Edge-Based Safety Monitoring for Industrial IoT Applications – Case Study from AGVs Operation

Outline

- Background
- Contribution
- Methods

Background

- With the development of Industrial IoT, the system of the factory becomes more **open, dynamic, flexible, adaptable, complex**
- The fundamental safety requirement of those systems
  - Aware of the changes in the environment
  - The feedback closed loop

Runtime Monitoring

- To assure the safety requirements of the system at design time would not be practical, due to
  - Continuous change of the observed systems on runtime
  - Only checks the design, not the real system

Motivation

- Safety Runtime Monitoring
  - Attempt to bridge the gap between formal methods and software testing
  - Monitoring for safety requirements in Industrial IoT should meet the following requirements
    - Consistency
    - Correlation
    - Flexibility

Contribution

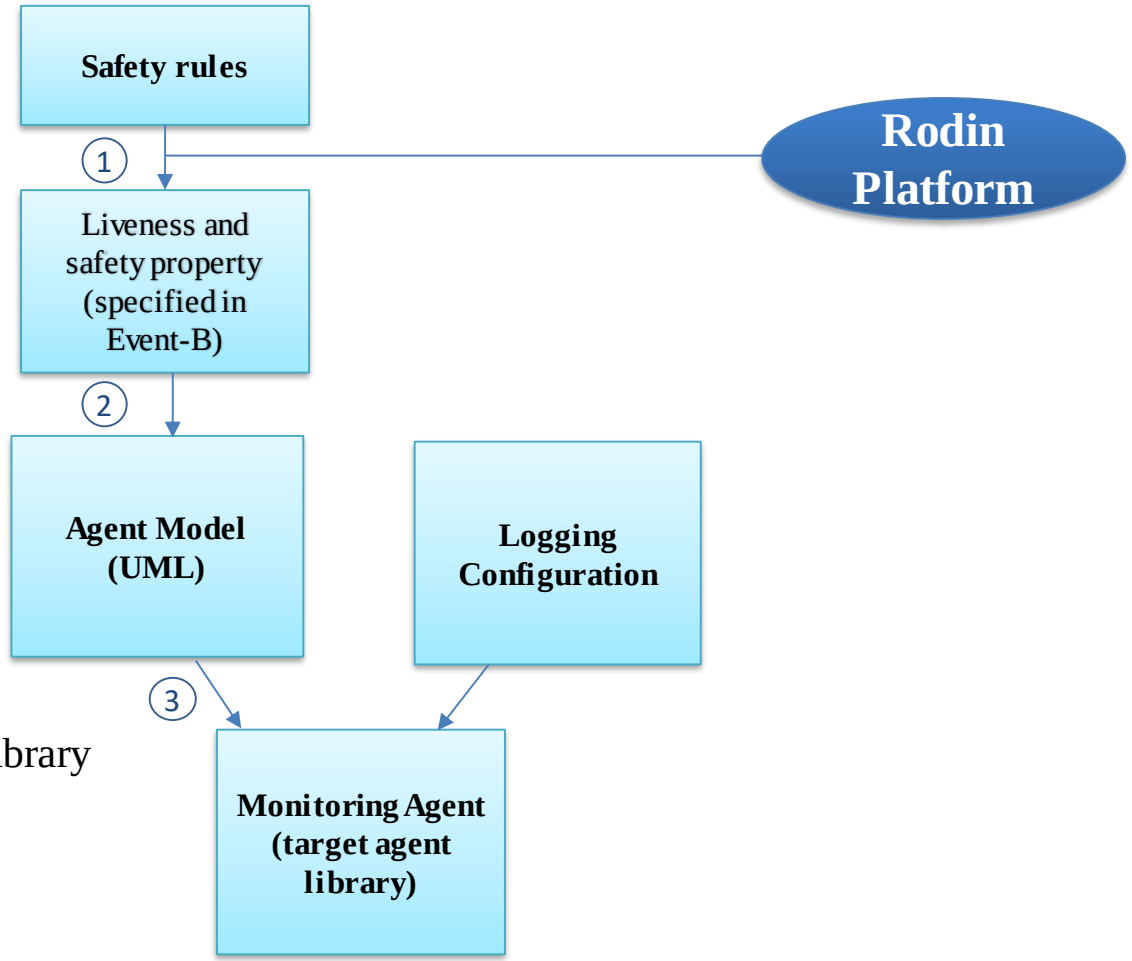
- A model-driven approach of the safety rules
- The design method in Event-B specification to support the feedback loop
- The monitoring architecture supporting safety monitoring agent

Overview of Safety Rules Modeling Process

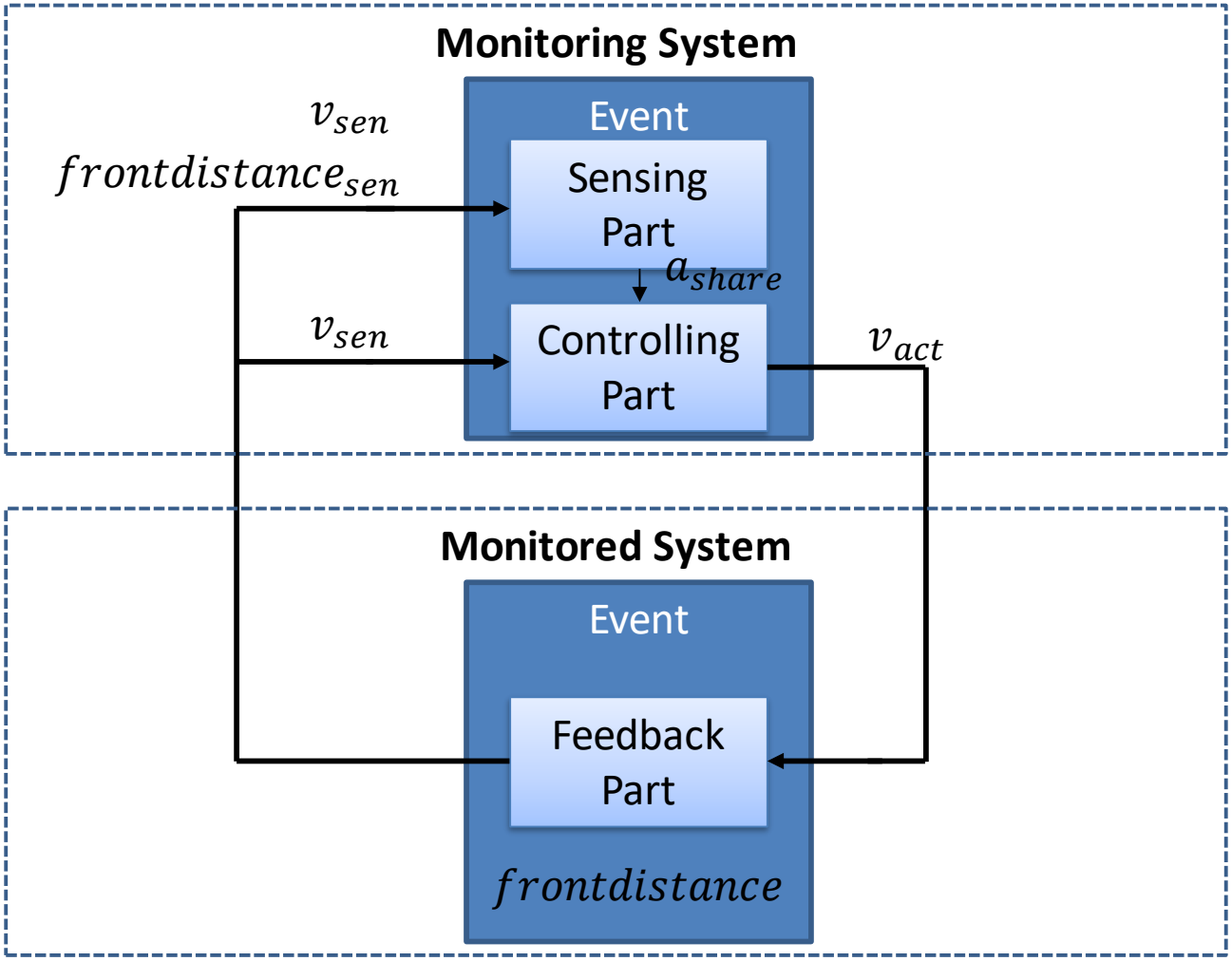
Analyze the variables and the property needed to be specified in Event-B

Transform Event-B formulation to the condition-action rule of agent model

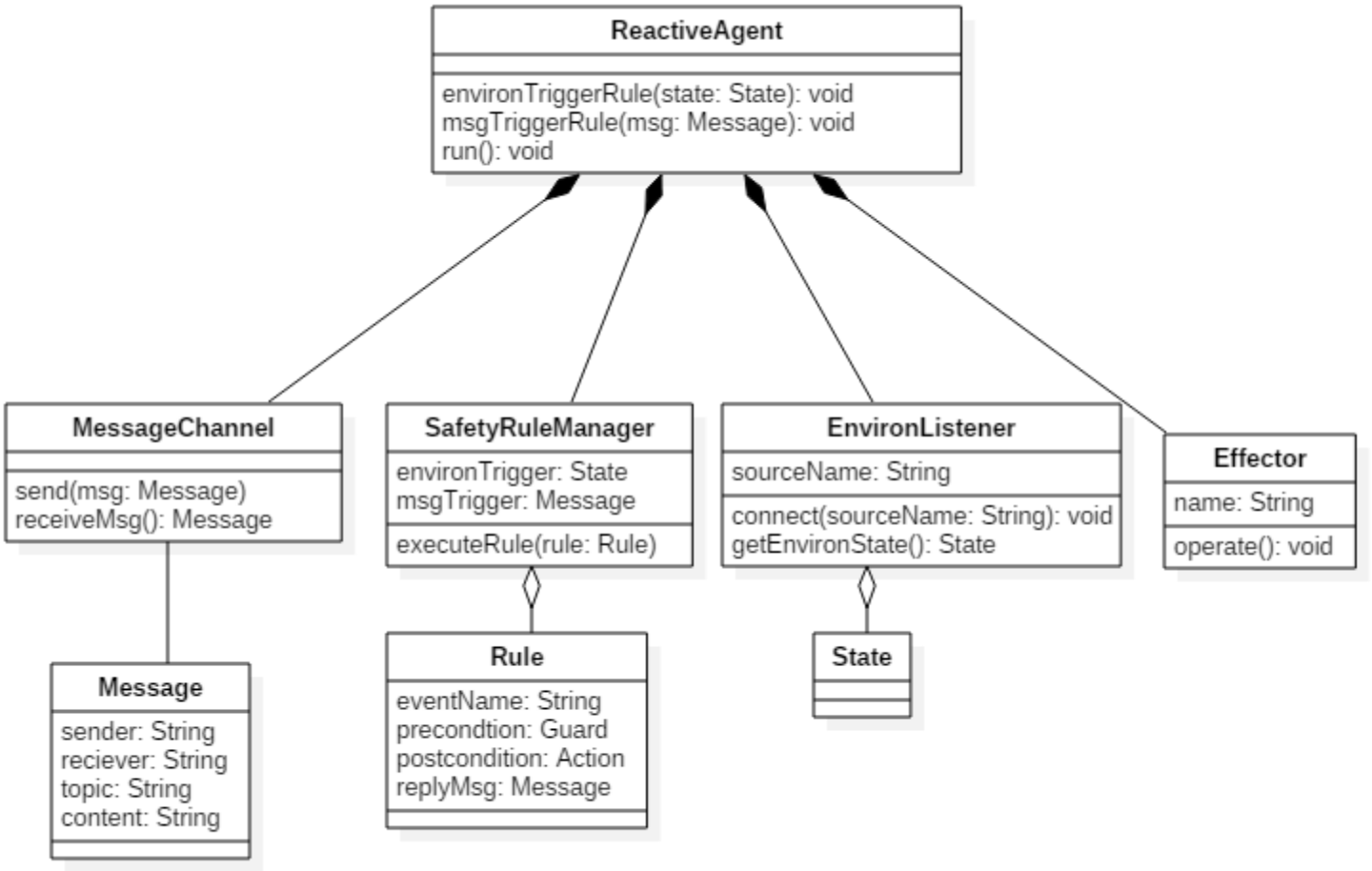
Deploy the safety monitoring agent using the target agent library



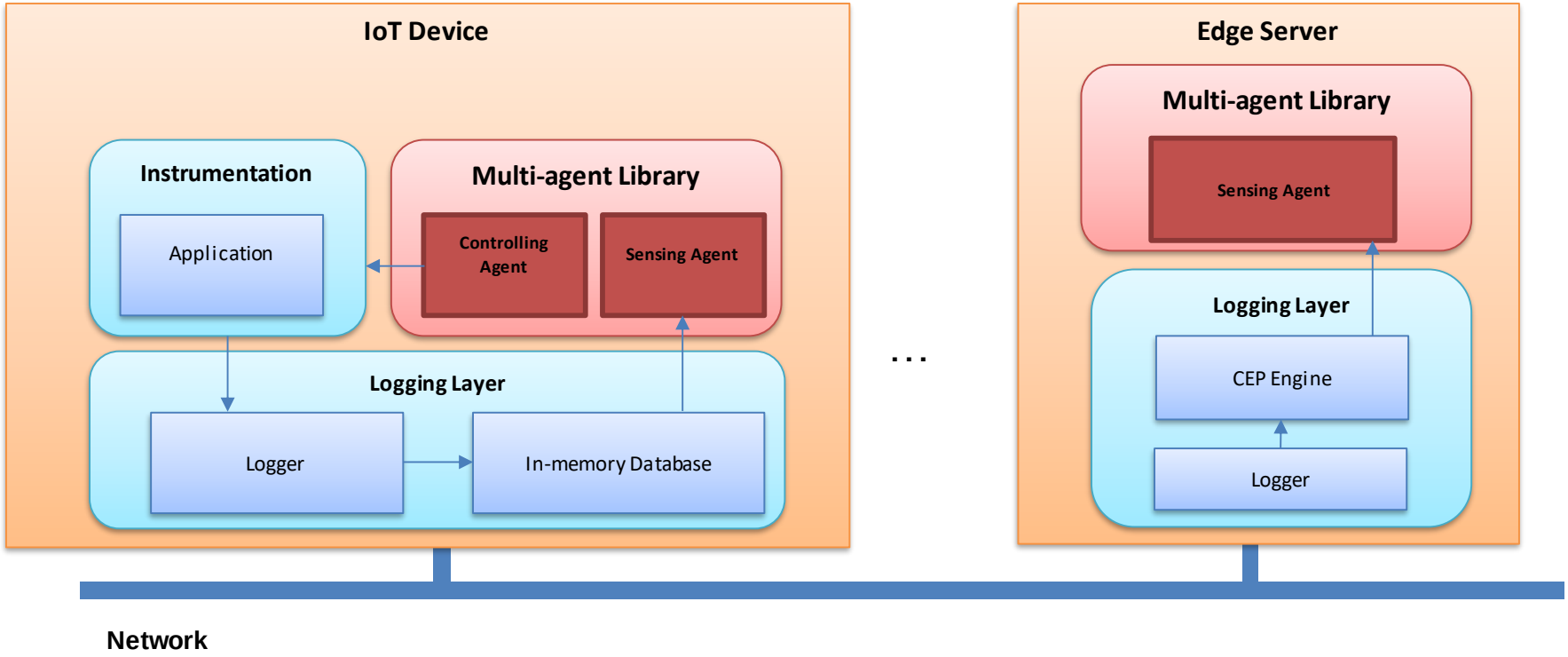
Event-B Specification Module



Reactive Agent Model

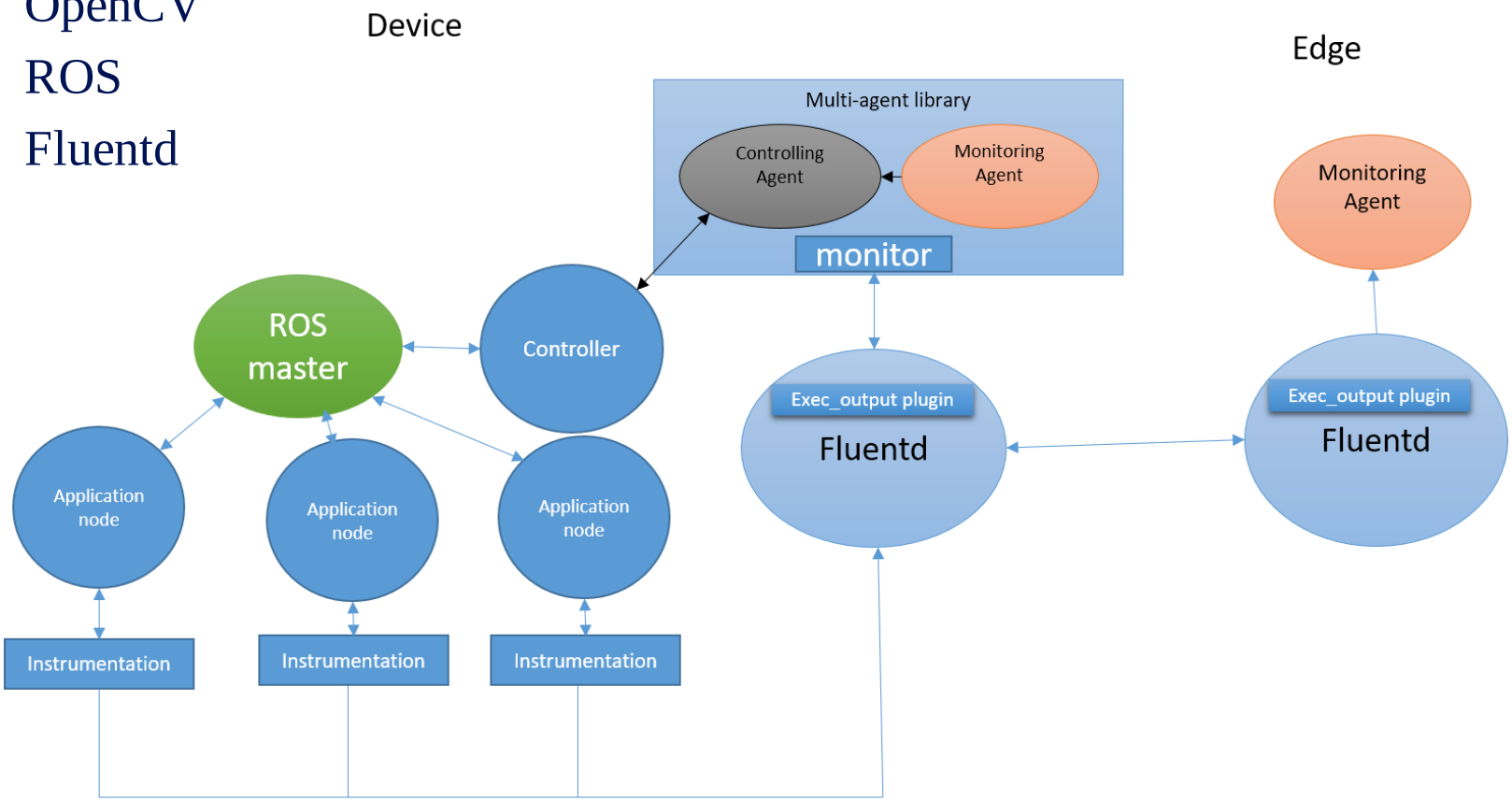


Monitoring Mission Deployment



Deployment

- Dependence
  - OpenCV
  - ROS
  - Fluentd



Tutorial: https://paper.dropbox.com/doc/Tutorial-jAVchYpTZRnEXerxVrI2t

Experiment Result

Definition of test cases			Executions			Assessment
Number	description	Test objective	Monitor	Braking system	Navigation system	Test verdict pass rate(20 times)
0	Put the obstacle in front of the AGV in any position and distance	Rule 1	Yes	Yes	Yes	100%
1	Put the obstacle in front of the AGV in any position and distance	Rule 2	Yes	Yes	Yes	90%
2	Put the obstacle in front of the AGV in any position and distance very quickly	Rule 2	Yes	Yes	Yes	50%
3	Using the camera on the top of the AGV to locate the obstacle in the range and the odometry on AGV to locate the AGV	Rule 3	Yes		Yes	100%
4	Push the AGV to the outside of the black track.	Rule 5	Yes		Yes	50%
5	Press the car to keep it from moving, to emulate the car into the pit or trip to the obstacles	Rule 6	Yes			100%
6	AGV enters the narrow space	Rule 7	Yes		Yes	100%

Experiment Result

- The velocity of the AGV when the multiple safety rules are applied