Adaptive Complex Event Processing over Fog-Cloud Infrastructure Supporting Transitions

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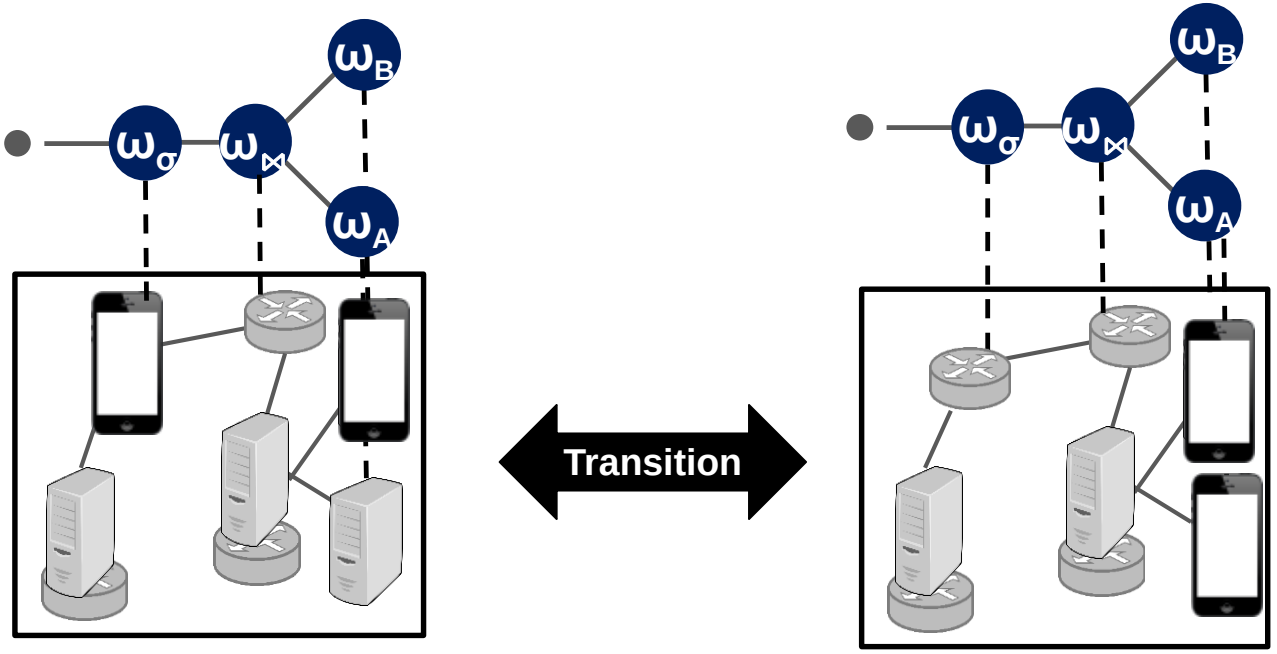

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Images: freepngimg.com

Introduction

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- Pervasive growth of Internet of Things (IoT) applications
  - IoT market $1.7 trillion until 2020
- Offers huge amount of live data
  - To derive insight in IoT
  - Adapt IoT processes
- Enables Innovative Applications
  - Smart City : Road traffic control
  - Health Monitoring

Challenges

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Presence of heterogeneous infrastructure

- User devices, network elements, data center

High dynamics

- Varying data rates
- Mobile devices
- Fluctuating comm. network properties e.g., bandwidth

Distinct QoS demands

- Reliability
- Low latency
- Bandwidth efficiency
- Privacy

Complex Event Processing

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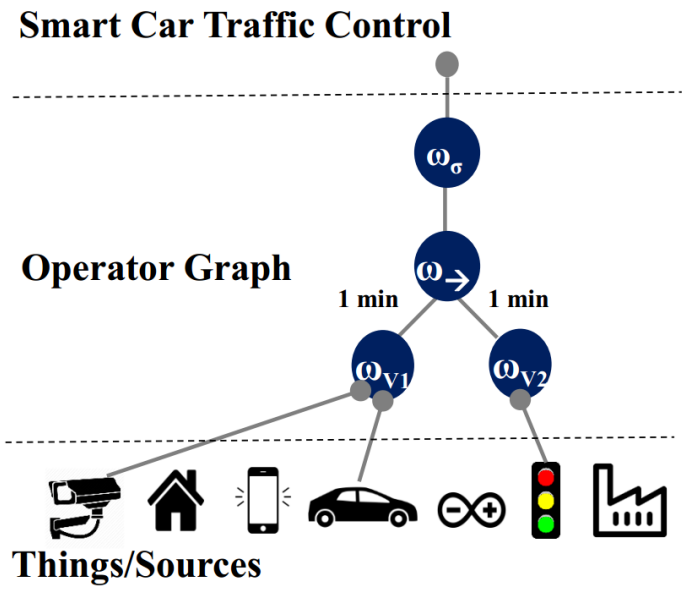
(Distributed) CEP provides a computational model to describe and detect events from distributed sensor sources

- „Car accident“ from low level sensor data in real-time.

CEP model

- Data flow by means of an operator graph
- e.g., join, sequence, etc) encapsulated in continuous queries (e.g., in SQL).

Operator graph corresponds to query execution plan of the consumer (user).



Motivational Scenarios
Smart City – Health Monitoring

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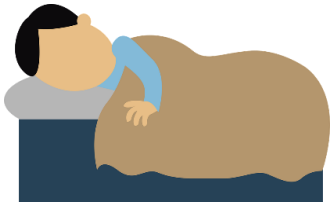
- *Early Warning Score (EWS)* [RPJ18] is a manual tool used in hospitals to track condition of patients.
- Five physiological parameters → heart rate, BP, breath rate, SPO_2, body temp.
- Various environmental conditions has an influence on the system accuracy e.g., **Heart rate of 120 beats per minute**

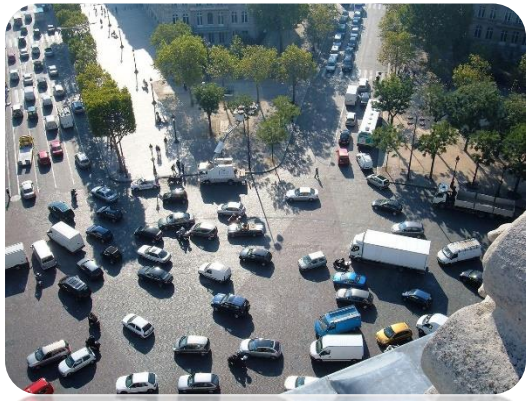
→ alarming (while sleep)



→ normal (while exercise)

Different environment conditions have distinct demands

Motivational Scenarios
Smart City – Traffic control



- Normal hours
- Highly mobile
- Sparse network
- QoS demands: stability, low control overhead

- Rush hours
- Less mobile
- Dense network
- QoS demands: delay and load efficiency

Different environment conditions have distinct demands

Data: http://inrix.com/scorecard/
Images: commons.wikimedia.org

Potential of Fog computing for CEP

The fog-cloud computing

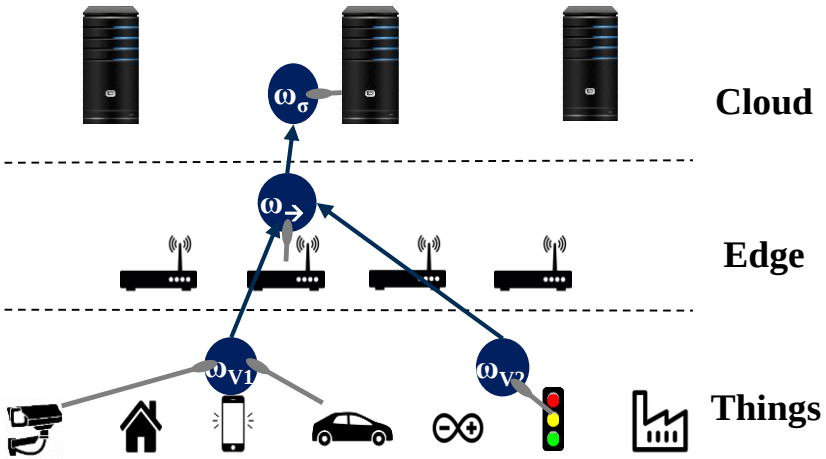
- Enables the flexible execution of operators

Allows to meet a wide range of performance objectives

In traffic scenario

- Latency sensitive operators can be deployed at fog
- While computational sensitive at cloud

Many Placement algorithms have been proposed in this context [SGK18]



Problem

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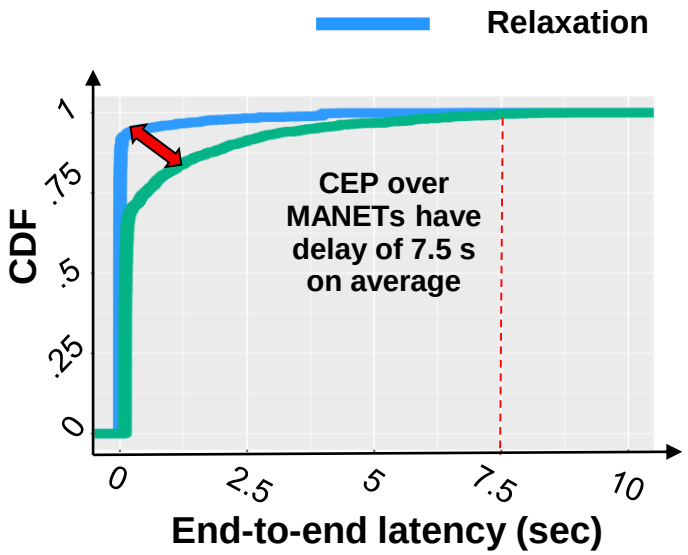
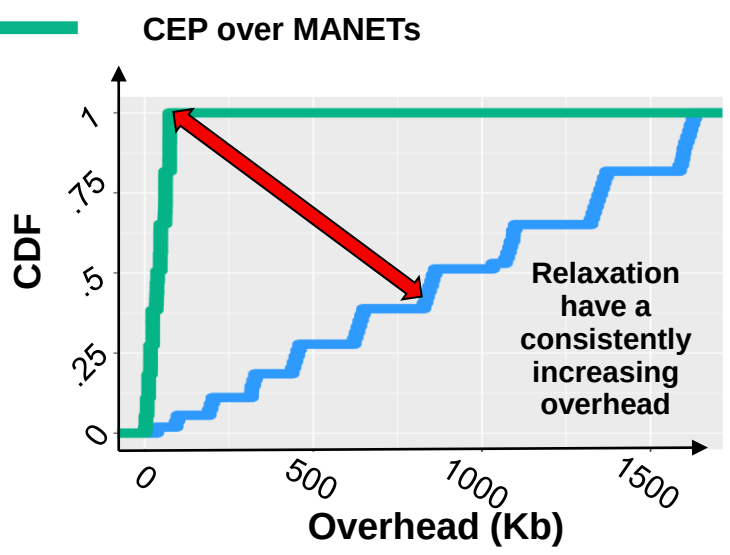
1. One CEP mechanism does not satisfy all constraints

2. QoS requirements even change dynamically





Different QoS demands in Scenarios

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Traffic congestion detection: Low latency

- Acceptable delays for traffic situations in the order of seconds for emergency vehicles [RPJ18]

Health Monitoring: Highly dynamic requirements

- Different requirements in different context (heart beats during sleep vs. during exercise)
- Order of milli seconds for EWS systems (towards symptoms of heart attack) [RPJ18]

Dynamically changing QoS Demands

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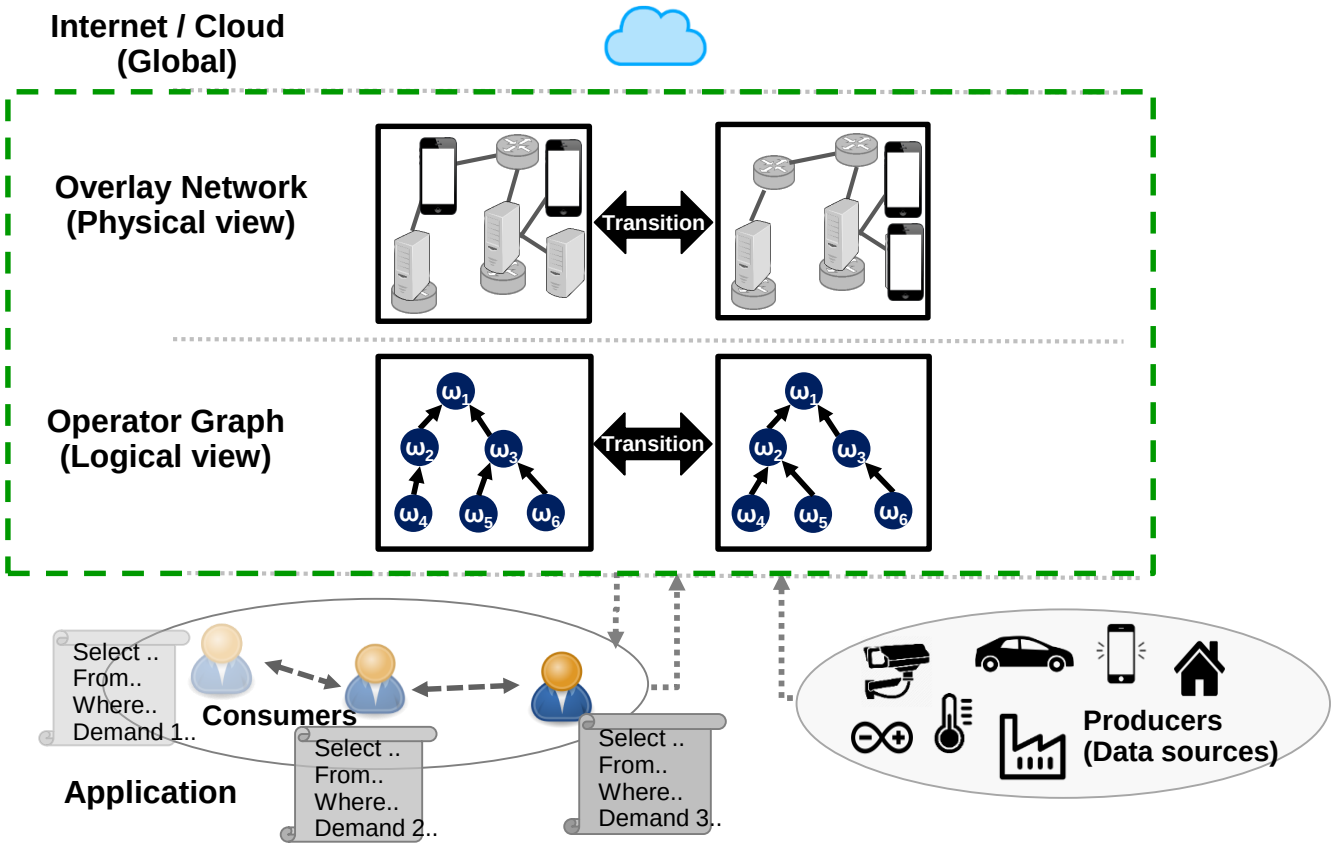
Even in the same scenario / application QoS demands changes over the time.

Traffic scenario:

- Sparse vs dense network
- Fixed vs mobile nodes
- Low overhead / stability vs delay and load efficiency

Key Idea:
Mechanism Transition in CEP System

Goal: Change the CEP mechanism in place in order to deal with multiple and changing QoS demands



Mechanism Transition Concept

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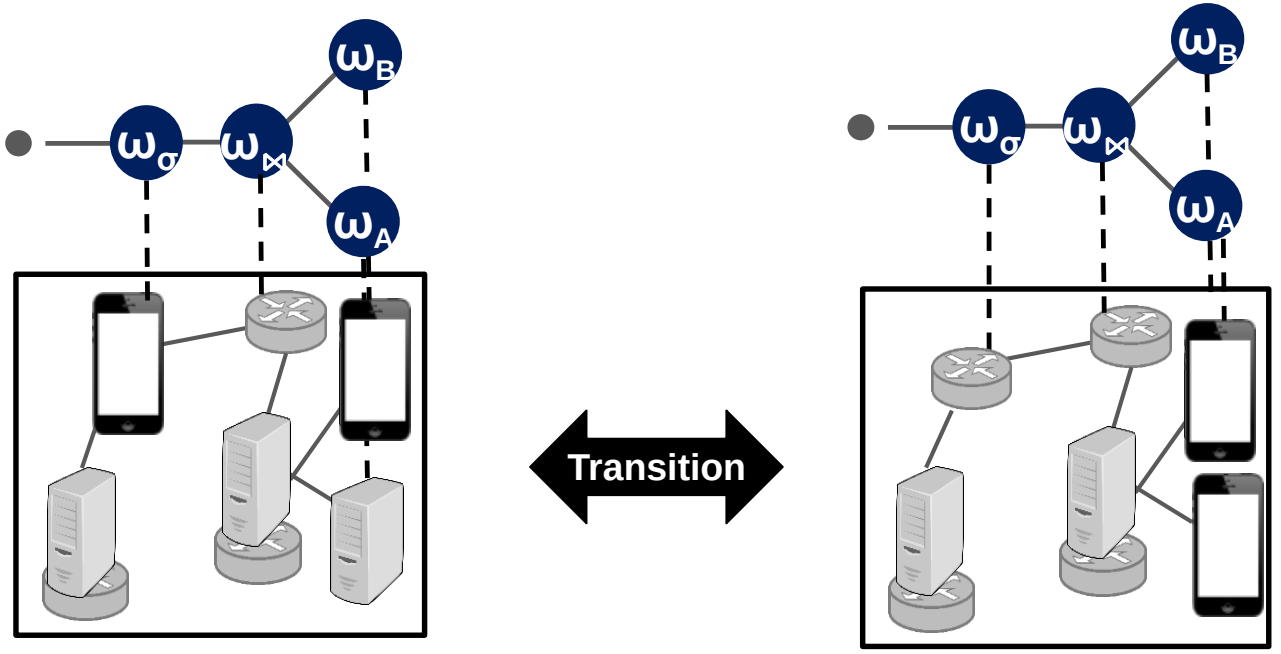
Overlay and operator graph transitions

- Exchange DCEP mechanisms at runtime for specific environmental conditions and QoS demands e.g., operator placement.



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Mechanism Transition Concept – Operator Placement

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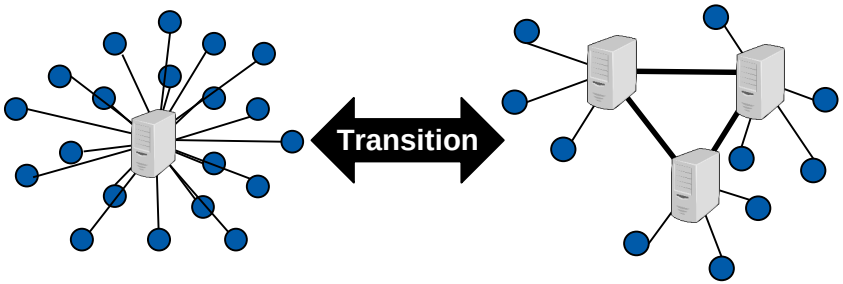
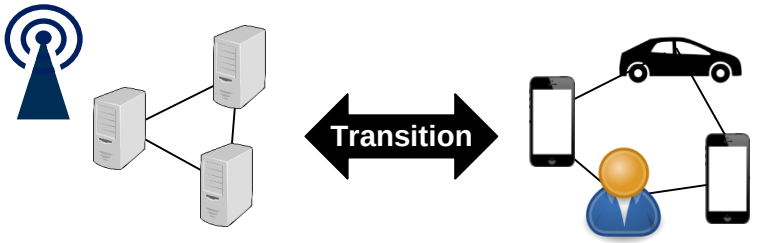
Centralized vs Decentralized Mechanisms

- Global vs local knowledge
- Optimal vs greedy placement
- Non-scalable vs scalable approach



Fixed vs Mobile Networks

- Fixed vs Mobile nodes
- Trade off: latency vs overhead
- Decentralized mechanisms can respond to dynamic changes



How can Transitions benefit from the Fog Compute Model

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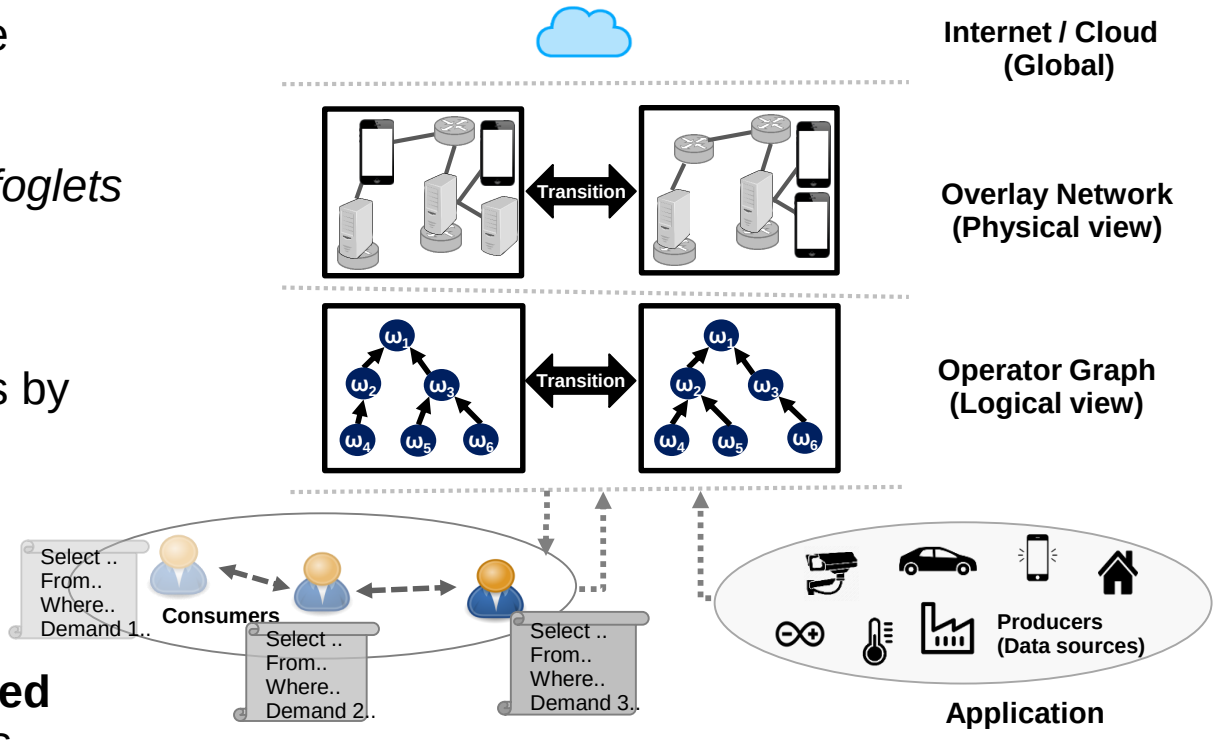
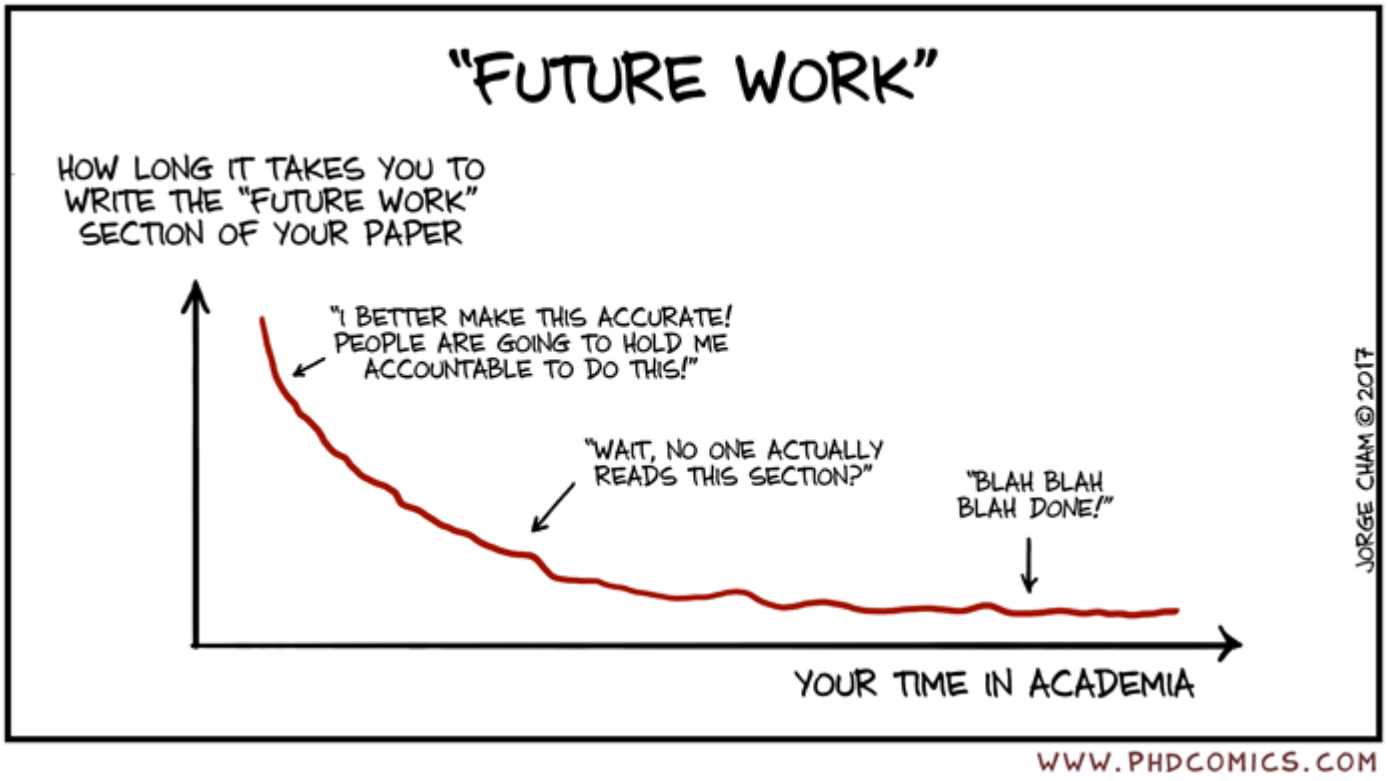
- Flexible deployment of operators over fog-cloud infrastructure based on ***QoS demands***
- Programming models e.g., *foglets* [HLR13] can be leveraged to realize **transitions**.
- Containerize CEP operators by means of virtualization technologies e.g. *docker containers*
- Future Work:
  Leverage **Software-defined Networking** for transitions



Leverage programming models such as *foglets* to realize transitions

Thank you


"FUTURE WORK"
HOW LONG IT TAKES YOU TO WRITE THE "FUTURE WORK" SECTION OF YOUR PAPER
"I BETTER MAKE THIS ACCURATE! PEOPLE ARE GOING TO HOLD ME ACCOUNTABLE TO DO THIS!"
"WAIT, NO ONE ACTUALLY READS THIS SECTION?"
"BLAH BLAH BLAH DONE!"
YOUR TIME IN ACADEMIA
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References

[Frömmgen 15]	Frömmgen, A. (2015). Towards the Description and Execution of Transitions in Networked Systems. Lecture Notes in Computer Science, 9122, 17–29.
[SGK17]	F. Starks, mobile Distributed Complex Event Processing – Ubi Sumus ? Quo Vadimus ? Mobile Big Data – A Roadmap from Models to Technologies, Springer 2017
[HLR13]	K. Hong, D. Lillethun et al, Mobile fog: a programming model for large-scale applications on the internet of things, Proceedings of the second ACM SIGCOMM Workshop on Mobile Cloud Computing, 2013
[RPJ18]	M. Rehmani, et al, Fog Computing in the Internet of Things, Springer International Publishing