Electrum

Lightweight specification of behavioral models
with rich configurations

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Observations

Many Alloy models feature both structural *and behavioral* aspects, but:

- Behavior modeling requires systematic “boilerplate”
  - explicit modeling of state (local/global state idiom)
  - every mutable construct must be indexed by state/time
  - specification of a *linear* model of time (most of the time (!))
  - specific handling of the last state of a trace
- Essentially to model check *safety* properties, indeed:
  - spurious counterexamples to *liveness* properties may happen, unless traces are enriched with *lassos* [Cunha 14, Biere *et al.* 99]
  - even then, limited to *bounded model-checking* (BMC)

(Safety properties rule out unwanted behaviors,
liveness properties characterize expected behaviors)

Remark

Linear temporal logic (LTL):

- is more expressive than propositional logic
- is decidable
- relies on a *simple* & *uniform* model of time: *infinite traces* of states
- benefits from dedicated, *complete* model-checking procedures

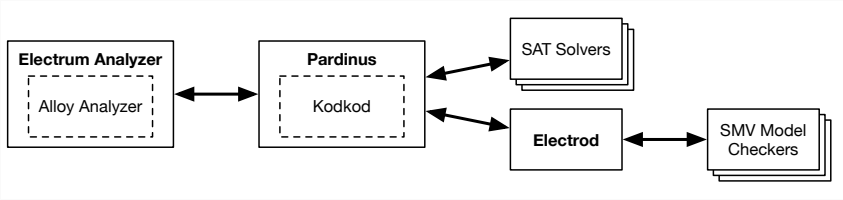
Introducing Electrum

Mark mutable fields or signatures as such (using a new **var** keyword).

Add *LTL* + primed variables (as, *e.g.*, in TLA+).

Dedicated analyses:

- BMC by reduction to Alloy + traces with lassos
- Unbounded MC (UMC) by reduction to NuSMV or nuXmv



Example: Chord

```
sig Node {
  var fst : lone Node,
  var snd : lone Node,
  var prdc : lone Node,
  var todo : Status→Node }

var sig members in Node {}

var sig ringMembers in members {}

fact {
  always members =
    { n: Node | some n.fst and
                some n.snd and
                some n.prdc }
  always ringMembers =
    { m : members | m in m.^succ }}

fun succ : Node → lone Node { ... }
...
```

```
pred join [new : Node] { // an event
  new not in members
  some m : members {
    between[m, new, m.fst]
    fst' = fst ++ new→m.fst
    snd' = snd ++ new→m.snd
    prdc' = prdc ++ new→m
    todo' = todo }}

fact strongFairness {
  all n, m : Node {
    (always eventually rectifyEnabled[n,m])
        ⇒ (always eventually rectify[n,m])
    ... }}

assert correctness {
  (eventually always not (join or fail)
    implies eventually always ideal ) }
```

Assessment

Fits well most Alloy models with *behavior*.

Often leaner than plain Alloy (not always: *e.g.* counting events).

BMC efficiency on par with classic Alloy.

UMC with nuXmv comparable to TLA+'s TLC (room for improvement)
(note: nuXmv is *not* free software; other, non-evaluated, tools exist).

Modeling [Zave 2017]'s version of Chord raised various corner cases:
analyzing "abstract" liveness properties if useful (even with BMC).

Prospect

Enhance modeling of the “system” (automaton) part, *e.g.*:
actions (guard + post-condition), frame rules, fairness constraints...

Most models may then rely on LTL for assertions only.

So add branching time (CTL) too?

No more a conservative extension of Alloy, though.