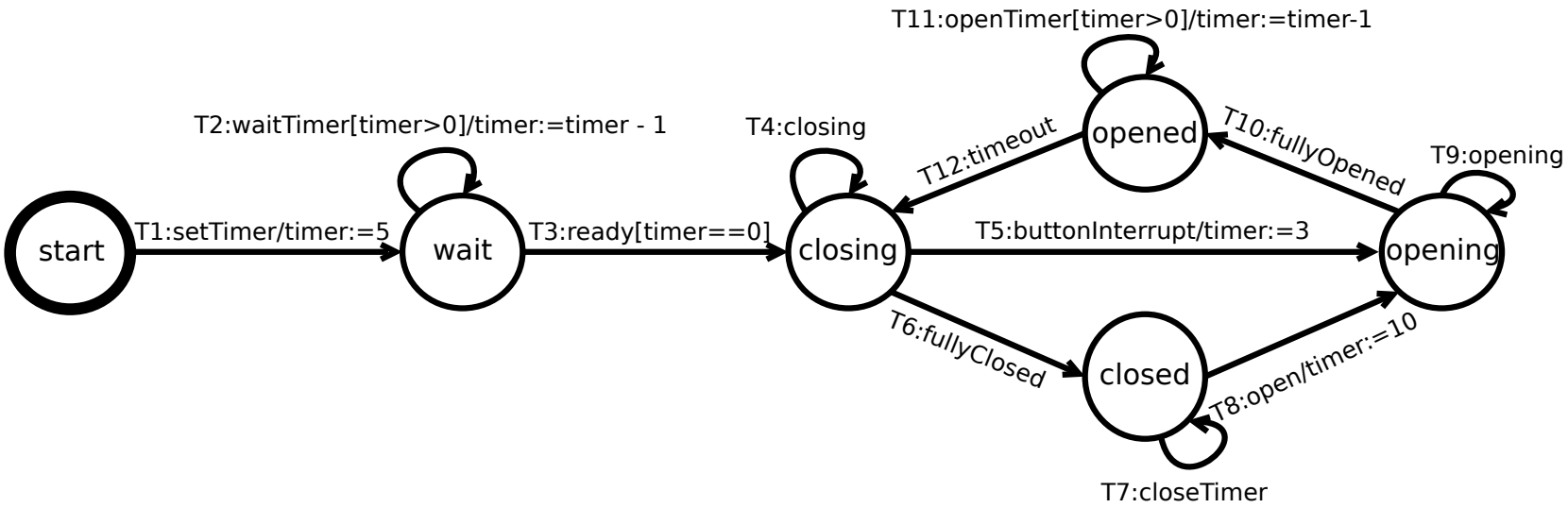

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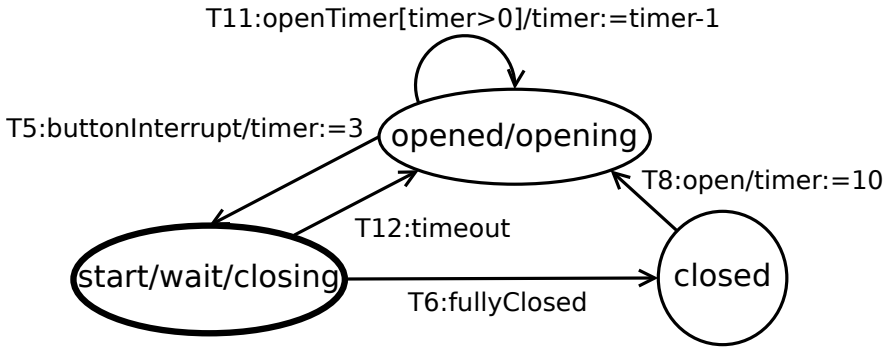

Korel et al.'s slicing algorithm[2] with NTICD

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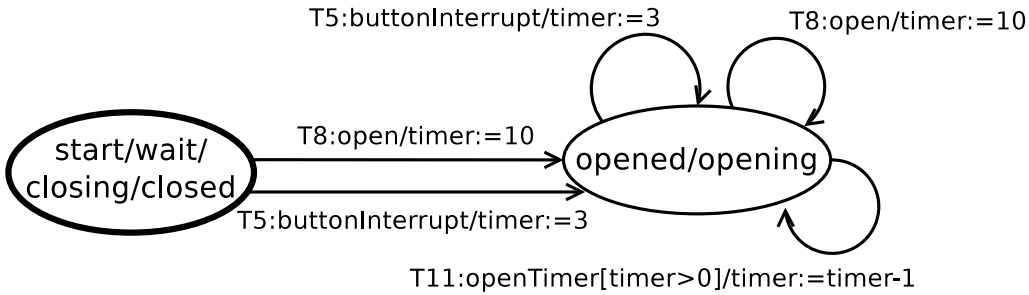

SLIM(NTICD)

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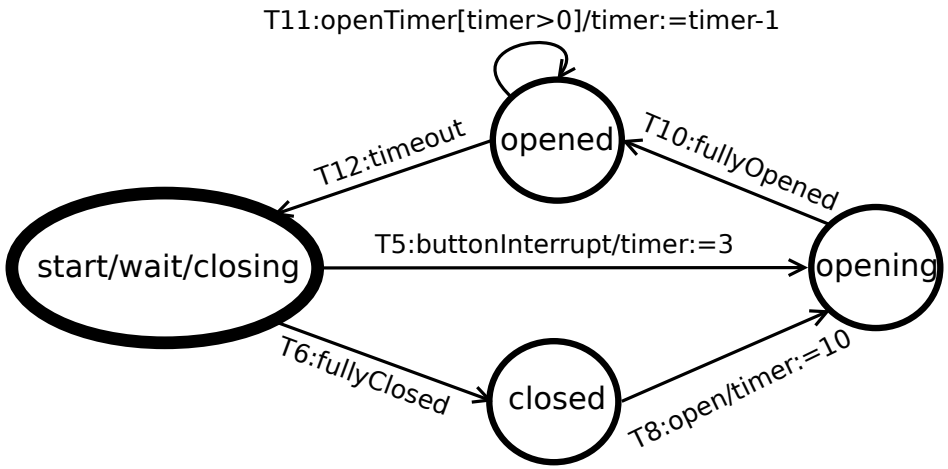
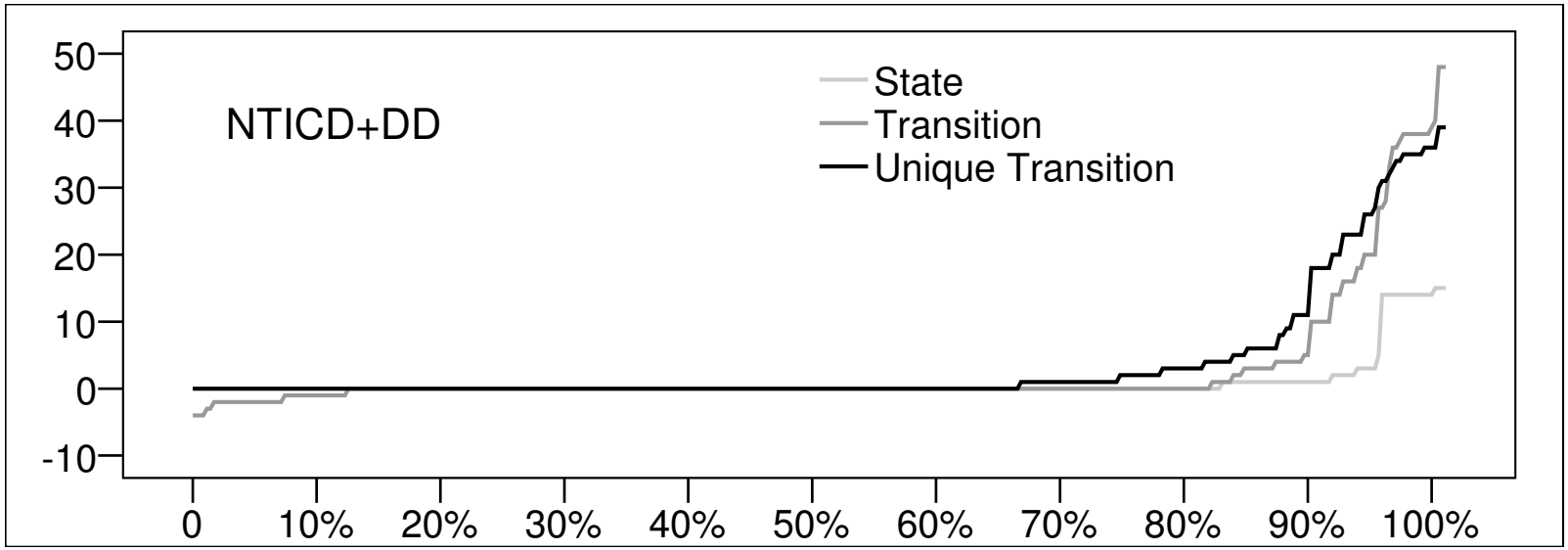


SLIM(UNTICD)

Relative slice sizes



SLIM & Korel et. al's algorithm[2] with NTICD

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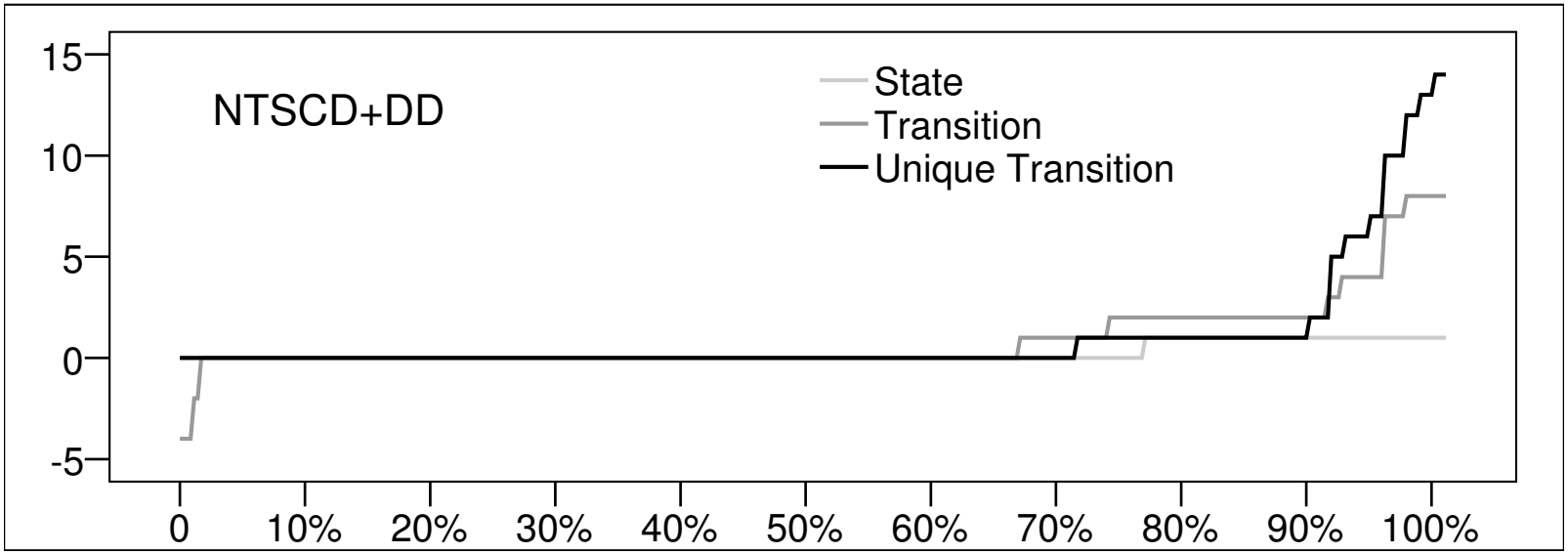

SLIM & Korel et. al's algorithm[2] with NTSCD

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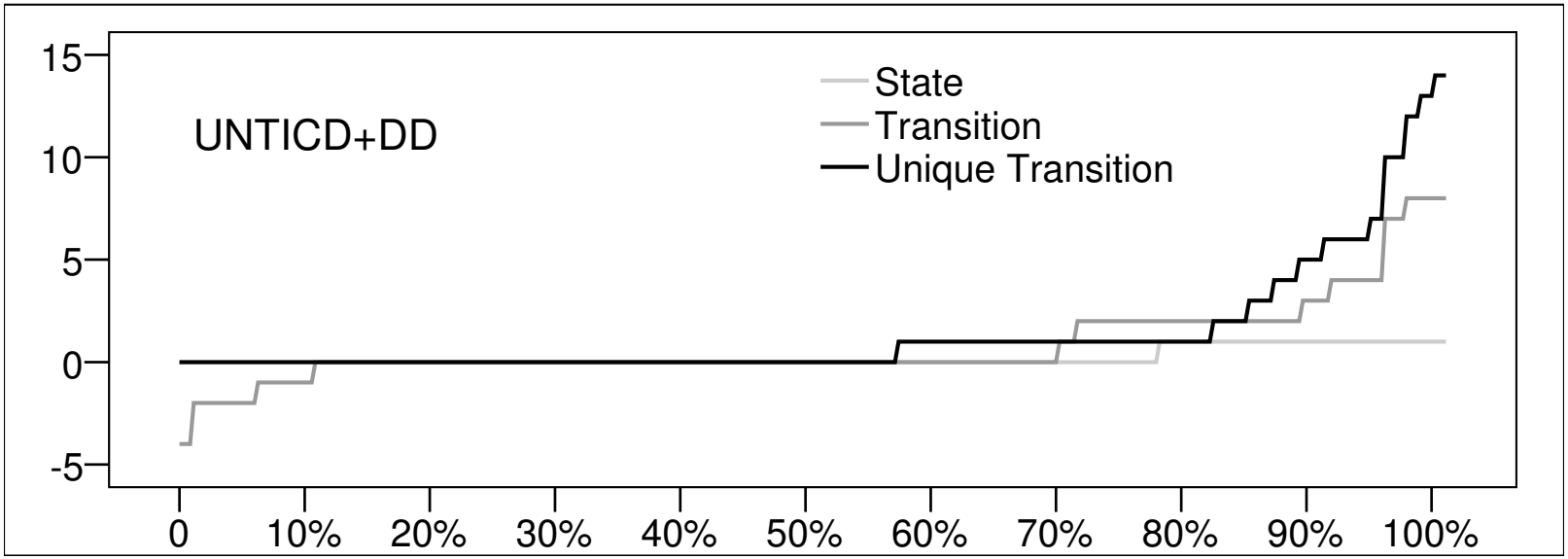

SLIM & Korel et. al's algorithm[2] with UNTICD

Software

- 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.

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