Adaptive Complex Event Processing over Fog-Cloud Infrastructure Supporting Transitions

Manisha Luthra, Boris Koldehое, Ralf Steinmetz
Multimedia Communications Lab, TU Darmstadt
Introduction

- 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

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

(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

- *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)

Images: pixabay.com
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

1. One CEP mechanism does not satisfy all constraints

2. QoS requirements even change dynamically

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<td>CEP over MANETs</td>
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CEP over MANETs have delay of 7.5 s on average

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Relaxation have a consistently increasing overhead
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Different QoS demands in Scenarios

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

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.

Internet / Cloud (Global)

Overlay Network (Physical view)

Operator Graph (Logical view)

Application

Consumers

Producers (Data sources)
Mechanism Transition Concept

**Overlay and operator graph transitions**

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

Images: freepngimg.com
Mechanism Transition Concept – Operator Placement

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

- 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

# References

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