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StreamReasoning
Reasoning Upon Rapidly Changing Information

VU VRIJE UNIVERSITEIT AMSTERDAM

Stream and Complex Event Processing
Discovering Existing Systems: esper

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Agenda

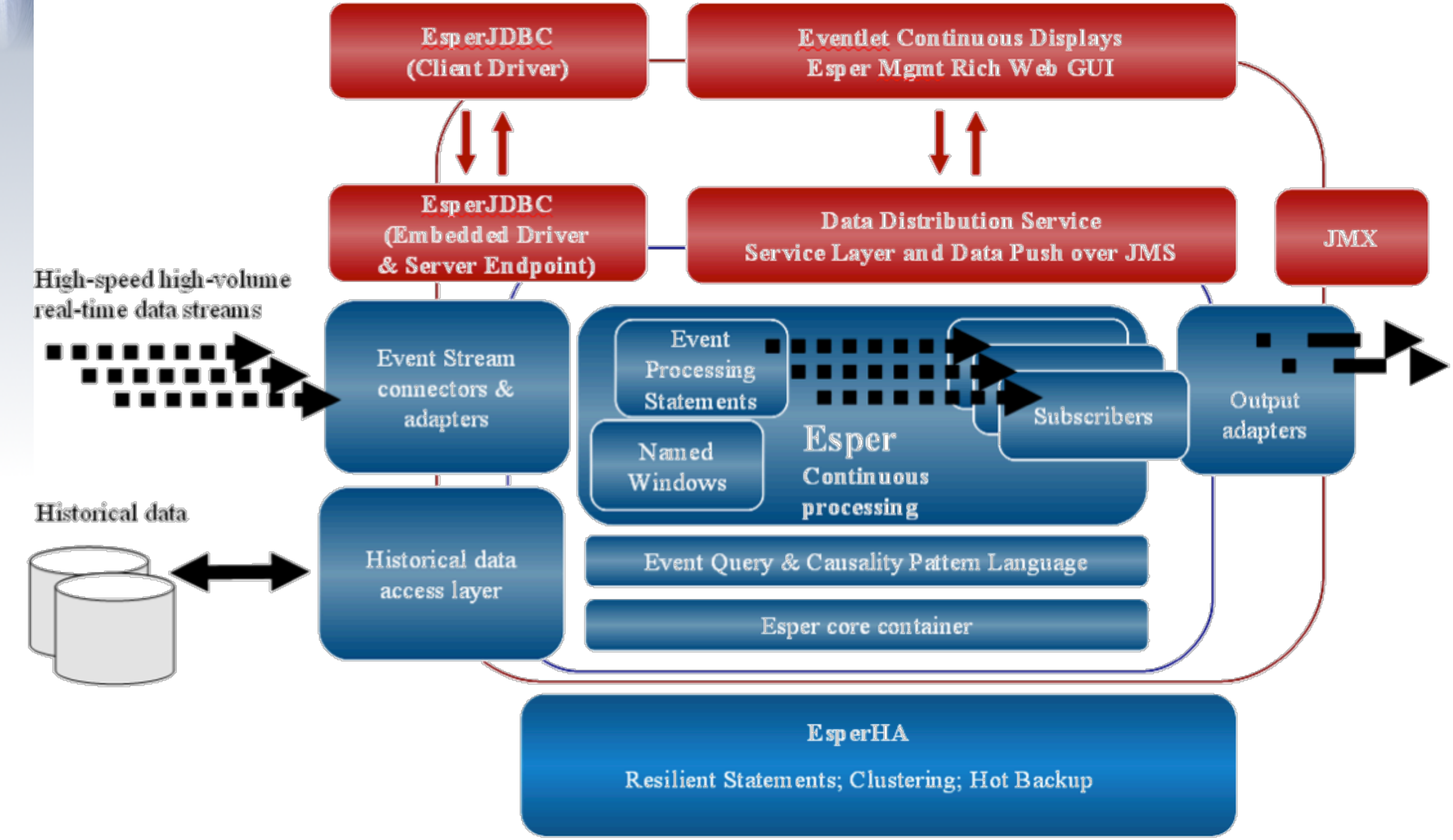
- Introduction
- Describing Events
- Event Stream Analysis
- Event Pattern Matching
- Combinations
- Resources

Esper

- Motto
  - EsperTech’s Event Stream and Complex Event Processing software turns large volume of disparate real-time event streams into actionable intelligence.
- Esper
  - Event Processing for Java
- Nesper
  - Event Processing for .Net

Introduction

Esper Architecture



Esper Features at a glance 1/4

- Efficient Event Processing
  - Continuous queries, filtering, aggregations, joins, sub-queries
  - Comprehensive pattern detection
  - Pull and Push
  - High performance, low latency

Esper Features at a glance 2/4

- Extensible Middleware
  - Java, .Net, Array, Map or XML events
  - Runtime statement management
  - API or configuration driven
  - Plug-in SDK for functions, aggregations, views and pattern detection extensions
  - Adapters: CSV, JMS in/out, API, DB, Socket, HTTP
  - Runtime management, operational visibility, interoperability
  - Data distribution service for data push management and service layer

Introduction

Esper Features at a glance 3/4

- Rich Web-Based User Interface
    - Real-time event displays: Eventlet technology allows customizable and interactive continuous displays
    - CEP engine management
    - Design EPL Statements
    - Drill-down and browser script
    - integration

Esper Features at a glance 4/4

- HA enabled (EsperHA)
  - Per statement configuration
  - Transient combinable with fully resilient behaviour
  - Hot standby API, hot backup
  - Highly optimized and fast data storage technology
  - Engine state RDBMS storage option

Event Stream and Complex Event Processing

- Design continuous queries and complex causality relationships between disparate event streams with an expressive Event Processing Language (EPL).
- EPL statements are registered into (N)Esper and continuously executed as live data streams are pushed through.

Rapid development and deployments

- EPL has a "SQL look alike”
- EPL statement matches trigger plain Java or .Net/C# objects for real-time customized actionable intelligence.
- (N)Esper is pure Java/.Net and can run standalone or embedded into existing middleware systems (application servers, services bus, in- house systems).

Running Example

- Count the number of fires detected using a set of smoke and temperature sensors in the last 10 minutes
- Events
  - Smoke Event: String sensor, boolean state
  - Temperature Event: String sensor, double temperature
  - Fire Event: String sensor, boolean smoke, double temperature
- Condition:
  - Fire: at the same sensor smoke followed by temperature>50

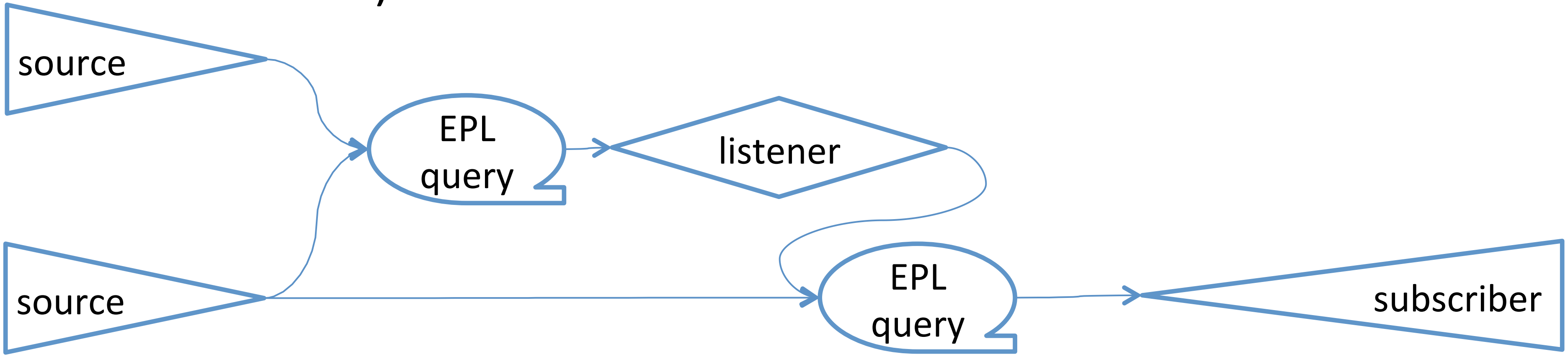
Query Processing Model in Esper 1/2

- The Esper processing model is continuous
- Four abstractions
  - Sources
    - Push based
    - Data tuples from sensors, trace files, etc.
  - Registered EPL Queries
    - Push Based
    - Continuously executed against the events produced by the sources
  - Listeners
    - Receive data tuples from queries
    - Push data tuples to other queries
  - Subscribers
    - Receive processed data tuples

Introduction

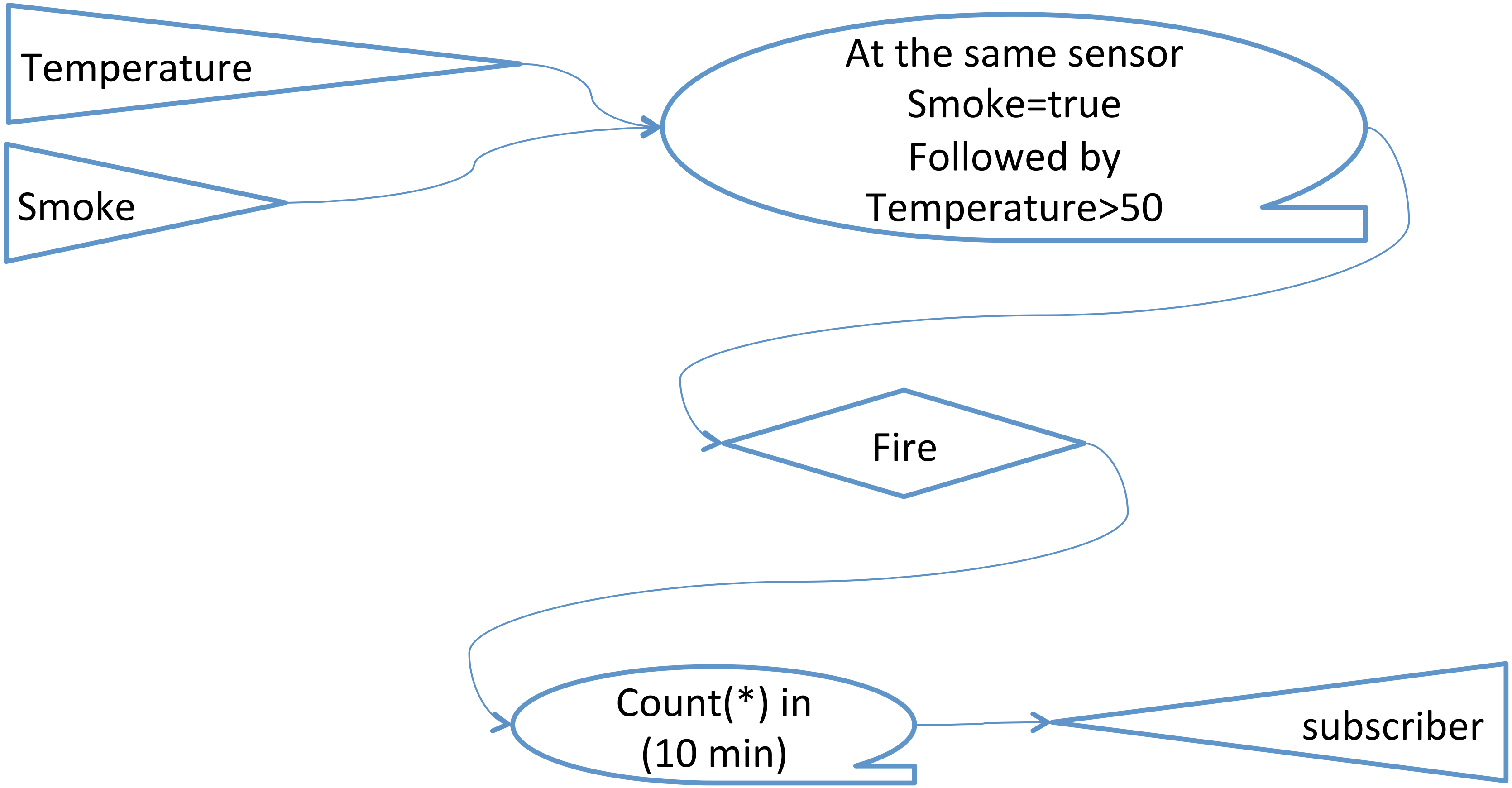
Query Processing Model in Esper 2/2

- Sources, queries, listeners and subscribers are manually connected to form graphs
  - Sources act as input
  - Subscribers act as output
  - EPL Queries integrate sources
  - Listeners propagates query results (they act internal sources)



Introduction

Graph for the running example



Temperature

Smoke

At the same sensor
Smoke=true
Followed by
Temperature>50

Fire

Count(*) in
(10 min)

subscriber

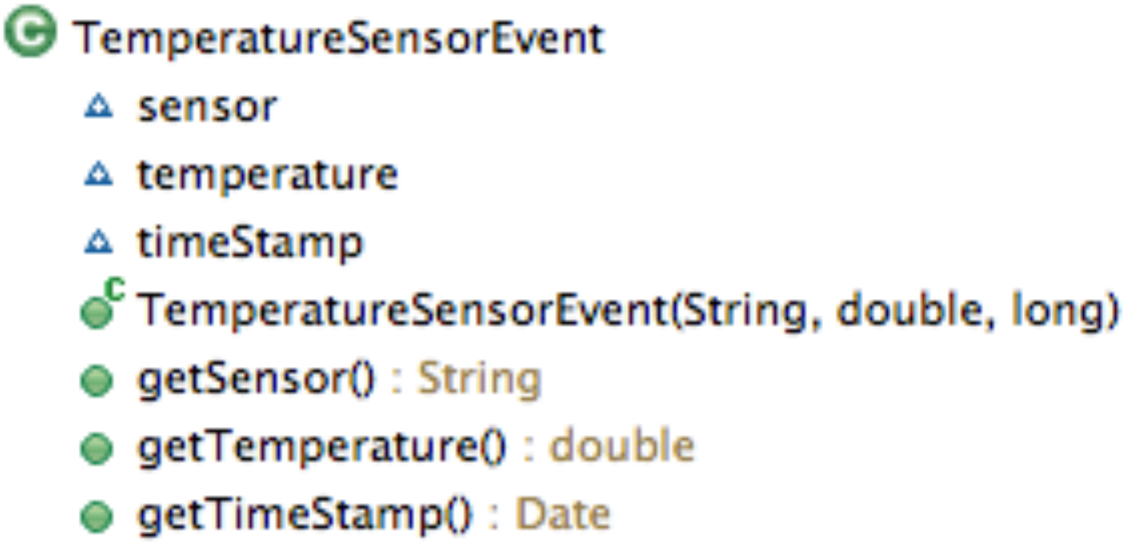
Describing events

- Possible methods:
  - Java classes, Maps, XML, EPL
- Java classes are a simple, rich and versatile way to represent events in Esper.
  - Follow JavaBeans-style getter methods and property names

Method	Property Name
getQ()	q
getQN()	qn

Describing events

Temperature event for the running example

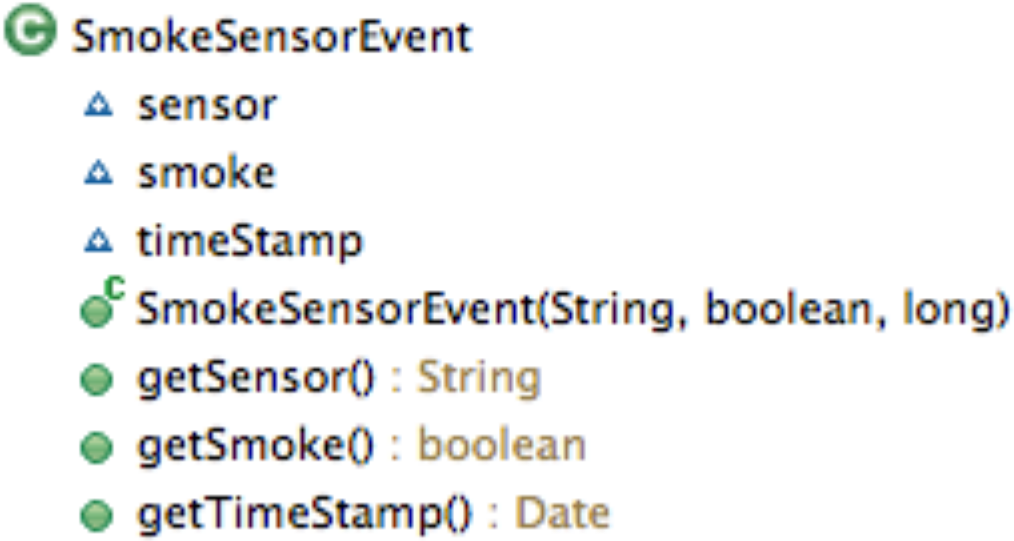


TemperatureSensorEvent
- sensor
- temperature
- timeStamp
- TemperatureSensorEvent(String, double, long)
- getSensor() : String
- getTemperature() : double
- getTimeStamp() : Date

- Note: in this and in the following examples the timeStamp property is not necessary

Describing events

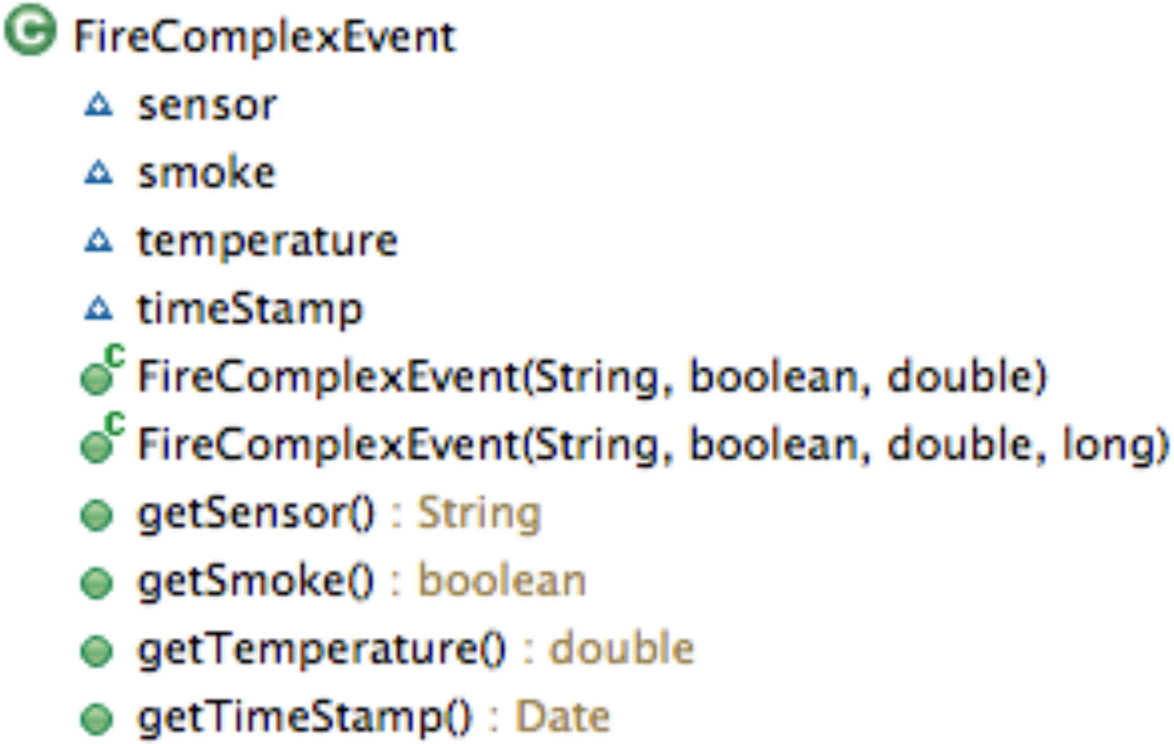
Smoke event for the running example



SmokeSensorEvent
- sensor
- smoke
- timeStamp
- SmokeSensorEvent(String, boolean, long)
- getSensor() : String
- getSmoke() : boolean
- getTimeStamp() : Date

Describing events

Fire event for the running example



FireComplexEvent
- sensor
- smoke
- temperature
- timeStamp
- FireComplexEvent(String, boolean, double)
- FireComplexEvent(String, boolean, double, long)
- getSensor() : String
- getSmoke() : boolean
- getTemperature() : double
- getTimeStamp() : Date

Describing events

Declaring an event type via the create schema

- EPL allows declaring an event type via the *create schema clause* and also by means of the static or runtime configuration API *addEventType* functions.
- Syntax
  - create schema *schema_name* [as] (*property_name property_type* [,*property_name property_type* [,...]]) [inherits *inherited_event_type*[, *inherited_event_type*] [,...]]
- Example
  - create schema FireComplexEvent (sensor string, smoke boolean, temperature double);

Event Stream Analysis

Event Processing Language (EPL)

- EPL statements
  - derive and aggregate information from one or more streams of events,
  - to join or merge event streams, and
  - to feed results from one event stream to subsequent statements.

Event Processing Language (EPL)

- EPL is similar to SQL in its use of the *select* clause and the *where* clause.
- EPL statements instead of tables use event streams and a concept called *views*.
- Views are similar to tables in an SQL statement
  - They define the data available for querying and filtering.
  - They can represent windows over a stream of events.
  - They can also sort events, derive statistics from event properties, group events or handle unique event property values.

EPL Syntax

[insert into *insert_into_def*]
select *select_list*
from *stream_def* [as name] [, *stream_def* [as name]] [,...]

[where *search_conditions*]
[group by *grouping_expression_list*]
[having *grouping_search_conditions*]
[output *output_specification*]
[order by *order_by_expression_list*]
[limit *num_rows*]

Event Stream Analysis

Simple examples

- Look for specific events

  -
    ```
    select * from SensorEventStream
    where temperature>50
    ```
- Aggregate several events

  -
    ```
    select avg(temperature) from SensorEventStream
    ```
- Joining two streams

  -
    ```
    select Tstream.sensor, Tstream.temperature,
               Sstream.smoke
    from TemperatureEventStream as Tstream,
             SmokeEventStream as Sstream
    where Tstream.sensor = Sstream.sensor and
               Tstream.temperature>50 and
               Sstream.smoke=true
    ```

Event Stream Analysis

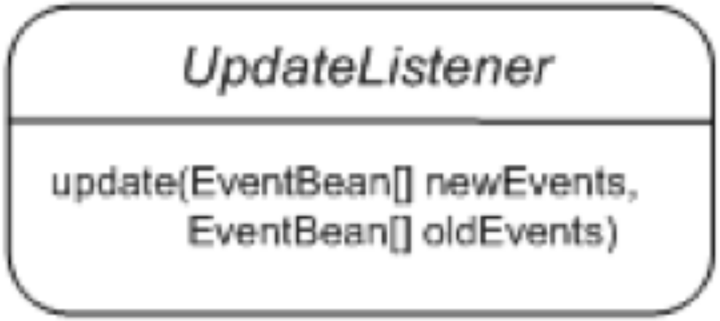
The EPL alone is not enough …

```
Configuration cepConfig = new Configuration();
cepConfig.addEventType("TemperatureEventStream",
                       TemperatureSensorEvent.class.getName());
cepConfig.addEventType("SmokeEventStream",
                             SmokeSensorEvent.class.getName());
String query = "<<any of the three in the previous slide>>";
EPServiceProvider cep =
   EPServiceProviderManager.getProvider("myCEP", cepConfig);
EPRuntime cepRT = cep.getEPRuntime();
EPAdministrator cepAdm = cep.getEPAdministrator();
EPStatement cepStatement = cepAdm.createEPL(query);
cepStatement.addListener(new CEPListener());
```

See also HelloWorldEsper in the Esper ready to go pack on the course Website

Listening to EPL query results 1/3

The interface for listeners is com.espertech.esper.client.UpdateListener. Implementations must provide a single update method that the engine invokes when results become available

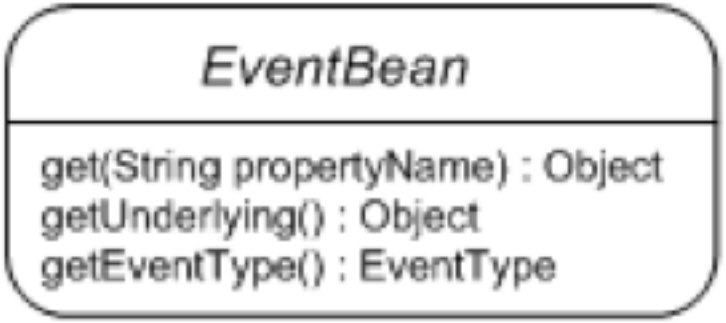


UpdateListener

```
update(EventBean[] newEvents,
         EventBean[] oldEvents)
```

Listening to EPL query results 2/3

- The engine provides statement results to update listeners by placing results in com.espertech.esper.client.EventBean instances. A typical listener implementation queries the EventBean instances via getter methods to obtain the statement-generated results.



EventBean

get(String propertyName) : Object
getUnderlying() : Object
getEventType() : EventType

Listening to EPL query results 3/3

For instance, the following code prints each new event received

```
public class CEPListener implements UpdateListener {
  public void update(EventBean[] newData,
                                   EventBean[] oldData) {
    for (EventBean e : newData) {
        System.out.println("Event received: " + e.getUnderlying());
    }
  }
}
```

NOTE: similar code can be used to access the events that are exiting the window (oldData), see also next slides.

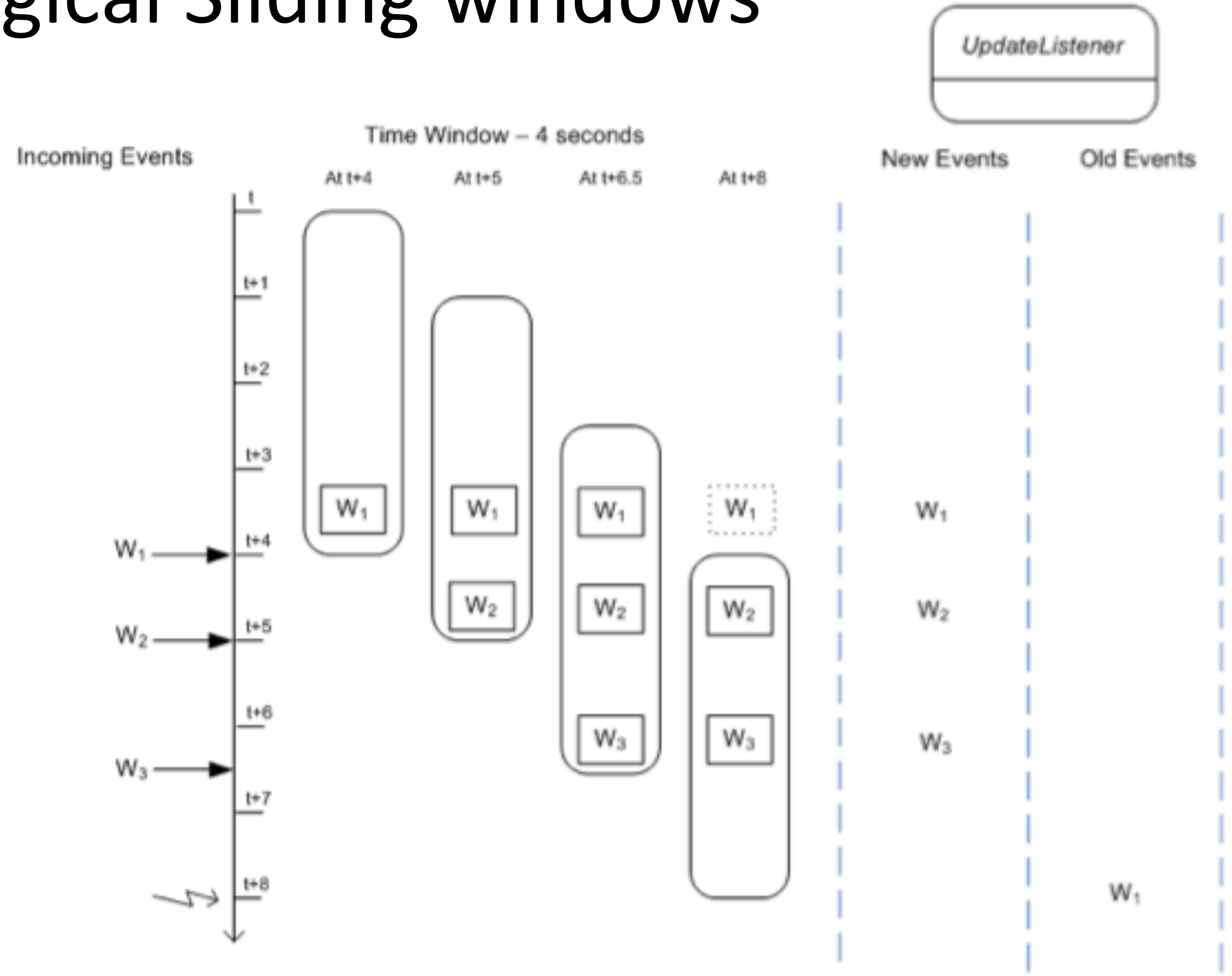
Event Stream Analysis

Windows

Type	Syntax	Description
Logical Sliding	win:time(*time period*)	Sliding time window extending the specified time interval into the past.
Logical Tumbling	win:time_batch(*time period*[,*optional reference point*] [, *flow control*])	Tumbling window that batches events and releases them every specified time interval, with flow control options.
Physical Sliding	win:length(*size*)	Sliding length window extending the specified number of elements into the past.
Physical Tumbling	win:length_batch(*size*)	Tumbling window that batches events and releases them when a given min- imum number of events has been col- lected.

Event Stream Analysis

Logical Sliding windows



Logical Sliding windows: example

- Query

  select avg(temperature)
  from TemperatureEventStream.win:time(4 sec)

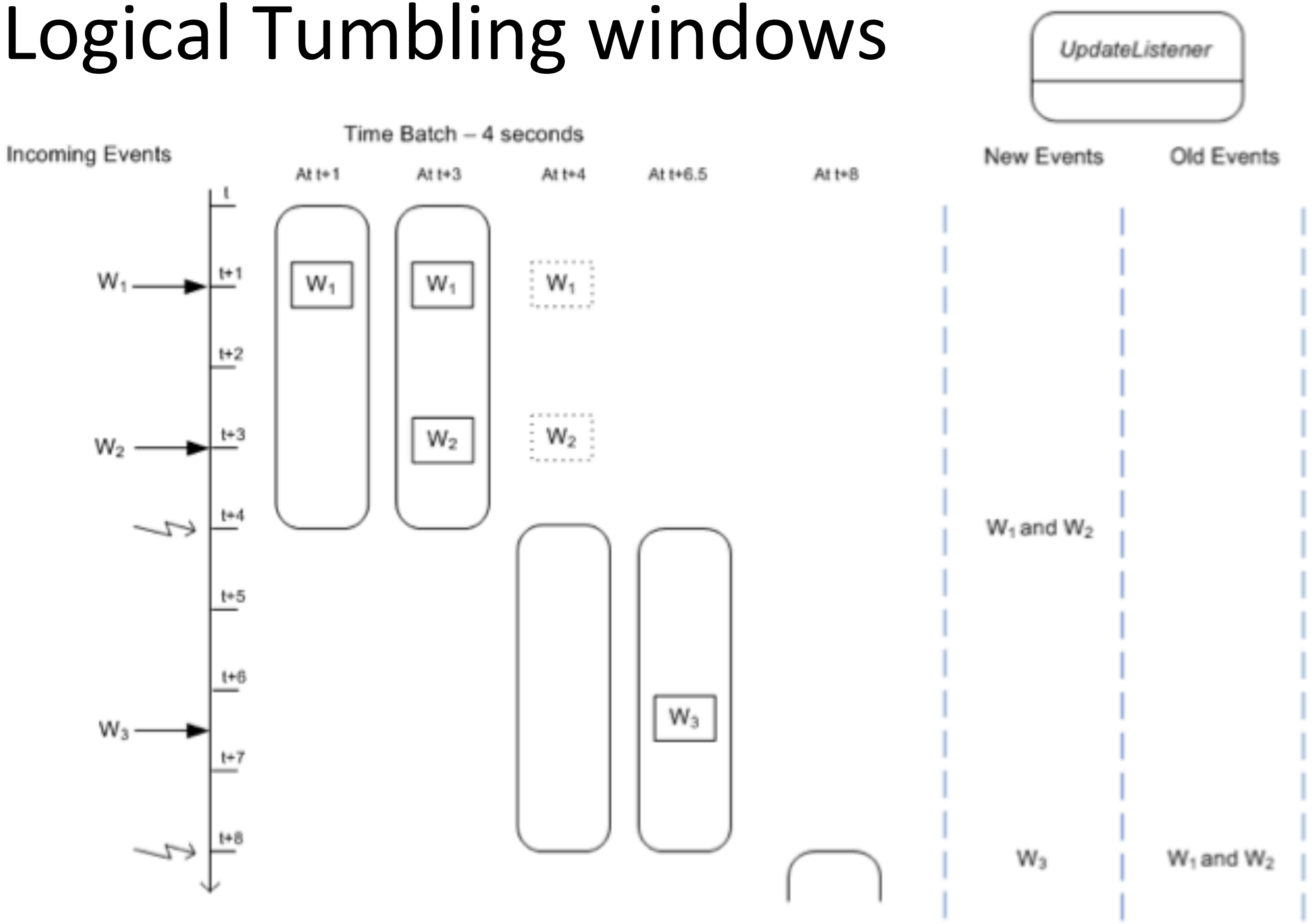
- Execution trace

```
Sending Event:[S1|24.0|Mon Apr 29 13:05:44 CEST 2013]
Event received: {avg(temperature)=24.0}
Sending Event:[S1|55.0|Mon Apr 29 13:05:45 CEST 2013]
Event received: {avg(temperature)=39.5}
Sending Event:[S0|1.0|Mon Apr 29 13:05:46 CEST 2013]
Event received: {avg(temperature)=26.666666666666668}
Sending Event:[S1|81.0|Mon Apr 29 13:05:47 CEST 2013]
Event received: {avg(temperature)=40.25}
Event received: {avg(temperature)=45.666666666666664}
Sending Event:[S0|20.0|Mon Apr 29 13:05:48 CEST 2013]
Event received: {avg(temperature)=39.25}
Event received: {avg(temperature)=34.0}
```

```
Sending Event:[S0|915.0|Mon Apr 29 13:05:49 CEST 2013]
Event received: {avg(temperature)=254.25}
Event received: {avg(temperature)=338.6666666666667}
Event received: {avg(temperature)=467.5}
Event received: {avg(temperature)=915.0}
Event received: {avg(temperature)=null}
Sending Event:[S0|30.0|Mon Apr 29 13:05:54 CEST 2013]
Event received: {avg(temperature)=30.0}
```

Esper, when using logical sliding windows, reports as soon as a new event arrives and an old one expires

Logical Tumbling windows



Event Stream Analysis

Logical Tumbling windows: example

- Query

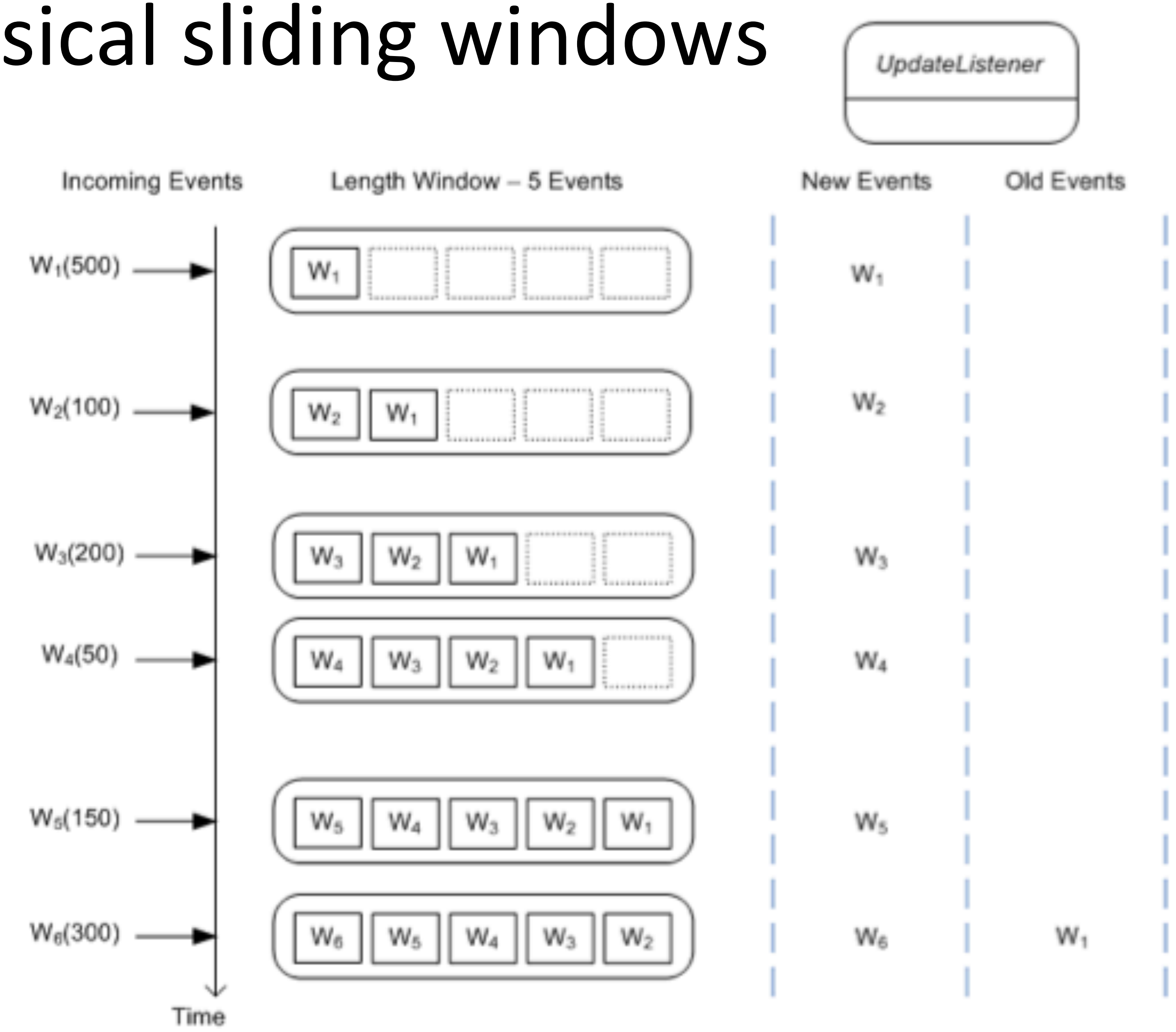
```
select avg(temperature)
from TemperatureEventStream.win:time_batch(4 sec)
```

- Execution trace

```
Sending Event:[S1|42.0|Mon Apr 29 13:31:44 CEST 2013]
Sending Event:[S1|55.0|Mon Apr 29 13:31:45 CEST 2013]
Sending Event:[S1|10.0|Mon Apr 29 13:31:46 CEST 2013]
Sending Event:[S1|25.0|Mon Apr 29 13:31:47 CEST 2013]
Event received: {avg(temperature)=33.0}
Sending Event:[S0|23.0|Mon Apr 29 13:31:48 CEST 2013]
Sending Event:[S1|276.0|Mon Apr 29 13:31:49 CEST 2013]
Event received: {avg(temperature)=149.5}
Sending Event:[S0|76.0|Mon Apr 29 13:31:54 CEST 2013]
Sending Event:[S0|20.0|Mon Apr 29 13:31:55 CEST 2013]
Event received: {avg(temperature)=48.0}
Sending Event:[S0|97.0|Mon Apr 29 13:31:56 CEST 2013]
Sending Event:[S0|59.0|Mon Apr 29 13:31:57 CEST 2013]
Event received: {avg(temperature)=78.0}
```

Esper, when using logical tumbling windows, reports only when the window closes

Physical sliding windows



Event Stream Analysis

Physical sliding windows: example

- Query

```
select avg(temperature)
from TemperatureEventStream.win:length(5)
```

- Execution trace

```
Sending Event:[S1|6.0|Mon Apr 29 13:35:50 CEST 2013]
Event received: {avg(temperature)=6.0}
Sending Event:[S0|48.0|Mon Apr 29 13:35:51 CEST 2013]
Event received: {avg(temperature)=27.0}
Sending Event:[S0|23.0|Mon Apr 29 13:35:52 CEST 2013]
Event received: {avg(temperature)=25.666666666666668}
Sending Event:[S1|89.0|Mon Apr 29 13:35:53 CEST 2013]
Event received: {avg(temperature)=41.5}
Sending Event:[S0|54.0|Mon Apr 29 13:35:54 CEST 2013]
Event received: {avg(temperature)=44.0}
Sending Event:[S0|877.0|Mon Apr 29 13:35:55 CEST 2013]
Event received: {avg(temperature)=218.2}
```

```
Sending Event:[S1|42.0|Mon Apr 29 13:36:00 CEST 2013]
Event received: {avg(temperature)=217.0}
Sending Event:[S1|7.0|Mon Apr 29 13:36:01 CEST 2013]
Event received: {avg(temperature)=213.8}
Sending Event:[S0|23.0|Mon Apr 29 13:36:02 CEST 2013]
Event received: {avg(temperature)=200.6}
Sending Event:[S0|10.0|Mon Apr 29 13:36:03 CEST 2013]
Event received: {avg(temperature)=191.8}
```

Esper, when using physical sliding windows, reports as soon as a new event arrives

Event Stream Analysis

Physical Tumbling windows: example

- Query

```
select avg(temperature)
from TemperatureEventStream.win:length_batch(5)
```

- Execution trace

```
Sending Event:[S1|66.0|Mon Apr 29 13:40:06 CEST 2013]
Sending Event:[S0|42.0|Mon Apr 29 13:40:07 CEST 2013]
Sending Event:[S1|51.0|Mon Apr 29 13:40:08 CEST 2013]
Sending Event:[S0|10.0|Mon Apr 29 13:40:09 CEST 2013]
Sending Event:[S1|61.0|Mon Apr 29 13:40:10 CEST 2013]
Event received: {avg(temperature)=46.0}
Sending Event:[S0|621.0|Mon Apr 29 13:40:11 CEST 2013]
Sending Event:[S0|40.0|Mon Apr 29 13:40:16 CEST 2013]
Sending Event:[S0|84.0|Mon Apr 29 13:40:17 CEST 2013]
Sending Event:[S1|21.0|Mon Apr 29 13:40:18 CEST 2013]
Sending Event:[S0|43.0|Mon Apr 29 13:40:19 CEST 2013]
Event received: {avg(temperature)=161.8}
```

Esper, when using physical tumbling windows, reports only when the window closes

Controlling Reporting

- The *output* clause is optional in Esper
- It is used
  - To control the rate at which events are output
  - to suppress output events.
- Syntax
  - Output [[all | first | last | snapshot] every *output_rate* [seconds | events]]

Controlling Reporting: examples

- Controlling the sliding in logical and physical windows
  - select avg(temperature)
    from TemperatureEventStream.win:time(4 sec)
    output snapshot every 2 sec
  - select avg(temperature)
    from TemperatureEventStream.win:length(4)
    output snapshot every 2 events

Event Pattern Matching

- Event patterns match when an event or multiple events occur that match the pattern's definition.
- Patterns can also be temporal (time-based).
- Pattern matching is implemented via state machines.

Event Pattern Matching

Pattern atoms

- Filter expressions specify an event to look for.
  - TemperatureEventStream(sensor="S0", temperature>50)
- Time-based event observers specify time intervals or time schedules.
  - timer:interval(10 seconds)
  - timer:at(5, *, *, *, *)

Every 5 minutes

Event Pattern Matching

Types of operators

- Operators that control pattern finder creation and termination: *every, every-distinct, [num] and until*
- Logical operators: *and, or, not*
- Temporal operators that operate on event order: *-> (followed-by)*
- Guards are where-conditions that filter out events and cause termination of the pattern finder, such as *timer:within, timer:withinmax* and *while*-expression
- Note: Pattern expressions can be nested arbitrarily deep by including the nested expression(s) in () round parenthesis.

Event Pattern Matching

Pattern example

- Query

```
select a.sensor
from pattern [every ( a = SmokeEventStream(smoke=true) ->
TemperatureEventStream(temperature>50, sensor=a.sensor)
where timer:within(2 sec) ) ]
```

- Execution trace

```
Sending Event:[S0|false|Mon Apr 29 14:33:54 CEST 2013]
Sending Event:[S1|28.0|Mon Apr 29 14:33:55 CEST 2013]
Sending Event:[S1|true|Mon Apr 29 14:33:56 CEST 2013]
Sending Event:[S1|43.0|Mon Apr 29 14:33:57 CEST 2013]
Sending Event:[S0|true|Mon Apr 29 14:33:58 CEST 2013]
Sending Event:[S0|74.0|Mon Apr 29 14:33:59 CEST 2013]
Event received: {a.sensor=S0}
Sending Event:[S0|true|Mon Apr 29 14:34:00 CEST 2013]
Sending Event:[S0|70.0|Mon Apr 29 14:34:01 CEST 2013]
Event received: {a.sensor=S0}
```

Pattern operators: every

- The *every* operator indicates that the pattern sub-expression should restart when the sub-expression qualified by the every keyword evaluates to true or false.
- Without the every operator the pattern sub-expression stops when the pattern sub-expression evaluates to true or false
- Every time a pattern sub-expression within an every operator turns true the engine starts a new active sub-expression looking for more event(s) or timing conditions that match the pattern sub-expression.

Pattern operators: every

- This pattern fires when encountering an A event and then stops looking:
  - A
- This pattern keeps firing when encountering A events, and doesn't stop looking:
  - every A

Pattern operators: every (A -> B)

- Events
    - $A_1\ B_1\ C_1\ B_2\ A_2\ D_1\ A_3\ B_3\ E_1\ A_4\ F_1\ B_4$
- Pattern
    - every (A -> B)
- Results
    - Detect an A event followed by a B event. At the time when B occurs the pattern matches, then the pattern matcher restarts and looks for the next A event.
        1. Matches on B_1 for combination $\{A_1, B_1\}$
        2. Matches on B_3 for combination $\{A_2, B_3\}$
        3. Matches on B_4 for combination $\{A_4, B_4\}$

Pattern operators: every A -> B

- Events
  - A_1 B_1 C_1 B_2 A_2 D_1 A_3 B_3 E_1 A_4 F_1 B_4
- Pattern
  - every A -> B
- Results
  - The pattern fires for every A event followed by a B event.
    1. Matches on B_1 for combination {A_1 , B_1}
    2. Matches on B_3 for combination {A_2 , B_3} and {A_3 , B_3}
    3. Matches on B_4 for combination {A_4 , B_4}

Pattern operators: A -> every B

- Events
  - $A_1\ B_1\ C_1\ B_2\ A_2\ D_1\ A_3\ B_3\ E_1\ A_4\ F_1\ B_4$
- Pattern
  - A -> every B
- Results
  - The pattern fires for an A event followed by every B event.
    1. Matches on B_1 for combination $\{A_1, B_1\}$
    2. Matches on B_2 for combination $\{A_1, B_2\}$
    3. Matches on B_3 for combination $\{A_1, B_3\}$
    4. Matches on B_4 for combination $\{A_1, B_4\}$

Pattern operators: every A -> every B

- Events
  - $A_1\ B_1\ C_1\ B_2\ A_2\ D_1\ A_3\ B_3\ E_1\ A_4\ F_1\ B_4$
- Pattern
  - every A -> every B
- Results
  - The pattern fires for every A event followed by every B event.
    1. Matches on B_1 for combination $\{A_1 , B_1\}$
    2. Matches on B_2 for combination $\{A_1 , B_2\}$
    3. Matches on B_3 for combination $\{A_1 , B_3\}$, $\{A_2 , B_3\}$ and $\{A_3 , B_3\}$
    4. Matches on B_4 for combination $\{A_1 , B_4\}$, $\{A_2 , B_4\}$, $\{A_3 , B_4\}$ and $\{A_4 , B_4\}$

Limiting sub-expression lifetime 1/3

- As the introduction of the every operator states, the operator starts new sub-expression instances and can cause multiple matches to occur for a single arriving event.
- New sub-expressions also take a very small amount of system resources and thereby your application should carefully consider when sub-expressions must end when designing patterns. Use the *timer:withi*n construct and the *and n*ot constructs to end active sub-expressions.
- Note: the data window onto a pattern stream does not serve to limit pattern sub-expression lifetime.

Event Pattern Matching

Limiting sub-expression lifetime 2/3

- Events
  - $A_1 A_2 B_1$
- Pattern
  - every A -> B
- Results
  - {A_1 , B_1} and {A_2 , B_1}

- Events
  - $A_1 A_2 B_1$
- Pattern
  - every A -> (B and not A)
- Results
  - {A_2 , B_1}
  - The *and not* operators cause the sub-expression looking for {A_1, B?} to end when A_2 arrives.

Event Pattern Matching

Limiting sub-expression lifetime 3/3

- Events
  - A_1 received at t_o+ 1 sec
  - A_2 received at t_o+ 3 sec
  - B_1 received at t_o+ 4 sec
- Pattern
  - every A -> B
- Results
  - {A_1 , B_1} and {A_2 , B_1}

- Events
  - A_1 received at t_o+ 1 sec
  - A_2 received at t_o+ 2 sec
  - B_1 received at t_o+ 3 sec
- Pattern
  - every A -> (B where timer:within(2 sec))
- Results
  - {A_2 , B_1}
  - The *where timer:within* operators cause the sub-expression looking for {A_1, B?} to end after 2 seconds.

Combining Event Pattern Matching and Stream Analysis Example

- Query

```
select count(a.sensor)
from pattern [every ( a = SmokeEventStream(smoke=true) ->
TemperatureEventStream(temperature>50, sensor=a.sensor)
where timer:within(4 sec) )].win:time(10 sec)
```

- Execution trace

```
Sending Event:[S0|true|Mon Apr 29 15:18:10 CEST 2013]
Sending Event:[S0|64.0|Mon Apr 29 15:18:11 CEST 2013]
Event received: {count(*)=1}
Sending Event:[S1|true|Mon Apr 29 15:18:12 CEST 2013]
Sending Event:[S1|63.0|Mon Apr 29 15:18:13 CEST 2013]
Event received: {count(*)=2}
```

Event Pattern Matching and Stream Analysis **in a graph** Example

- The *insert into* clause forwards events to other streams for further downstream processing.
- Query

```
cepConfig.addEventType("FireStream", FireComplexEvent.class.getName());
```

```
insert into FireStream
select a.sensor as sensor, a.smoke as smoke, b.temperature as
temperature
from pattern [every ( a = SmokeEventStream(smoke=true) -> b
= TemperatureEventStream(temperature>5, sensor=a.sensor)
where timer:within(2 sec) ) ]
```

- Downstream query

```
select count(*) from FireStream.win:time(10 sec)
```

Event Pattern Matching and Stream Analysis in a graph

Example: execution trace

```
Sending Event:[S0|false|Mon Apr 29 15:30:23 CEST 2013]
Sending Event:[S0|52.0|Mon Apr 29 15:30:24 CEST 2013]
Sending Event:[S1|true|Mon Apr 29 15:30:25 CEST 2013]
Sending Event:[S0|65.0|Mon Apr 29 15:30:26 CEST 2013]
Sending Event:[S0|true|Mon Apr 29 15:30:27 CEST 2013]
Sending Event:[S0|65.0|Mon Apr 29 15:30:28 CEST 2013]
Event received: Fire:[S0|true|65.0|Mon Apr 29 15:30:28 CEST 2013]
Event received: {count(*)=1}
Sending Event:[S0|true|Mon Apr 29 15:30:29 CEST 2013]
Sending Event:[S0|71.0|Mon Apr 29 15:30:30 CEST 2013]
Event received: Fire:[S0|true|71.0|Mon Apr 29 15:30:30 CEST 2013]
Event received: {count(*)=2}
Sending Event:[S0|true|Mon Apr 29 15:30:31 CEST 2013]
Sending Event:[S1|93.0|Mon Apr 29 15:30:32 CEST 2013]
Sending Event:[S1|true|Mon Apr 29 15:30:33 CEST 2013]
Sending Event:[S1|761.0|Mon Apr 29 15:30:34 CEST 2013]
Event received: Fire:[S1|true|761.0|Mon Apr 29 15:30:34 CEST 2013]
Event received: {count(*)=3}
Event received: {count(*)=2}
Event received: {count(*)=1}
```

Resources

- Download Esper (for Java)
  - http://esper.codehaus.org/esper/download/download.html
- Download Nesper (for .net)
  - http://esper.codehaus.org/nesper/download/download.html
- Quick start
  - http://esper.codehaus.org/tutorials/tutorial/quickstart.htm
- Tutorial
  - http://esper.codehaus.org/tutorials/tutorial/tutorial.html
- Questions on EPL
  - http://esper.codehaus.org/tutorials/solution_patterns/solution_patterns.html
- Documentation
  - http://esper.codehaus.org/esper/documentation/documentation.html
- A not-trivial example: DEBS 2011 Challenge
  - http://esper.codehaus.org/tutorials/tutorial/debs2011_challenge.html

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- Large part of the content of are taken from
  - EsperTech: “Event Stream Intelligence Continuous Event Processing for the Right Time Enterprise Products Data Sheet”
  - EsperTech: "Reference Documentation Version: 4.2.0"