HACMS kickoff meeting: TA4

Technical Area 4: Integration

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Overview

- There are several parts to our effort under TA4
- Bob Bolles will cover vehicle integration in the breakout
- I'll mention other parts at the end
- But here I'm going to focus on
  The Evidential Tool Bus (ETB)
- Because that is what we use to develop and assemble and deploy proofs and code in a distributed manner
  - We use it in the DARPA CASIO project
  - We and Honeywell use it on a NASA project
  - But the HACMS applications are much more ambitious

Integration Opportunities

- Assemble code from various developers, integrate it, get it on the vehicle, test it

- But this code is formally verified or synthesized
  - So need a chain of provenance from top-level claims

- And the formal assurance needs to be "assembled" also
  - Intially, stovepipes and a pile of disparate claims
  - Later, shared assumptions, mutual assumes/guarantees
  - Later still, fully compositional

- And the formal tools need to interoperate
  - Initially, stovepipes, but mutually accessible
  - Later, integrated workflows
  - Later still, modular tools built from components

- And may want distinct development and certify modes

Evidential Tool Bus: Purpose

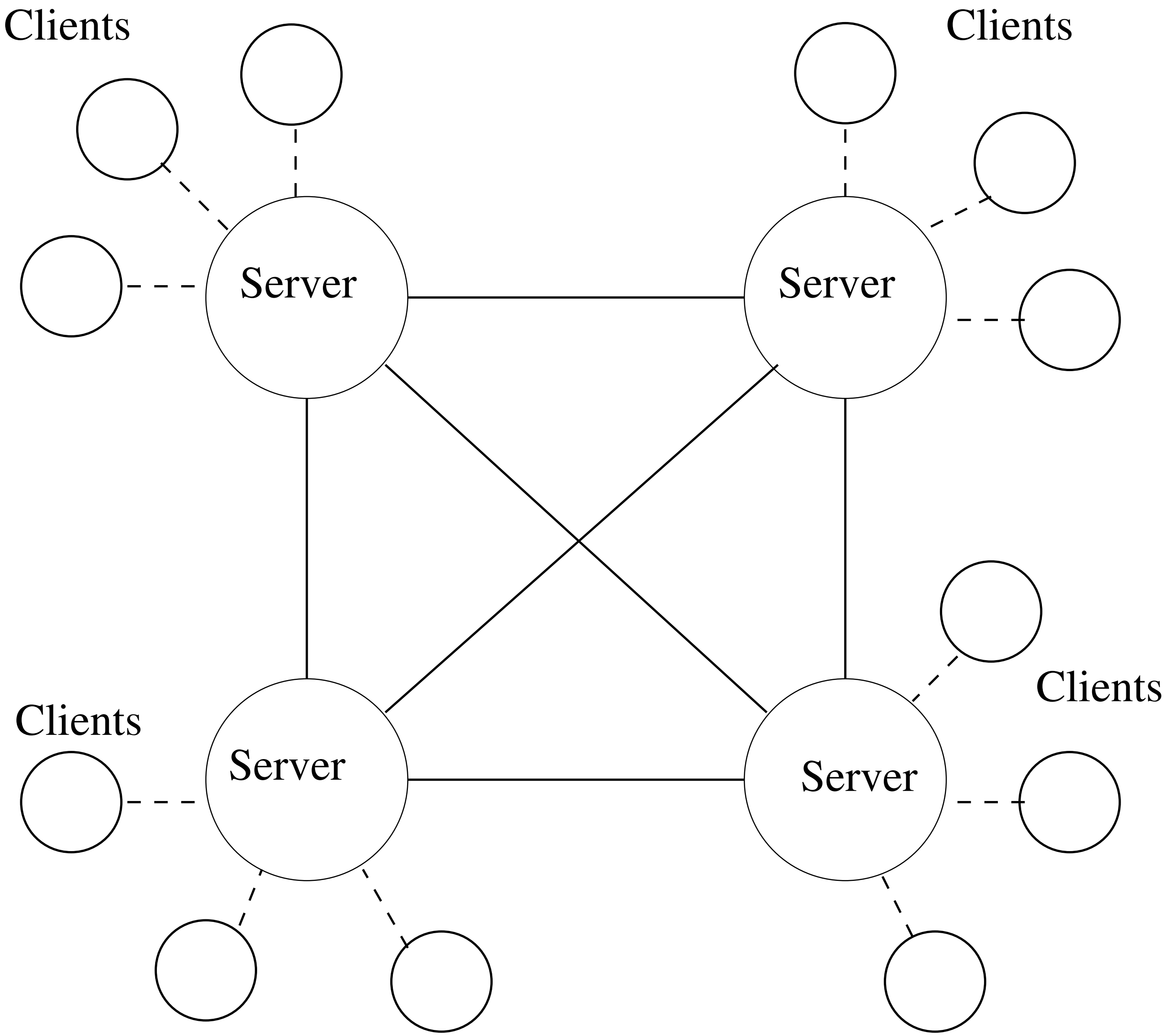
The Evidential Tool Bus

- A way to assemble the claims made by different tools
  - And to compose them into an assurance case
- And a way to assemble the code they generate
- In a way that keeps everything consistent

The Evidential Tool Bus

- A distributed, location-transparent way of invoking tools
  - A way for one tool to invoke services of another
  - And for scripting workflows
- And for accessing files, specs, etc.
- Cost of attaching tools to the ETB is low
  - Lightweight wrappers
  - No mandated logic, format, methodology

ETB: Picture


Clients
Clients
Server
Server
Clients
Clients
Server
Server

ETB Architecture: Servers, Tools and Files

- The ETB is a fully connected graph of servers
- Servers are distributed
  - On a subnet or via SSH tunnels
- Servers can come and go
- Servers can run various tools
  - Some servers may run no tools
  - Some may run many
  - Tools can run on one or more servers
  - Tools can be scripts
- Servers also store files

Architecture: Clients

- Humans interact with the ETB via clients

- Which connect to a server using an API (about 20 methods)

- Clients have no ETB state,

- Currently, we provide just a simple shell

- You can also write your own (e.g., for Eclipse)

- We do have a Java-based project-specific graphical client for CASIO

Architecture: Mechanisms

- Each server runs a simple daemon (written in Python) that exchanges messages with the others
  - When something happens
  - Or periodic heartbeat
- Underlying protocols use XML-RPC
  - With data represented in JSON
- Files are stored in a GIT repository on each server
  - Hence, are global, but consistency is lazy (by need)
  - Referenced by name (relative to server directory) and SHA1 hash
  - Hence, unique

ETB Predicates

- The unit for computation and for claims is a predicate
  - Like a (remote) function call that also attests a claim

- An ETB predicate is of the form
  - `name(arg1, arg2, ..., argn)`

  Where the `arg`s are variables, or data

- The `name` can be interpreted or uninterpreted
  - interpreted predicates cause invocation of tools
  - uninterpreted predicates invoke workflows

Example Interpreted Predicates

- `YicesCheck(Fmla, SAT?)`
  - Where `Fmla` is an SMT formula (or file)
  - And `SAT?` is a variable

  Is a query (queries can also be ground)

- Can be evaluated by a server that has the Yices SMT solver
  - Will instantiate the variables
  - And yield a claim (attested ground predicate)
  - e.g. `YicesCheck(Fmla, "satisfiable")` where `satisfiable` is a literal that indicates `Fmla` is satisfiable

- Can then do `YicesShowModel(Fmla, MODEL?)` to obtain model

- Claims Table keeps detailed log of claims

Tools, Wrappers, Scripts

- Tools attach to the ETB via wrappers
  - Typically a dozen lines of Python
  - Export appropriate predicates for that tool
  - Possibly of various granularities
    - ⋆ e.g., specific proof vs. all proofs in a file
- A wrapper may include fairly complex scripting
  - Can issue queries, make claims (including "error claims")
  - Can establish sessions, run interactive tools and invoke external activity (e.g., "ask Sam to prove this")
- Later, may want to deconstruct tools into shared components
- Claims established by interpreted predicates provide attestation (e.g., "proved by PVS", "John says it's so")
- But are internally opaque (trust bottoms out here)
  - i.e., they do not provide an ETB-level proof
  - That's what uninterpreted predicates are for

Support Tools

- Some interpreted tools just check the format of a file

- Others do translations between formats/logics

- Not everything is a specification or a theorem
  - Also have counterexamples, sets of predicates (for predicate abstraction), interpolants, etc.
  - Anticipate evolution of a 2-dimensional ontology
    - ⋆ Kinds of things x logic/representation

- Some tools run a makefile, create code
  - Code goes in a file, just like other data

- Limited fault tolerance, load balancing, security, job management at present

Uninterpreted Predicates

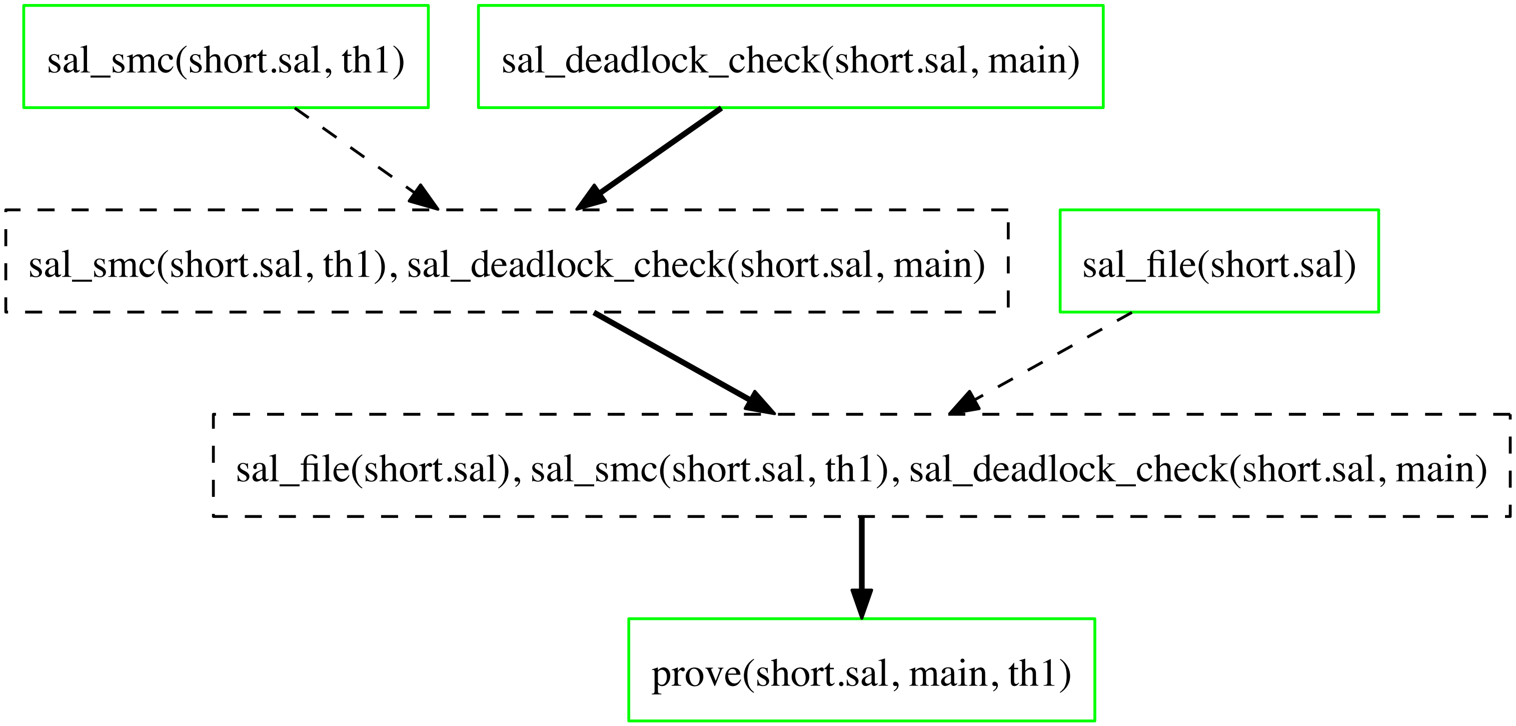
- ETB has a simple logic engine (inspired by Datalog)
- Uninterpreted predicates are defined by Horn-clause rules that are evaluated directly by the ETB: e.g.,

```
prove(F,M,P) :- sal_file(F),
                sal_smc(F,P),
                sal_deadlock_check(F,M).
```

- These define workflows
- Evaluation builds an ETB proof connecting claims
- Workflows can provide different proof modes
  - ◦ e.g., discovery vs. certification
  - ◦ First might call many SMT solvers, use first to complete
    - ⋆ There's an API query for tool completion
  - ◦ Second might call many, require all to give same answer
  - ◦ Or might call a trusted solver

ETB: Proof Tree

This is from the query `prove(short.sal, main, th1)` using the rule on the previous page


sal_smc(short.sal, th1)
sal_deadlock_check(short.sal, main)
sal_smc(short.sal, th1), sal_deadlock_check(short.sal, main)
sal_file(short.sal)
sal_file(short.sal), sal_smc(short.sal, th1), sal_deadlock_check(short.sal, main)
prove(short.sal, main, th1)

Plan

- Further develop and deploy the ETB
    - Gregoire Hamon

- With your input
    - This is our third attempt, also the simplest
    - Seek early adopters
    - Technical introductions by Webex, welcome visitors

Other Parts of TA4

- Trusted tools: Kernel Of Truth (KOT), Shankar
    - Tower of increasing powerful verifiers and synthesizers
    - Each formally verified using the ones below
- Compositional Verification: Lazy Composition, Shankar
    - Assume/Guarantee is sound but not credible for genuine components
    - Designed in ignorance, why would my guarantees match your assumes?
    - So synthesize weakest assumptions
- Top-Level: Assurance Case, John Rushby
    - Tradeoff epistemic and logic doubt