LDIC 2012, Bremen, 29th March 2012

Towards Agile and Flexible Air Cargo Processes With Localization Based on RFID and Complex Event Processing

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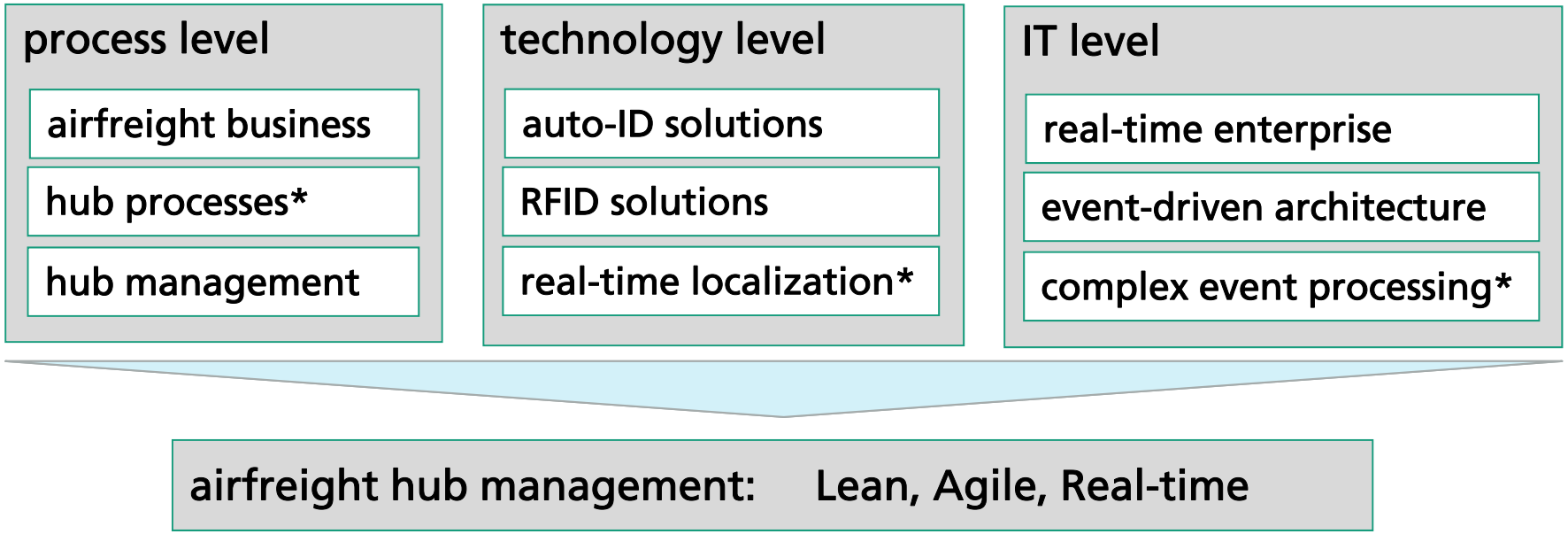
General Overview

- Central Topics
  - How can one transfer the concept of a “real-time enterprise” to the air cargo business?
  - What are the challenges from a technological and information technology point of view?



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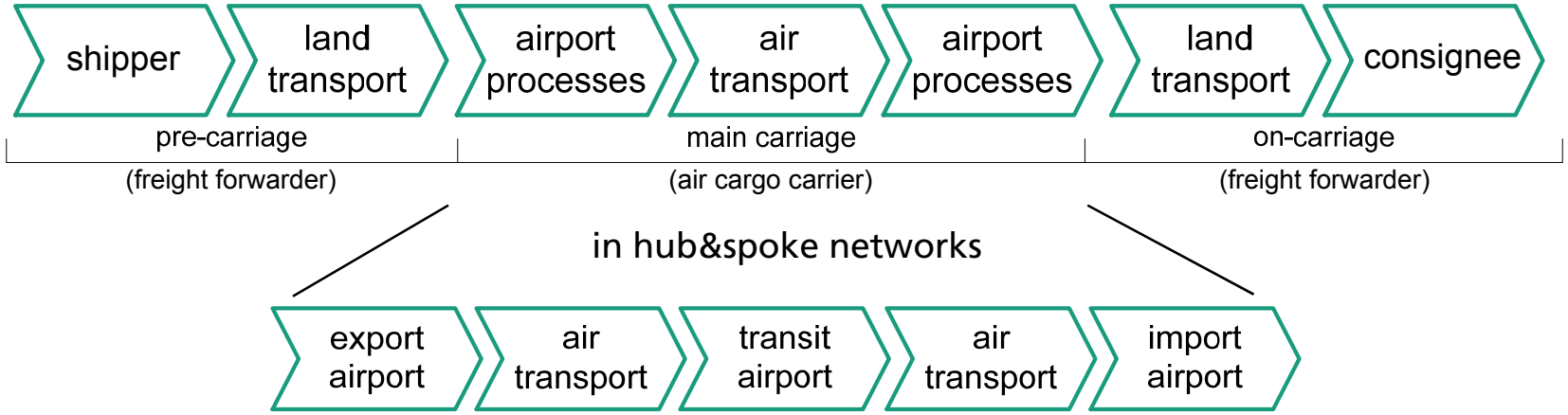
* = scope of todays presentation

Introduction to Airfreight Business

- international airfreight



- airfreight hub

87% (material flow)

main processes	production areas involved		hub activity*
export	export handling	outbound handling	15%
transit	inbound handling	outbound handling	75%
import	inbound handling	import handling	10%

* = own estimations for major German airfreight hubs, based on annual transshipments

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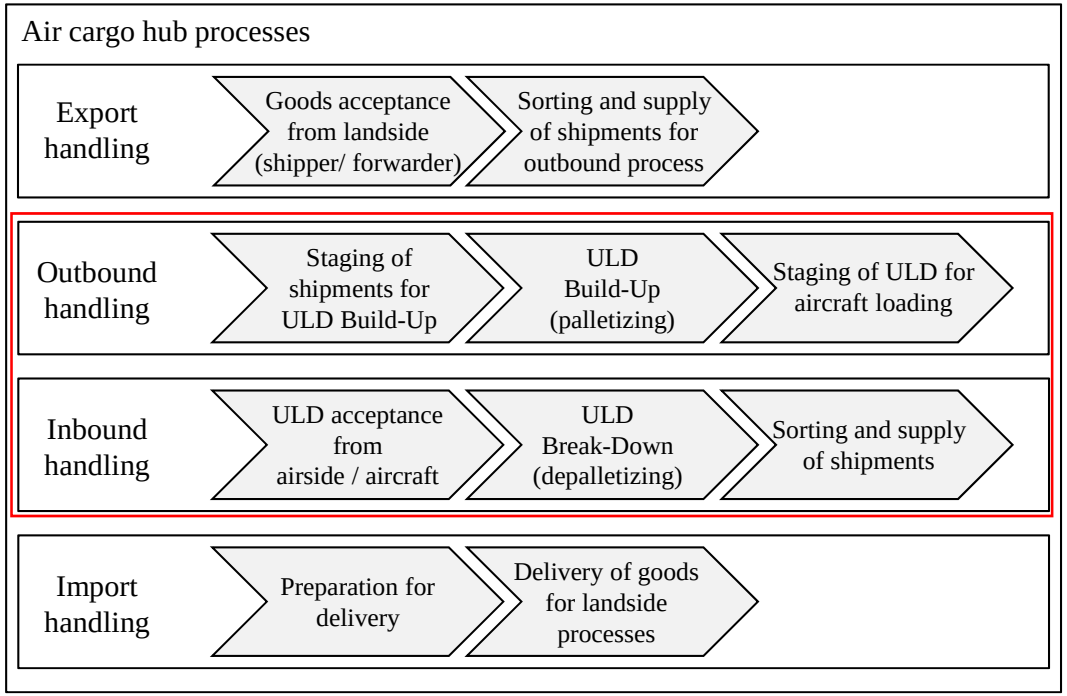
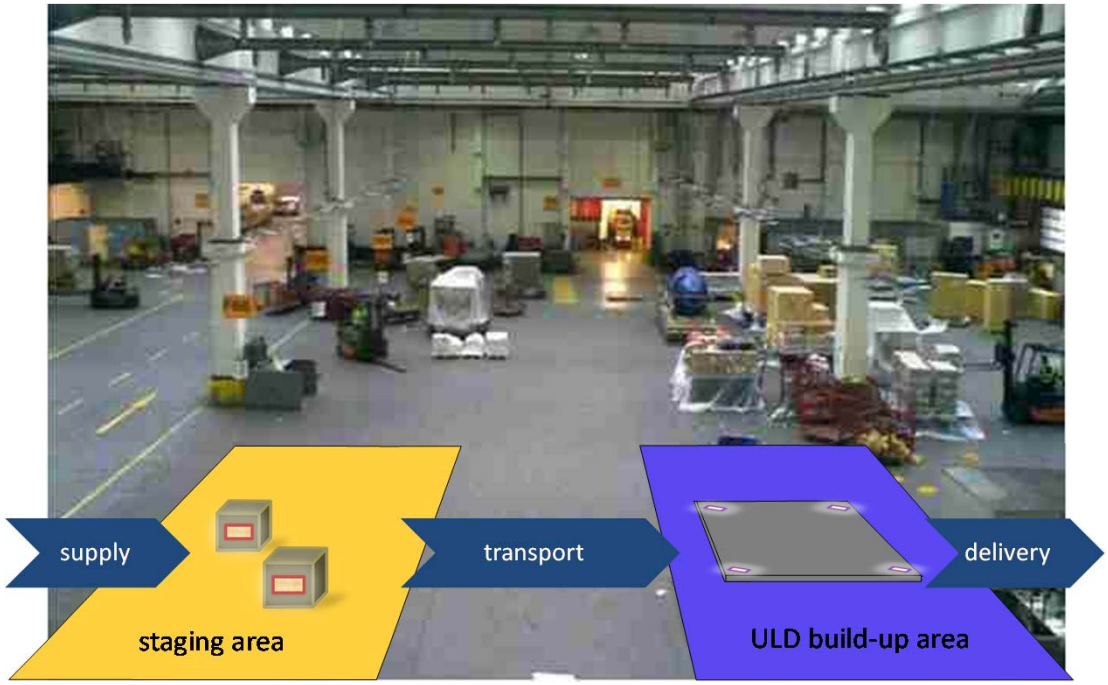
Optimization in Airfreight Hubs



- reducing general lead times / greater throughput
- increasing area utilisation
- increasing producition capacities
- increasing general process quality

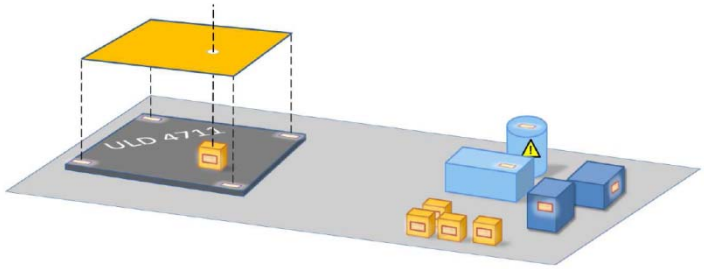
➢ focus on ULD build-up and ULD break-down

Approach 1 – Flexible Production Areas



source: Lufthansa 2010

example detection of physical aggregation



- situation
  - rigid allocation of areas to processes
  - low degree of utilization
- solution
  - occurring processes define the function of areas (accurate asset visibility required)
  - increased area utilization
  - increased area capacities
- preconditions
  - RFID based localization system
  - event-driven IT architecture

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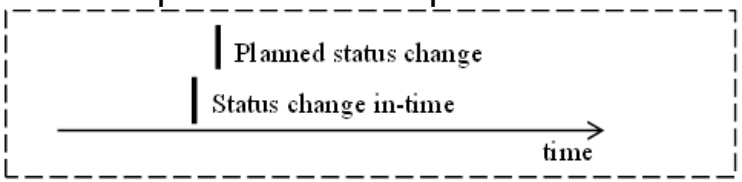
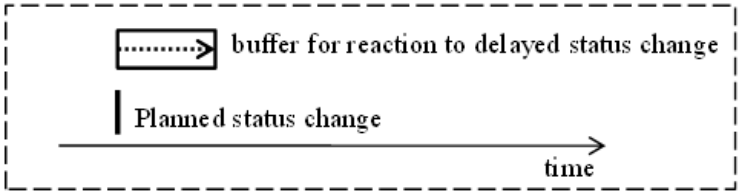
source of image: Lufthansa 2010

Approach 2 – Real-time Hub Management

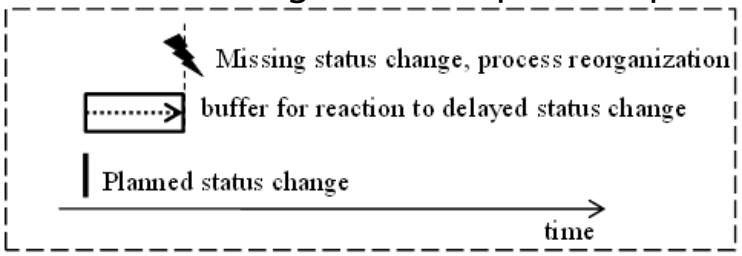
Case A: process flow as planned



Case B: initiation of correction process



Case C: re-configuration of planned processes



Industrial example:
ULD in build-up process waits for export shipments to be supplied (unloading problems at truck gate)

- situation
  - rigid scheduling of hub processes
  - high overall lead times
- solution
  - permanent status control of processes
  - dynamic scheduling of hub processes
  - reduced overall lead times
- preconditions
  - RFID based localization system
  - event-driven IT architecture

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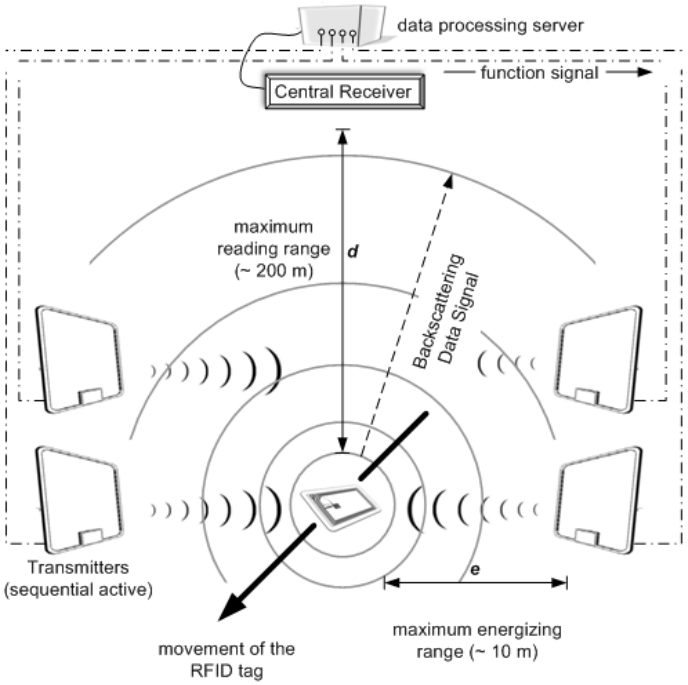
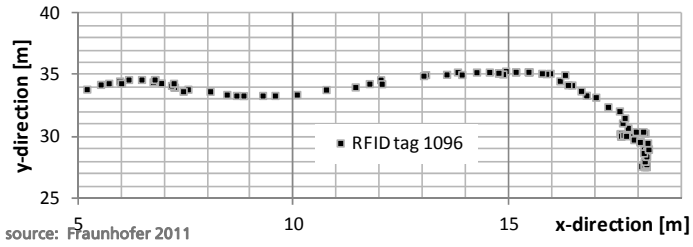
RFID based Real-time Localization



sample Mojix Output (bird´s eye view)



- Mojix STAR system
  - passive UHF RFID system
  - several energizing RFID antennas [2 W ERP] (steerable phased-array antennas which can be mounted on the ceiling of a facility)
  - one central reader (which is designed for the extraction of low-level RFID signals)
  - ➢ maximum reading range up to 200 meter
- Real-time localization
  - non-line-of-sight identification of passive RFID tags
  - localization based on “triangulation” and
    - time-difference-of-arrival
    - radio signal strength indicator

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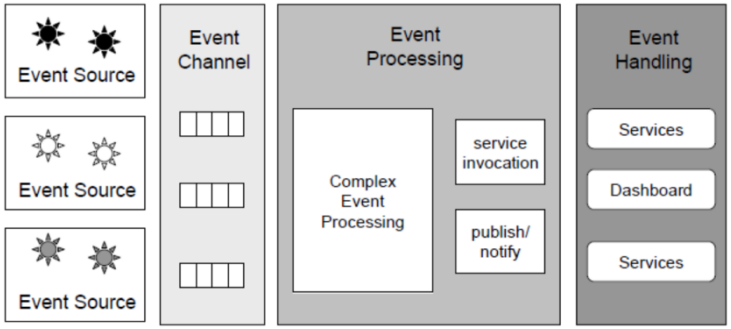
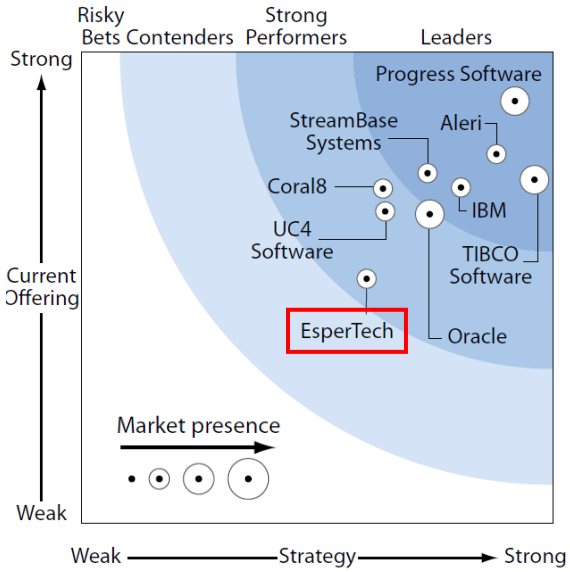
Introduction to Complex Event Processing



source: J. Dunkel et al. : Systemarchitekturen für Verteilte Anwendungen



source: Forrester Wave™: Complex Event Processing (CEP) Platforms, Q3 '09

- Complex Event Processing technology enable applications to monitor, analyze and decide on data in motion
- Key attributes
  - identification of meaningful events (continuously)
  - event pattern matching → complex event
  - context enrichment (a layer built on top of EDA)
  - turning data to decisions
- Industrial CEP applications
  - financial sector – fraud detection
  - energy sector – energy grid monitoring
  - logistics (?)

Introduction to Event Processing Language

simple CEP statements in Esper
(correlating event streams)

```
SELECT      ... Attribute...
FROM        ... Ereignisstrom 1 ...  AND Ereignisstrom 2...
WHERE       ... Attributs 1 > „Wert“ ... OR Attribut 2 = „Wert“...
ORDER BY    ... Zeitstempel...
```

complex CEP statements in Esper
(event pattern matching)

```
SELECT          ... Attribute...
FROM PATTERN  [ ... (m=Ereignisstrom1) → (n=Ereignisstrom2(Attribut=m.Attribut) ... ]
WHERE           n.Attribut > „Wert“
```

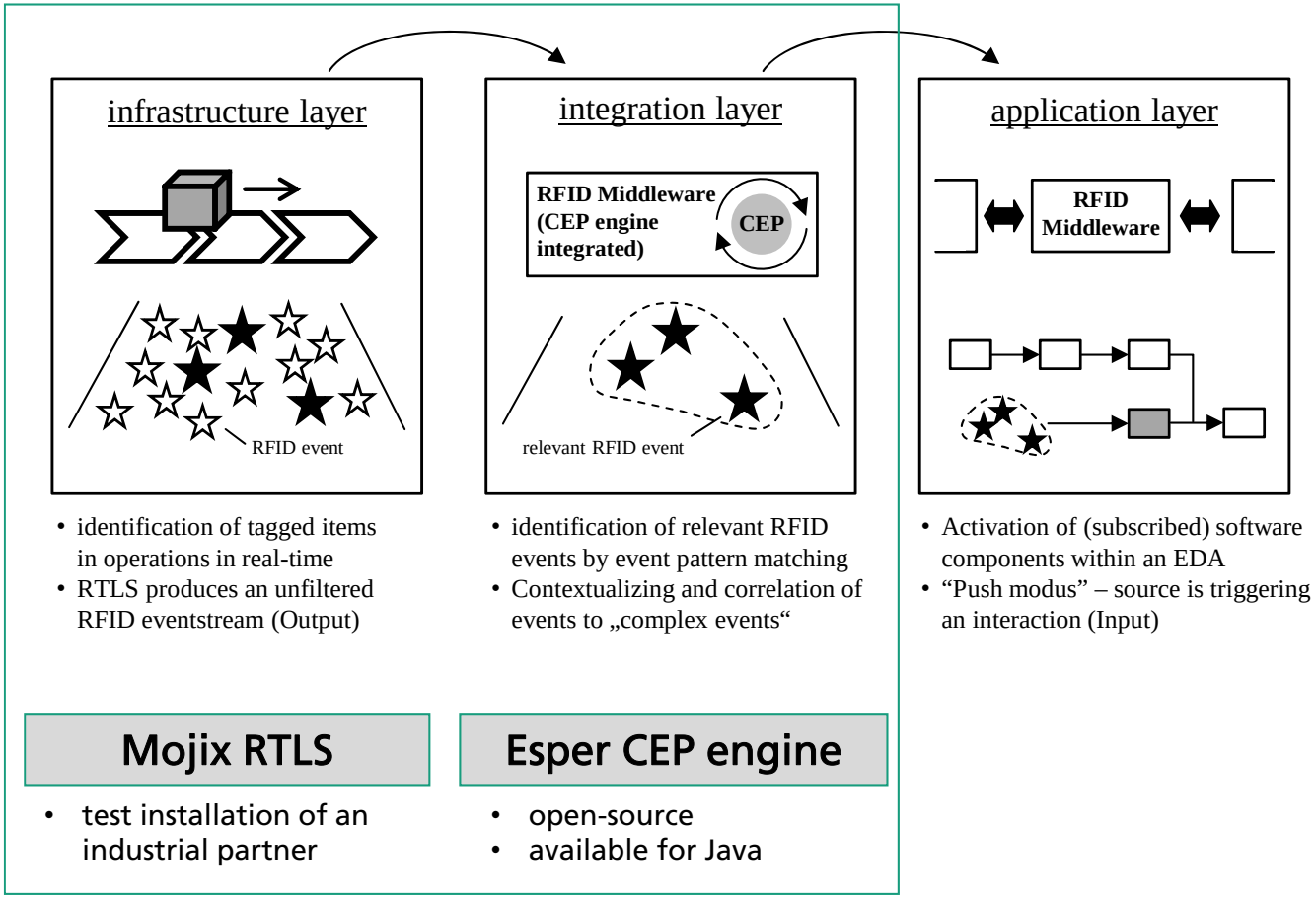
```
SELECT    ... avg(m.Attribut) AS Average, ... sum(m.Attribut) AS Sum ...
FROM      ... Ereignisstrom1.win:length(x) AS m ...
WHERE     ... Average > „Wert” ... OR Sum > „Wert” ...
```

- high number of Event Processing Languages (EPL) exist due to missing standards
- most EPL are derived from the logic of SQL

- FROM: defining event streams to be analyzed
- FROM PATTERN: definition of pattern criteria to a set of data of different event streams
- SELECT: defining the event attributes to be analyzed
- WHERE: event correlation and filtering

Test Implementation – General System Architecture

Test implementation:



- identification of tagged items in operations in real-time
- RTLS produces an unfiltered RFID eventstream (Output)

- identification of relevant RFID events by event pattern matching
- Contextualizing and correlation of events to „complex events“

- Activation of (subscribed) software components within an EDA
- “Push modus” – source is triggering an interaction (Input)

Mojix RTLS

- test installation of an industrial partner

Esper CEP engine

- open-source
- available for Java

Test Implementation – Esper Statements for Approach 2

1.) Combining location information with spatial information

```
INSERT INTO  EventBuffer1
SELECT       mov.EPC as EPC,mov.timestamp as timestamp, top.locationId as locationId
FROM         MovementEvent.win:keepall() as mov, TopologyEvent.win:keepall() as top
WHERE        mov.xPosition >= top.xStart AND mov.xPosition < top.xEnd
ORDER BY     mov.timestamp
```

2.) Comparision of actual and planed process progress

```
INSERT INTO  EventBuffer2
SELECT       Buff1.EPC as EPC, plan.locationId as locationId, plan.timestamp as timestamp,
             Buff1.timestamp as timestamp2, Buff1.locationId as locationId2,
             (case when (Buff1.locationId – plan.locationId) < 0 then "WARNING"
             else "OK" end) as status,
FROM         EventBuffer1.win:length(1) as Buff1, PlandataEvent.win:keepall() as plan
WHERE        Buff1.timestamp <= plan.timestamp
ORDER BY     Buff1.timestamp
```

3.) Extraction of critical events

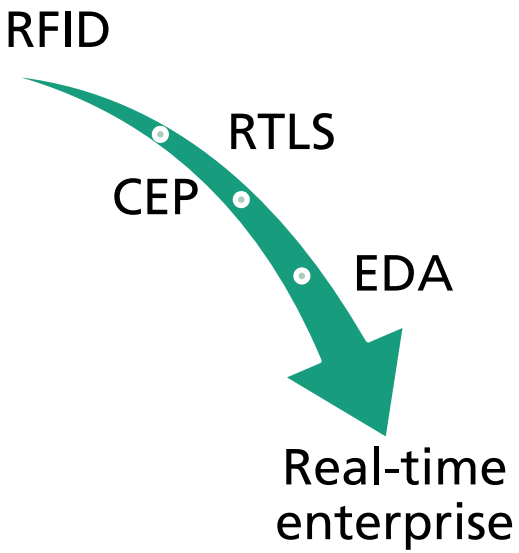
```
INSERT INTO  EventBuffer3
SELECT       Buff1.EPC as EPC, Buff1.timestamp as timestamp,
             Buff1.locationId as locationId
FROM         EventBuffer1.win:keepall() as Buff1
WHERE        prev(Buff1.locationId) != Buff1.locationId
ORDER BY     Buff1.timestamp
```

4.) Monitoring of reactions

```
SELECT       Buff2.locationId, Buff2.timestamp, Buff3.locationId, Buff3.locationId
FROM         EventBuffer2.win:length(1) as Buff2, EventBuffer3.win:length(1) as Buff3
WHERE        Buff2.locationId = Buff3.locationId AND Buff3.timestamp > Buff2.timestamp
ORDER BY     Buff3.timestamp
```

- Input of three event streams
  - Movement event stream (output of Mojix RTLS)
  - Plan data event stream (operational temporal information)
  - Topology event stream (spatial information of system topology)
- Output
  - Controlling permanently the progress of processes
  - Displaying time critical events to managerial staff in real-time
  - Recommendations how to solve the identified problems

Conclusions



- Complex Event Processing is well-suited for monitoring and controlling the processes in air cargo hubs
- In Combination with an appropriate RTLS manual scan processes will be eliminated and immediate quality checks will be enabled
- Following the concept of a real-time enterprise and its central idea of permanent control about on-going business
  - the company´s ability to react to internal / external irregularities will be sharpen
  - a differentiated communication with customers will be enabled

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Thank you for your attention!

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