



# Tasks and combinatorics

Modules of constrained workflow management

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# Content



- Motivation and principles
- Hierarchical distributed workflows
- Domain-specific language



# Programming CPS



## 🔗 Independent, side effect free modules

- Predictive model, decision making under uncertainty
- Error in abstraction gives rise to stochasticity
- Failure in hardware, software, network
- Changing conditions in the physical world



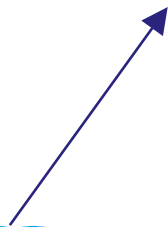
# Cyber-Physical Systems as workflows

- Hierarchical, loosely-coupled building blocks
- Smoothly executing in a distributed environment
- Testability, dependability
- Dynamic construction of workflows
- Tasks are first class citizens

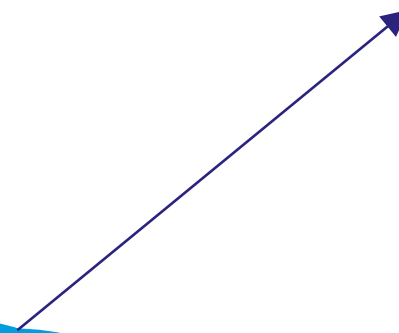
Specify constraint



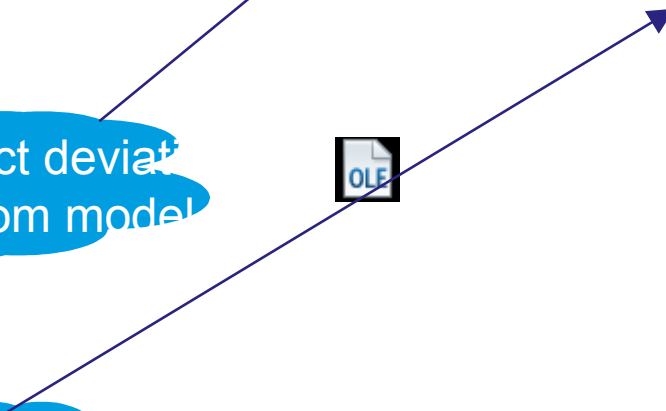
Control actuator



Detect deviation from model



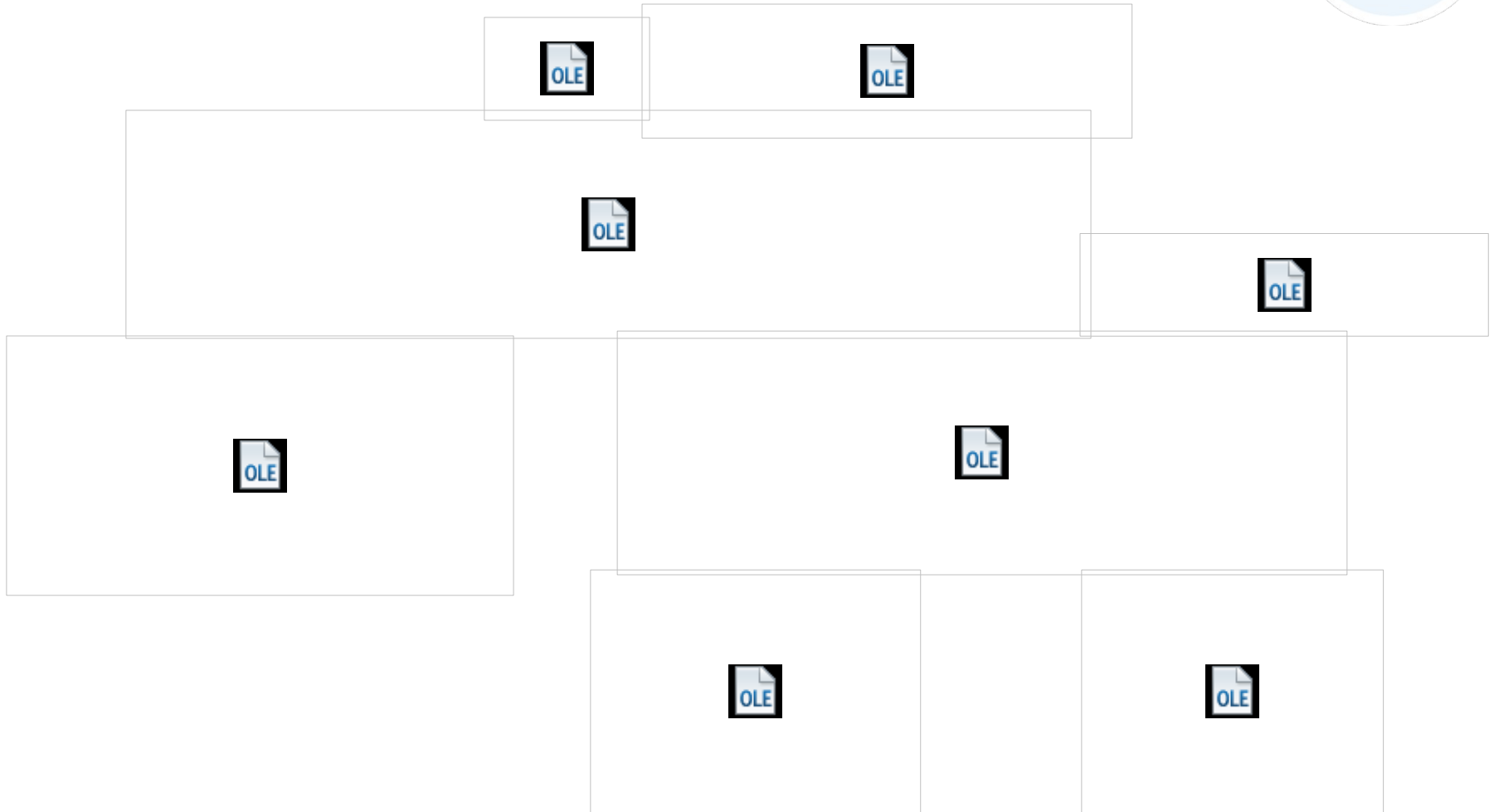
Correction module



Read sensor



# Task-oriented programming



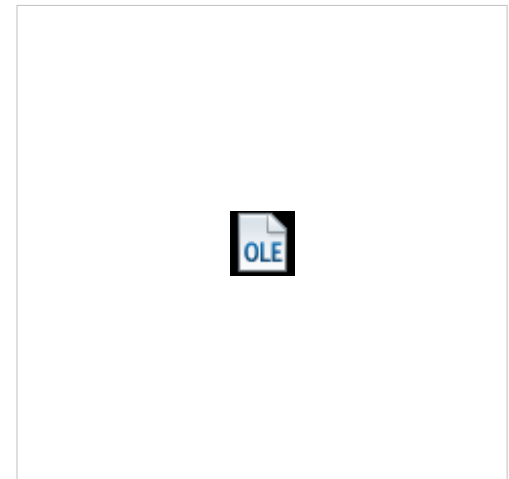
# Combinators: basic examples



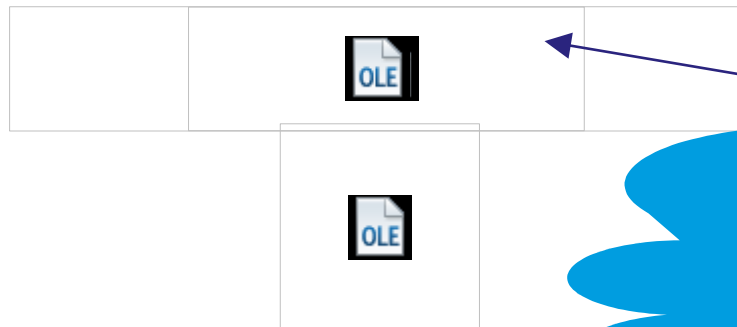
Sequential constructor



Parallel constructor



Specifiers



Remote execution with  
transfer of code

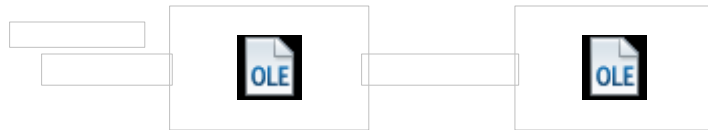
Distributed work



# Controlling a (sub-)system



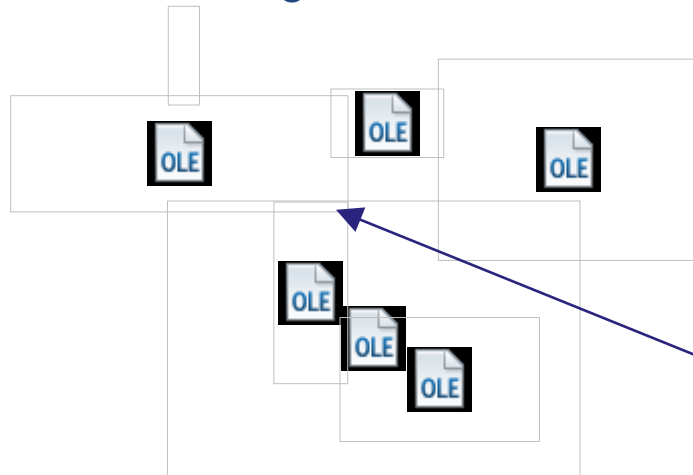
Unstable values are raised in sequences



Reading a sensor



Reacting on unstable values using a controller



Hierarchical work





Specifier



Sequential  
constructor



Unstable  
values



Parallel  
constructor



Actively correlating  
model and reality



# Domain-specific language

```
Kettle_control.set_coil(on) >>|
par [rec Kettle_control.read_thermometer(i) >>= \t →
    continue with t
    | i ← [1,2,3]]
controlled by \ (acc, ts) →
    average(ts) >>= \t →
    if
        t > 97 →
            Kettle_control.set_coil(off) >>|
            t;
        acc - t > error_threshold →
            Kettle_control.set_alarm(on) >>|
            Kettle_control.set_coil(off) >>|
            (error, t)
        else
            continue with (t, t)
    with accumulator 0 @ [kettle].
```

# Summary



- Paradigm based on side effect free modules
- Hierarchical distributed compositional
- Domain specific language
  - Task-oriented programming
  - Semantics: Domain-specific combinators
  - Model-based prediction
  - Syntax may evolve
  - DSL embedded in Erlang



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