IBM Software Group – Event Processing technologies

# Event Processing – a semantic approach

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*IBM Software Group*

# Where am I coming from ?

I am wearing three different hats

The hat that is paying my salary:

Lead Architect of Event Processing Technologies for IBM Software Group

Once a week I am wearing the Professor hat and teach an event processing course

Additional hat – a catalyst in establishing this community

# Syntax, Semantics, Pragmatics

Green cat is the five ones

The rain in Spain stays mainly in the plain

The shallow cat splits the sea

# One of my favorite examples will be used for most of the talk..

THE LUGGAGE PERSPECTIVE:

Across the 24 largest airlines more than 5.6 million bags went missing in 2006, this is an average of 15.7 bags per 1,000 travelers. 15% of the bags are never found.

BBC News, April 4, 2007

Orchestrate: If missed the connection, can be re-routed anyway and the luggage will get there with the passenger

Orchestrate: Bag has reached to the wrong aircraft

Notify: Bag has been checked but did not reach the ULD within 20 minutes

Notify: Bag has been checked but did not reach the connecting flight

# Outline

Event Semantics

Event Processing in the large - Semantics

Event Processing in the small - semantics

Pragmatic Conclusion

# *Event Semantics*

# Event Semantics

Event – types, content,

Event – relationships to the rest of the universe

# Event Example 1 – raw event

- What happened ? --- bag has been checked
- When it happened ? --- June 18, 05:30
- Who is involved ? --- Passenger = John Galt; Airline = Air Canada, Flight = 1181, Bag (ID = 496351).
- What else we can say about the event ?, From = Toronto; To = Edmonton; type = direct; bag's weight = 15 KG
- Who reported it ? Check-in system
- [where did it happen ?] Counter 6
- [why did it happen ? ] Part of check-in process
- [what is the certainty it happened ?]

# Event Example 2 – derived event

- What happened ? --- bag has reached the wrong aircraft
- When it happened ? --- June 18, 06:00 [or during an interval ?]
- Who is involved ? --- Bag (496351), Flight = AC7910
- What else we can say about the event ? Intended Flight = AC1181
- Who reported it ? Sensor on vehicle going to the airplane
- [where did it happen ?]
- [why did it happen ? ]
- [what is the certainty it happened ?]

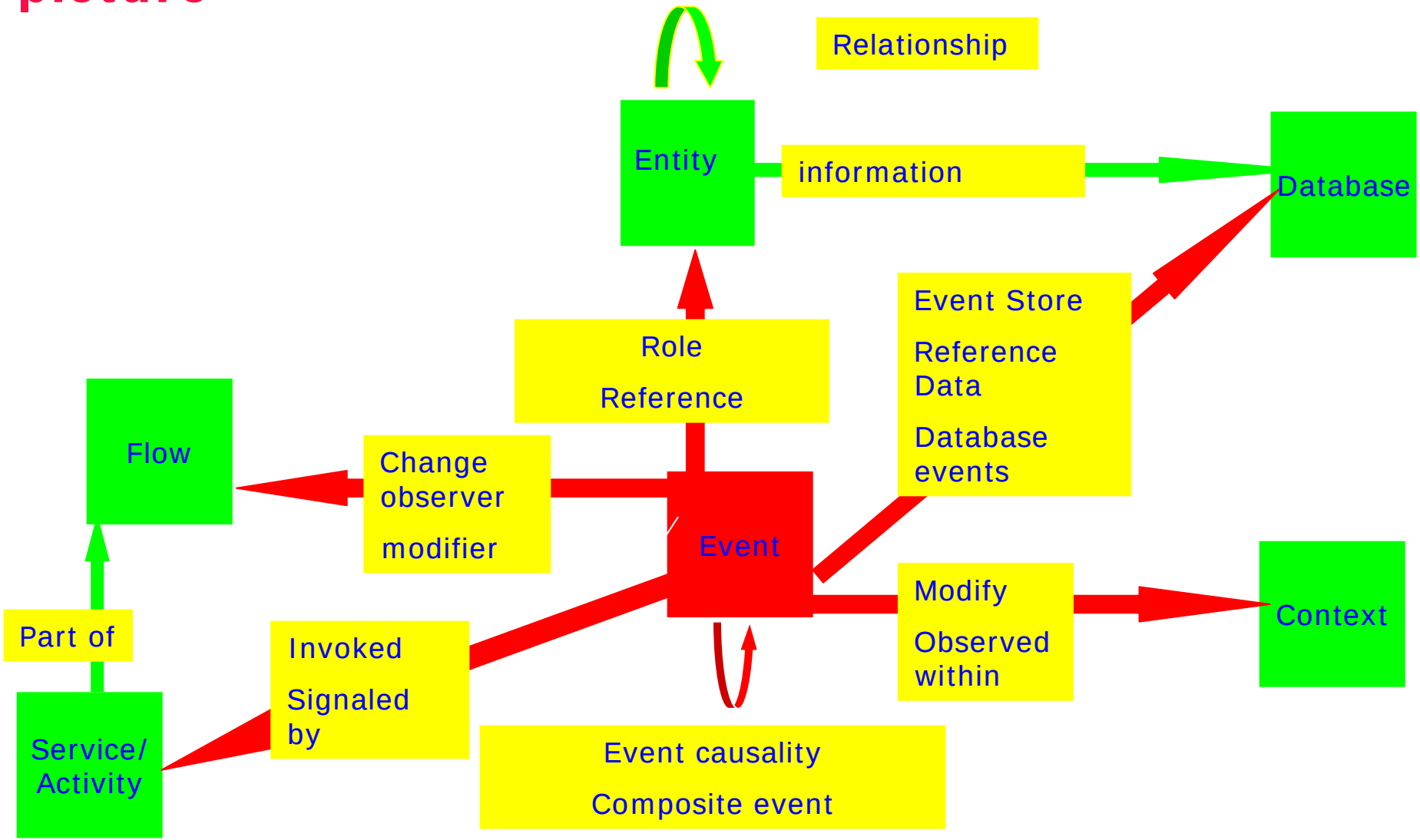
# Time Point or Interval

- Events occur over an interval –
- In many cases (especially for raw events) event interval can be mapped to time-point and treated like a discrete space
- However – the semantics of derived event can be:
  - The time-stamp of the last event that occurred
  - The time-interval starting in the earliest participating event, ending in the latest participating events.

# Spatial dimension

- Relative to the time dimension, the space dimension contributed to an event in limited (but growing) set of applications.
- Space can be: coordinates; Space abstraction that is well-defined: e.g. inside the kitchen…

# Event is a semantic term and a part of a larger picture



# Event Causality

- Type I : Explicit
  - The event "passenger notifies about lost luggage" is caused by the event "luggage did not arrive" that can be detected as a derived event.
- Type II : Induced
  - The event "bag has re-routed" is caused by the event "passenger missed the connection" (but not every time that passenger misses the connections there are bags to re-route)…
- Type II : Implicit
  - The event "luggage was not found within 72 hours" triggers a "compensation process" which in turn results in the event "transfer money to passenger". The compensation process by itself is a black box for us (and may be totally manual) – yet, there is a causality relationship between the two events

# Event Hierarchy

- Generalization / Specialization/delegation
  - The event "passenger notifies about lost luggage" is a generalization of the event "platinum passenger notifies about lost luggage". (can be done by context)
    - May be conditional / context-related ("in the night hours, in USA airports")

# Temporal issues in event processing

- Temporal dimensions:
  - Arrival time
  - Occurrence time
  - (more times: reporting time, transaction time, valid time).
- Temporal derivation
  - Event occurs over an interval
  - Derive future events
  - Derive past events – retroactive derivation

# *Event Processing in the large - Semantics*

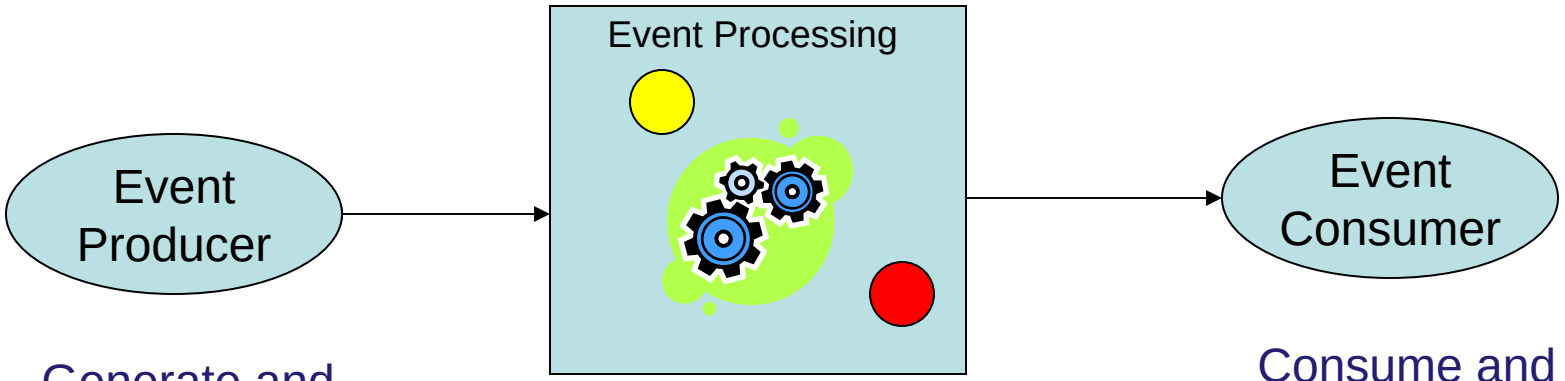
# Event Processing Semantics

Event Flow and Event Processing Networks

Nodes and Edges in the networks

Agents type: simple, mediated and complex event processing

# Event Processing – The Big Picture

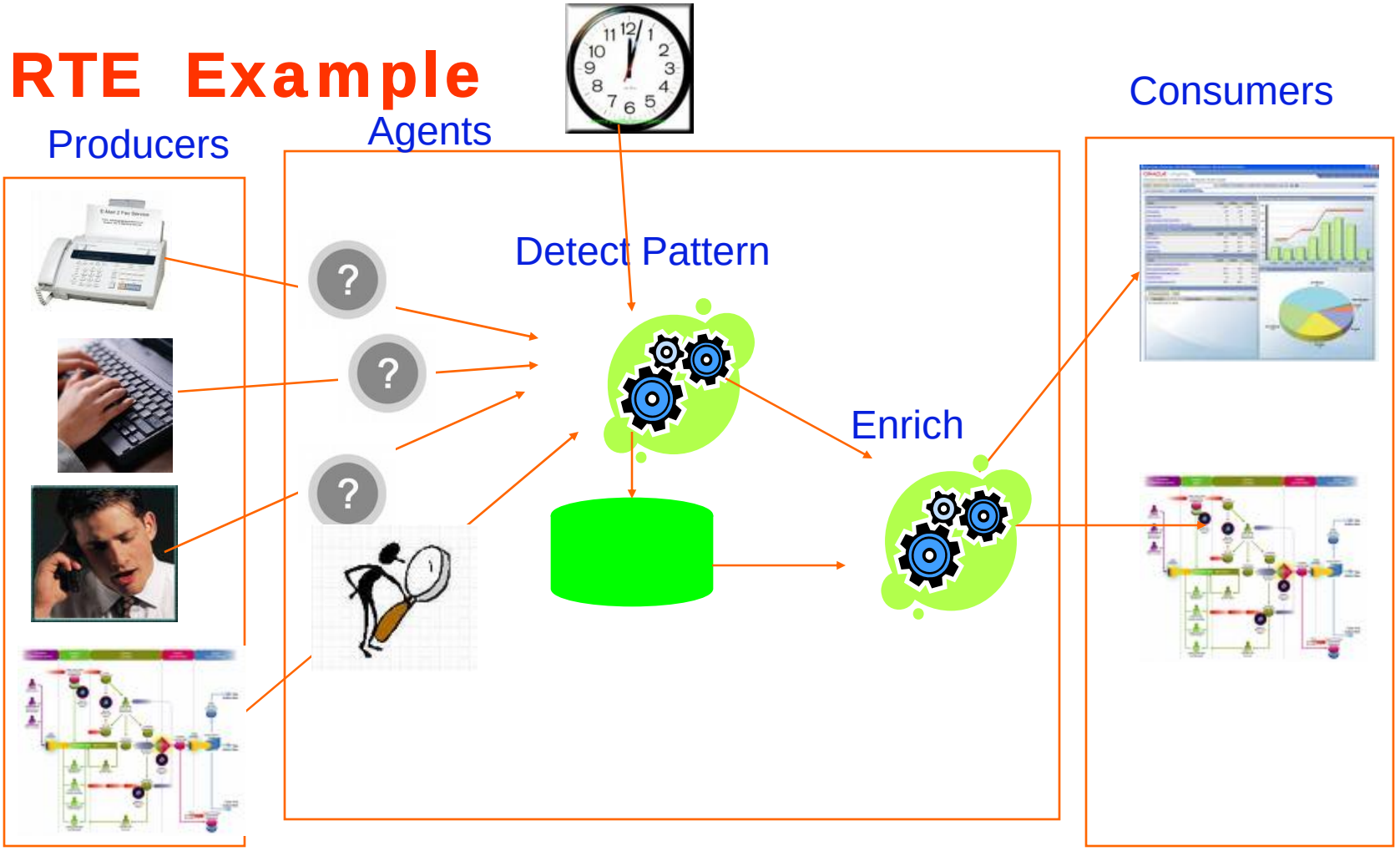



Generate and may publish events

perform operations on events

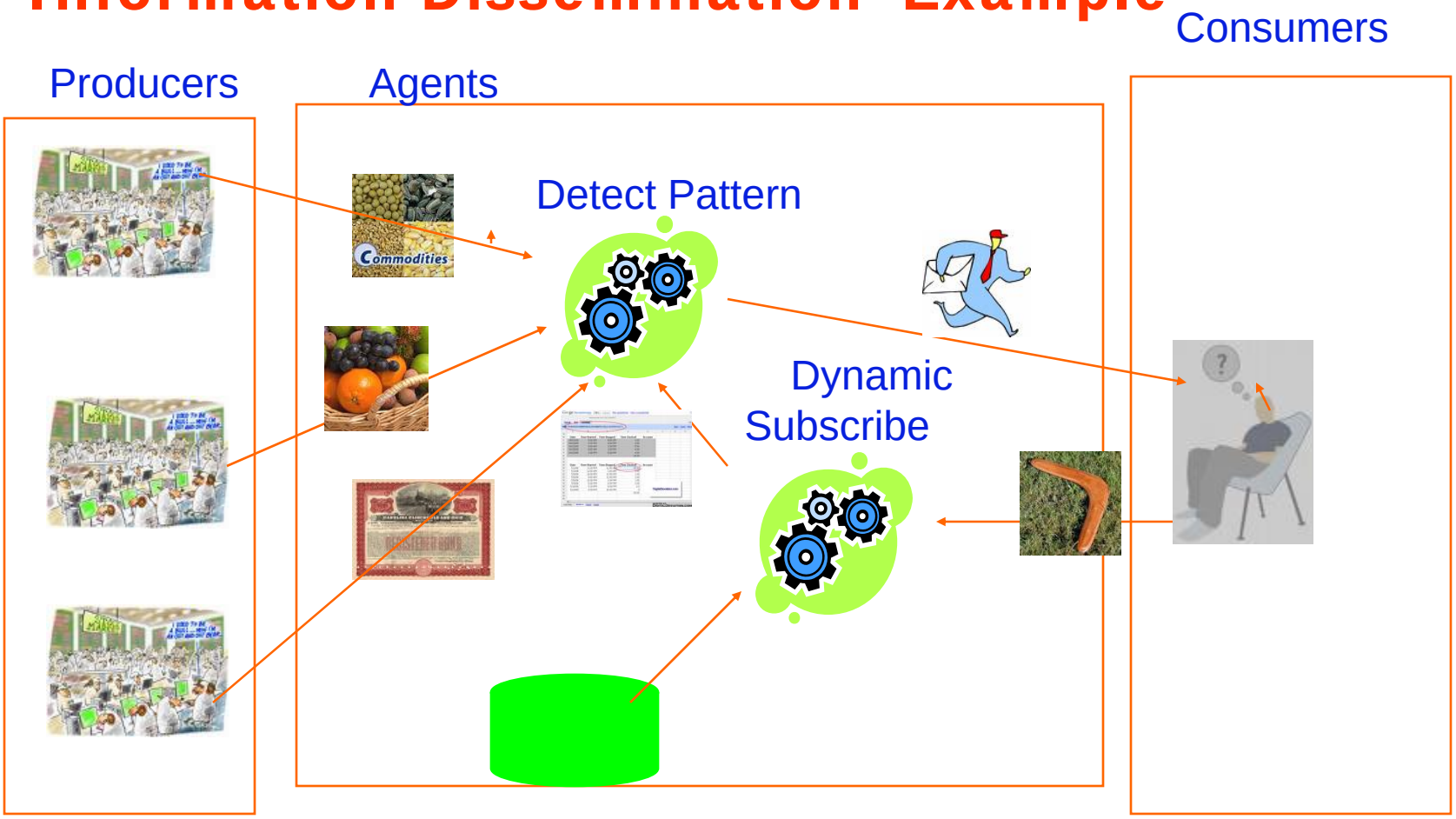
Consume and react to either raw or complex events

# RTE Example




If a customer cancels an order, cancel the order, divert it to another customer, or produce for stock, according to the type of order and current state.

# Information Dissemination Example




I am interested to know of all corporate actions in my portfolio

# Event Processing Network

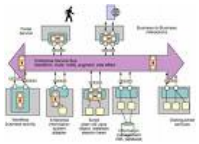
- An implementation-neutral abstraction from the point of view of event flow.
- Each

  - can be implemented as – Java class, rule, query, hybrid..

# Network semantics

- Nodes:
  - Producer
  - Consumer
  - Agent
  - Channel – push / pull (periodic / on-demand).
- Edges:
  - (P, CH); (CH, A); (A, CH); (CH, C); (CH, P); (C, CH)
- Stream = an edge in the graph
- Cloud = collection of all incoming edges to an agent.

# The Players – Event Producers

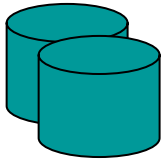
Applications/services



Direct Media

BP state observers


Sensors

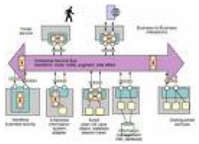


Data Stores

**Event Producing Modes:**

- **Push** - producer sends an event over a channel by its own initiative
- **Periodic pull** - Channel uses “pulling adapter” to obtain events periodically
- **On-Demand pull** - An agent initiates pull in an ad-hoc fashion.

# The Players – Event Consumers

Applications/services

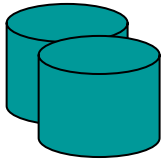
Actuators



Individuals and Groups

Workflows

Dashboards



Data Stores

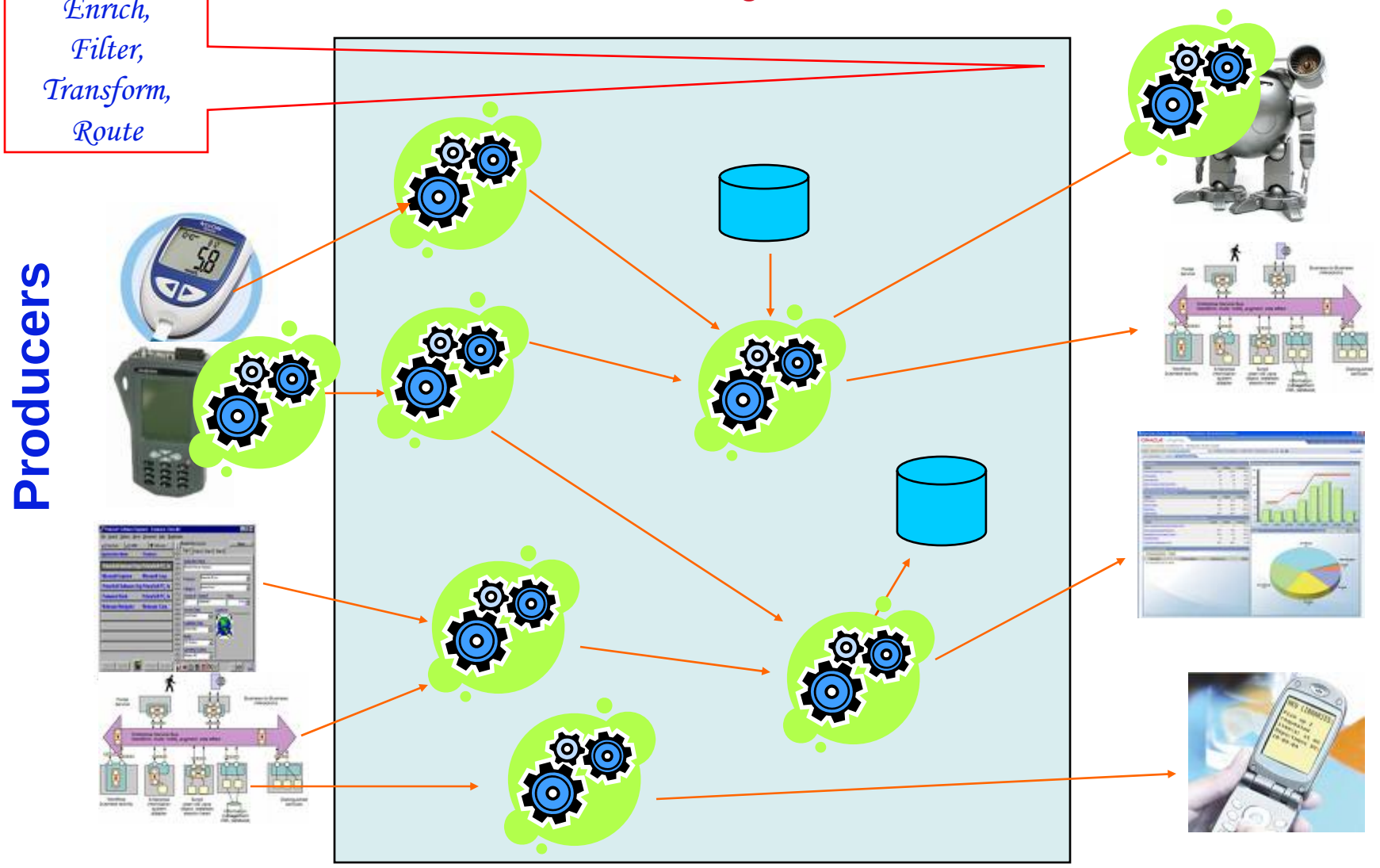
**Event Consumption Modes:**

- **Notification** – The consumer is notified
- **Orchestration –** The consumer acts

# The Players - Processing Agents

*Detect Patterns, Enrich, Filter, Transform, Route*

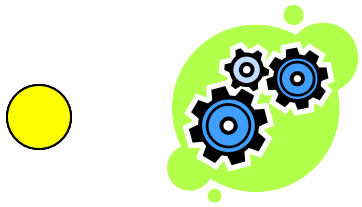
Event Processing Network




*Event Processing Overview*

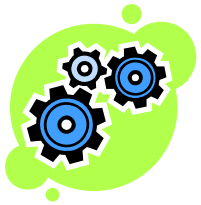
# Event Processing Agents - Filtering

Filtering is a stateless agent that filters events. It is the most common agent, and a filtering agent has been required by many applications.



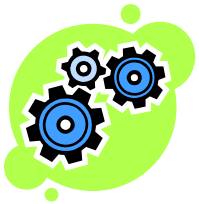
# Event Processing Agents - Routing


Itinerary-based routing

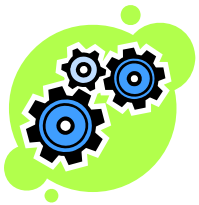




Subscription-based routing

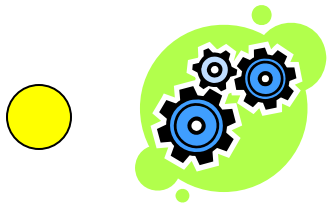


Intelligent routing

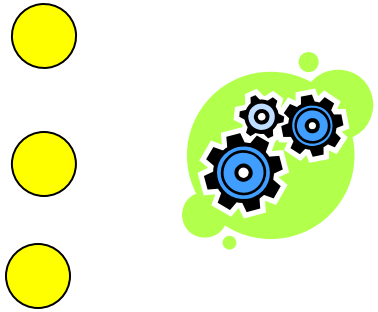


# Event Processing Agents - Transformation

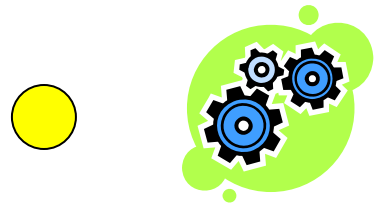
Translator: Both transformation and translation



Aggregator: statistical aggregator or concatenating events, can be stand alone agent or a scalar derivation. May be in network edge.

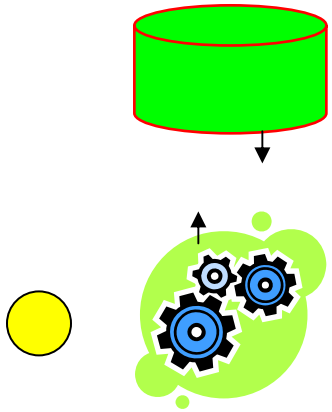


Splitter: Splits events to multiple events



# Event Processing Agents - Enrichment

Enricher: Enriches the content of events from reference data in databases, spreadsheets, Email messages, text files etc..



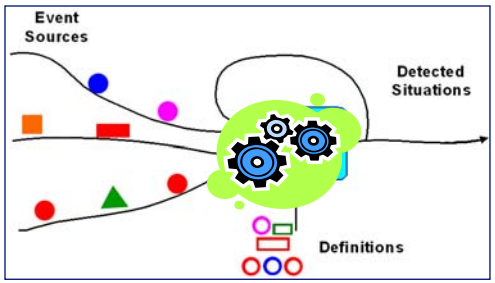
# Event Processing Agents - Pattern Detection

Time series pattern detector:
"Set at a time" pattern detector.

Basic pattern detector: fixed set of most common patterns.

Advanced pattern detector:
various packaging of patterns, pattern policies.

Output is "complex event" representing the situation detected by the specified pattern



# Context as a first class abstraction

- First class citizen –
  - during working hours
  - For important customers
- Partition of the stream – each partition may have different rules
  - Partition by time
  - Partition by space
  - Partition by property (one or more)

# Transactional semantics of event processing

- Event processing typically considered as asynchronous – thus, non transactional
- But --→ in some applications has to have transactional properties
  - A part of a larger transaction
  - Transactional properties of EPN
- Easy semantics:
  - Each event that enters the EPN starts a sub-transaction
  - If an agent derives event (even if most participants are not part of this transaction) it is considered as a part of this transaction
  - The transaction is atomic (rollback is provided)
  - Questions:
    - Can we semantically say that event is withdrawn ?
    - Is it the simple solution – always the correct one ?

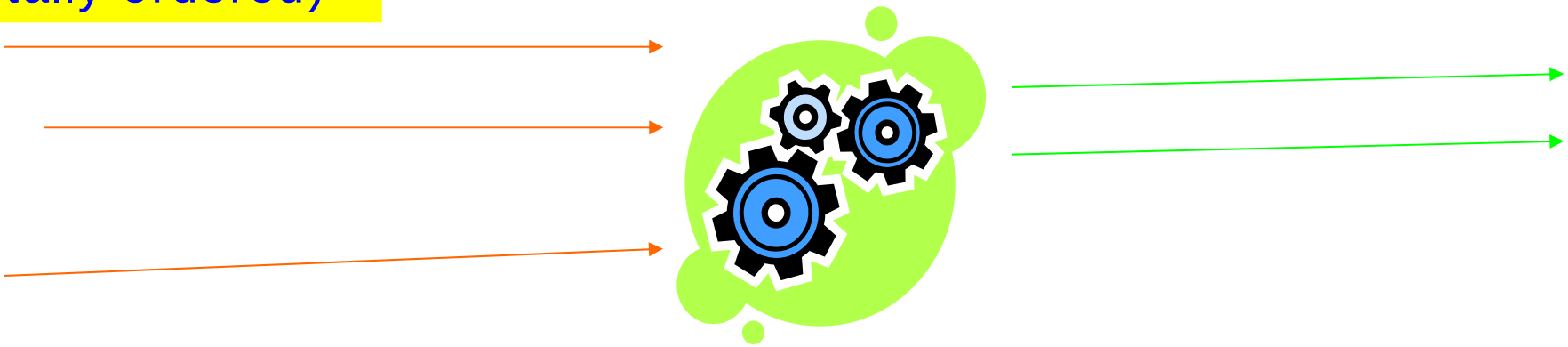
# *Event Processing in the small - semantics*

# Agent Semantics

An agent does three things:

- Selects which of the events in the cloud are relevant for it
- Perform the function
- Decide how to route the results

Stream (sometimes totally ordered)



Input Cloud = collection of stream in context

# Pattern Detection Semantics – pattern type

- Operation on Event Type + Predicate on content (together)
- Some examples:
  - Conjunction
  - Disjunction
  - Sequence (where supported)
  - Negation (can be detected when context ends)
  - Counting
  - ….

# *Scenario number 1: The heavy trading example*

- **Given:**
  - **A stream of events of a single topic, about the activity in the stock market for a certain stock.**
  - **An event is produced every 10 minutes when there is trade in the stock.**
  - **Each event consists of: quote (current stock-quote), volume (an accumulated volume of traded events within these 10 minutes).**
  - **A selection specification: "trigger an automatic trade program if the volume exceeds 300,000 3 times within an hour; pass as an argument the last quote and the sum of the 3 volume values".**

**Does it provide a complete semantics?**

# But now look at the actual stream

| Event-Id | Time-Stamp | Quote | Volume |
|---|---|---|---|
| E1 | 9:00 | 33.23 | |
| E2 | 9:10 | 33.04 | 320,000 |
| E3 | 9:20 | 33.11 | 280,000 |
| E4 | 9:30 | 33.01 | 400,000 |
| E5 | 9:40 | 32.90 | 315,000 |
| E6 | 9:50 | 33.04 | 320,000 |
| E7 | 10:00 | 33.20 | 303,000 |
| E8 | 10:10 | 33.33 | 219,000 |
| E9 | 10:20 | 33.11 | 301,000 |
| E10 | 10:40 | 33.00 | 210,000 |
| E11 | 10:50 | 32.78 | 400,000 |
| E12 | 11:00 | 32.70 | 176,000 |

- How many times the trade programming is triggered ;
- Which arguments are used in each triggering?

# Semantic decisions (some examples)

- **Decision 1: When is the selection applicable?** Every day – distinctly from trade-start – start new context every half hour, close the context after an hour
- **Decision 2: Single or multiple time windows?** Multiple (in this case 2 can co-exist).
- **Decision 3: When a detected event should be reported?** Immediately.
- **Decision 4: Within an interval – one or many result streams?** Only Once.
- **Decision 5. What quantifier is used in case of multiple instances?** First
- **Decision 6: Can a consumed event be re-consumed?** no
- **Decision 7: Are new events override previous events?** no

# Scenario number 2: The matching example in electronic bidding system – specification including decisions

- **Given:**
  - A stream of events that belongs to 2 event-topic: buy-request and sell-request
  - The buy-request consists of : item, customer-id, quantity, upper-limit
  - The sell-request consists of: item, customer-id, quantity, lower-limit
  - If a customer sends another sell or buy request before the previous one was settled, it overrides the previous one.
  - The result is a "settlement" event that occurs which matches buy-request with sell-request such as upper-limit >= lower-limit. The result event is: item, buying-customer, selling-customer, minimum of quantities, lower-bound, upper-bound.
  - The buy-request and sell-request do not participate in any matching again, even if not all desired quantity was settled.
  - The matching should be "fair" in the sense of "first bid, first matched", where the time of a bid is considered as the time of the last override.

# Semantic decisions (some examples)

- **Decision 1: When is the selection applicable?** For each item – distinctly when a bid for this item is open
- **Decision 2: Single or multiple time windows?** One time window in parallel
- **Decision 3: When a detected event should be reported?** At the end of the bid period
- **Decision 4: Within an interval – one or many result streams?** Multiple.
- **Decision 5. What quantifier is used in case of multiple instances?** First
- **Decision 6: Can a consumed event be re-consumed?** no
- **Decision 7: Are new events override previous events?** Yes, for a buy or sell event in the same context – a new event overlaps the old one.

# *Pragmatics Conclusion*

# Implementation

- This semantics can be defined using various types of implementations / APIs.
- The question of ordered vs. unordered is one characteristic, but there are many of them:
  - Requirements for latency, throughput
  - Need to support – transaction, recoverability
  - Size of state
  - ….
- One size fits all will not work – but the partition is not necessarily stream processing / CEP…
- Hybrid implementations are emerging…

# API and standards

- It seems that the “religious” war is on API type:
  - SQL extensions
  - Scripts
  - Rules:
    - Inference Rules
    - Derivation Rules
  - Visual Languages
- Using unified semantics we can get to a *standard meta-language*