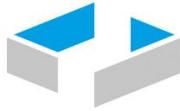


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# RESILIENT BPMN OVER WIRELESS

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RALF TÖNJES

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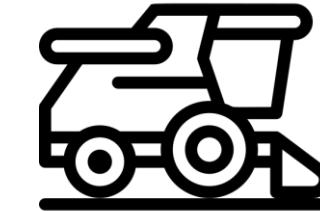
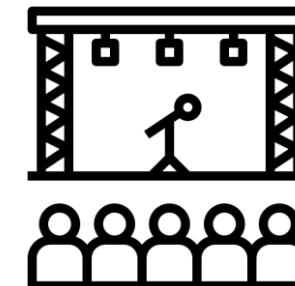
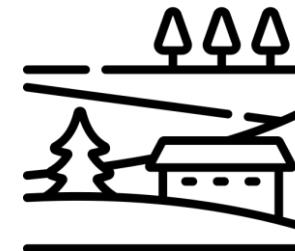
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1. MODELING UNRELIABLE COMMUNICATION ENVIRONMENTS IN BPMN
2. RESILIENT BPMN
  - 2.1 MODELING RESILIENT PROCESSES
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4. CONCLUSION

# UNRELIABLE COMMUNICATION ENVIRONMENTS

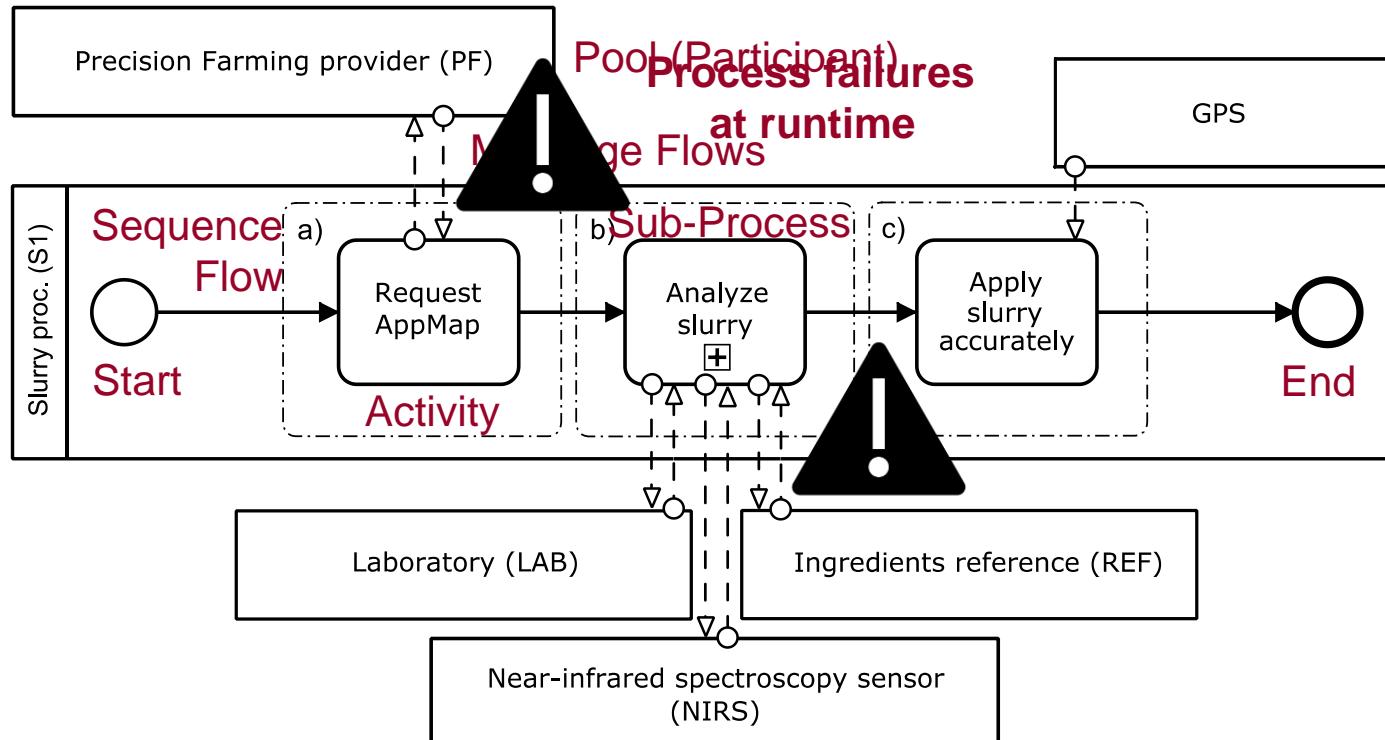
Dynamically changing connectivity

- Intermittent
- Delayed
- Failing
- Non-Existing

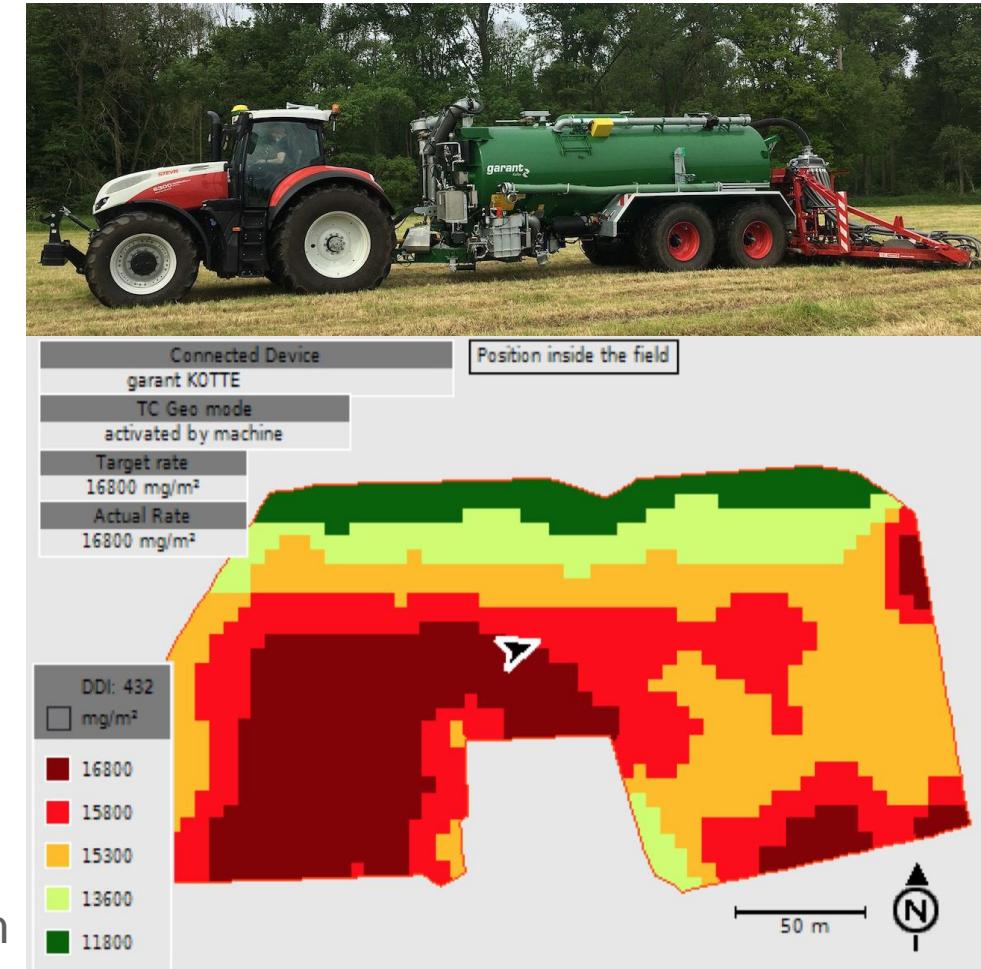


Internet of Things (IoT)  
Cyber Physical Systems (CPS)

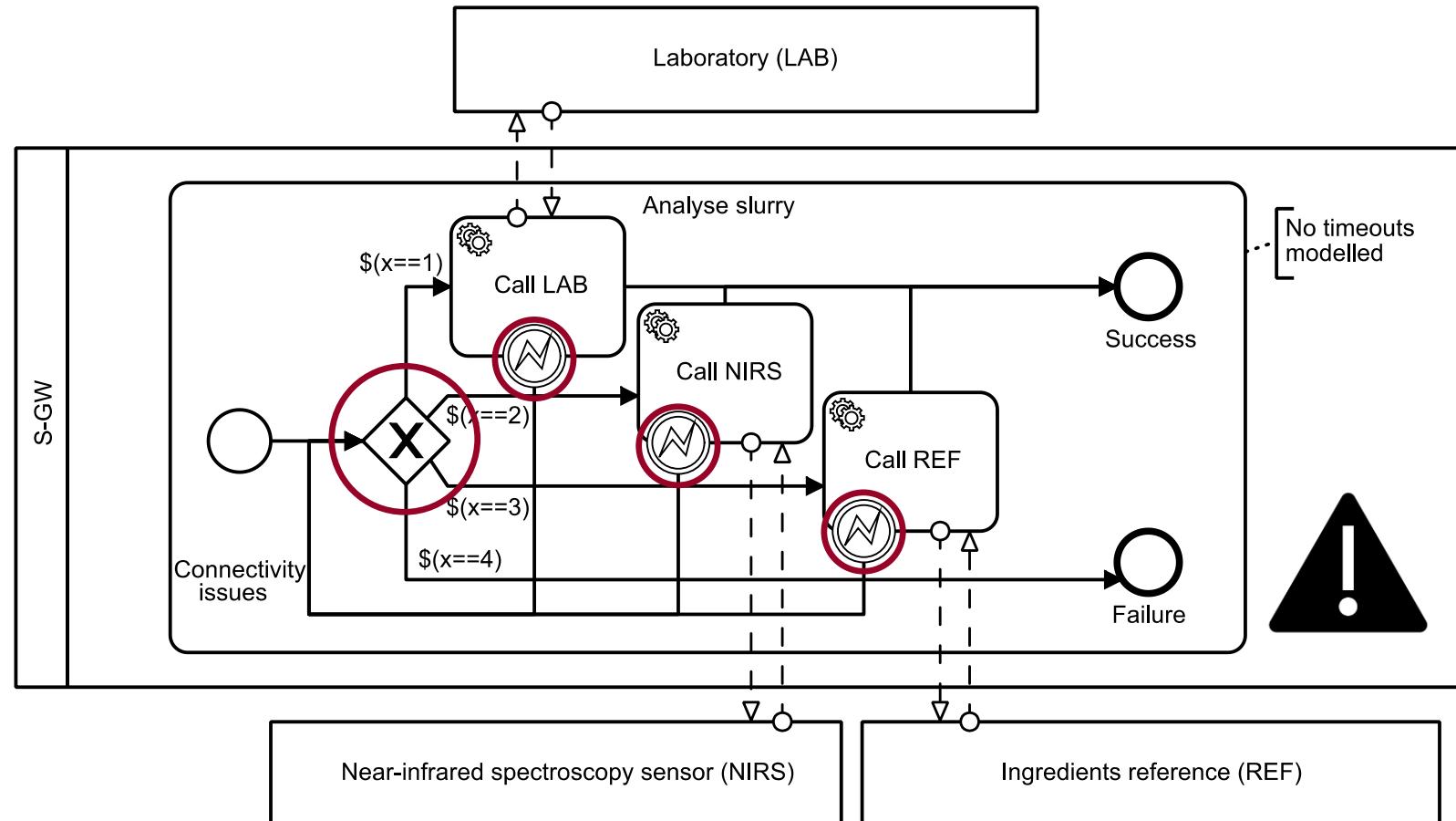
## AN ENVIRONMENTAL-FRIENDLY SLURRY APPLICATION IN BPMN



Courtesy of ANEDO / FARMsystem



## MODELING USING GATEWAYS / ERROR EVENTS

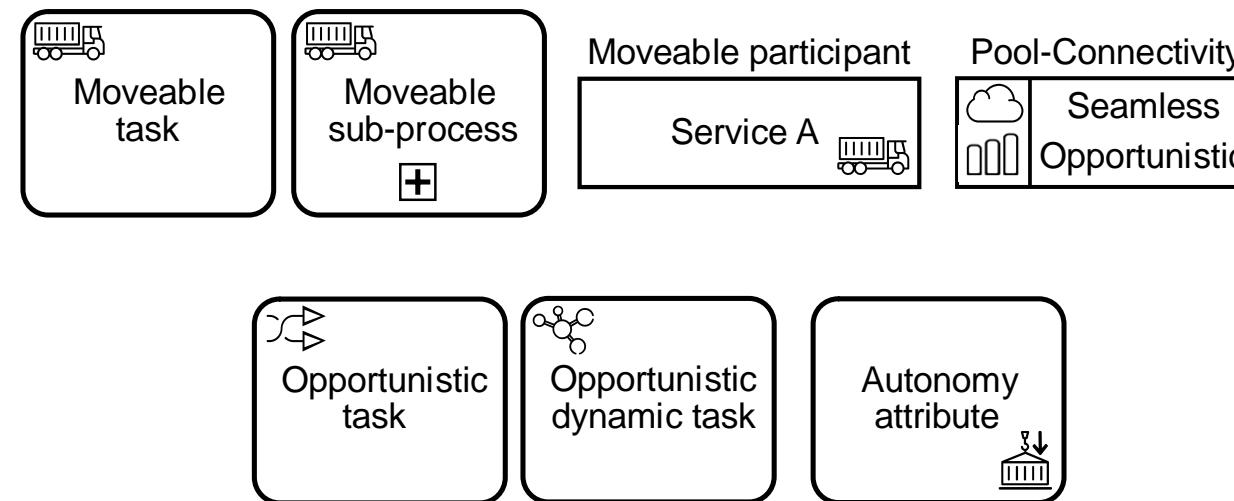
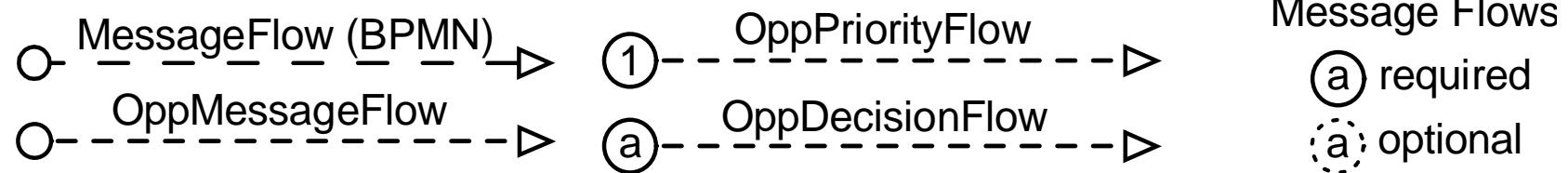




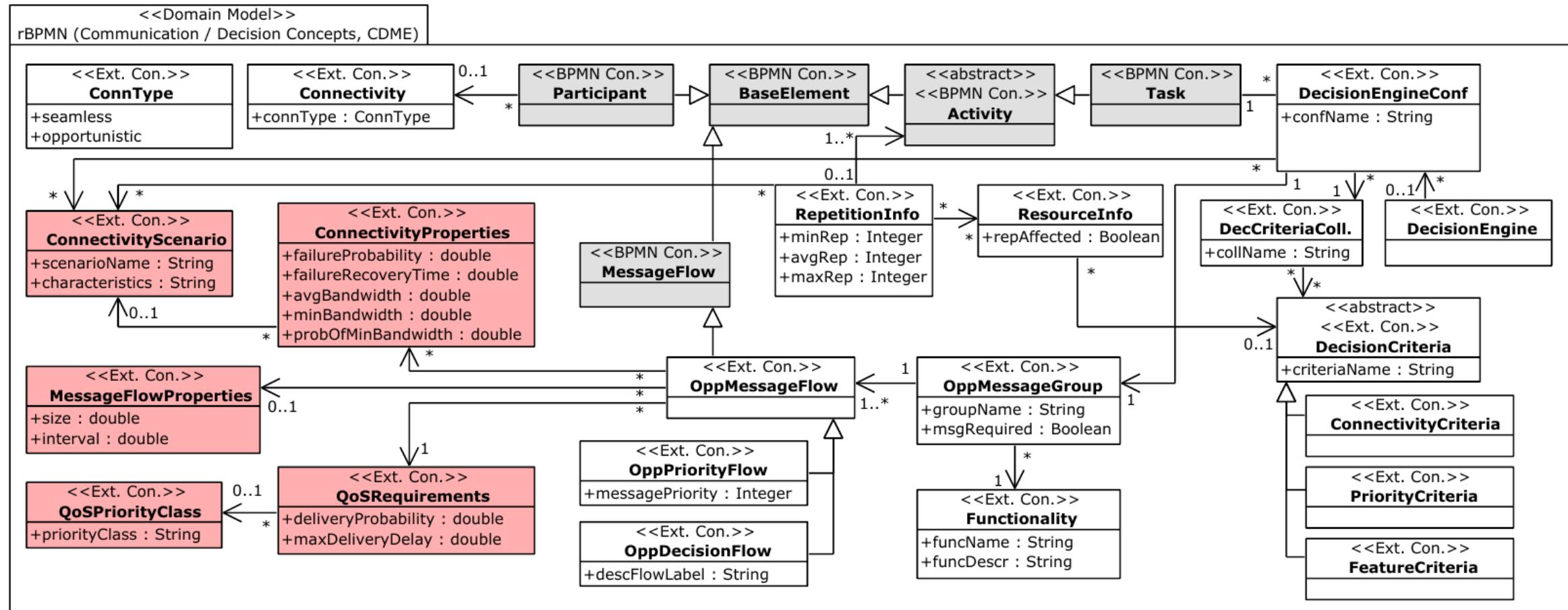
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## rBPMN MODELING ELEMENTS



## rBPMN META MODEL (EXCERPT)



## RESILIENCE CALCULATIONS

### Foundations for resilience calculation

- Connectivity statistics
- Connectivity estimations

$$N_f = \left\lceil \frac{M_s}{F_{pl}} \right\rceil$$

$N_f$  Number of frames  
 $M_s$  Message size  
 $F_{pl}$  Frame payload size

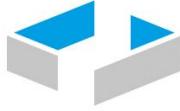
$$T_{wc} = \frac{N_f * F_h + M_s}{BW_{min}}$$

$T_{wc}$  Worst case time  
 $F_h$  Frame header size  
 $BW_{min}$  Minimum bandwidth

$$R = \frac{T_d}{T_{wc}}$$

$T_d$  Allowed time delivery delay  
 $R$  Resilience of message flow

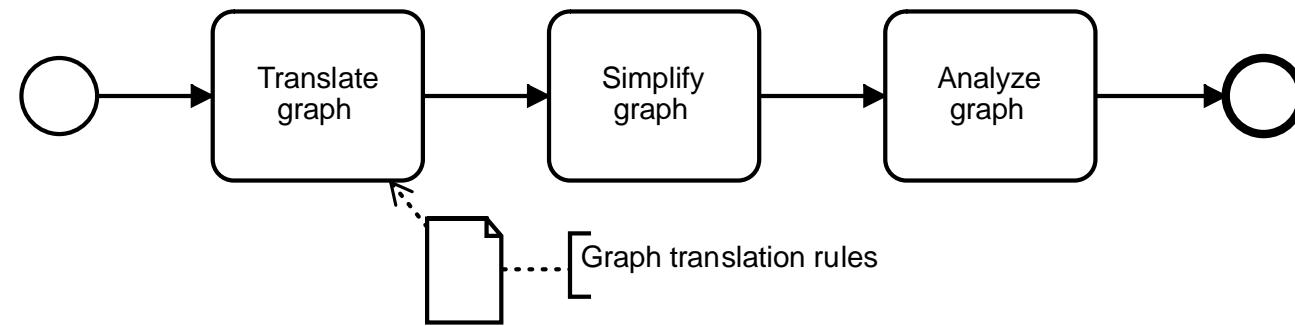
$$R \begin{cases} \text{resilient } \forall R \geq 1 \\ \text{non-resilient } \forall R < 1 \end{cases}$$



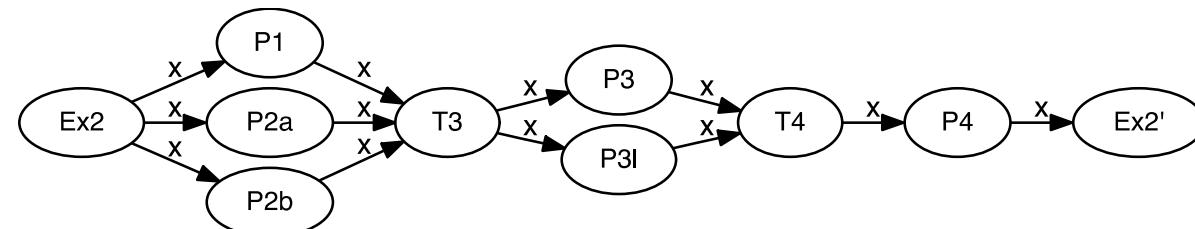
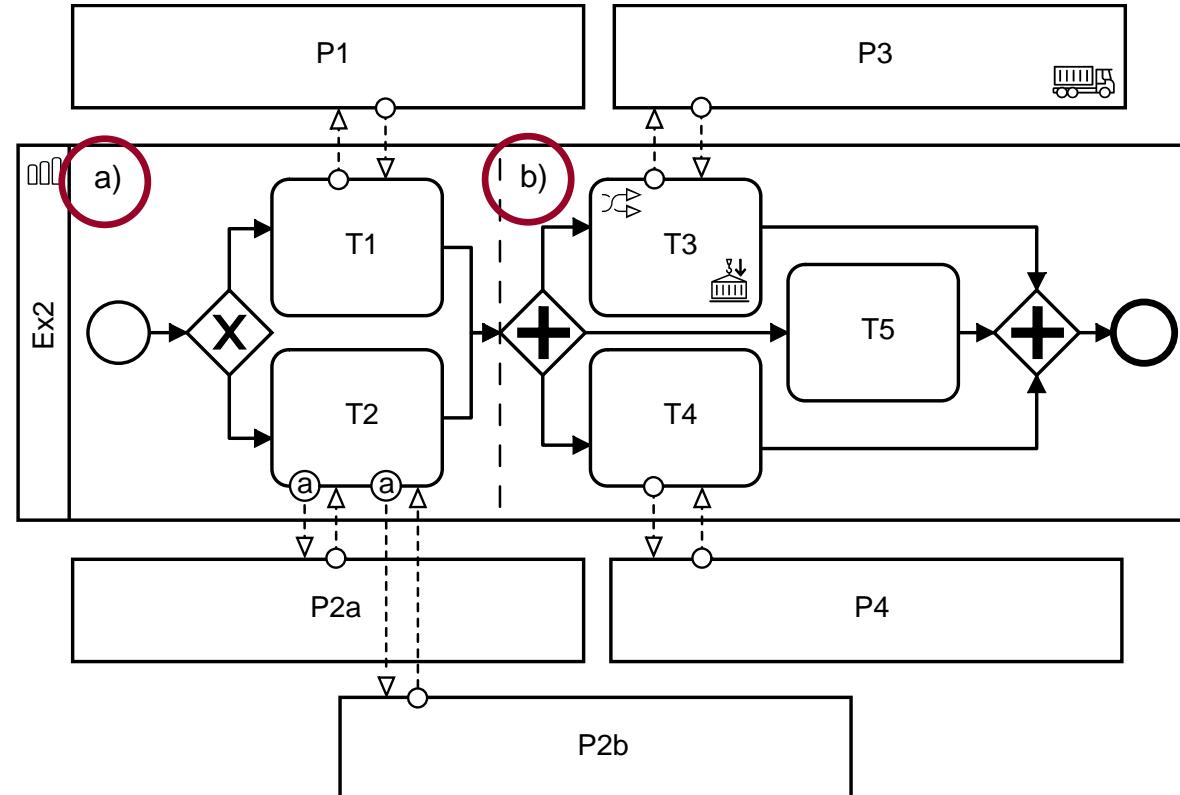
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## RESILIENCE ANALYSIS PROCEDURE



## PROCESS-TO-GRAF TRANSLATION

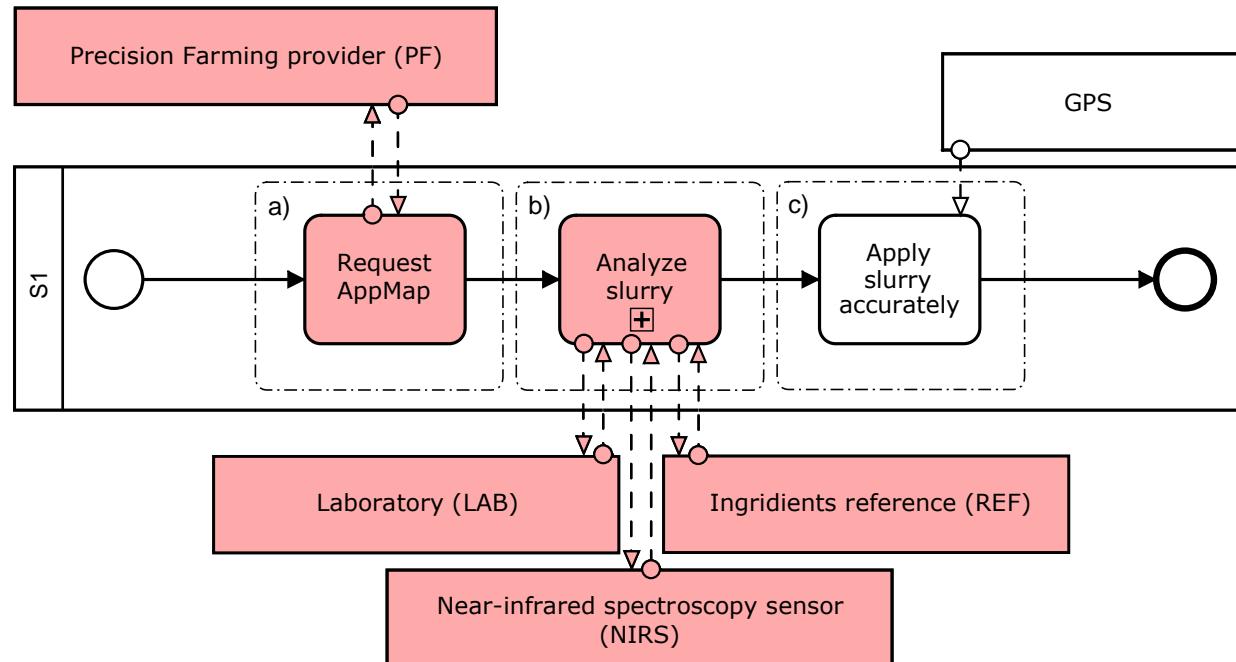




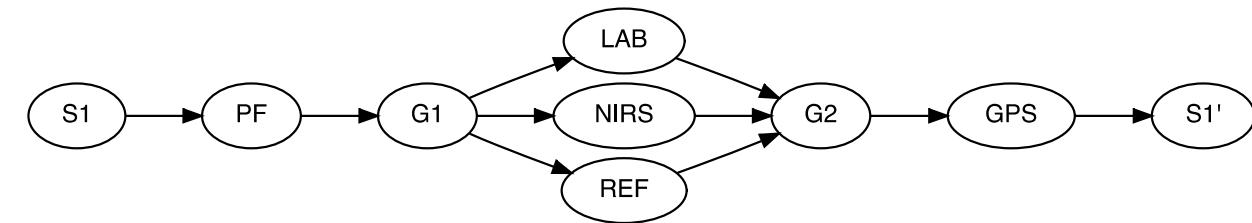
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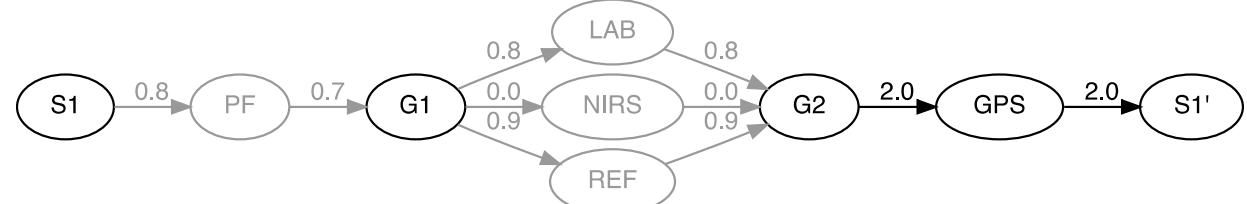
## RESILIENCE VERIFICATION



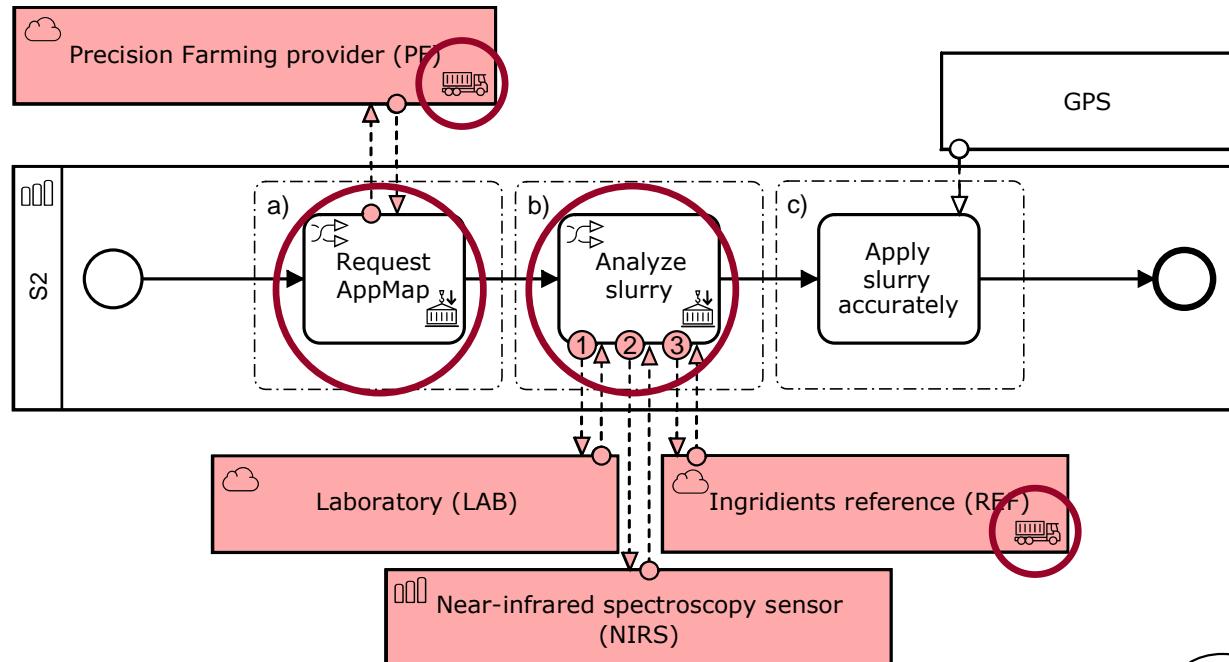
Resilience graph



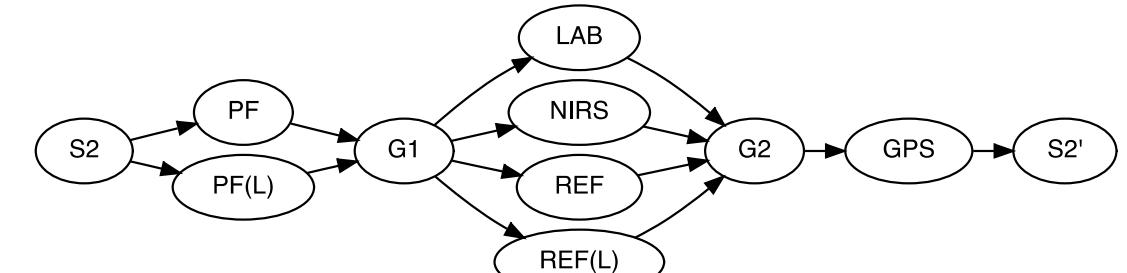
Resilience analysis



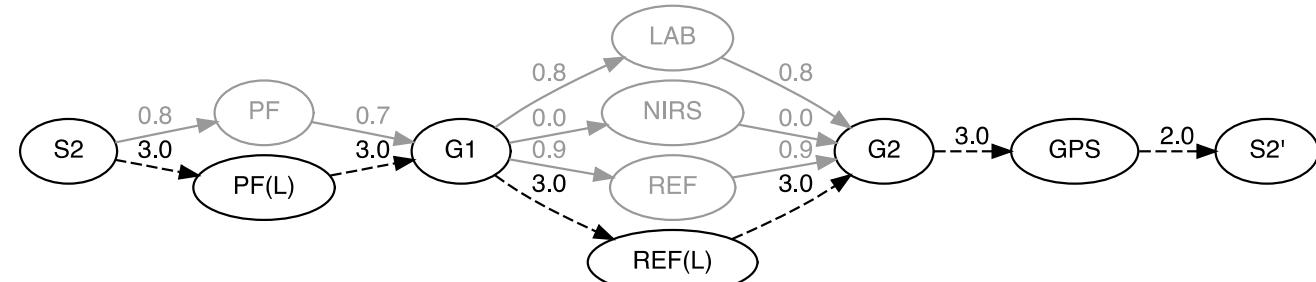
# RESILIENCE OPTIMIZATION



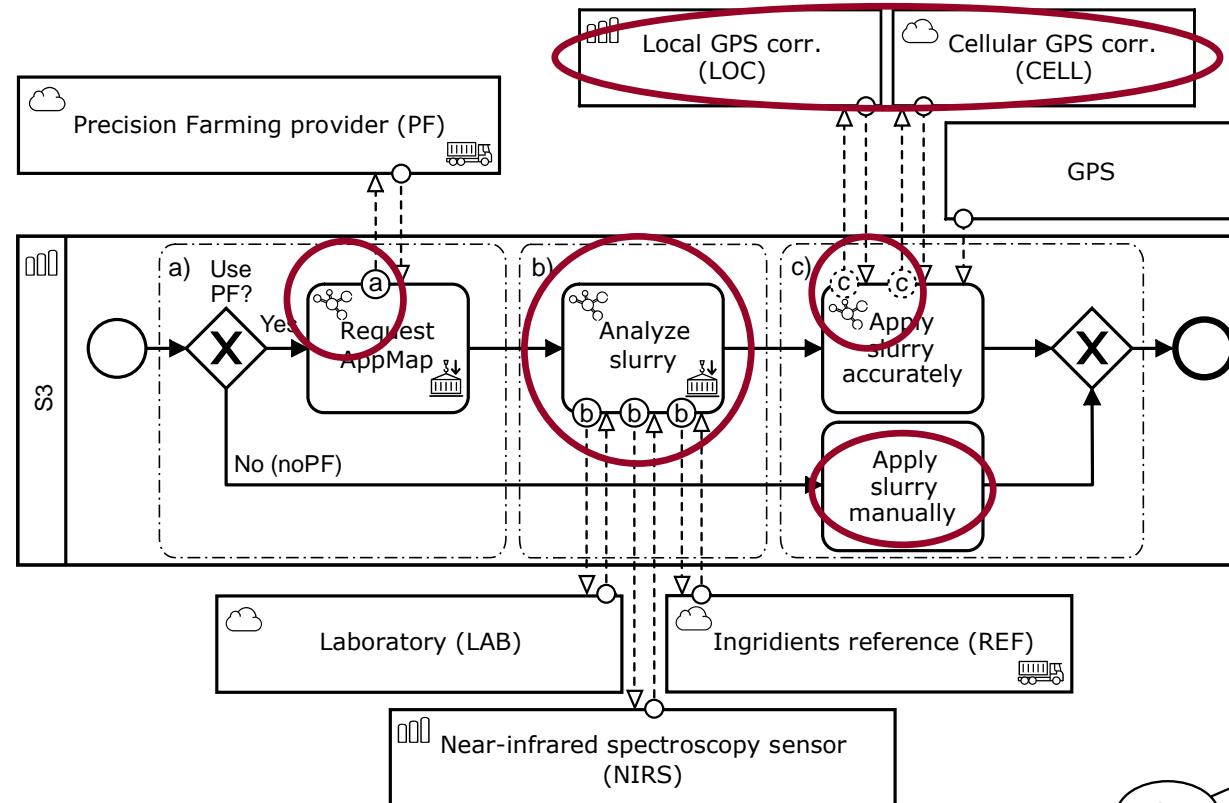
Resilience graph



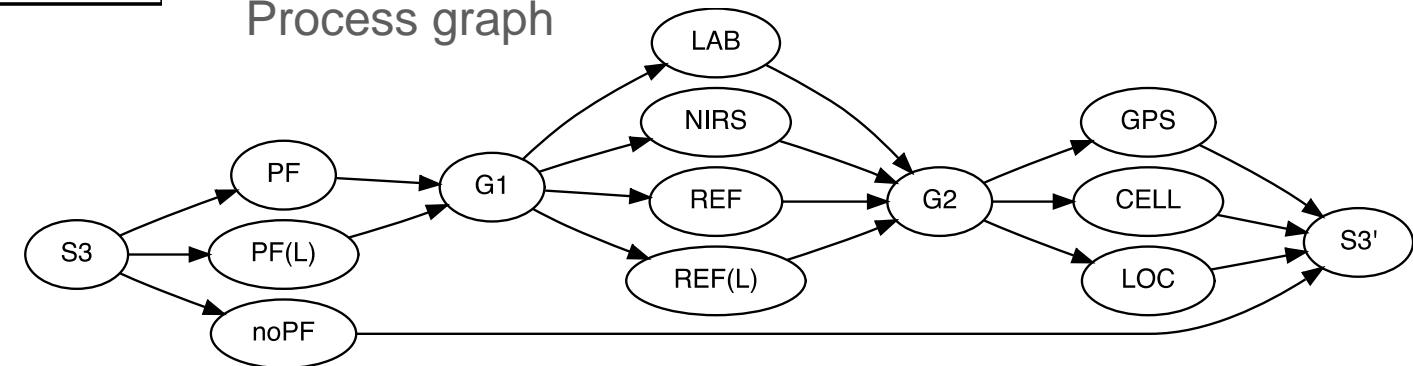
Resilience analysis



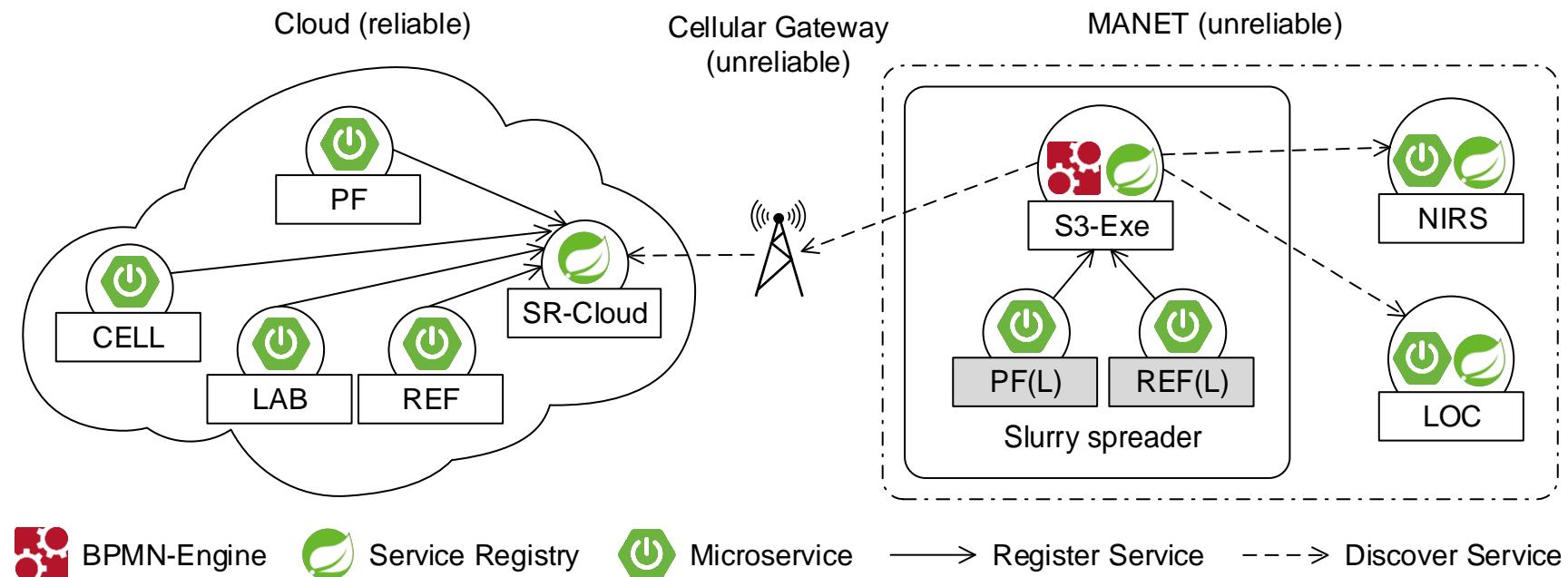
# PROCESS MODEL GENERALIZATION



Process graph



## PROCESS IMPLEMENTATION



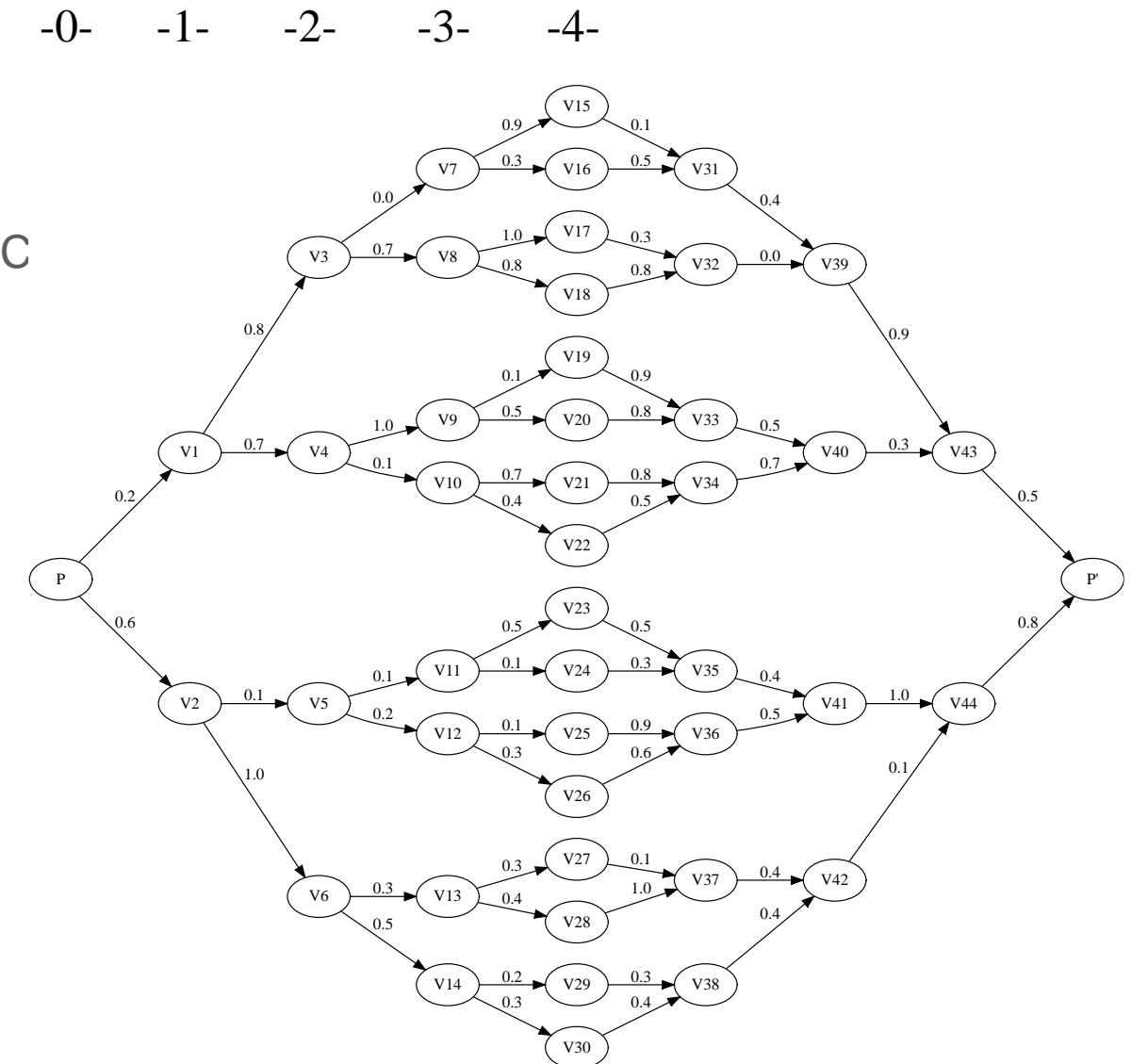
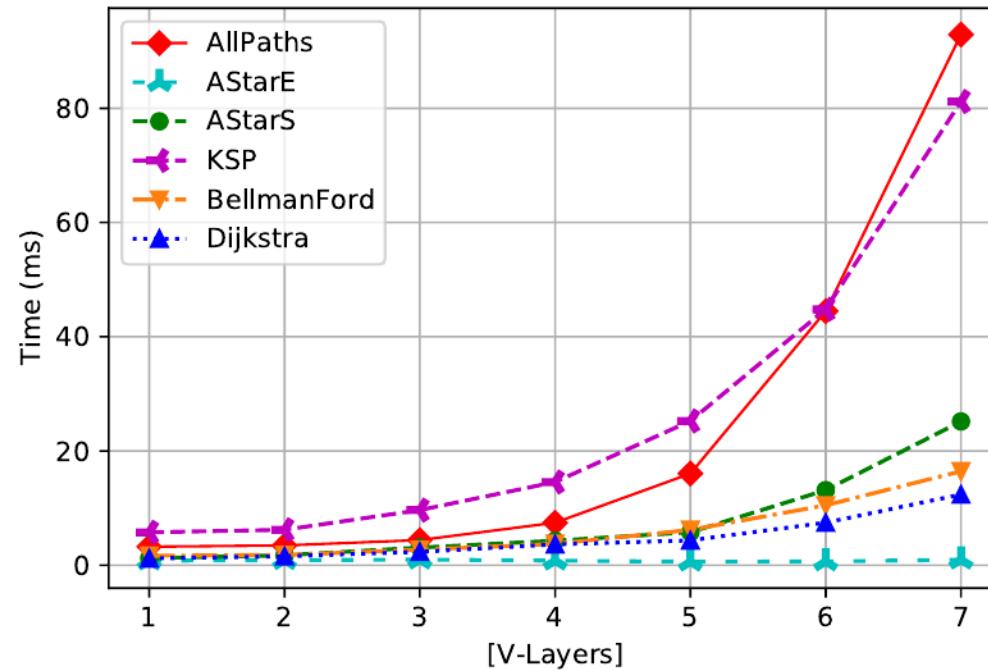


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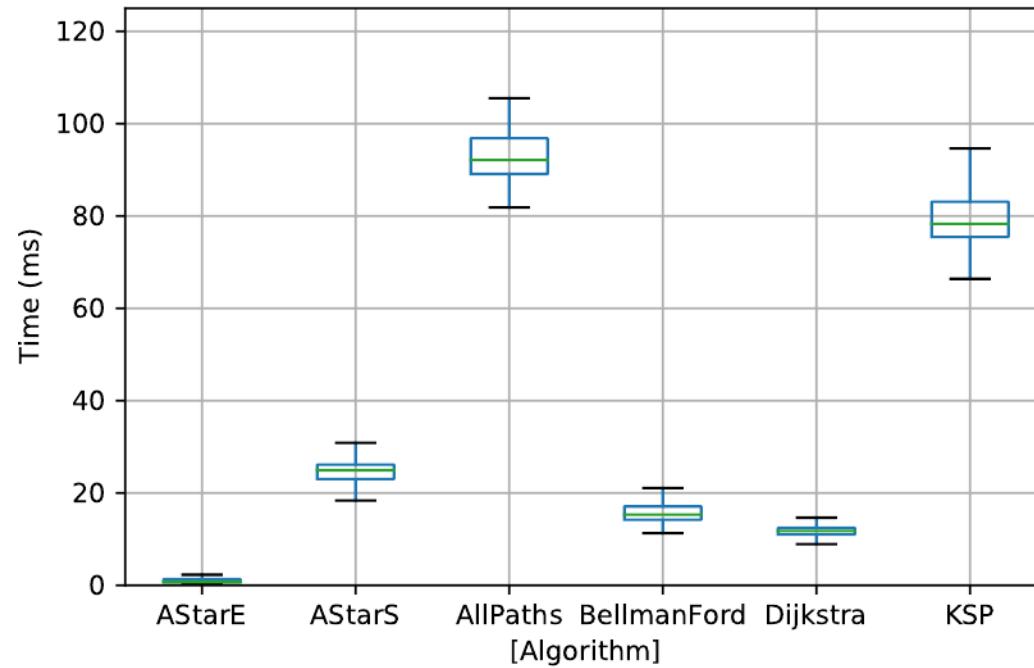
# PERFORMANCE EVALUATION (1)

Line chart of computation times

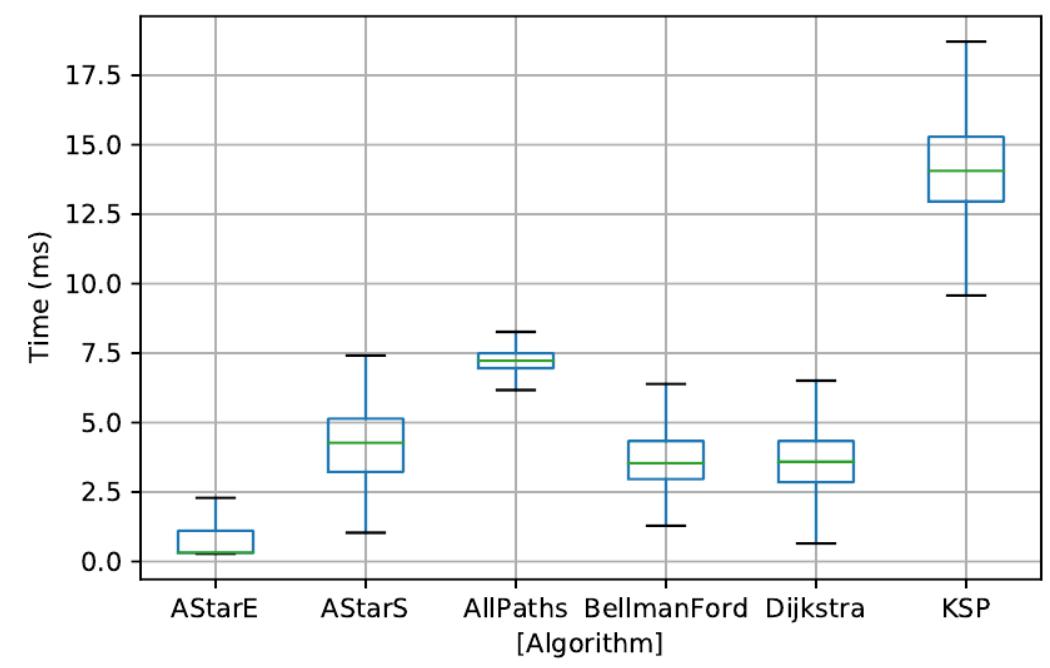


## PERFORMANCE EVALUATION (2)

Computation times at 7 V-Layers

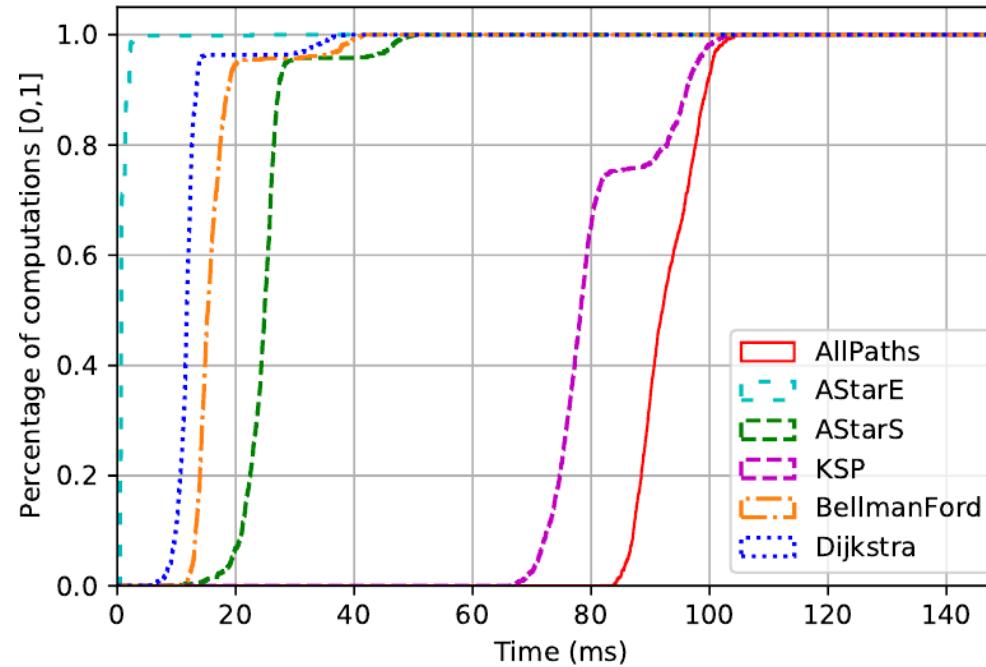


Computation times at 4 V-Layers

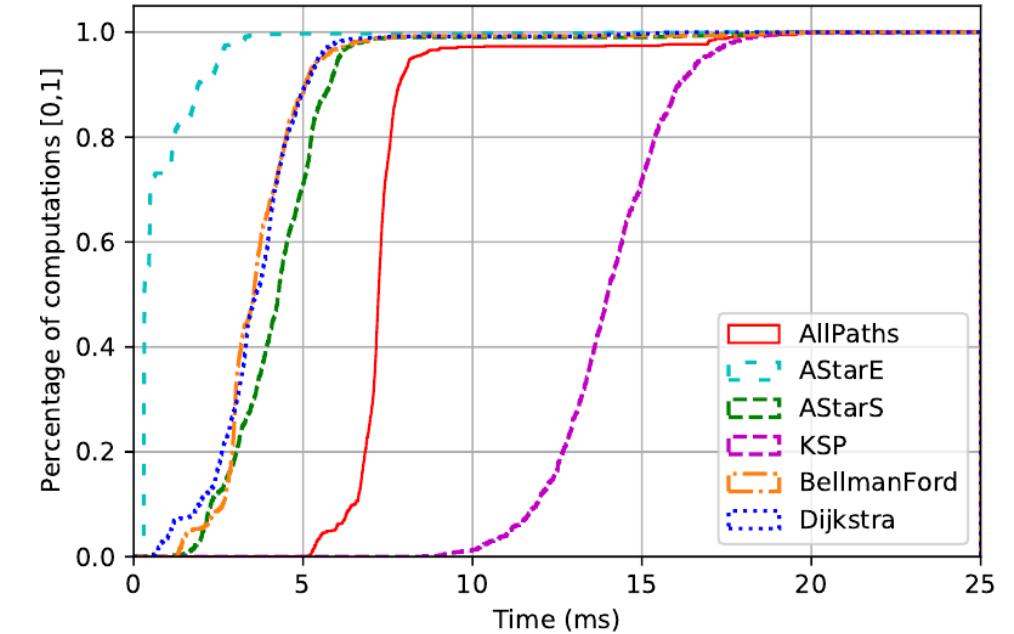


## PERFORMANCE EVALUATION (3)

CDF at 7 V-Layers



CDF at 4 V-Layers





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# CONCLUSION

## *rBPMN*: a resilient BPMN extension

### Problem statement

- Limited suitability of BPMN for unreliable communication environments.
- Consequences are interrupted and failing process executions.

### *rBPMN* integrates modeling elements for

- alternatives for failing message flows,
- moving functionality across participants, and
- dynamically choosing the best-suited alternative.

### Resilience analysis

- Identify and optimize non-resilient process segments before runtime.
- Dynamically adapt process operation at runtime.

### Performance analysis

- Solid performance of graph-based decision-making for most scenarios.
- Possibilities for speeding-up graph path calculations.



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THANK YOU FOR YOUR ATTENTION  
ANY QUESTIONS?

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