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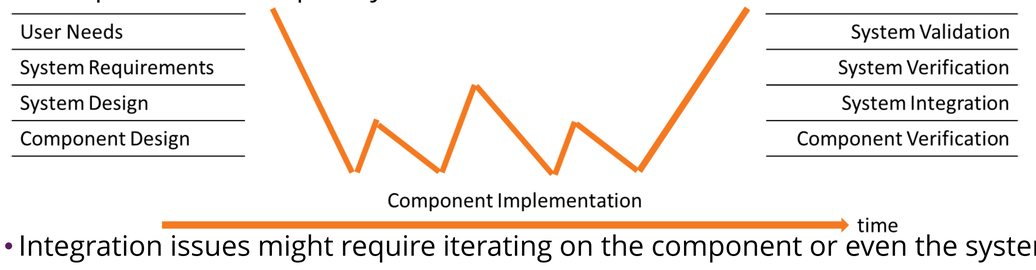
Preventing and Diagnosing System Integration Issues

Using an open-source approach: Component Modeling & Analysis (ComMA)

CHALLENGES

- Many integration issues arise from unclear interfaces between components
  - Problems with 3rd party components
  - Components developed by different teams



- Integration issues might require iterating on the component or even the system design
- Hard to predict when iteration ends, and full integration is achieved

CAUSES

- Interface descriptions are often minimal
  - Typically, listing only call signatures
  - A document-based engineering approach
    - Can lead to ambiguity and imprecision
- Commonly missing elements include
  - The allowed order of calls
  - Expected timing behavior
  - Constraints on data

SOLUTION DIRECTION

- Models include commonly missing elements
  - Behavior by protocol state machine
    - Contract between client(s) and server; allowed sequences of calls
  - Constraints
    - Timing; specifying timing intervals between calls
    - Data; valid value ranges for call parameters
  - Unambiguous, precise models can mitigate integration problems

COMMA DESIGN MODELS

- The Domain Specific Languages (DSLs) incorporate previously missing elements
  - The DSLs use an interface/implementation technology agnostic notation

SIGNATURE

```
commands
   Status PowerOn
   int TakePicture(Time timestamp)
signals
   PowerOff
notifications
   Click
```

TIME & DATA CONSTRAINTS

```
timing constraints
TC1 in state On command TakePicture - [ 10.0 ms .. 75.0 ms ]
      -> notification Click
TC2 in state Off command PowerOn and reply(Status::OK)
      -> [ .. 100.0 ms ] between events
```

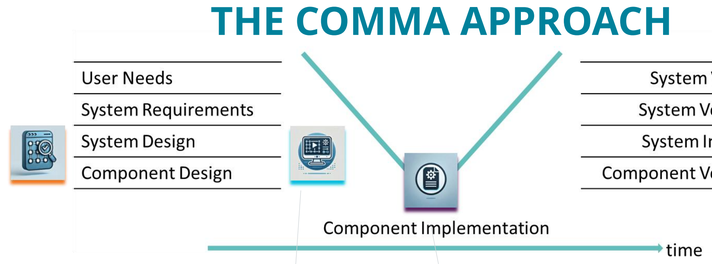
INTERFACE (BEHAVIOR)

```
initial state Off {
  transition trigger: PowerOn
  do: reply(Status::OK)     next state: On
  OR
  do: reply(Status::Failed) next state: Off
}
state On {
   transition trigger: TakePicture(Time timestamp)
   do: reply(*) Click next state: On

   transition trigger: PowerOff next state: Off
```

COMPONENTS

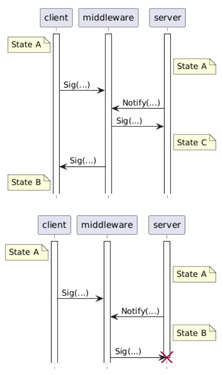
```
component componentCamera
provided port ILens lensPort
provided port ISystem systemPort

functional constraints
// SetZoom and AutoFocus are only allowed when system is on
FC1 {
    use events
    command systemPort::PowerOn
```

THE COMMA APPROACH



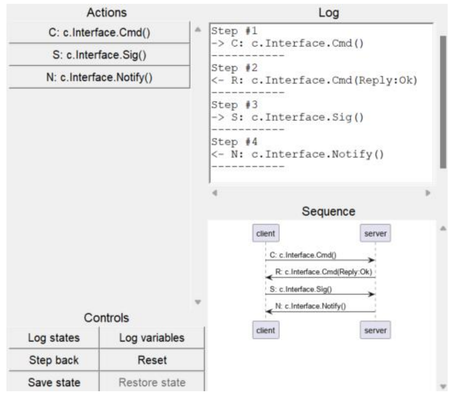
MODEL QUALITY CHECKS (VERIFICATION)

- Goal: detect interface design errors before implementation begins
- Quality of interface model
  - Unreachable states: if there is no sequence of transitions to get to that state
  - Deadlock states: if no transitions can be executed in that state
  - Sink states: if there is no transition that allows to leave that state
  - Livelock states: if there is no sequence of transitions to get to the “home” state
- Quality of interactions
  - Race conditions: if both a client and a server can independently make a choice to execute a transition



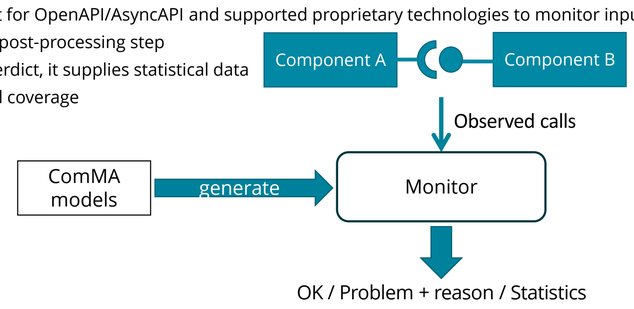
SIMULATOR (VALIDATION)

- Goal: identify design model errors before the implementation phase
- Explore an **interface** or **component** model’s execution behavior



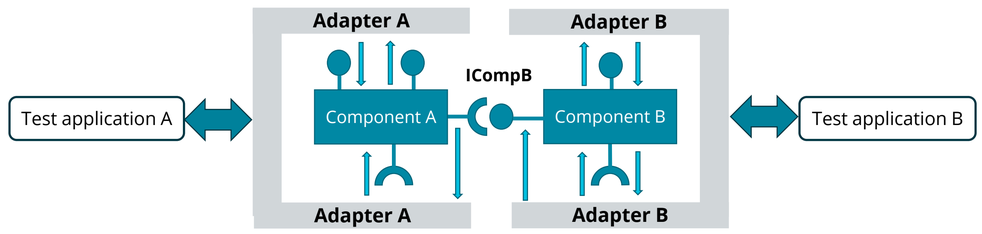
OFFLINE RUNTIME MONITORING (DURING & POST-INTEGRATION)

- Goal: investigate integration issues during and post-integration
- Offline runtime monitoring of stored execution logs
  - Translators exist for OpenAPI/AsyncAPI and supported proprietary technologies to monitor input
  - Performed as a post-processing step
  - Alongside the verdict, it supplies statistical data
    - Such as model coverage



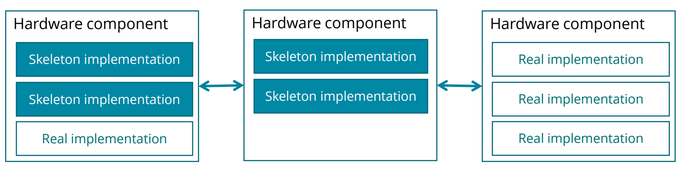
ONLINE MODEL-BASED TESTING (PRE-INTEGRATION)

- Goal: test components pre-integration to prevent issues during the integration phase
- Online MBT for confidence testing, i.e., for checking the ICompB interface (see figure below)
- Test applications are automatically generated from **interface** and/or **component** models
- Adapters are automatically generated for OpenAPI/AsyncAPI and supported proprietary technologies



SKELETON IMPLEMENTATIONS (EARLY INTEGRATION)

- Goal: verify program flows by early integration with real and skeleton implementations
- Generate a skeleton implementation from component model
  - Component model specifies partial behavior, typically the main program flows
  - Skeleton implementations comply with specified timing budgets



This functionality is not yet included in the open-source release

- CommaSuite is an Eclipse Foundation project
- https://eclipse.dev/comma

www.esi.nl