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An Introduction to Complex Event Processing

Andy Piper & Robin J Smith

Oracle

Oracle CEP Group

Agenda

- > Introduction
- > Conceptual Overview
- > What is CEP?
- > Why CEP?
- > Customer Use Cases
- > Q&A



Introduction

- > Dr Andy Piper
 - | A CEP architect at Oracle
 - | Background in application server design
- > Robin J. Smith
 - | Product Management / Strategy Director for EDA/ CEP at Oracle
 - | Background in EDA, SOA infrastructure & Java Development Tooling, Worldwide Product Delivery and Distribution

What is an Event?

“Something that happens” webster.com

Anchored in *time*

Not under your control

The Complex World Of Event Processing

- > The world has radically changed
 - | Exponential increase in hardware capability
 - | Huge volumes of increasingly *temporal* data generated and stored every second
 - | Here today, junk tomorrow
 - | Real-time processing
 - | Exponential increase in connectivity
 - | The internet has connected everything
 - | Huge volumes of data available everywhere
 - | Changing business models and user expectations
 - | Google-level latencies demanded by users
 - | Different business models now supportable
 - | *Faster – better – cheaper*

The World of Complex Event Processing

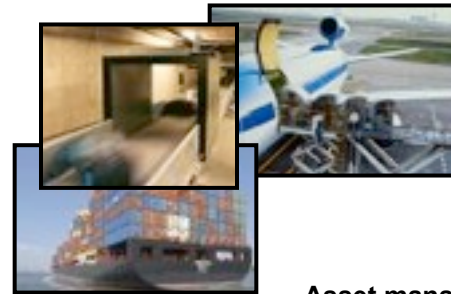
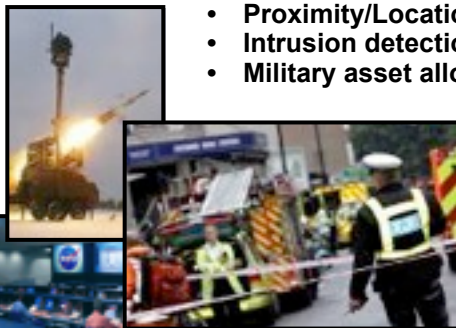
- > To support *faster* response times processing moving closer to the data
- > To support more *accurate* responses processing moving closer to the data source
 - | Batch -> OLTP -> *Streaming Queries*
- > Data processed as it is available
 - | “When?” is as important as “what?”
- > The questions are increasingly complex
 - | Requires semantically rich expression

Event-Driven Applications

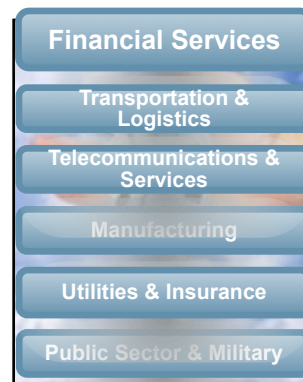


Algorithmic trading

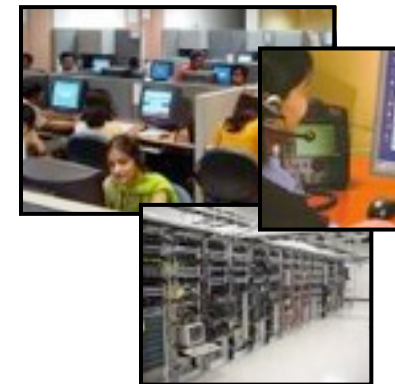
- Proximity/Location Tracking
- Intrusion detection systems
- Military asset allocation



Asset management



Distributed order orchestration



'Negative Working Capital' inventory management



Grid Infrastructure Management
Responses to calamities –
earthquake, flooding



Event-Driven Applications



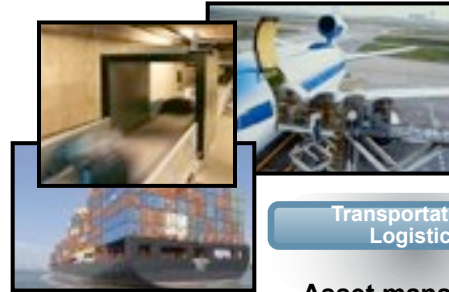
Financial Services

Algorithmic trading

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Public Sector & Military

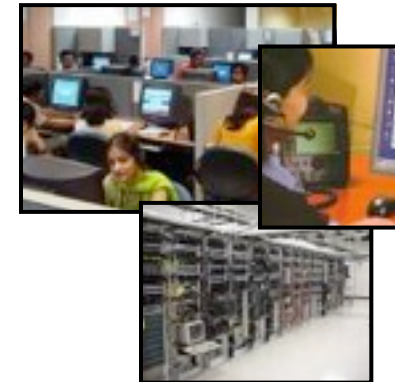


Transportation & Logistics

Asset management



Distributed order orchestration



Telecommunications & Services

'Negative Working Capital' inventory management

Manufacturing



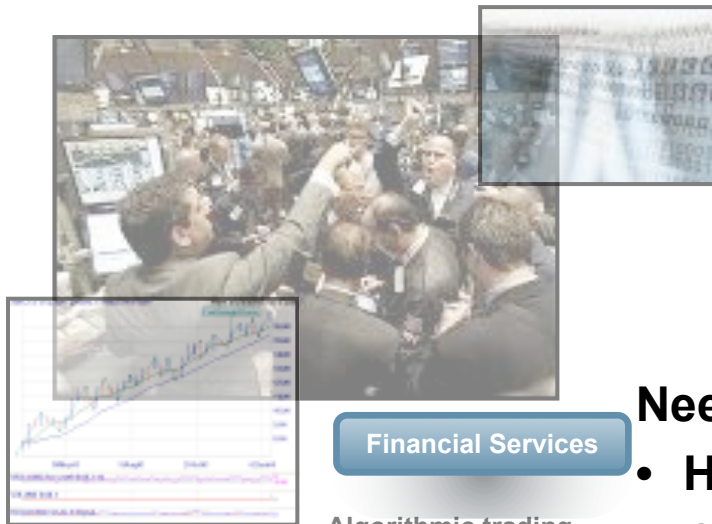
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Utilities & Insurance

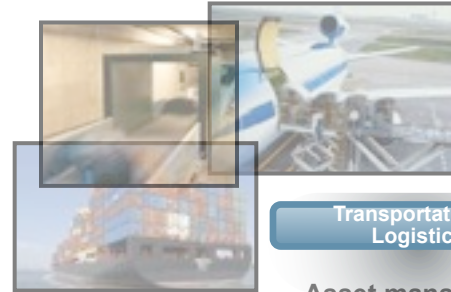


Event-Driven Applications



Financial Services

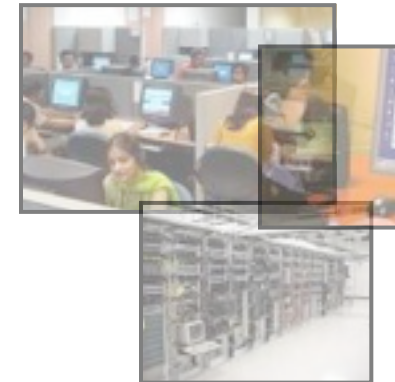
Algorithmic trading



Transportation & Logistics

Asset management

Distributed order orchestration



Telecommunications & Services

Need to support one or more of:

- High volume
- Continuous streaming
- Sub-millisecond latency

- Proximity/Location Tracking
- Intrusion detection systems
- Military asset allocation

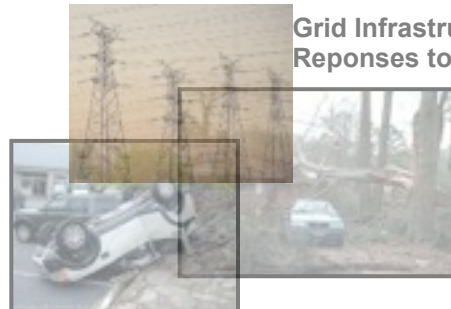
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Manufacturing

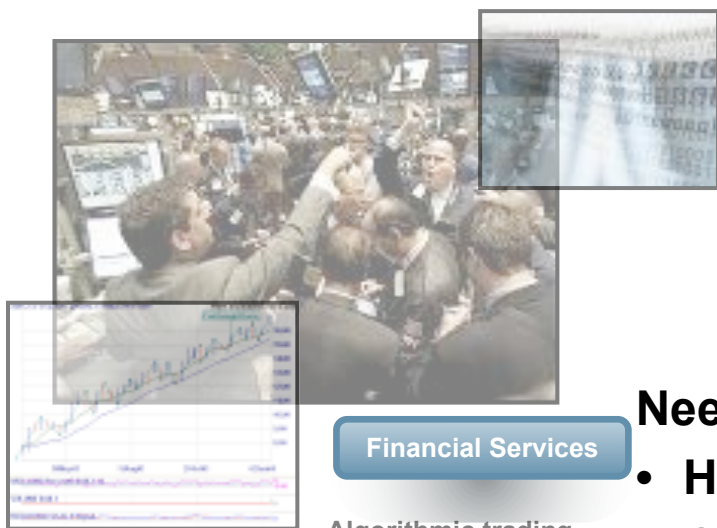
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Utilities & Insurance

Public Sector & Military

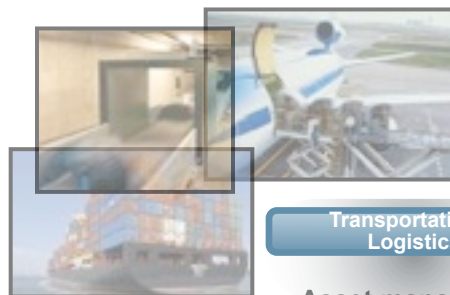


Event-Driven Applications



Financial Services

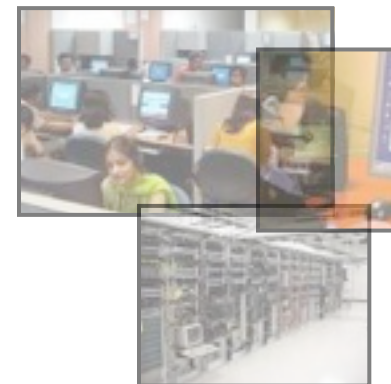
Algorithmic trading



Transportation & Logistics

Asset management

Distributed order orchestration



Telecommunications & Services

Need to support one or more of:

- High volume
- Continuous streaming
- Sub-millisecond latency
- Disparate sources
- Time window processing
- Complex pattern matching

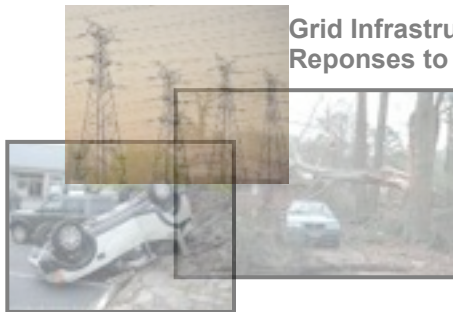
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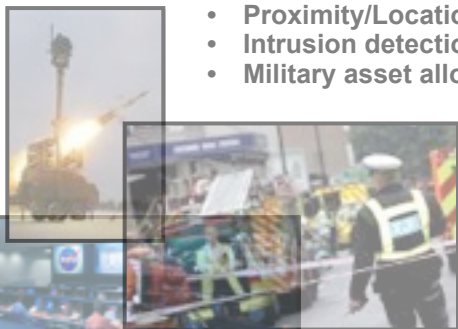
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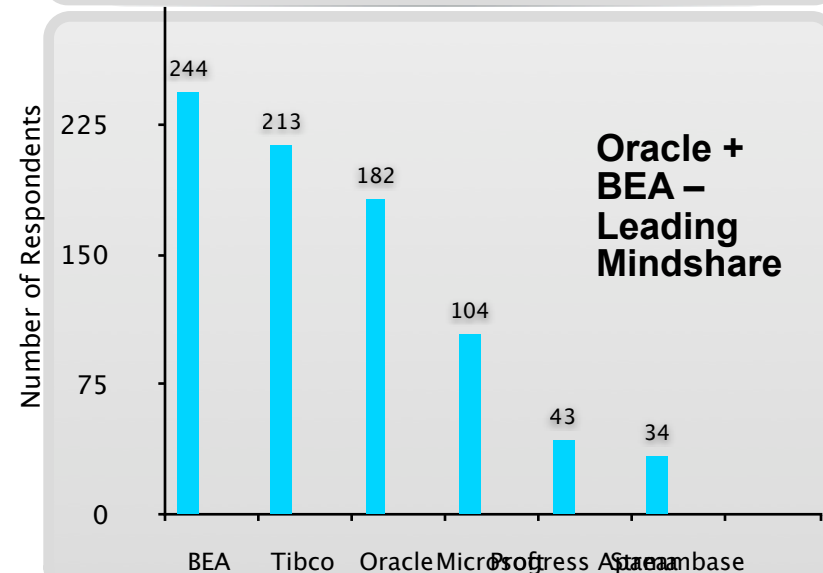
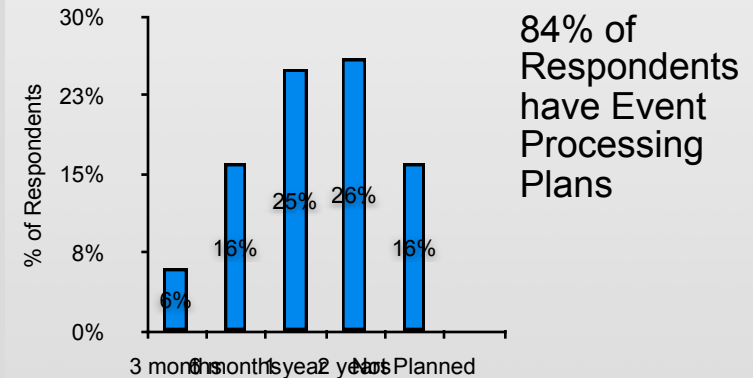
>\$1 Billion Dollar Market by 2012

Secondary Research

- > **Forrester – Over 70% using/aware of CEP/EDA (survey of 1,017)**
 - | 33% already using CEP/EDA, 38% were aware of
 - | Market size \$100M 2007
- > **Gartner – First Event Processing Summit in 2007**
 - | Market size – \$100M 2007
- > **IDC – CEP Middleware 140% YoY growth**
- > **Aberdeen** (in an EII report)
 - | 39% of Best-in-class companies rated EDA a “MOST” important feature of EII solution
- > **Strong Investments from EDA/CEP Vendors**
 - | IBM – bought AptSoft
 - | “IBM WebSphere CTO sees CEP as SOA's 'next big thing'” – 01/02/08, SearchSOA.com
 - | Tibco – BusinessEvents platform
 - | Progress – Bought Apama
 - | Others – Streambase, Coral-8 & Aleri Merge

Primary Research ebizQ Survey Results

Expected Event-Driven Solution Implementation Timeline



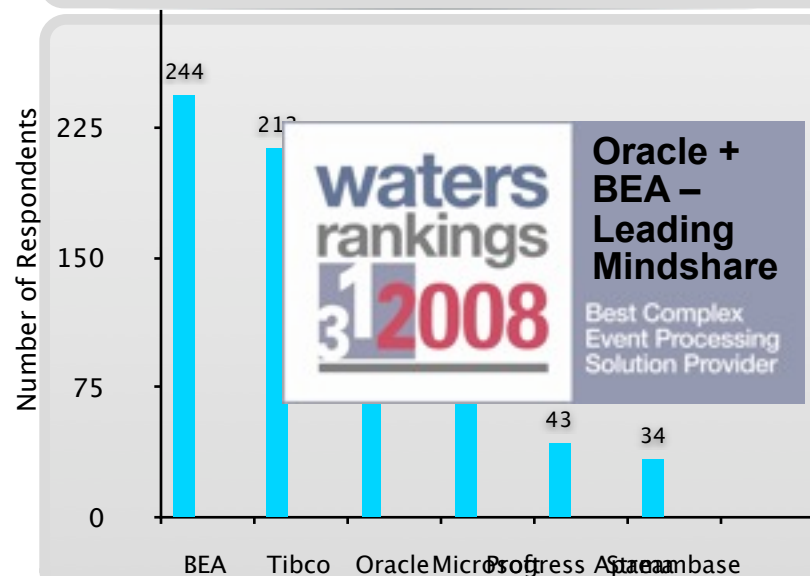
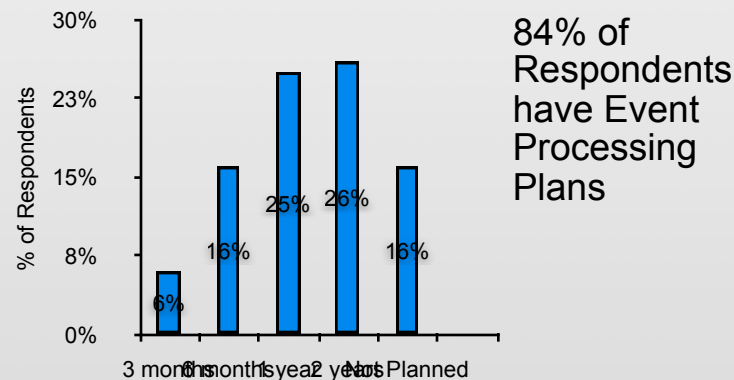
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> Market Evolved from Early Adoption to Mainstream

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Trading Technology - 1 Apr 2009

A Bridge to FX

Complex event processing isn't just for trading and equities. A new trading solution for foreign exchange that is powered by complex event processing (CEP) has long been on the equity side of the business. Thanks to a maturing platform for handling vast stores of market data inside a trading firm, CEP is entering foreign exchange (FX) with a laser-like focus.



DBMS2

May 13, 2009


IBM System S Streams, aka InfoSphere Streams, aka stream processing, aka "please don't call it CEP"

IBM has hastily announced a new technology supposed to be called InfoSphere Streams. Apparently, the rush is because it's coming later this week, and perhaps some of IBM's advertising and team got to me fast, and unfortunately, but otherwise, and without any NDAs. That's why I'm writing this now. Microsoft, who also introduced

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DBMS2

May 13, 2009


Microsoft announced CEP this week too

Microsoft still hasn't worked out all the kinks regarding when and how intensely to brief me. So most of what I know about their announcement earlier this week of a **CEP/stream processing product*** is what I garnered on a consulting call in March. That said, I sent Microsoft my notes from that call, they responded quickly and clearly to my question as to what remained under NDA, and for good measure they included a couple of clarifying comments that I'll copy below.

**"In the SQL Server 2008 R2 timeframe," about which Microsoft wrote "the first Community Technology Preview (CTP) of SQL Server 2008 R2 will be available for download in the second half of 2009 and the release is on track to ship in the first half of calendar year 2010."*

Perhaps it is more than coincidence that IBM rushed out its own announcement of an immature CEP technology — due to be more mature in a 2010 release — immediately after Microsoft revealed its plans. Anyhow, taken together, these announcements support my theory that the small independent CEP/stream processing vendors are more or less ceding broad parts of the potential stream processing market.

The main use cases Microsoft talks about for CEP are in the area of **sensor data.**



What is Complex Event Processing?

- > In-memory, continuous queries
 - | Windows instead of tables
- > Declarative query expression language
 - | SQL with temporal extensions
 - | Emerging standard is CQL
 - | Too difficult to represent in Java
- > High volume, low latency required

In-Memory Continuous Queries

Ø Event Processing Output

- Ø Filtering for specific criteria
 - Ø e.g. stock price > \$22
- Ø Correlation & Aggregation
 - Ø Scrolling, time-based window metrics, e.g. average hourly trades
- Ø Pattern Matching
 - Ø Notification of detected event patterns, e.g. price changes A, B and C occurred within 15 minute window

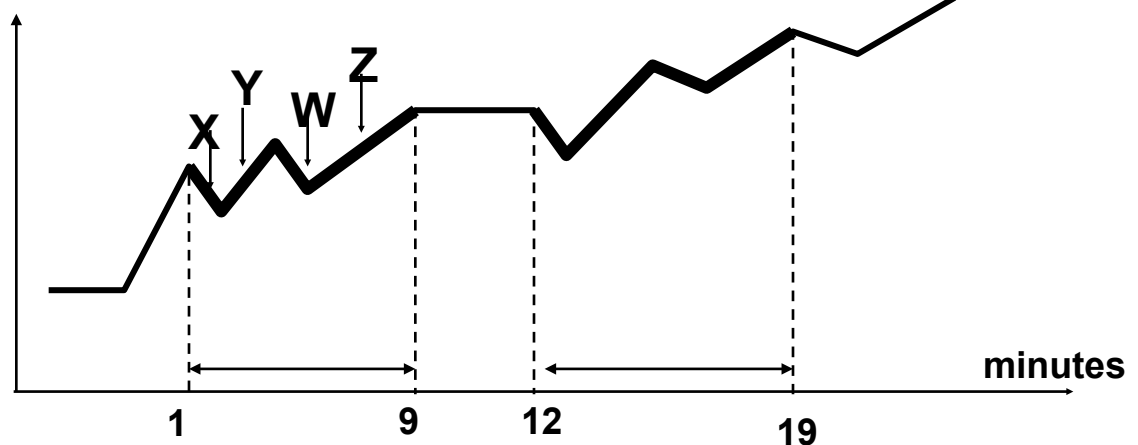
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DD	DUPONT	D	41.575	3000	20080605 10:03:04.12
AA	ALCOA INC.	D	25.125	1000	20080605 10:03:01.05
ADP	AMER EXPRESS CO	D	43.875	500	20080605 10:03:02.10
BA	BOEING	D	77.575	800	20080605 10:03:02.78



Runs In-Memory (not in Database)

Logic is defined through Continuous Queries on the data

Example: Stock Trading “W” Pattern



Continuous Query Language

- > Extend the relational model to support “continuous” queries
- > Construct “windows” over event streams
 - | Bounded by time or count
 - | Partitioned based on values
 - | Processed incrementally or in batches
 - | Defines a “working set” of events
- > Use relational operators to characterize the event streams
 - | Filtering, aggregation, and correlation of events

Sample Complex Queries

Ø Filtering

- Ø **Stock price more than \$22**

- Ø CREATE QUERY f_query AS SELECT * FROM S [Range 10] WHERE S.A > 22;

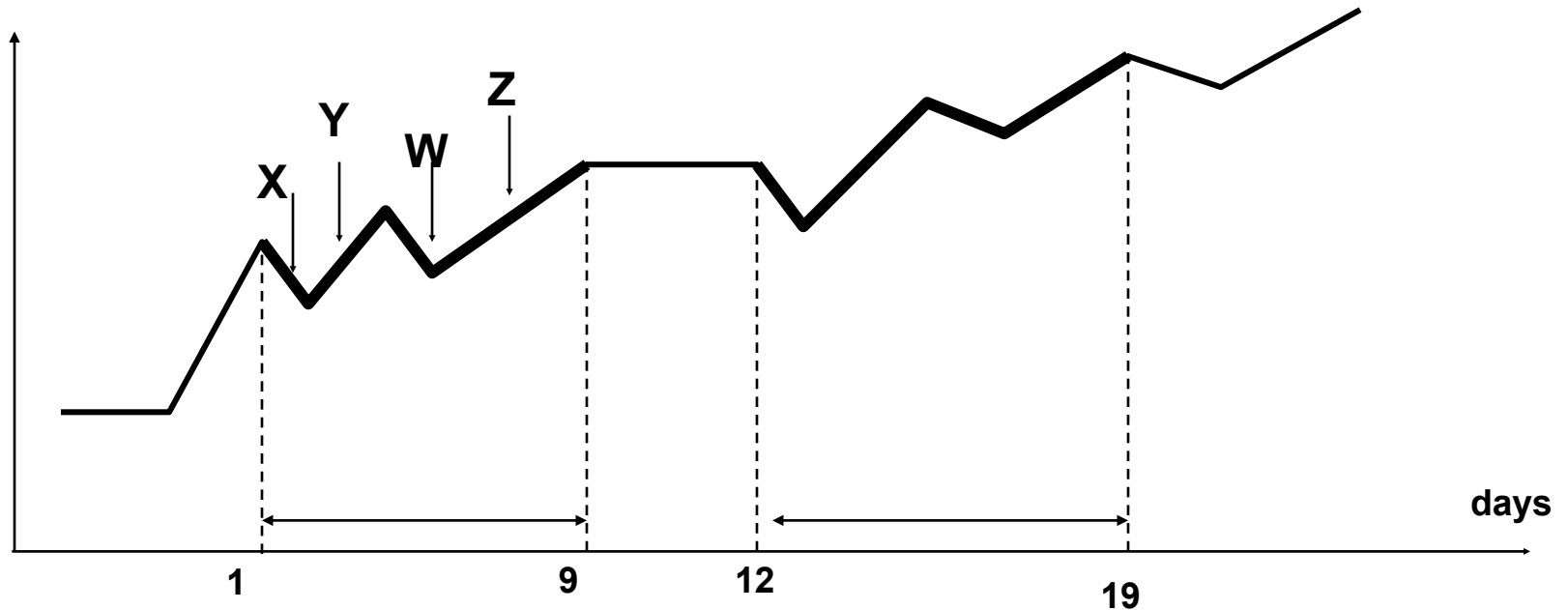
Ø Correlation & Aggregation

- Ø CREATE QUERY ca_query AS SELECT AVG(S1.C) FROM S1 [RANGE 10], S2[RANGE 5] WHERE S1.A = S2.B;

Ø Pattern Matching – Detect a W Chart Pattern

- Ø CREATE QUERY wp_query AS SELECT MATCH_RECOGNIZE
(MEASURES A.c1 as first(W), last(Z) as last(Z) PATTERN(A W+ X+ Y+ Z+)
DEFINE W as W.c2 < prev(W.c2), X as X.c2 > prev(X.c2), Y as Y.c2 < prev
(Y.c2), Z as Z.c2 > prev(Z.c2)) as T;

Pattern Matching Example



```
SELECT FIRST(x.time), LAST(z.time)
FROM ticker MATCH_RECOGNIZE (ONE ROW PER MATCH PARTITION
    BY name
        PATTERN (X+ Y+ W+ Z+)
        DEFINE X AS (price < PREV(price))
              Y AS (price > PREV(price))
              W AS (price < PREV(price))
              Z AS (price > PREV(price)))
```


Why NOT Complex Event Processing?

- > “I can do it in Java”
- > “I don’t need those kinds of data rates”
- > “My data is cached, so I can just query it”
- > “It’s too expensive”
- > “I just use JMS/JBI/BPM for my event-driven needs”

Why Complex Event Processing?

- > Writing temporal window-based queries is challenging and error-prone on Streaming Event Data
- > Data rates and volumes are on the rise
- > Query-based polling is compute intensive and very inefficient when there are no events
- > CEP systems provide a TCO benefit, just like any other server platform
- > Only CEP can provide rich queries *and* high performance

Complex Query Language - CQL

- > CQL is the emerging CEP Standard
 - | Pattern matching standard proposal submitted to ANSI SQL in 2008 jointly by IBM and Oracle
 - | Preparations currently underway for submitting the complete CQL extensions to ANSI
- > Developing a more formal (and complete) model
 - | Extend the rigor of the relational model to event stream processing
 - | Results in a more robust implementation with broader applications



Complex Event Performance

- > The data rates involved can be huge
 - | Oracle benchmark of 1m events / second
- > Important to discard meaningless data quickly
 - | Store and query simply not possible
- > In-memory caching of query results often required
 - | Event streams can be joined to caches
- > Performance can be radically affected by query complexity
 - | Query optimization is an import part of CEP

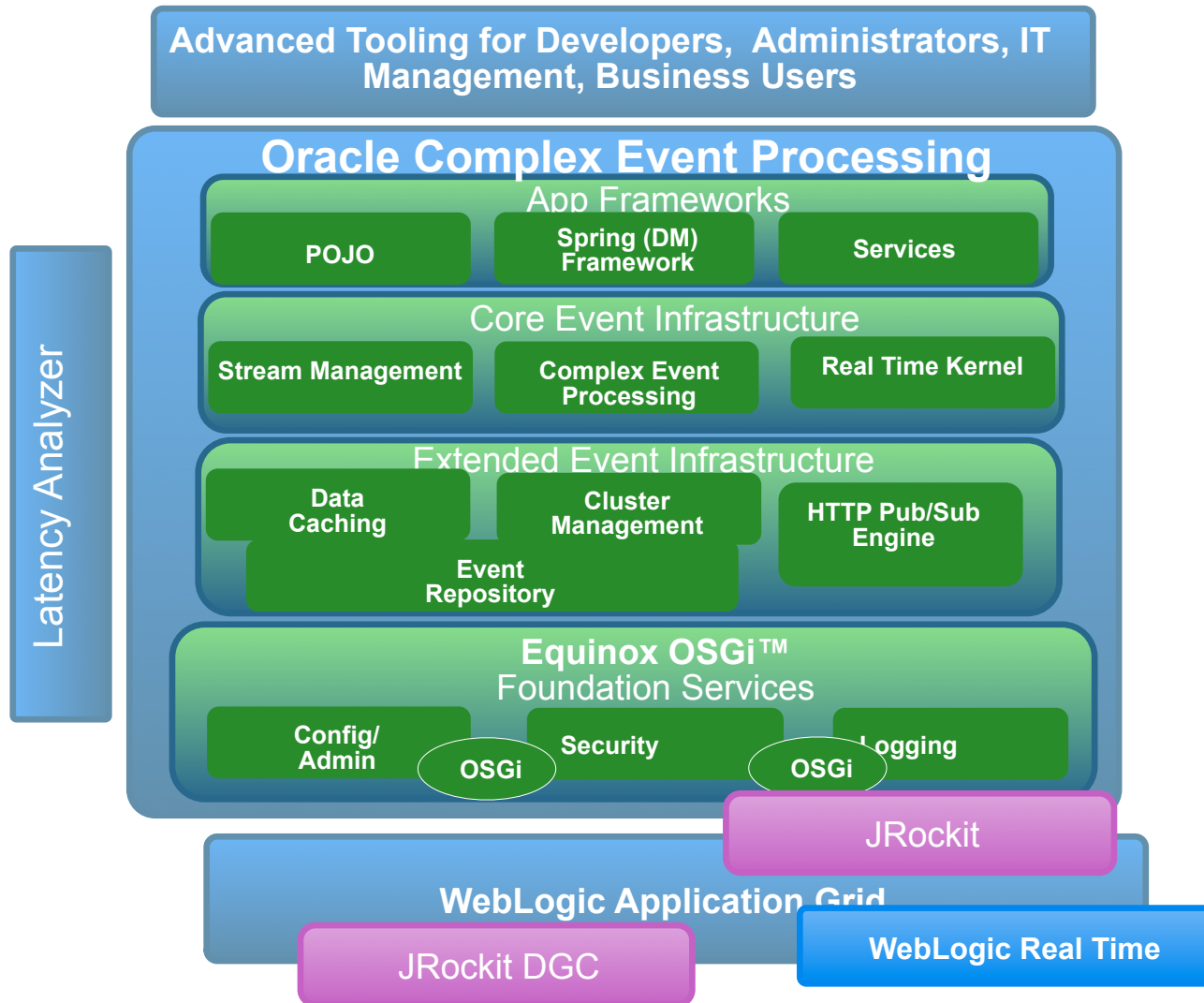
Complex Event Platform

- > A query engine is necessary but not sufficient
- > Applications always require integration
 - | Java libraries
 - | Java platforms
 - | e.g. Java EE
 - | Feeds and sinks
 - | e.g. JMS, HTTP, ESB, RMI, JDBC
- > Applications always require general purpose coding
 - | Sometimes you just need Java!

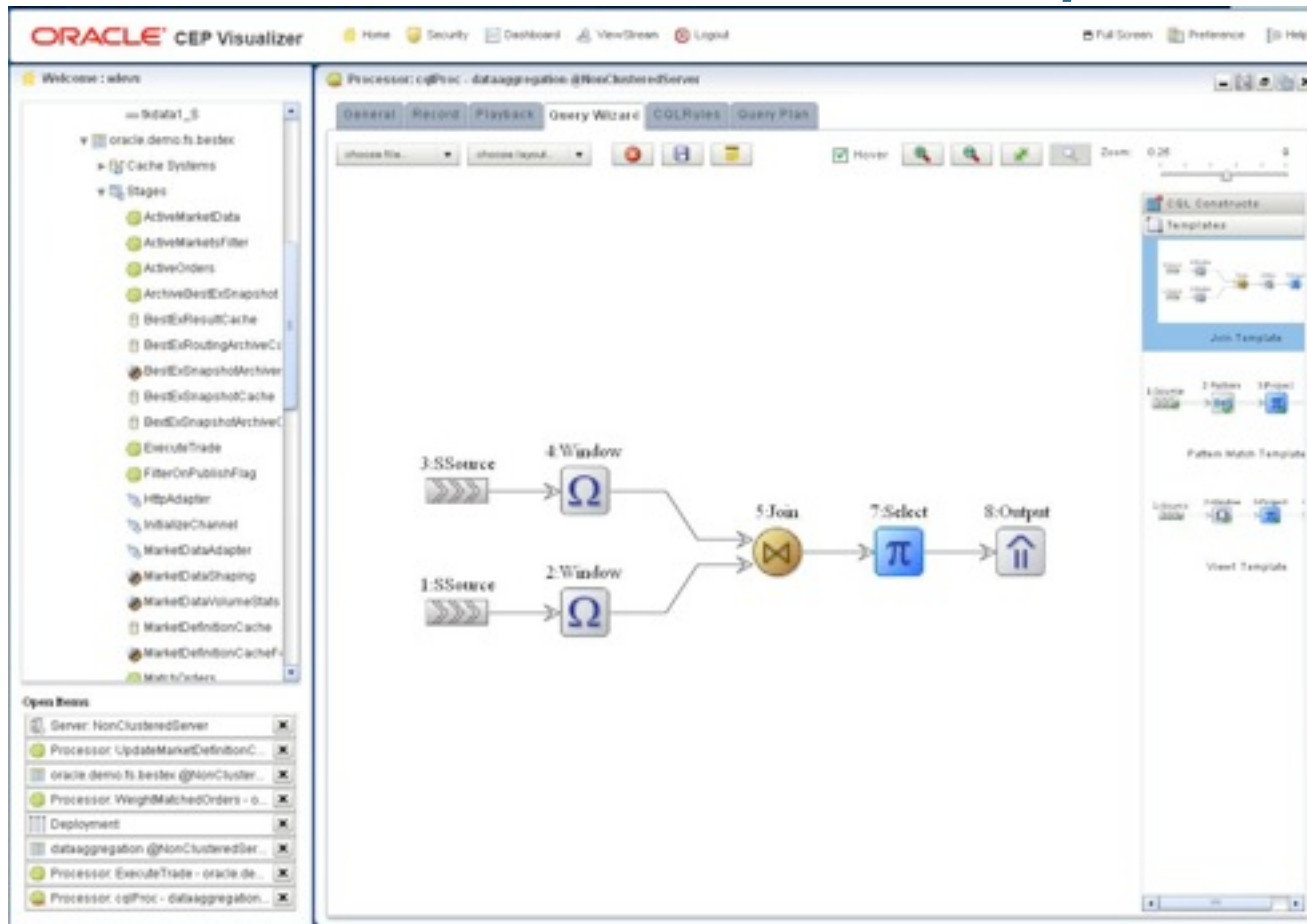
Complex Event Platform

- > Tooling is vital
 - | Seamless integration between Java and CQL
- > Management is vital
 - | Console support
 - | Performance & SLA monitoring
 - | BAM
- > Reliability, availability, serviceability and performance critical

Complex Event Platform Example



Complex Event Platform Example

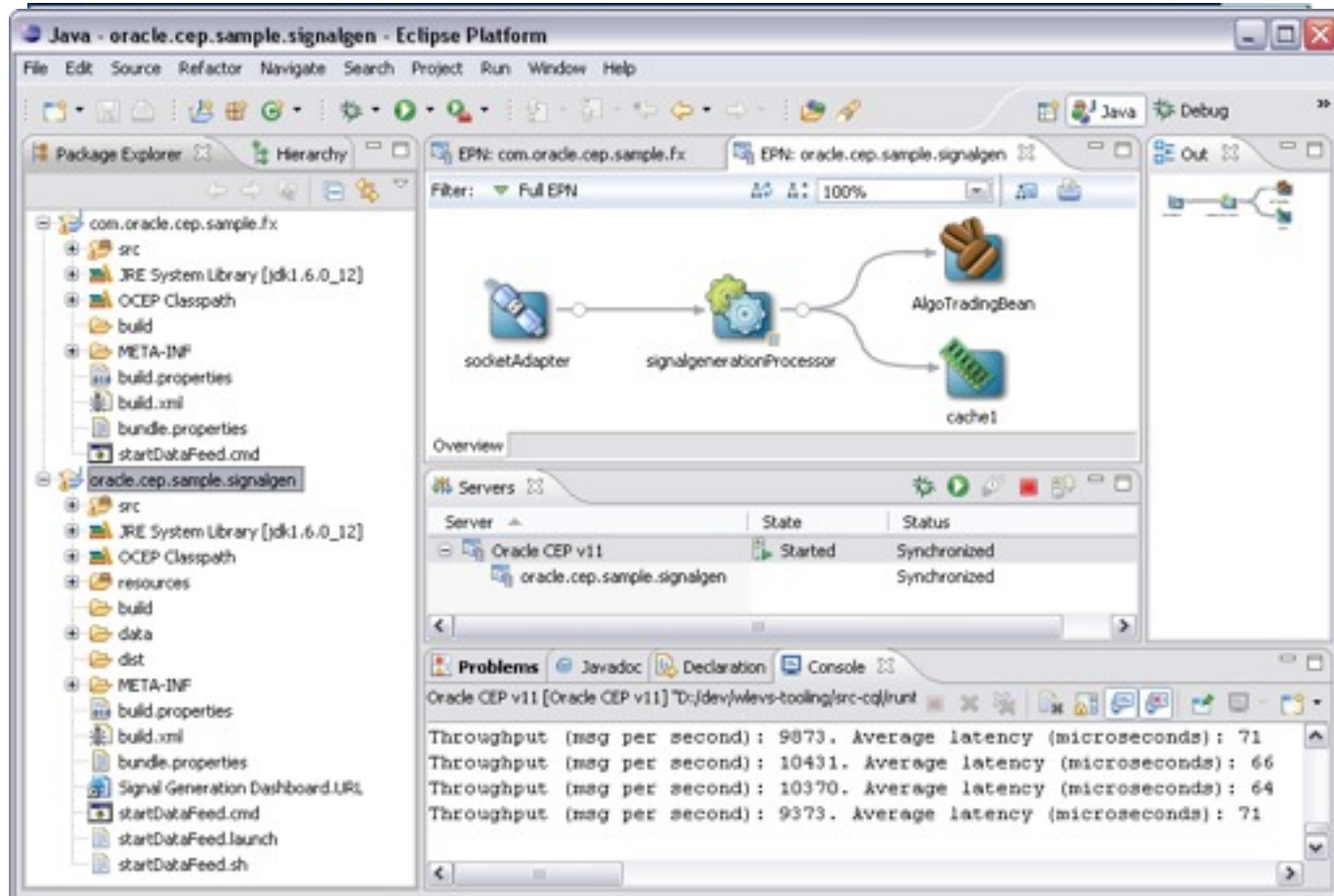


WebLogic Application Grid

JRockit DGC

WebLogic Real Time

Complex Event Platform Example



WebLogic Application Grid

JRockit DGC

WebLogic Real Time

EDA and Monitoring

Measuring the Business Impact of Events

- Ø **Monitor** business processes & services in real-time
 - Ø Key Performance Indicators (KPIs)
 - Ø Service-Level Agreements (SLAs)
- Ø **Analyze** events as they occur
 - Ø Correlate events & KPIs
 - Ø Identify trends as they emerge
 - Ø Alert users to bottlenecks & solutions
- Ø **Act** on current conditions
 - Ø Event-driven alerts
 - Ø Real-time dashboards
 - Ø BPEL processes & web services integration



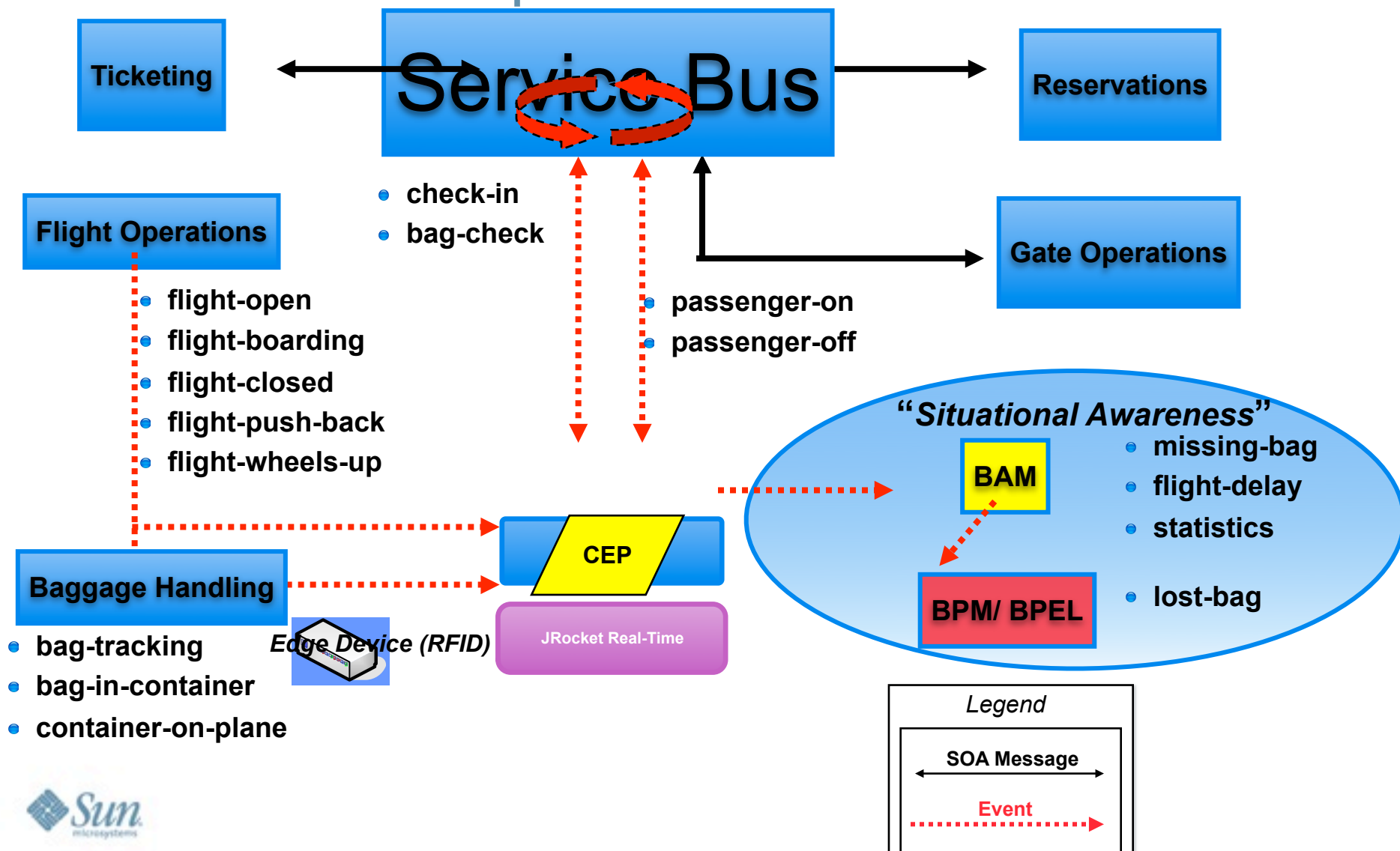
Complex Event HA

- > Some events *must* be preserved
 - | Sometimes inputs, usually outputs
- > Standard failover architectures not usually fast enough
 - | CEP is very stateful
 - | Requires active-active architecture
 - | Use cases dictate specifics
 - | For instance whether catch-up is required

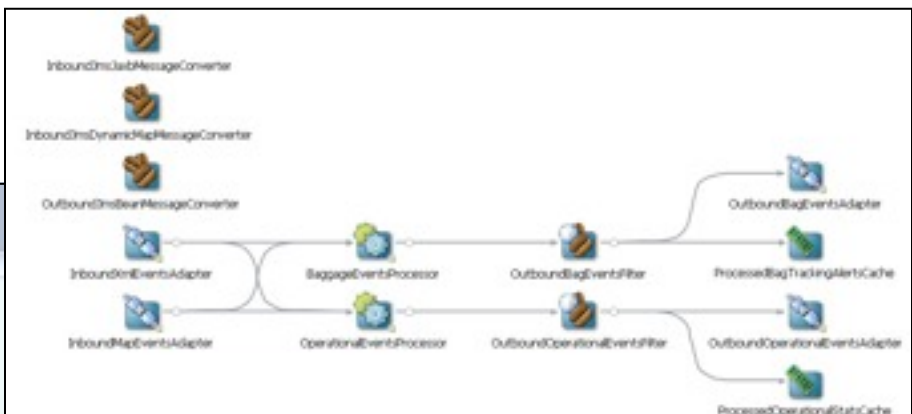
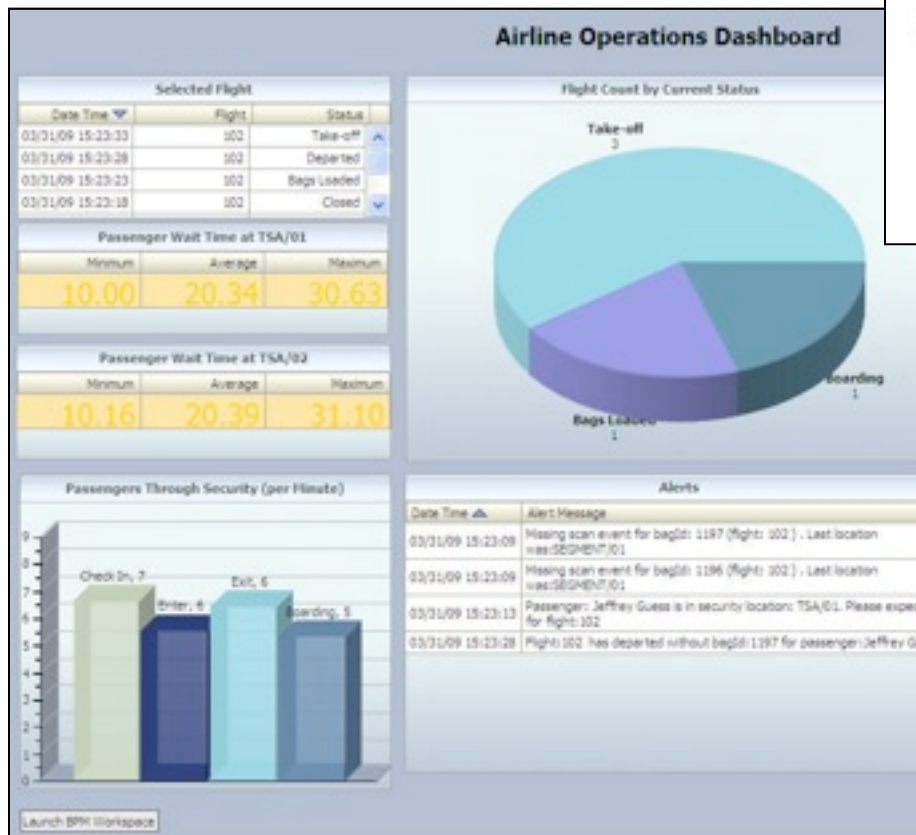
Many CEP Customer Use Cases

- > Border Security, Transportation Logistics
- > Dynamic Aircraft Maintenance
- > Realtime Slot Machine Usage “persuasion”
- > Online Fraud Detection
- > Smart Meters
- > Roadways Toll Management Systems
- > Intelligent Cable Box Management
- > Border Security, Transportation Logistics,

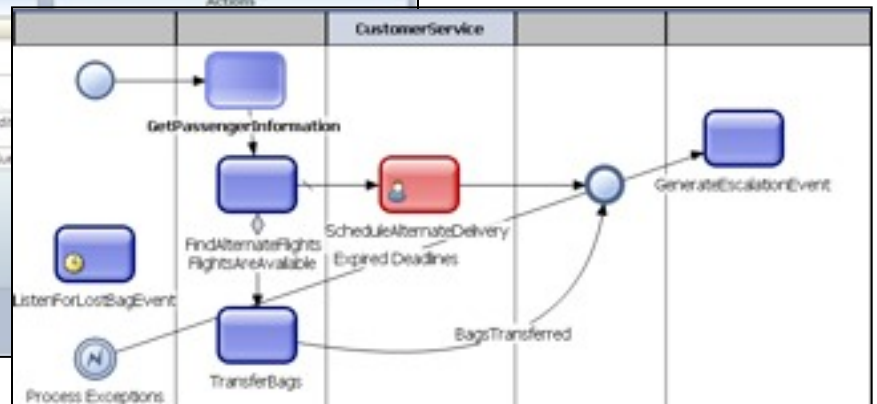
SOA and Event-Driven Architecture Airport Scenario



Airport Scenario

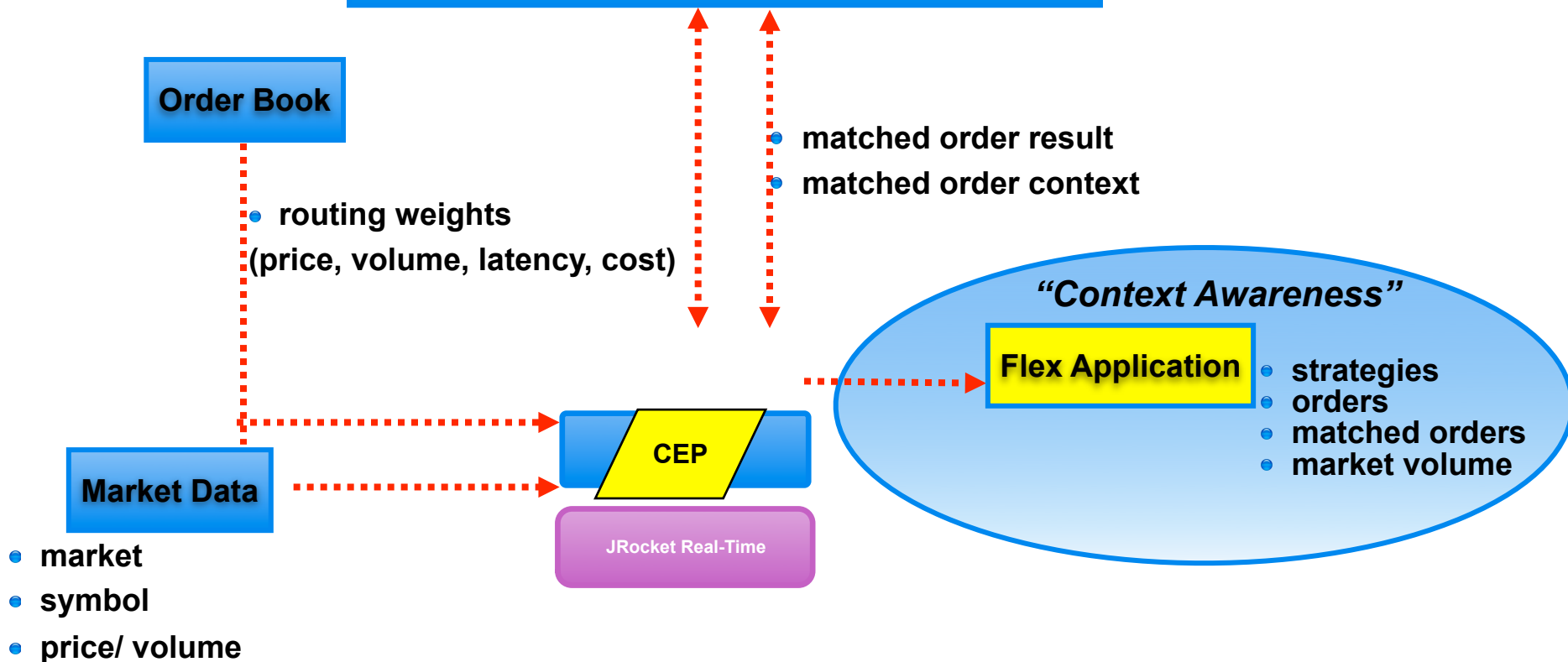


Date Time	Flight	Status
03/31/09 15:24:44	009	Open
03/31/09 15:24:36	007	Departed
03/31/09 15:24:34	008	Boarding
03/31/09 15:24:34	007	Bags Loaded
03/31/09 15:24:26	007	Closed
03/31/09 15:24:24	006	Take-off
03/31/09 15:24:24	007	Final
03/31/09 15:24:24	008	Open
03/31/09 15:24:15	006	Departed

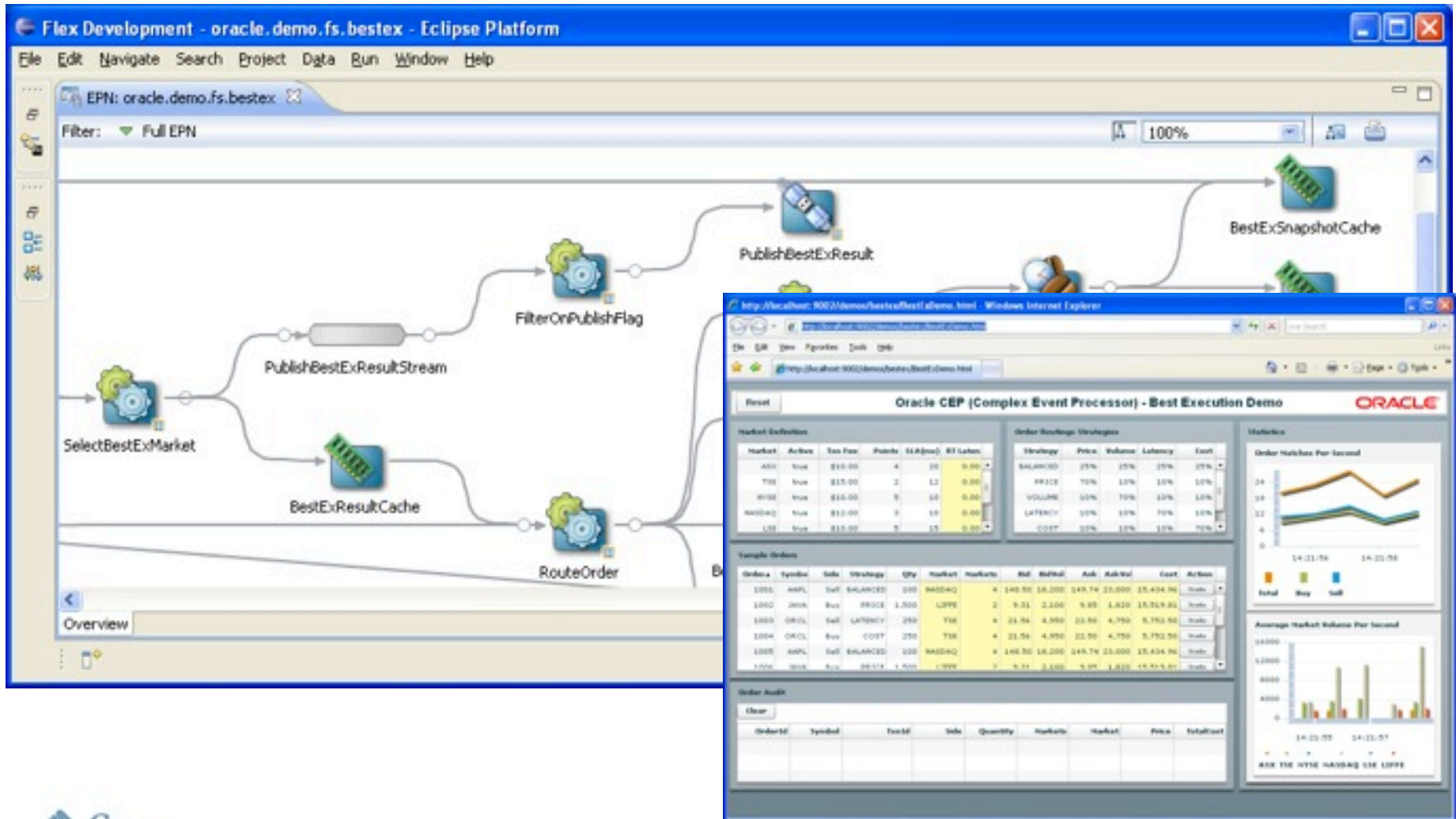


Data Grid and Event-Driven Architecture Best Execution Scenario

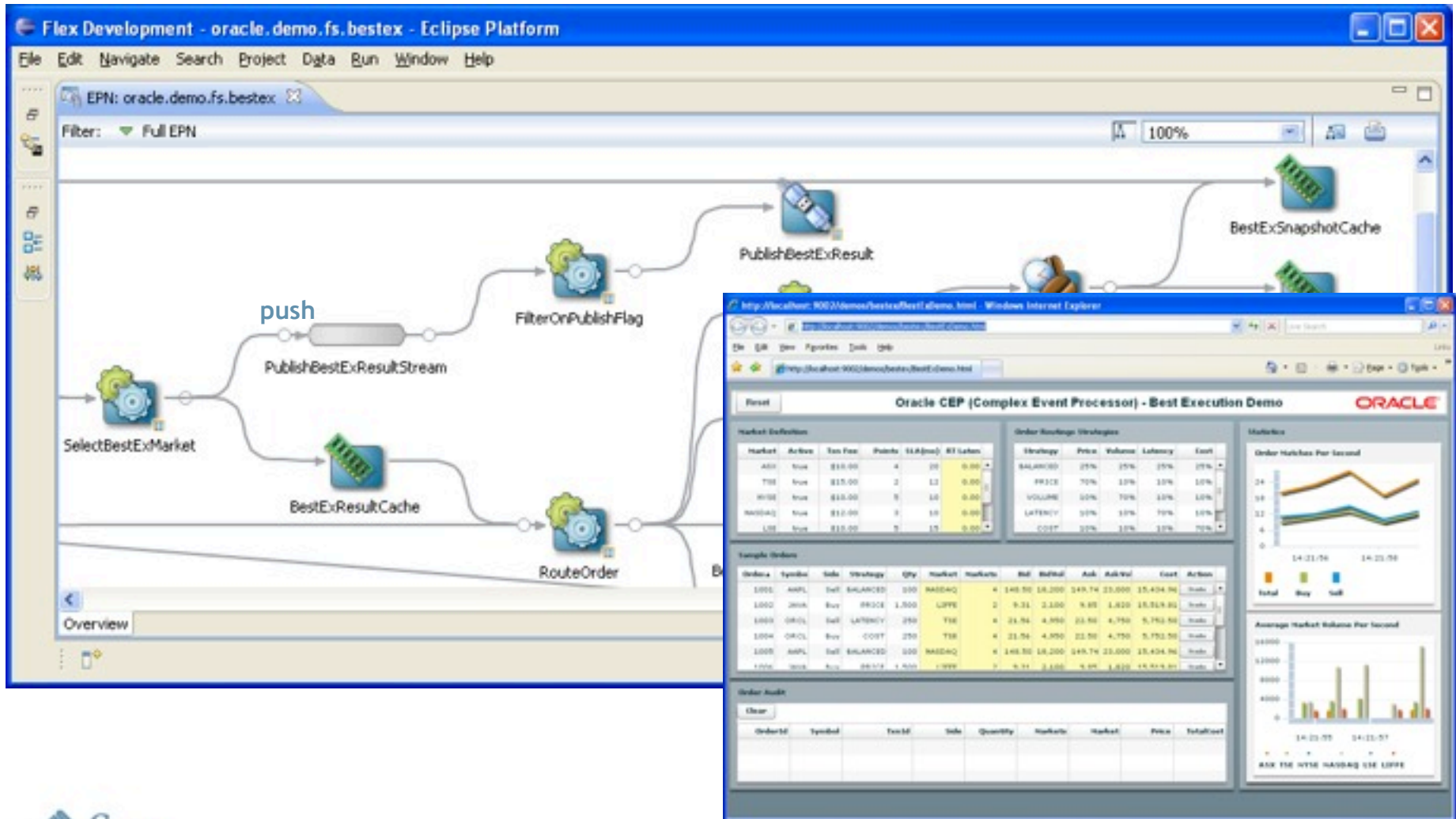
Oracle Coherence



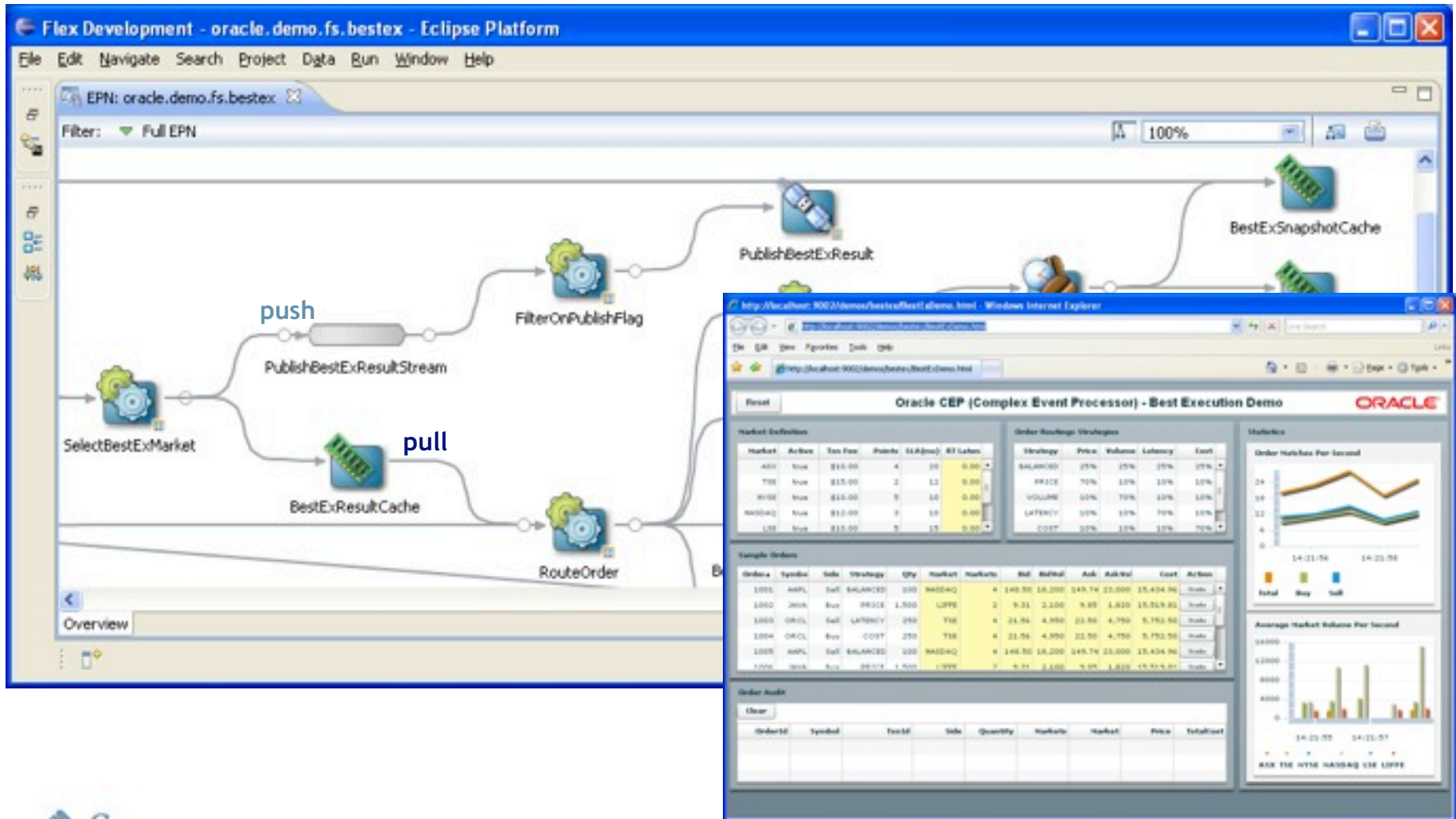
Best Execution Scenario



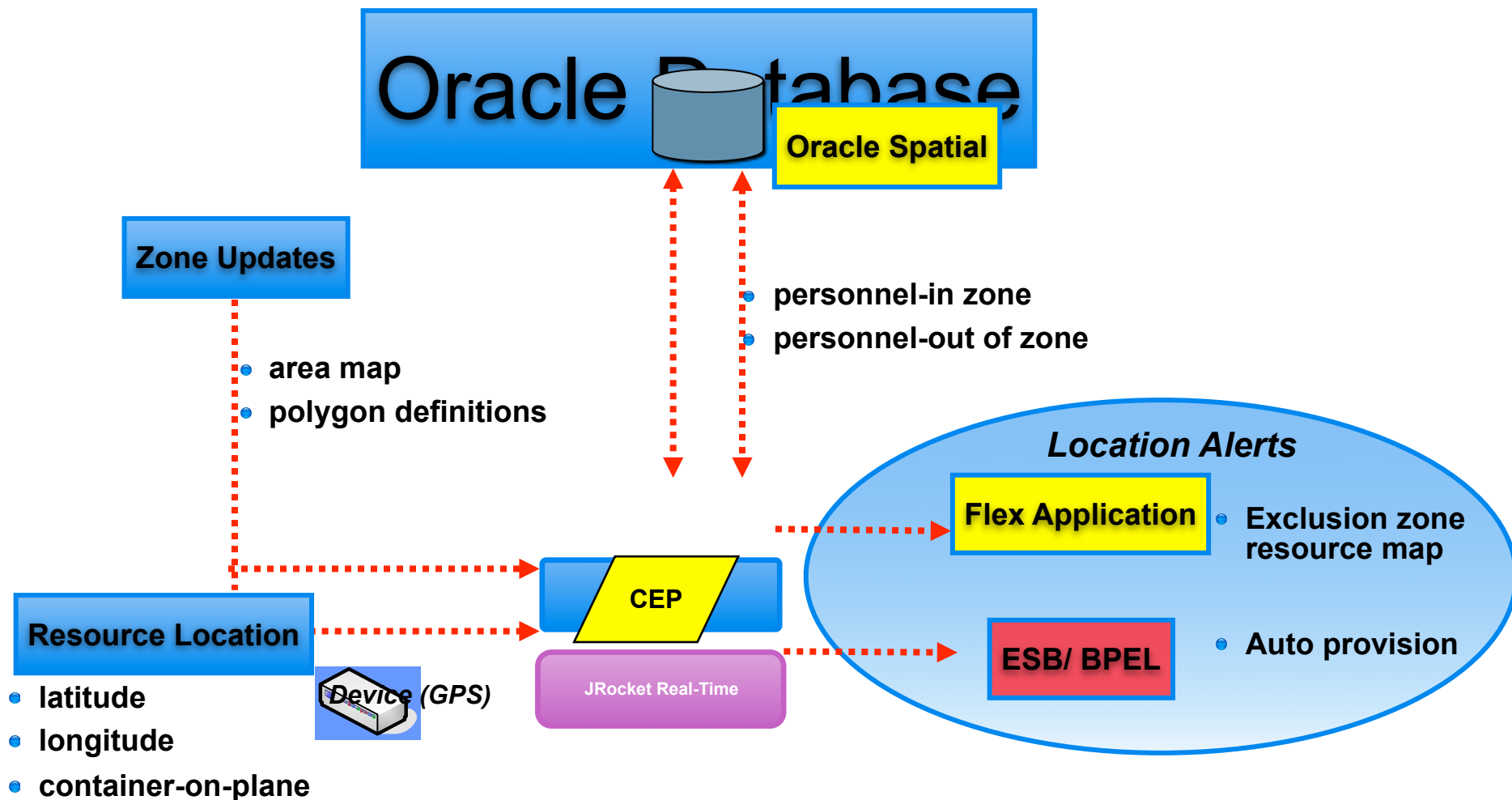
Best Execution Scenario



Best Execution Scenario



Database and Event-Driven Architecture Emergency Services Scenario



Emergency Services Scenario - DEMO

Refresh
Mark

Oracle Complex Event Processing (CEP) - Location Tracking POC

ORACLE

Resource	Zone	Type	EventId	LocationEvent
B	1	NEAR	2	4
A	1	NEAR	1	2

Resource	Zone	Type	EventId	LocationEvent
B	1	NEAR	2	4
A	1	NEAR	1	3

Id	Extime	Intime	EventId	Lat	Lng
C	00-Jan 24:00	15-Jan 20:46	5	53.4376	-2.9694
B	00-Jan 24:00	15-Jan 20:46	4	53.4395	-2.9668
A	00-Jan 24:00	15-Jan 20:46	3	53.4383	-2.9651
A	00-Jan 24:00	15-Jan 20:46	2	53.4382	-2.9634
B	00-Jan 24:00	15-Jan 20:46	1	53.4389	-2.9701


Id	LastUpdated	Name	Pver	Gver	Sides	Lat	Lng
1	00-Jan 24:00:00	Everton	3	3	9	53.4392	-2.9673
2	00-Jan 24:00:00	This is Anfield	1	1	89	53.4317	-2.9609

Emergency Services Scenario - DEMO

Oracle Complex Event Processing (CEP) - Location Tracking POC

Refresh Mark

ORACLE



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Zones

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Highlights Emergency Area (ZONES)

Alerts

Resource	Zone	Type	EventId	LocationEvent
B	1	NEAR	2	4
A	1	NEAR	1	2

Matches

Resource	Zone	Type	EventId	LocationEvent
B	1	NEAR	2	4
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Resource Events

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Refresh Mark

Lat: 53.4376 Lng: -2.9694

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Continuous monitoring of Resource Movements

Emergency Services Scenario - DEMO

Oracle Complex Event Processing (CEP) - Location Tracking POC

Refresh Mark

Lat:53.4376 Lng:-2.9694

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A	1	NEAR	1	2

Matches

Resource	Zone	Type	EventId	LocationEvent
B	1	NEAR	2	4
A	1	NEAR	1	3

Location Proximity CEP Analysis

Resource Events

Id	ExtTime	IntTime	EventId	Lat	Lng
C	00-Jan 24:00	15-Jan 20:46	5	53.4376	-2.9694
B	00-Jan 24:00	15-Jan 20:46	4	53.4395	-2.9668
	00-Jan 24:00	15-Jan 20:46	3	53.4383	-2.9651
A	00-Jan 24:00	15-Jan 20:46	2	53.4382	-2.9634
B	00-Jan 24:00	15-Jan 20:46	1	53.4389	-2.9701

Continuous monitoring of Resource Movements

Emergency Services Scenario - DEMO

Oracle Complex Event Processing (CEP) - Location Tracking POC

Refresh Mark

Lat:53.4376 Lng:-2.9694

Map data ©2009 Tele Atlas - Terms of Use

Zones

Id	LastUpdated	Name	Pver	Gver	Sides	Lat	Lng
1	00-Jan 24:00:00	Everton	3	3	9	53.4392	-2.9673
	00-Jan 24:00:00	This is Anfield	1	1	89	53.4317	-2.9609

Alerts

Resource	Zone	Type	EventId	LocationEvent
B	1	NEAR	2	4
A	1	NEAR	1	2

Matches

Resource	Zone	Type	EventId	LocationEvent
B	1	NEAR	2	4
A	1	NEAR	1	3

Resource Events

Id	ExtTime	IntTime	EventId	Lat	Lng
C	00-Jan 24:00	15-Jan 20:46	5	53.4376	-2.9694
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Highlights Emergency Area (ZONES)

Critical Proximity Alert Notification to Downstream

Location Proximity CEP Analysis

Continuous monitoring of Resource Movements

Complex Event Processing Vendors

- > Oracle
- > IBM
- > Microsoft
- > Sun
- > Streambase
- > Progress/Apama
- > Corel8/Aleri

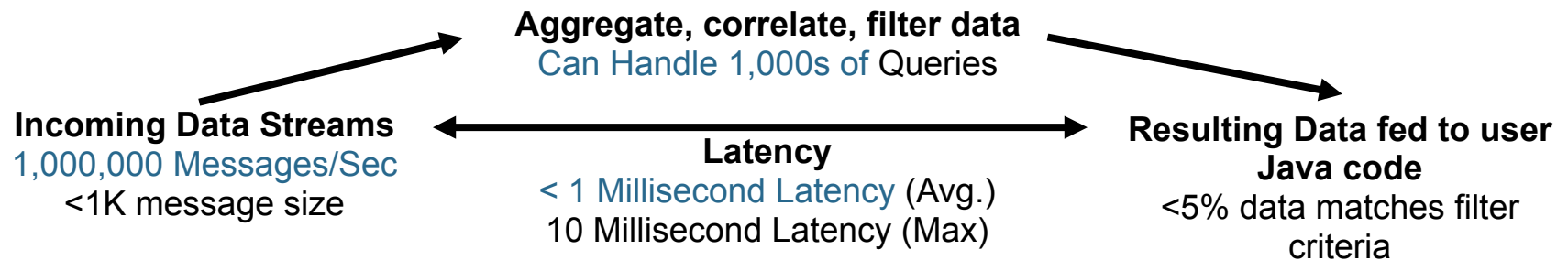
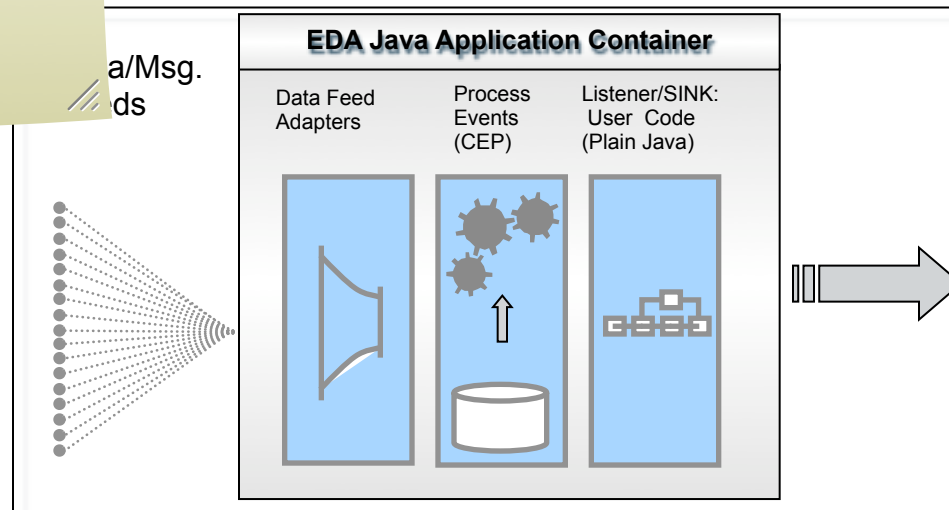
smcreyno 03/11/2008

Add Statistics from
Benchmark Study



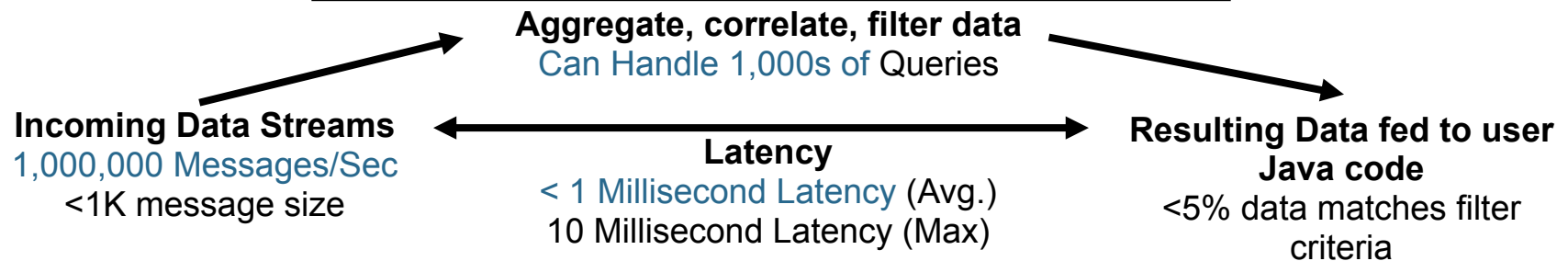
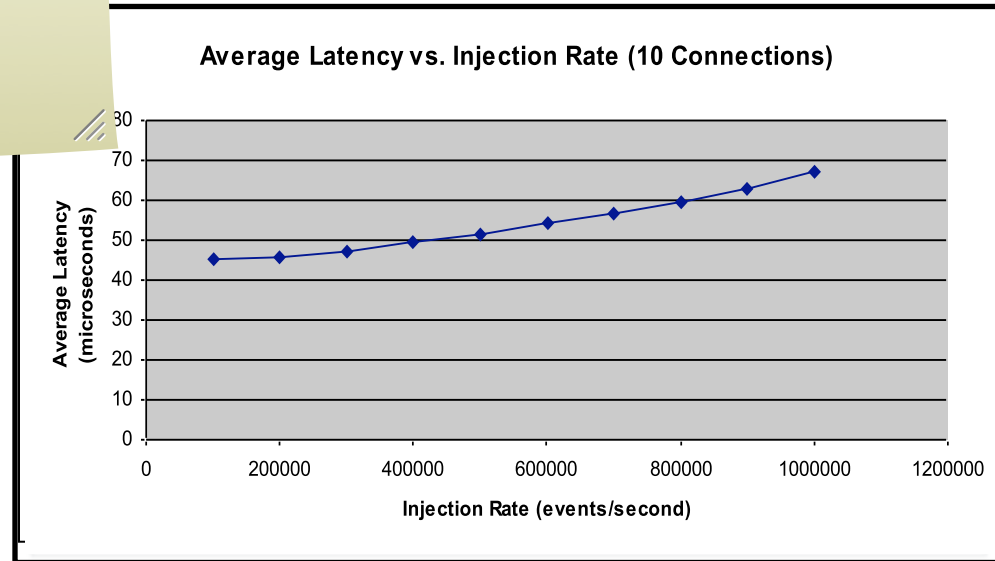
EDS - A Specialized Server for CEP

Extreme High Throughput, and Java-based



SP - A Specialized Server for CEP

Extreme High Throughput, and Java-based



Oracle CEP Value Proposition

- **Oracle CEP, is fast, standards based, has a comprehensive design time, monitoring & management capability and is strongly integrated with Coherence**
- **Integrated tightly with Oracle BAM, for Business User interrogation and visualization into Real Time processes, services and transactions**
- **Superior Oracle CEP integration with Oracle DB**
- **Hot pluggable with SOA Fusion Middleware Portfolio**
- **Oracle driving Event Language Standards Initiatives**
- **Deterministic, Real Time Lightweight EDA Java Application Server**
 - **Provided all of the value of a traditional JEE Container but built specifically for EDA/CEP**
 - **Supports parallel multi-thread processing and a performance level not possible with other vendors in the market on standard commodity H/W**

Q&A



JavaOne™

Thank You

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