OACTree Sequencer

Operation, Automation and Control using Behavior Trees

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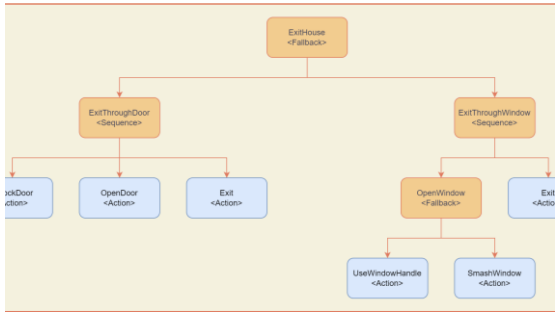
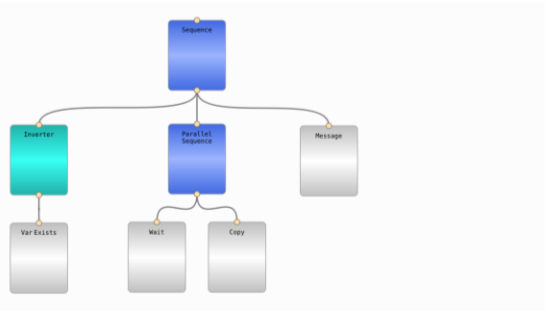
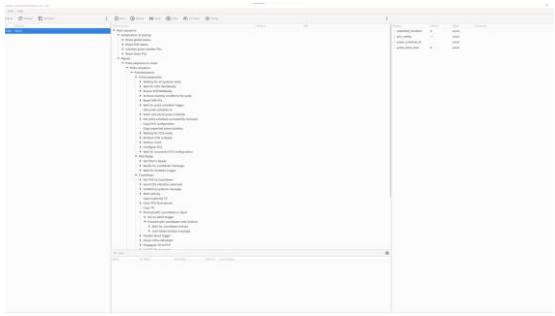
Overview

- Motivation
- Behavior tree semantics
- Extensible and composable:
  - New Instructions and/or Variables can be provided through plugins
  - Decoupled user interactions (input/output) allows for CLI, daemon, GUI, etc.
  - Include(Procedure) allows building procedures from a collection of input procedure files
- Instructions & Variables
- Plugins allow custom extensions
- GUI
- Status and Plans

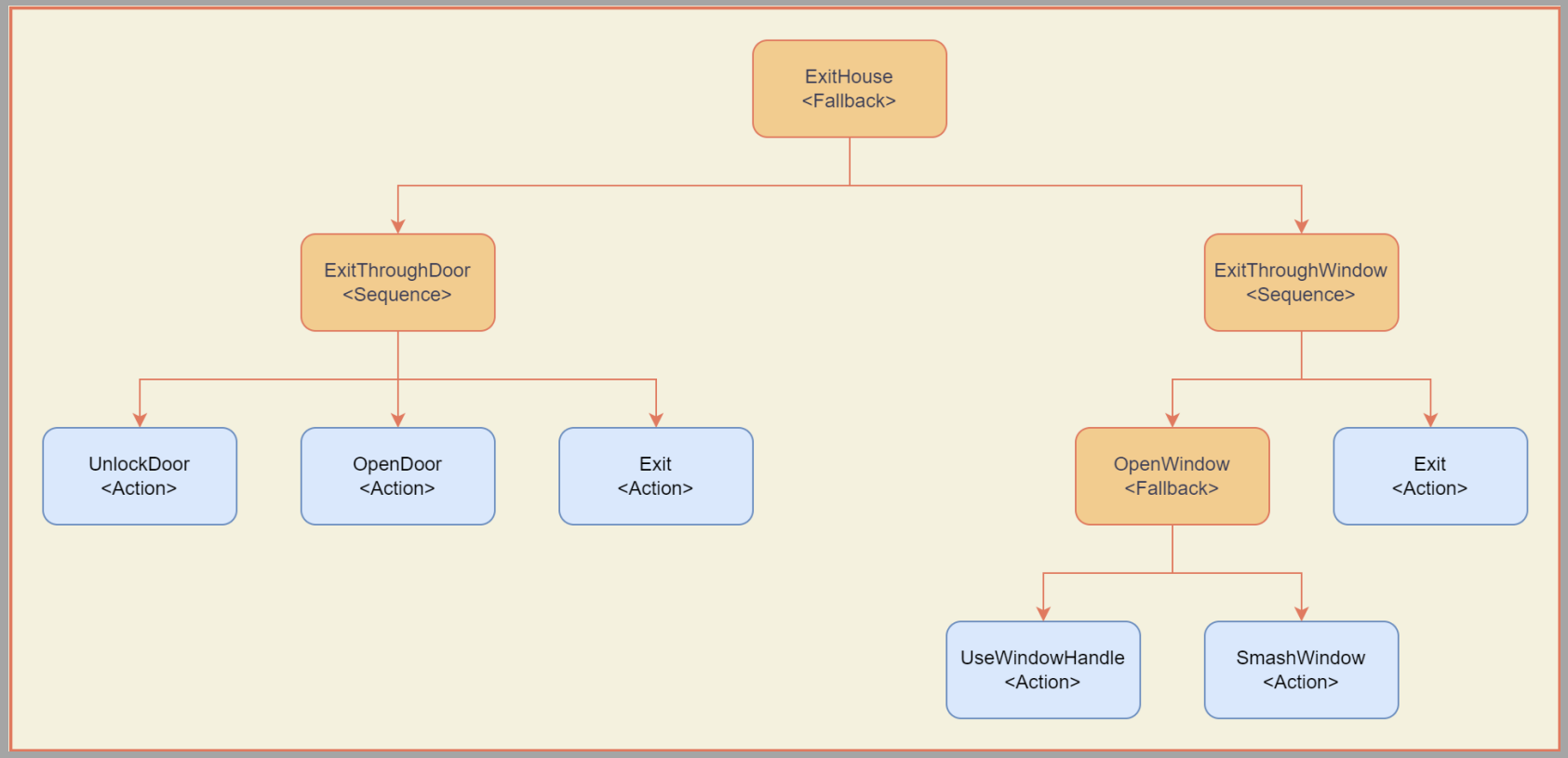






Motivation

- The traditional EPICS SNC-Sequencer is a powerful tool, very well documented and tested
- ITER systems are very large and complex;
  often commissioned in stages
- E.g., the start-up procedure for the CC2D cooling loop (1/6) has about 1k instructions
- Finite state machines don’t scale well enough
- Behavior Trees are a concept that allows for better modularization and parametrization of large procedures



Behavior tree semantics

Goal based, rather than action based

Decompose main goal into subgoals

Used in AI, robotics, control systems and video games

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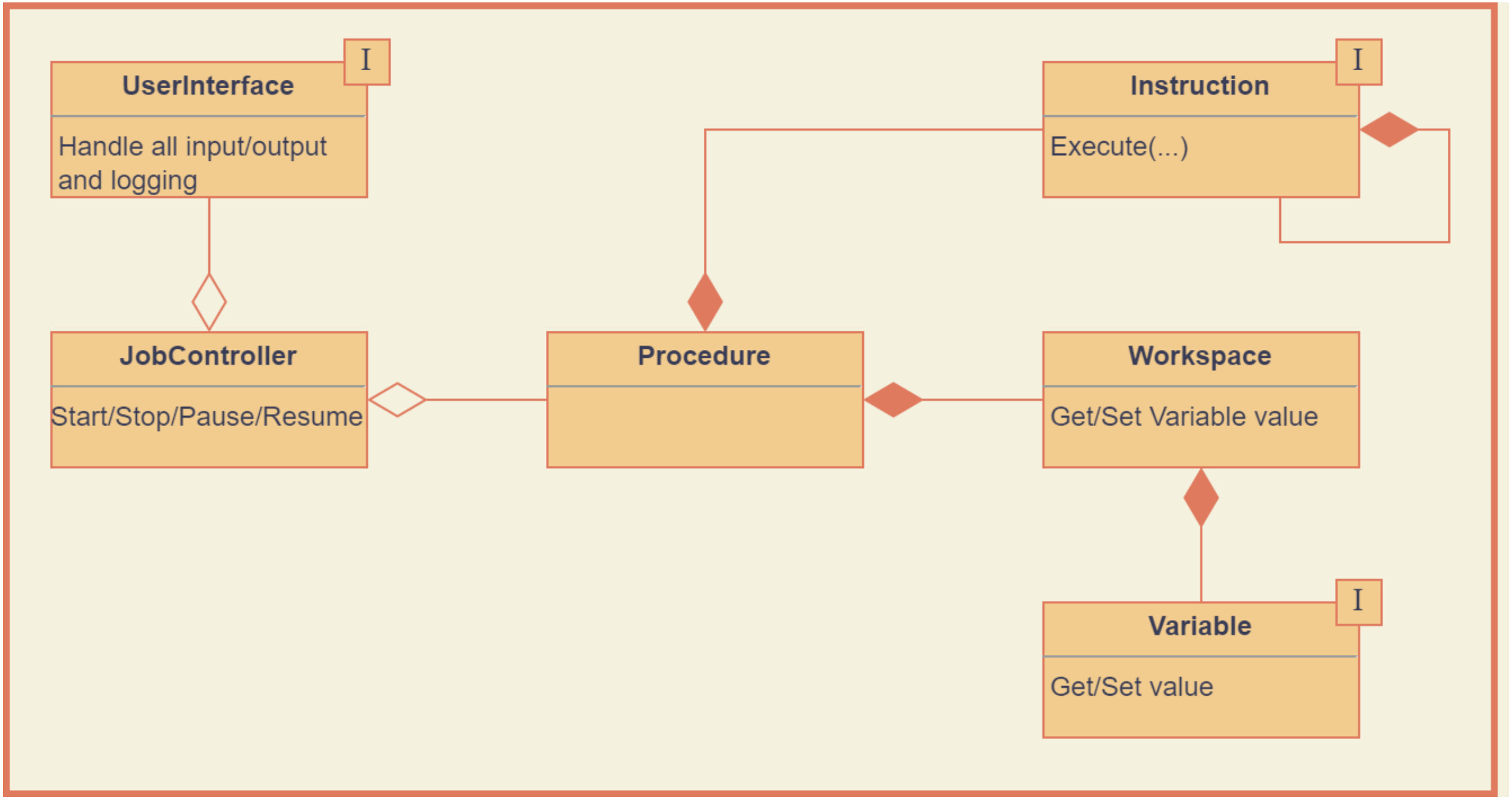
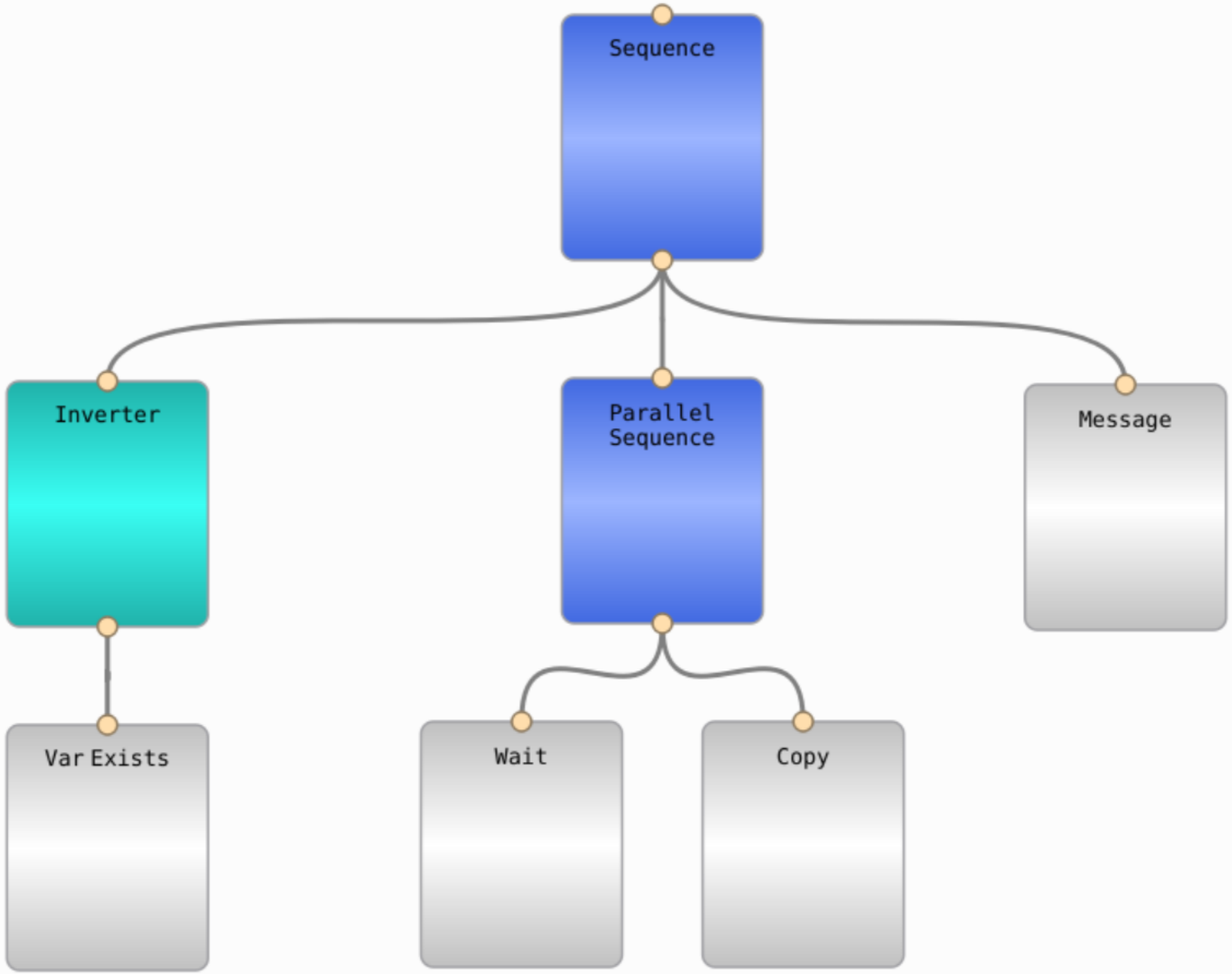

I
UserInterface
Handle all input/output and logging
I
Instruction
Execute(...)
JobController
Start/Stop/Pause/Resume
Procedure
Workspace
Get/Set Variable value
I
Variable
Get/Set value



Instruction categories

Composite

- Sequence
- Fallback
- ParallelSequence

Decorator

- Inverter
- Listen
- Include(Procedure)

Action

- Wait
- Copy
- Output
- Input

```xml
<?xml version="1.0" encoding="UTF-8"?>
<Procedure xmlns="http://codac.iter.org/sup/sequencer" version="1.0"
           name="Procedure for testing purposes"
           xmlns:xs="http://www.w3.org/2001/XMLSchema-instance"
           xs:schemaLocation="http://codac.iter.org/sup/sequencer sequencer.xsd">
    <Sequence>
        <Copy name="Copy variables" inputVar="var1" outputVar="var2" />
        <Output fromVar="var2" description="Hello" />
    </Sequence>
    <Workspace>
        <Local name="var1" type='{"type":"string"}' value='"Hello, world!"' />
        <Local name="var2" type='{"type":"string"}' />
    </Workspace>
</Procedure>
```

Workspace variables

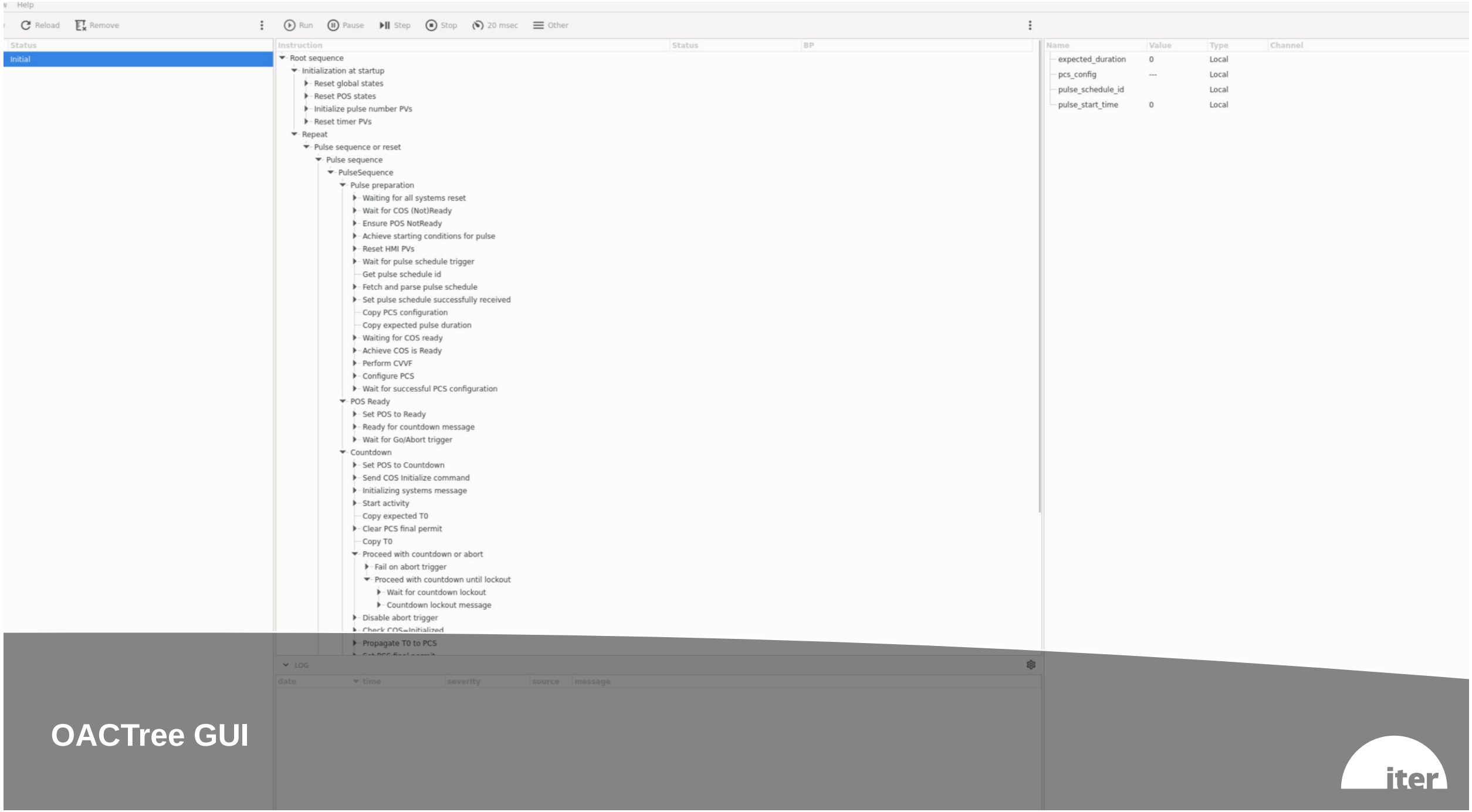
Procedure-scoped workspace of variables

Plugins

New instructions and variables can be added with the use of plugins.

Current plugins:

- **sequencer-plugin-control** : composite instructions that are common in control systems
- **sequencer-plugin-epics** : read/write process variables; RPC client; supports both ChannelAccess and PvAccess
- **sequencer-plugin-mathexpr** : exposes sup-mathexpr to sequencer
- **sequencer-plugin-sup** : for configuration reading/writing and calling CVVF functions
- **sequencer-plugin-psps** : provides interface to pulse schedule database


Help
Reload
Remove
Run
Pause
Step
Stop
20 msec
Other
Status
Initial
Instruction
Status
BP
Root sequence
Initialization at startup
Reset global states
Reset POS states
Initialize pulse number PVs
Reset timer PVs
Repeat
Pulse sequence or reset
Pulse sequence
PulseSequence
Pulse preparation
Waiting for all systems reset
Wait for COS (Not)Ready
Ensure POS NotReady
Achieve starting conditions for pulse
Reset HMI PVs
Wait for pulse schedule trigger
Get pulse schedule id
Fetch and parse pulse schedule
Set pulse schedule successfully received
Copy PCS configuration
Copy expected pulse duration
Waiting for COS ready
Achieve COS is Ready
Perform CVVF
Configure PCS
Wait for successful PCS configuration
POS Ready
Set POS to Ready
Ready for countdown message
Wait for Go/Abort trigger
Countdown
Set POS to Countdown
Send COS Initialize command
Initializing systems message
Start activity
Copy expected T0
Clear PCS final permit
Copy T0
Proceed with countdown or abort
Fail on abort trigger
Proceed with countdown until lockout
Wait for countdown lockout
Countdown lockout message
Disable abort trigger
Check COS=Initialized
Propagate T0 to PCS
Name
Value
Type
Channel
expected_duration
0
Local
pcs_config

Local
pulse_schedule_id
Local
pulse_start_time
0
Local
LOG
date
time
severity
source
message

OACTree GUI

Status and Plans

Core libraries:
Complete and in maintenance mode

Plugins:
Depends on the plugin.
EPICS Plugin needs more testing.

GUI:
Stable, still needing UX improvements

Next:
Remote Sequencer Servers to allow running procedures continuously

Availability:
Currently still under ITER IP rules…
Please contact us !!

Thank you!

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