The TLA+ Toolbox

Celebrating its 10th Anniversary

Markus Alexander Kuppe

Microsoft

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Outline

TLA$^+$ & PlusCal

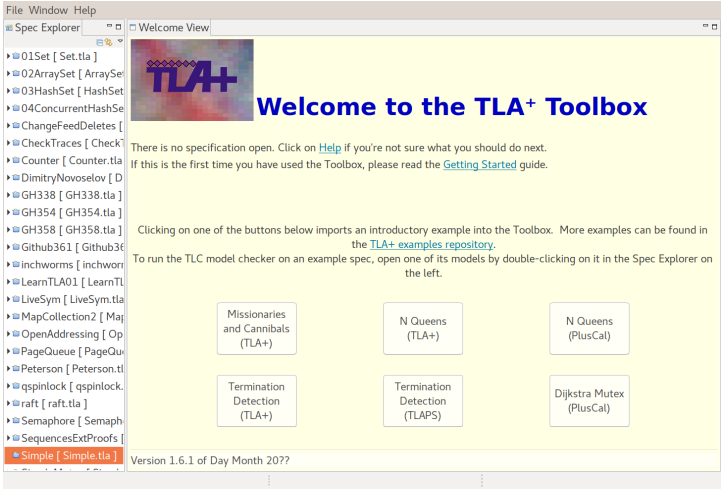
- TLA$^+$ [Lamport, 1994]
  - High-level specification language
    - Design above the code level
  - Math-based, Untyped
  - Linear-time framework: Temporal Logic of Actions

- PlusCal [Lamport, 2009a]
  - "*A gateway drug for programmers*" (C. Newcombe)
  - (Imperative-style) pseudo-code with precise semantics
  - Transpiles to TLA$^+$
    - $\Rightarrow$ Verifiable with Tools

TLA$^+$ Tools

- PlusCal transpiler, SANY, Pretty-Printer, ...
- TLC [Yu et al., 1999]
  - Explicit state model-checker
  - Addresses state space explosion by scaling (safety) checking
- TLAPS [Chaudhuri et al., 2008]
  - Unbounded Domains
  - Proof Manager on top of
    - CVC3, Zenon, Isabelle, ...
- Apalache [Konnov et al., 2019]
  - Symbolic model-checker (z3)
  - Supplement or successor to TLC?!

Demo[1]



[1] Recordings at
https://www.youtube.com/playlist?list=PLWLcqZLzY8u8-g47T_zHiK2zvPpIohRsA

Architecture

- Toolbox implemented on the Eclipse Rich Client Platform [McAffer et al., 2010]
  - Platform-independent[2]
  - Easy deployment (bundles Java & TLC)
- Eclipse "opinionated" framework
  - Eclipse is open source => Do not work around limitations
- Early years of Toolbox development too little emphasis on testing
  - UI testing remains hard
  - => Still paying the price with every new feature
- Eclipse was the right choice 10 years ago

[2] "Write once, test everywhere"

Back-ends

- Back-end integration:
  - Nested process
  - Low-level, text-based "API"
    - Custom input/output parser
- Flexible, can accommodate any back-end
- Schema-less challenge to evolve
- Alternative: IPC (structured data)

Conclusion

- Toolbox one-stop solution for:
  - Model-Checking with TLC
    - Profiler to find and remove performance bottlenecks and spec errors
    - CloudTLC for large-scale model checking & parallelized design space exploration
  - Interactive Theorem Proving with TLAPS
    - MC aids in finding inductive invariants
    - Proof decomposition
- $\sim 20k$ downloads in ~ 12 months indicate usefulness

Outlook

- Integrate Trace Exploration with third-party tools [Schultz, 2018]
- Study usefulness of Profiler on real-world specs
- Toolbox workflow for probabilistic validation of inductive invariants
- Integrate Apalache as additional back-end into Toolbox
  - TLA$^+$ type inference engine for Toolbox and back-ends
- Toolbox 2.0 as "cloud native" application
  - Lets specify a *Verification Server Protocol* (inspired by LSP)?!

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Q&A

(TLA$^+$ @ Tools Exhibit)

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TLA+

MODULE M

VARIABLE v

$Init \triangleq \ldots$ Defines initial states

$Next \triangleq v' = v + 1 \land \ldots$ Constraints allowed transitions

$Spec \triangleq Init \land \Box[Next]_v$ Defines system executions

$\land F$ and optionally Fairness

$Safety \triangleq \Box \ldots$

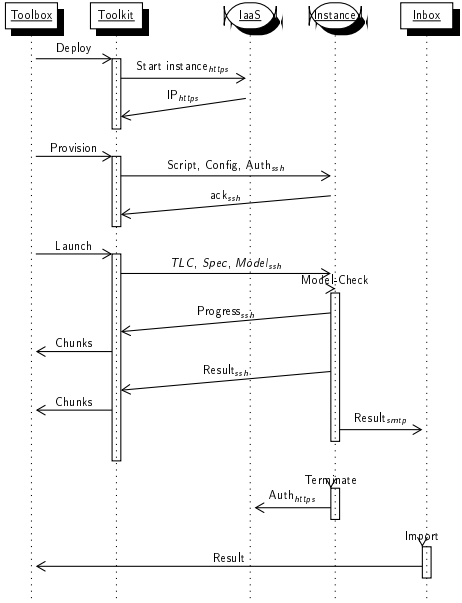
$Liveness \triangleq \Diamond\Box \ldots$

PlusCal

```
--algorithm Euclid{
  variables x = M, y = N ; {
    while (x ≠ y){
      if (x < y){y := y − x}
      else       {x := x − y}
    }
  }
}
```

Sequential algorithms need no labels (atomicy via labels)

CloudTLC


Toolbox
Toolkit
IaaS
Instance
Inbox
Deploy
Start instance$_{https}$
IP$_{https}$
Provision
Script, Config, Auth$_{ssh}$
ack$_{ssh}$
Launch
TLC, Spec, Model$_{ssh}$
Model-Check
Progress$_{ssh}$
Chunks
Result$_{ssh}$
Chunks
Result$_{smtp}$
Terminate
Auth$_{https}$
Import
Result