Testing MDA Platform Independent Models

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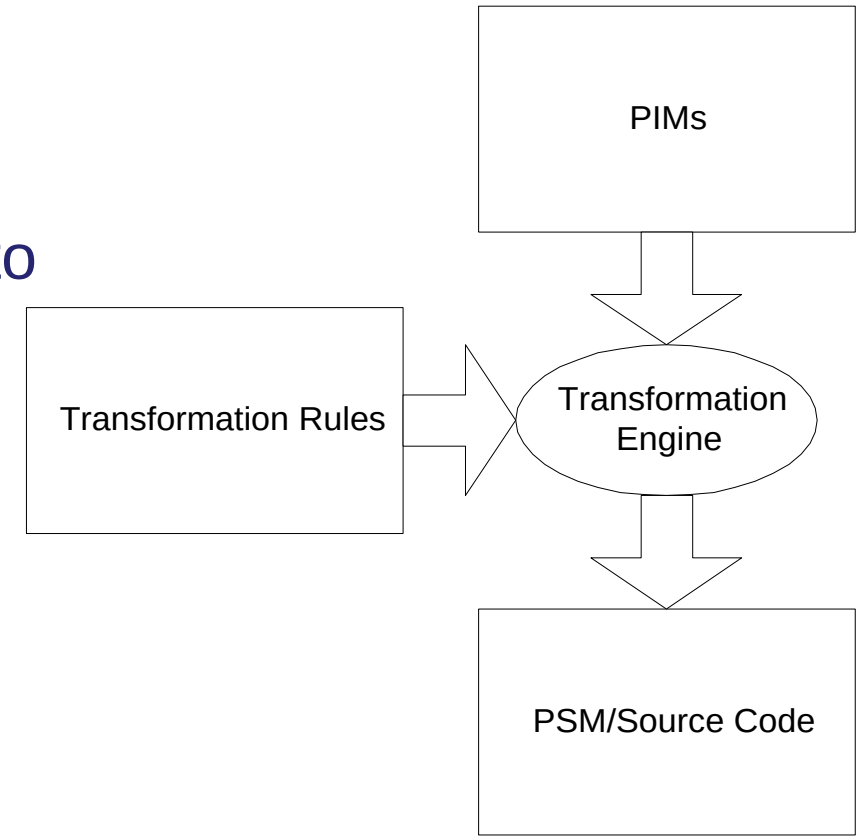
Model Driven Architecture

- Model components independent of implementation technologies
- Transformations map model to implementation
- Leverage models into integration testing
- Test Independently
  - Models
  - Transformation rules



Embedded MDA

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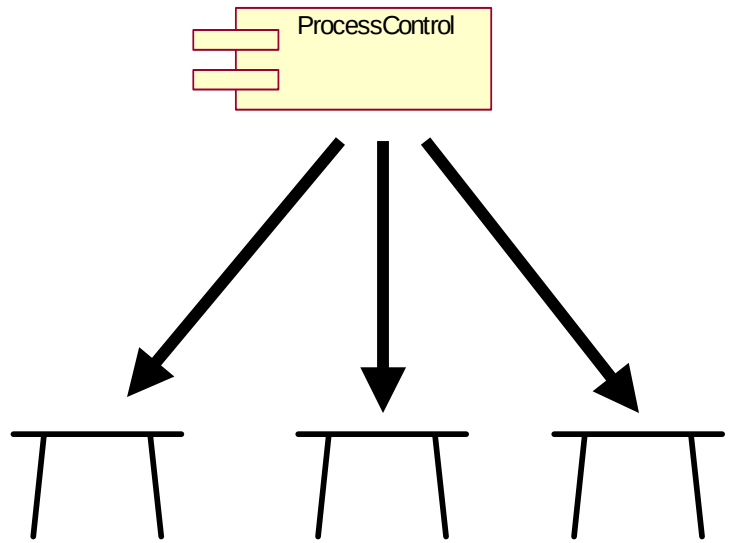
- Executable models
- Large number of embedded systems platforms
- Non-functional requirements
- Models tested on one platform may not work on another



What Is a Platform?

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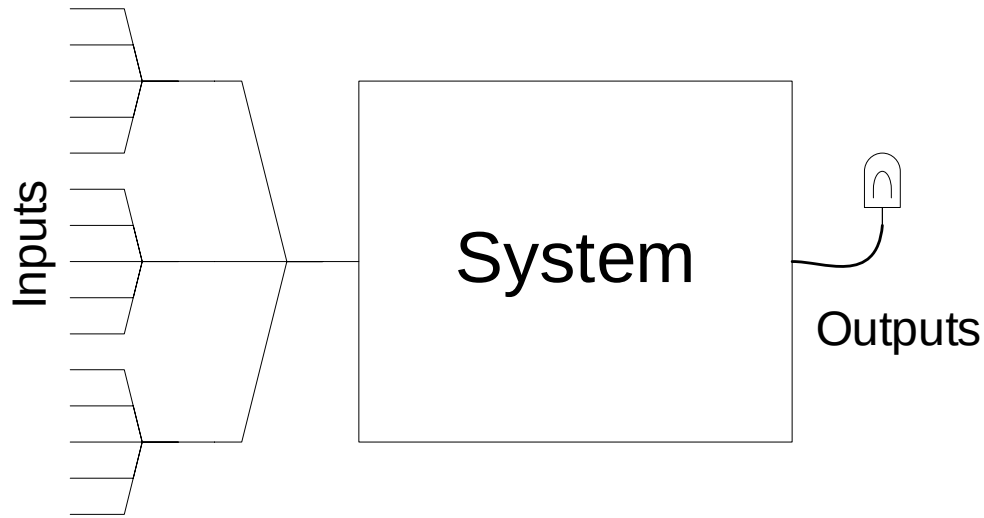
- Provides the support for model execution:
  - Architectural topology (processors, processes, threads)
  - Communication technologies
  - Supporting components
  - Operating system
  - Implementation language
  - Design and implementation patterns

Testing Embedded Systems



- *Initial State + Inputs ⇨Final State + Outputs*

Testability

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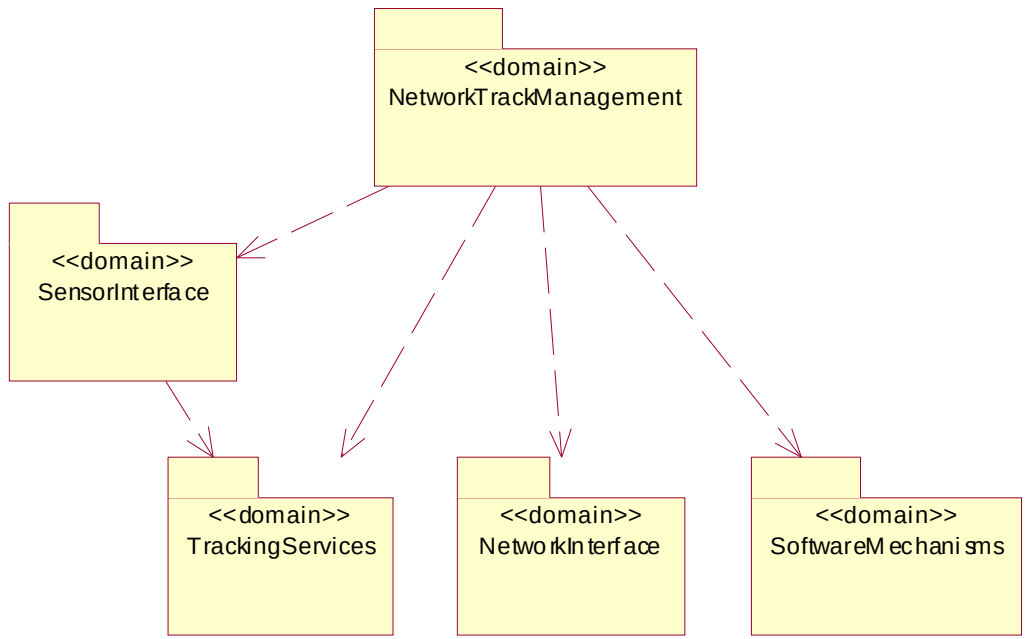
- *Testability* - relative effort to verify a system is correct
- *Observability* - the ability to detect errors in the output or the internal state
- *Controllability* - the ability to force system through a particular path
- *Repeatability* - the ability to reproduce test results

MDA Components: Domains

- Logical Separation
- Well defined boundaries
- Modeled domains consist of:
  - API
  - Classes
  - Statecharts
  - Action Language



Design for Test

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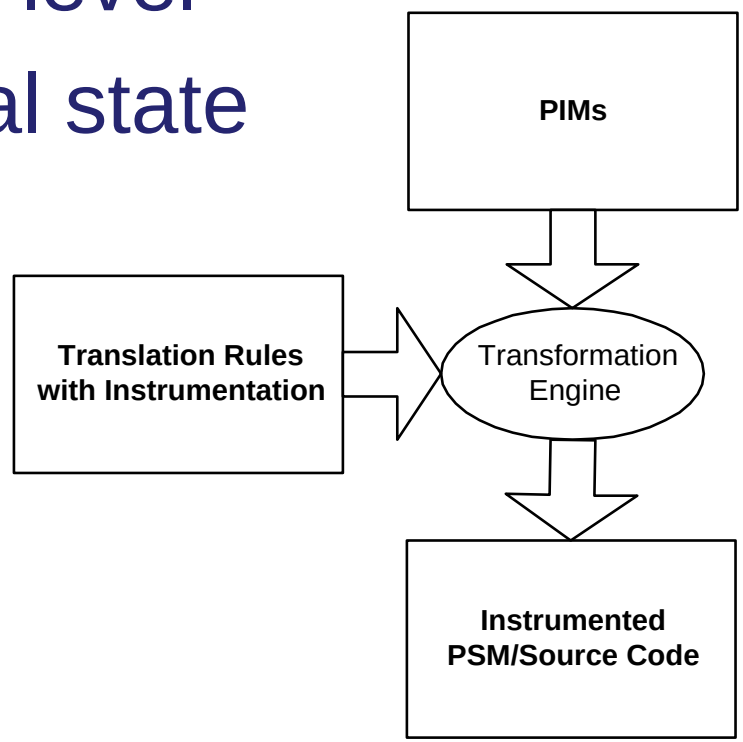
- Set of rules and methods applied during design and translation to make high quality testing possible
- Facilitate the execution of tests
- Simplify the process of finding defects
- Design for Test does not add any additional functionality to the application.

Instrumentation

- Test hooks
- Source code debugger symbol table
- Test and debug at model level
- Need visibility into internal state
  - Testability
  - Controllability
  - Observability
- Probe effect
- Emulation



Reactive Systems

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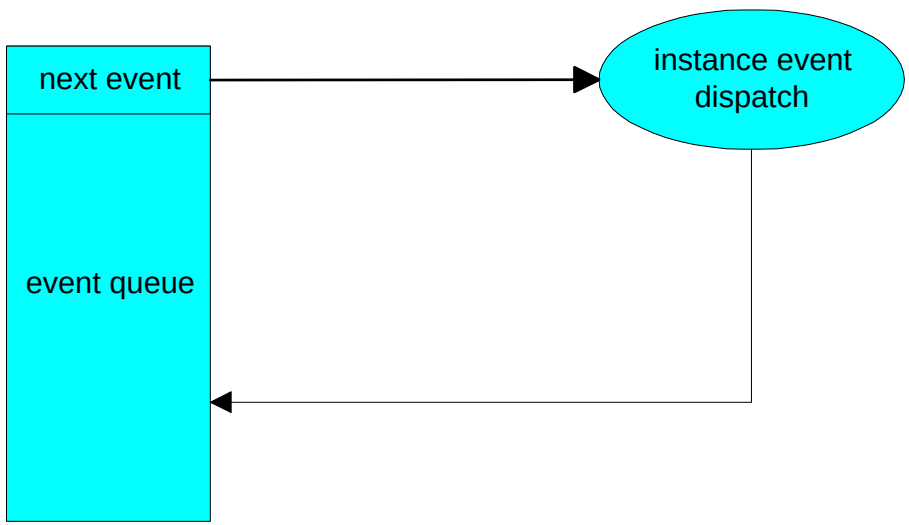
- **Event Loop**
  - Central point of control for sequencing events
  - Thread of control event dequeue algorithm:
    - `while events in queue:`
      - `get next event from queue`
      - `dispatch to destination class instance`
      - `delete event`



Event Queue Instrumentation

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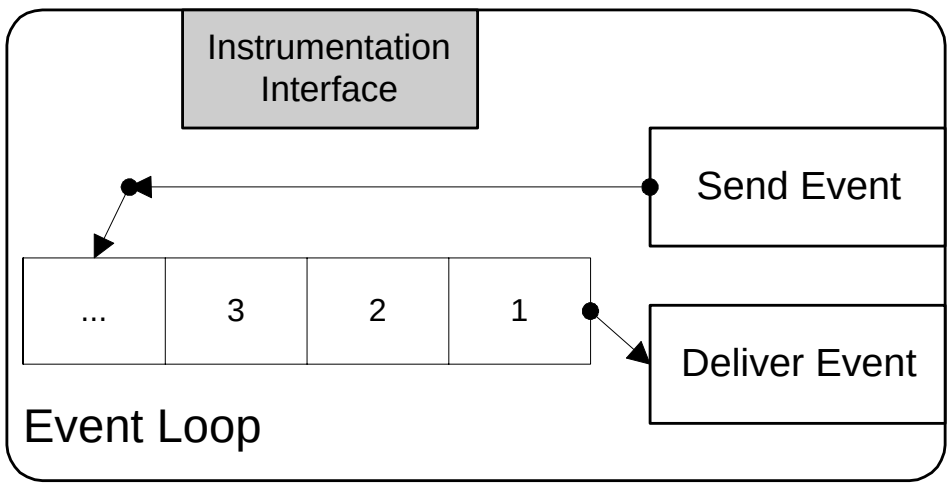
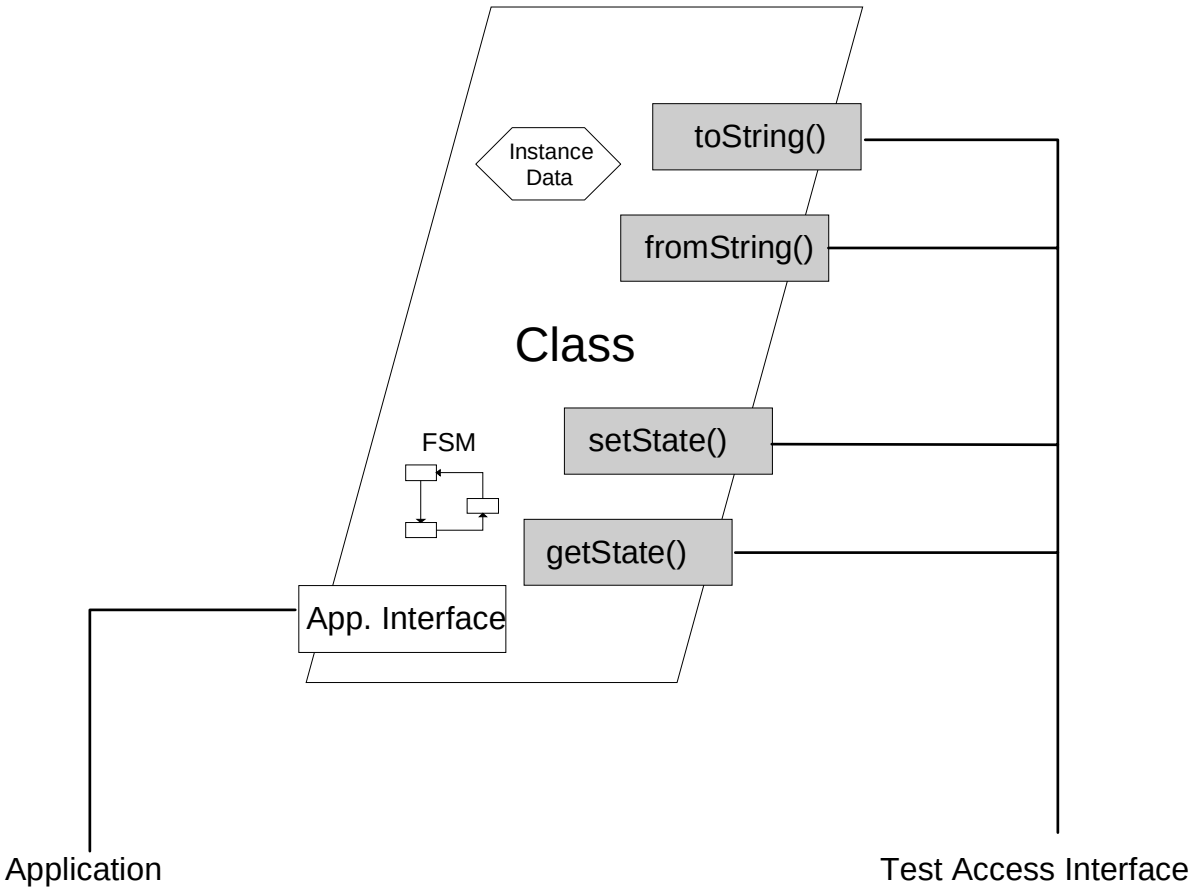
- Access to event queue allows
  - Reordering of events
  - Control over sequence of execution
  - Add an event to simulate external input
  - Simulate time by firing a timeout event



Class Instrumentation

- Monitoring and Browsing of instance data



Breakpoints

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- Event breakpoint code fragment

```
static List regBreaks;
void checkBreakpoint(Event e) {
for (Breakpt b=regBreaks.top();
    b!=NULL;b=regBreaks.next()){
if (b.matches(e)){
Agent::notifyBreakpoint(e);
Agent::waitForGo();
    }
  }
}
```

Breakpoints

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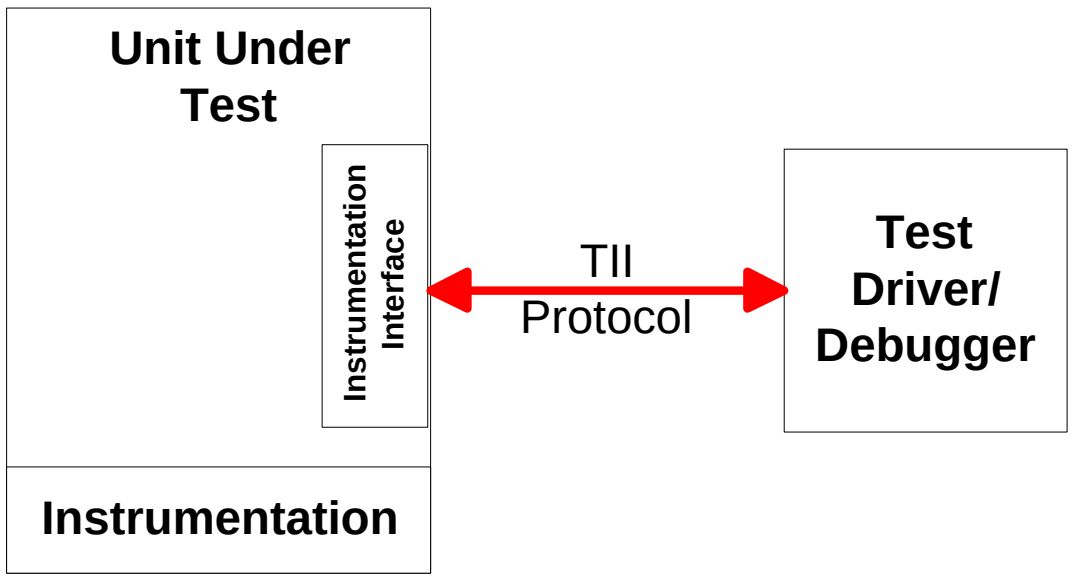
```
void Agent::waitForGo() {
while (msg = Agent::waitForMessage() != 0) {
if (msg.isGo()) { return; }
else { msg.process(); }
}
```

Test Instrumentation Interface

- Standardize test driver-application interface
  - Model-level Testing and Debugging
- Facilitate testing of models across platforms
- Package test cases with PIMs



Instrumentation Communication

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- Communication channel: TCP/IP, RS232, …
- Messages are commands and supplemental data or responses

Type	Class	Attributes
ADD_INSTANCE	"Aircraft"	"Altitude=13000"

Test Execution - Initialization

- Determine the initial state of the system
- Does not need to be the startup state
- Determine instance population and values
- Error conditions

Test Execution - Stimulus

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- Stimulus is application dependent
  - API calls
  - Message buffers
- Timing and sequencing of calls
- Emulate target environment

Test Execution - Data Collection

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- Collect outputs
  - Outgoing messages
  - Calls to other components
  - Trace information
- Capture/playback
- Collect relevant aspects of internal state
- Verify results against expected data

Emulation

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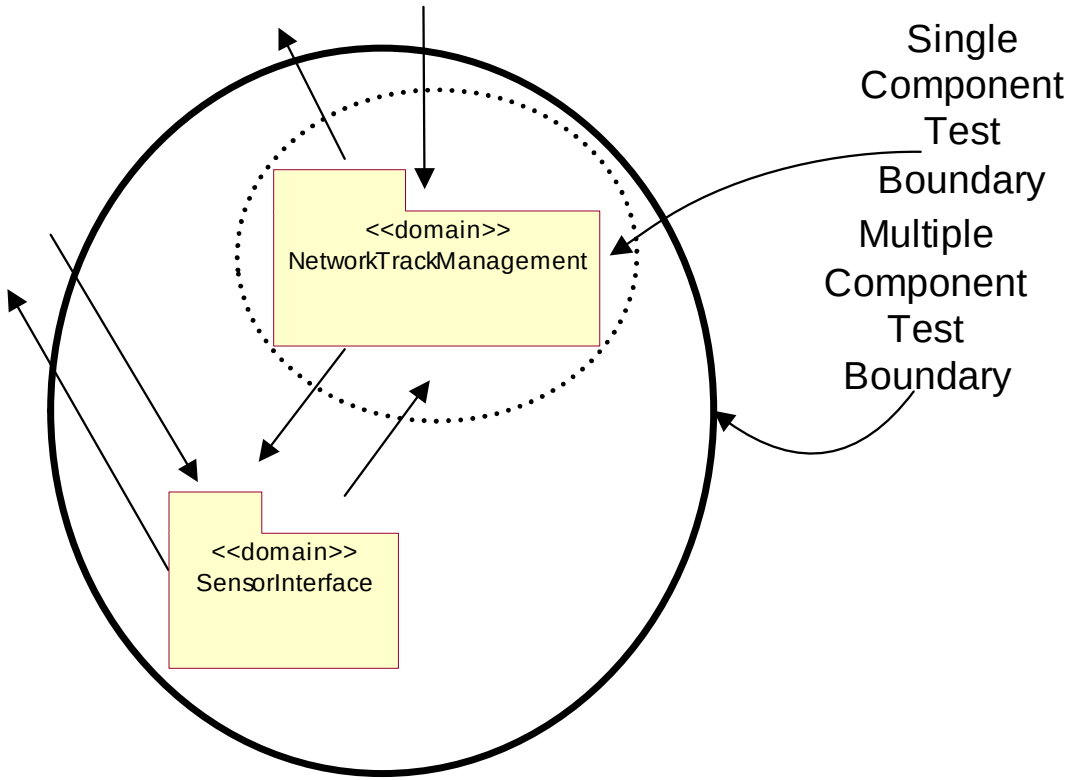
- The replacement of part of the system with a simulated version for the purposes of testing
- Greater controllability of software under test
- Understanding of interfaces and emulation boundary provided by models
- Tests conditions that would otherwise be difficult to recreate

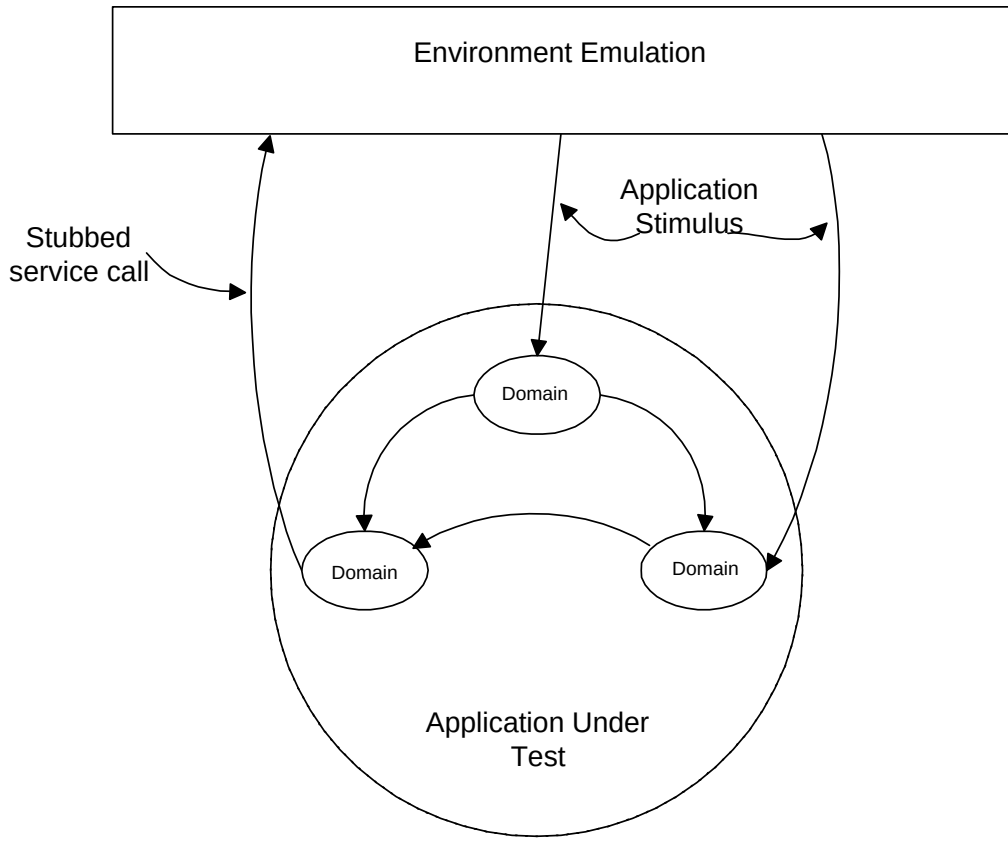
Component Boundaries

- Test individual components
- API
- Understand boundaries and dependencies

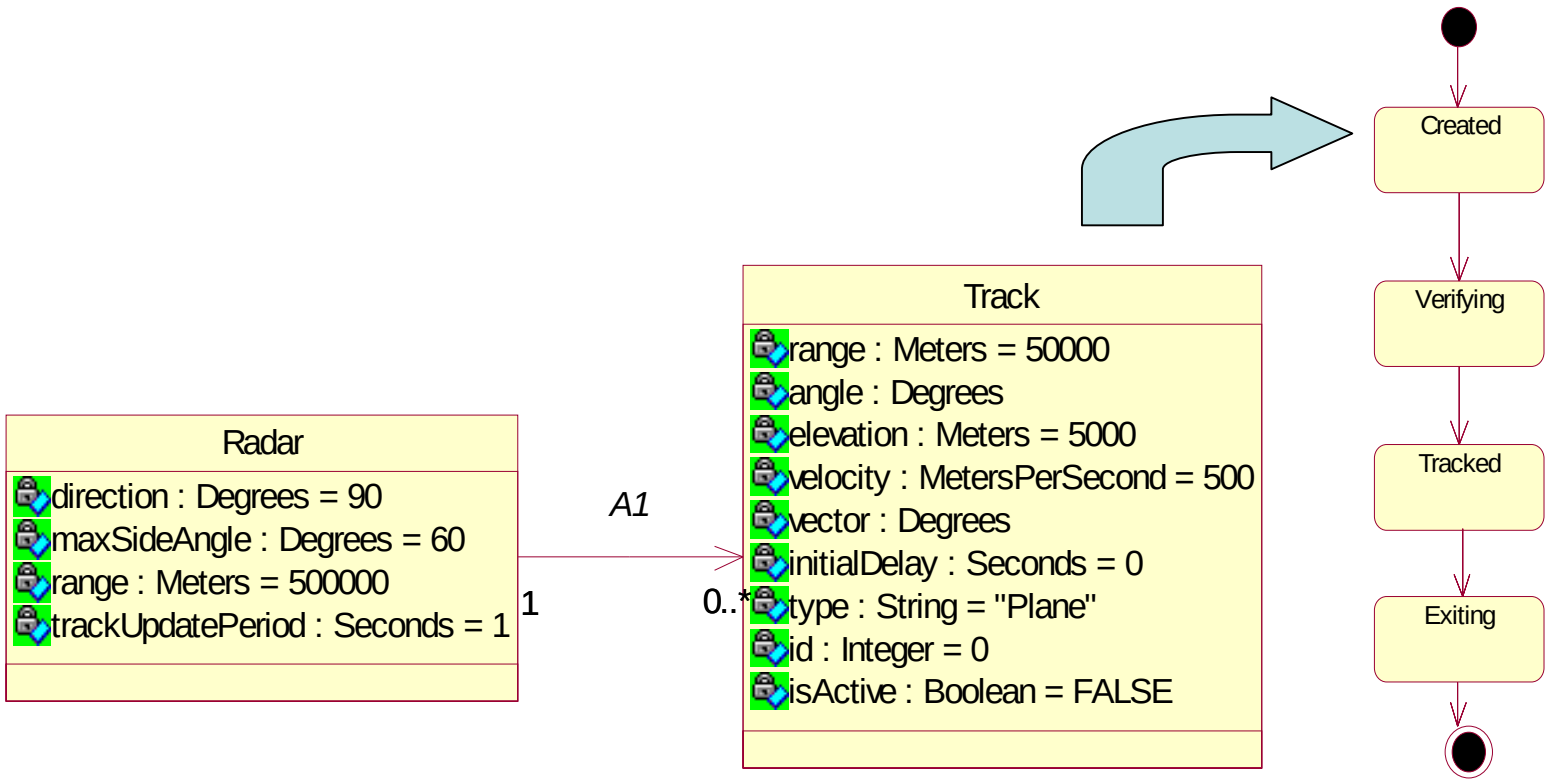


Emulation

- Emulation approaches:
  - Simple stubs
  - Test driver to apply input stimulus
  - Controllable scripted or interactive support for flexible emulation
- Scenarios to help determine required drivers and emulation stubs



Modeling the Test



Built-in Self Test

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- Check the state of the system
- Tagged as integration support
- Usually not in final product
- Types of checking
  - Assertions
  - Preconditions
  - Postconditions
  - Invariant

Invariants

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- An expression that should hold true at all times during execution
  - Checked periodically during execution
  - Used to automatically detect faulty internal states during execution
- Express safety properties as invariant

Scalability

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- The scalability of a system can be verified through stress testing targeting:
  - Number of instances
  - Number of events
  - Application-specific throughput
  - Degraded and error conditions

Performance

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- Throughput
- Response time
- Real-time constraints
- Memory usage
- Tailor instrumentation
  - Collect required metrics
  - Minimize impact on execution

Coverage

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- Use models to help measure test coverage
- Use trace logs to determine coverage
- Non-executed states may be unreachable or point to holes in the test suite
- Operation coverage
- Path Coverage

Automation

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- Critical for embedded systems of any complexity
- Repeatability
- Test harness
- Allow for interactive debug when problems are found
- Validation of test results
  - Visual inspection
  - Result prediction

Conclusion

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- Dynamic testing of models is required
- Test { Model + Transformation + Platform }
- Instrumentation increases controllability, observability, and testability
- Used during integration testing
  - In development environment
  - On target platforms
- Translation generic instrumentation test harness applicable to any application

Thank You!

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