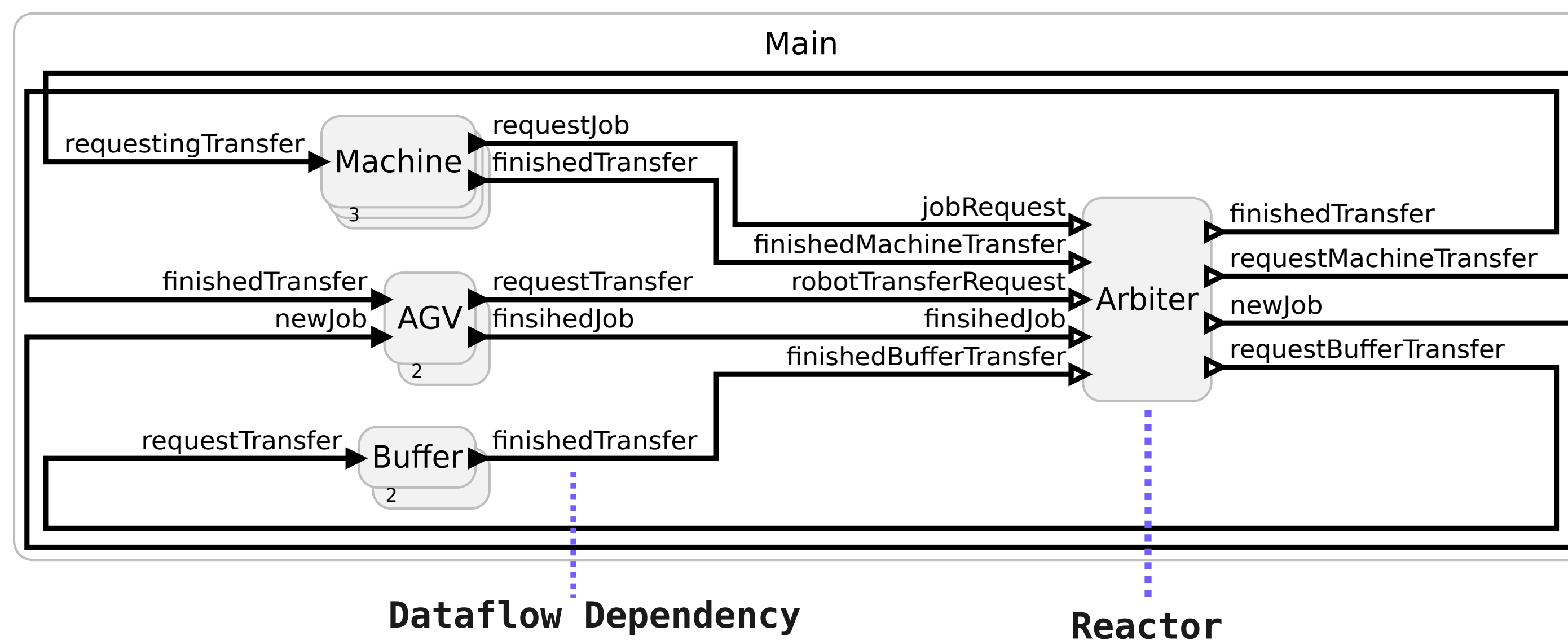


# Behavior Trees in Lingua Franca

## Lingua Franca

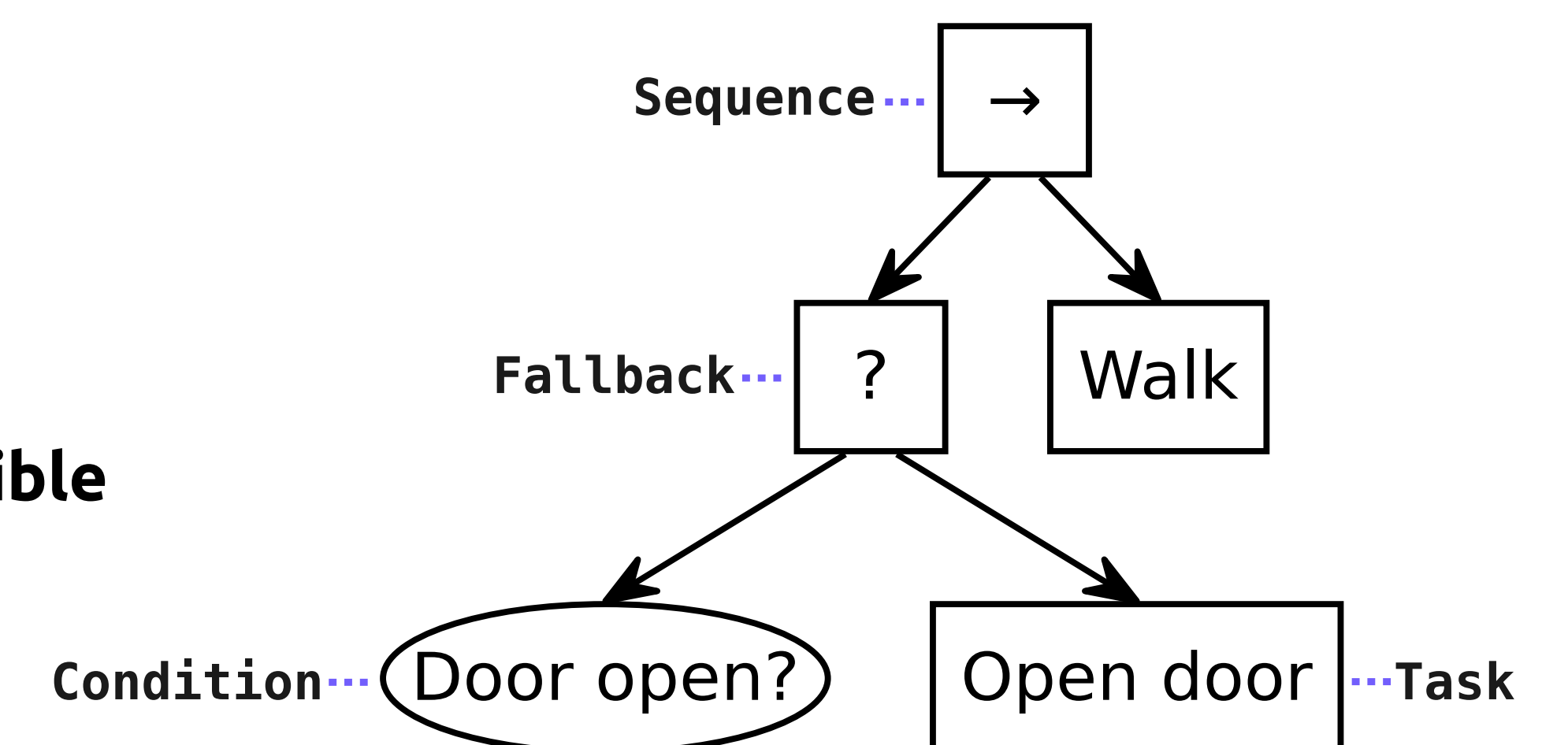
- Reactor-Based
- Coordination-oriented
- Polyglot
- Open-source
- Deterministic
- Distributed
- Time-sensitive



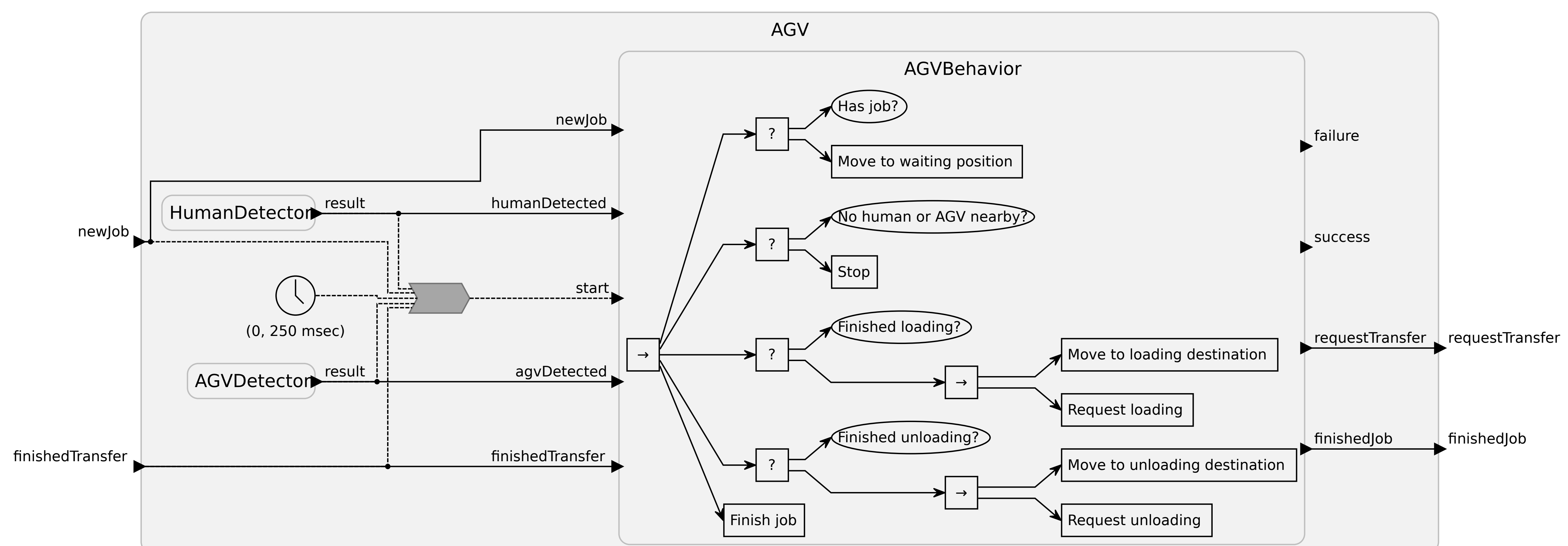
## Behavior Trees

Behavior Trees originated in the gaming industry and have since been adapted for real-world applications, such as industrial automation. [4]

- Lean
- Reactive
- Modular
- Extensible
- Comprehensible



## A Lingua Franca reactor for an Automated Guided Vehicle containing a Behavior Tree



## Key Features

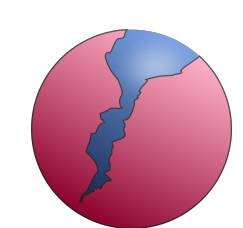
We implemented behavior trees for Lingua Franca, combining their respective strengths, which lead to an elegant way of modelling behavior for cyber physical systems. The noteworthy features are the following:

- Seamless textual and graphical extension of LF for BTs
- Structural transformation of Behavior Trees to reactors
- Deterministic concurrency for 'parallel' nodes
- Behavior Trees with explicit data handling
- Side-effect free, modular Behavior Trees

## Involved Technologies:



Eclipse Layout Kernel  
<https://www.eclipse.org/elk/>



KIELER Lightweight Diagrams  
<https://github.com/kieler/KLighD>

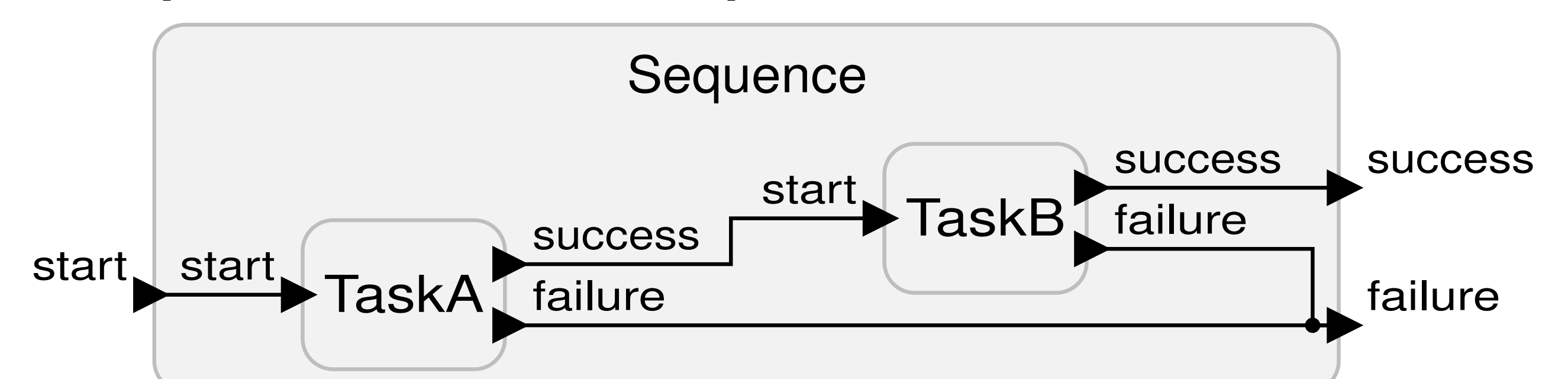
## Pattern-based Translation

### Example for a small Behavior Tree in Lingua Franca

```
behaviortree Sequence() { // name of the tree

    sequence { // keyword for sequence nodes
        task "TaskA" {= ... code ... =}
        task "TaskB" {= ... code ... =}
    }
}
```

### Example Translation of example to reactors



## Contacts

Alexander Schulz-Rosengarten, Akash Ahmad,  
Malte Clement, Reinhard von Hanxleden  
{als, stu222517, mac, rvh}@informatik.uni-kiel.de  
Kiel University, Kiel, Germany  
Benjamin Asch, Marten Lohstroh, Edward A. Lee  
{benjamintasch, marten, eal}@berkeley.edu  
UC Berkeley, Berkeley, USA  
Gustavo Quiros, Ankit Shukla  
{gustavo.quiros, ankit.shukla}@siemens.com  
Siemens Technology, USA

- [1] A. Schulz-Rosengarten, A. Ahmad, M. Clement, R. von Hanxleden, B. Asch, M. Lohstroh, E. A. Lee, G. Quiros, A. Shukla. 2024. Behavior Trees with Dataflow: Coordinating Reactive Tasks in Lingua Franca. ICSE 2024
- [2] M. Lohstroh, C. Menard, S. Bateni, and E. A. Lee. 2021. Toward a Lingua Franca for Deterministic Concurrent Systems. ACM TECS 20, 4 (May 2021), Article 36.
- [3] R. von Hanxleden, E. A. Lee, H. Fuhrmann, A. Schulz-Rosengarten, S. Domrös, M. Lohstroh, S. Bateni, and C. Menard. 2022. Pragmatics Twelve Years Later: A Report on Lingua Franca. Isola 2022.
- [4] Michele Colledanchise and Peter Ögren. 2018. Behavior Trees in Robotics and AI: An Introduction. CRC Press.



<https://www.lf-lang.org>