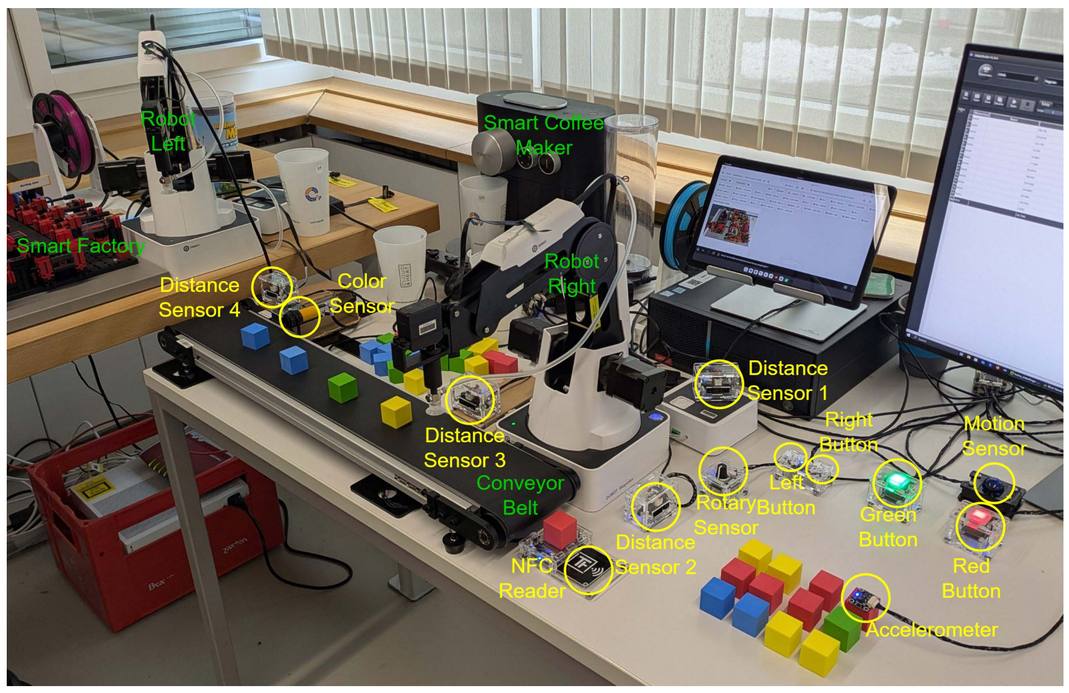
University of St.Gallen
Institute of Computer Science

Motivation

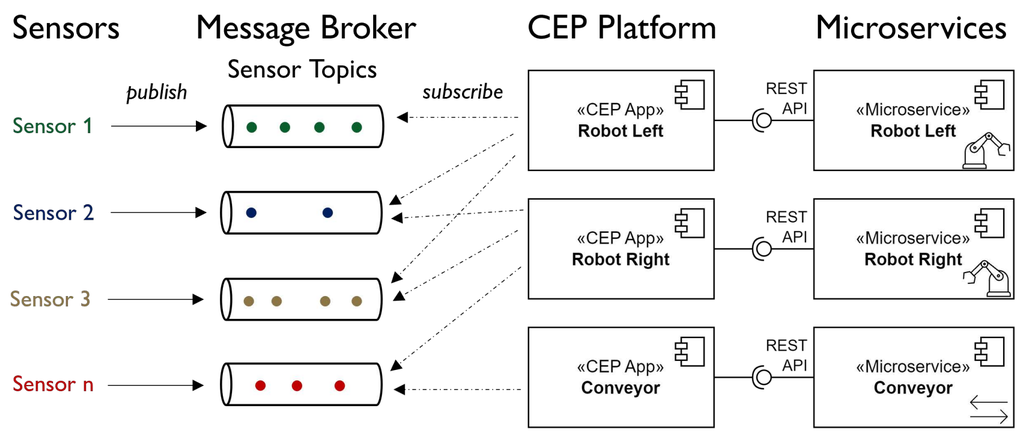
- Cobots are expensive.
- External sensors are cheap.
- Perception of and reaction to human presence and movements is hardwired and limited in cobots.
- It is a high effort to integrate external sensors and adjust robot programming to it.

Lab Setup



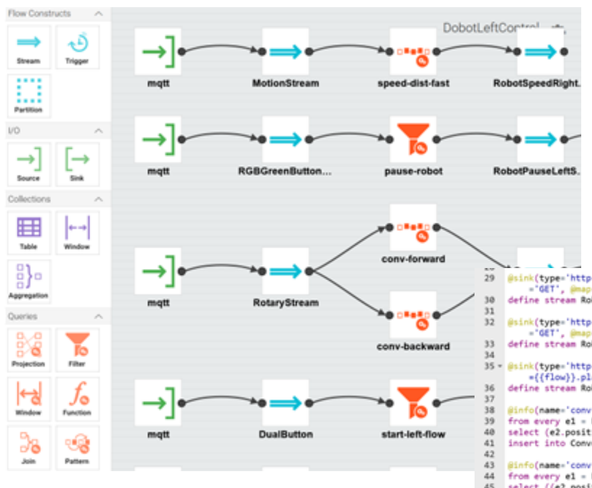
2 Dobot Magicians, 1 Conveyor Belt, Sensors by Tinkerforge

Approach

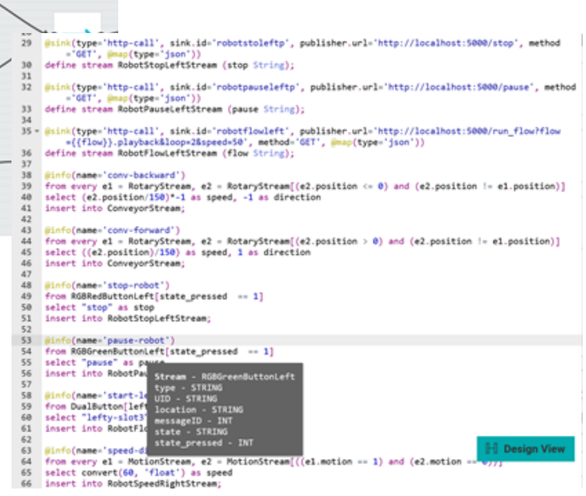


Software Architecture with Event-driven Microservices and Complex Event Processing (CEP)

Flexible Event Topology and Query Specification



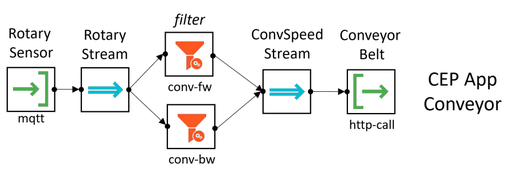
Visual Editor for Event Topologies in Siddhi



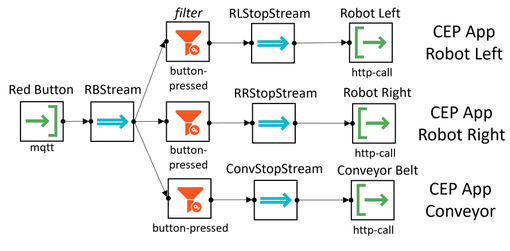
Textual Editor for CEP Queries in Siddhi

Event Topologies and Patterns

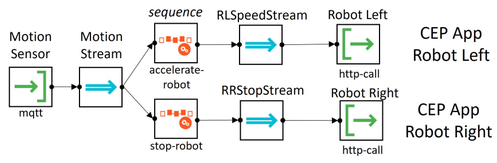
1. Active Machine Control (1:1)



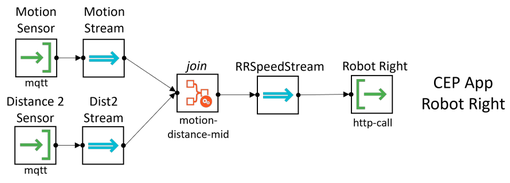
2. Active Machine Control (1:n)



3. Reactive Machine Control (1:n)



4. Reactive Machine Control (n:1)



Corresponding Partial CEP Queries in StreamingSQL:

```
@info(name='conv-bw')
from RotaryStream[position < 0]
select (position/150)*-1 as speed, -1 as direction
insert into ConvSpeedStream;
```

1. Active Machine Control (1:1)

```
@info(name='button-pressed')
from RBStream[state_pressed  == 1]
select 'stop' as stop insert into RLStopStream;
```

2. Active Machine Control (1:n)

```
@info(name='accelerate-robot')
from every e1 = MotionStream, e2 =
  MotionStream[((e1.motion == 1) and (e2.motion == 0))]
select 60 as speed insert into RLSpeedStream;
```

3. Reactive Machine Control (1:n)

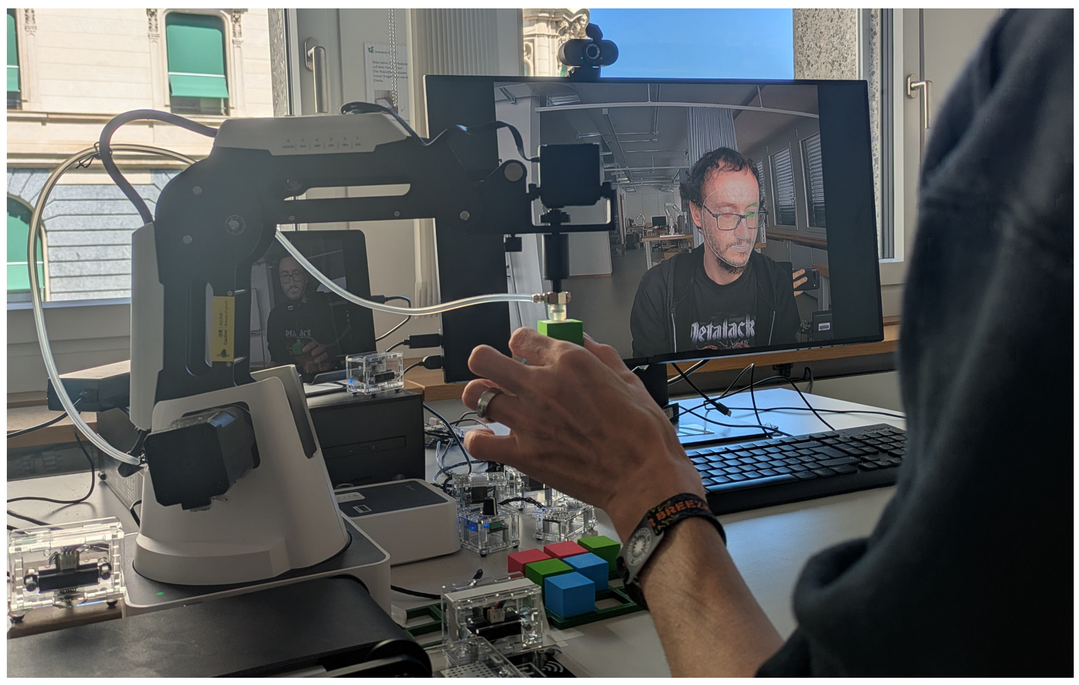
```
@info(name='motion-distance-mid')
from Dist2Stream[(dist > 10) and (dist <= 30)] as D
  join MotionStream[motion == 1]#window.time(2 sec) as M
  on D.location == M.location
select 20 as speed insert into RRSpeedStream;
```

4. Reactive Machine Control (n:1)

Ongoing & Future Research

Investigation of:

- Safety and real-time capabilities
- Distributed CEP and Edge CEP
- Camera-based perception of human attention, combined with eye-tracking
- More advanced co-working workflows and machines



Attention-based Adaptation of Robot Movements from Face Detection with Google MediaPipe

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Towards Flexible and Adaptive Human-Robot Collaborations via Event-driven Microservices