The Role of Rules in CEP

Paul Vincent,
CTO Business Rules and CEP, TIBCO Software

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What is CEP?
Simple Event Processing

- **Synchronous Events**
- **Fixed to specific event types**

1. **new order**
2. **BPM: business process**
3. **SOA: IT services**
4. **Data Persistence (service)**
5. **fulfilment**
Multiple Simple Event Processing

- new order
- new supplier
- change order
- delivery

Multiples of Processes

Multiples of Services

Multiples of Database Views

- fulfilment
- purchasing
- rectification
- billing
Multiple Simple Event Processing (theory)

- new order
- new supplier
- change order
- delivery

Multiples of Processes
- fulfilment
- purchasing
- rectification
- billing

Multiples of Services

Multiples of Database Views
This model does NOT exploit ALL the information / data / events ALL the time

Behaviour (and business logic) is silo’d
Real-world Events

- Customer Logon
- Fed Base Rate Increase
- Production Item Arrives at Store
- Rental Car Crashed
- New Liability Added
- Rental Car Returned
- Mobile Call from CT @11.13
- Contract Submitted
- Contract Returned thru EDI
- New Order
- Customer Checks "Close Account" Web Page
- Item 8
Complex Event Processing

Asynchronous Events

Continuous identification of event patterns

Flexible to any event types

source events

CEP: complex event processing

State store

BPM: business process

SOA: IT services

Data Persistence (service)
CEP’s role: detect patterns, in real-time
What does CEP cover?

“CEP applies to a very broad spectrum of challenges in information systems” e.g.

- Business process automation
- Service routing and coordination
- SLA, Policy fulfillment and breach checking
- Security and fraud detection
- Activity Monitoring

Historic Background

to CEP
Command and Control

- Correlate all available information
- Determine tactics based on strategy and up-to-date information

-- from RAF Battle of Britain Fighter Control System 1940
Message process automation

- Collossus - http://www.tnmoc.org/ColRbd.htm
- Searched for patterns in encrypted messages
- Hardware-based
Data Fusion Domain

- Level 0 Processing: Sub-Object Assessment
- Level 1 Processing: Object Assessment
- Level 2 Processing: Situation Assessment
- Level 3 Processing: Impact Assessment

DISTRIBUTED Processing

Level 4 Processing: Process Refinement

Database Management System
- Support Database
- Fusion Database

EVENT SOURCES
- EXTERNAL
- LOCAL
  - Sensors
  - Documents
  - People
  - Data Sources

Human/Computer Interface

-- Revised JDL data fusion model, 1998

Condition Based Maintenance

--- from “Data Fusion for Developing Predictive Diagnostics for Electromechanical Systems”
CEP Timeline

- **Military, Logistics etc systems**
  - High cost / analog
  - Low re-use

- **Financial investment etc systems**
  - High cost
  - High value

- **Commercial systems**
  - Lower cost ROI

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Generic CEP tooling

Custom CEP implementations
Considerations about Events
Events = Data in Motion
Complex Business Problems

- **Fraud / Theft**
  - Thousands-to-millions of high-value small-size product items or transactions
  - How do you identify known patterns of “suspicious” behavior?

- **Logistics / Scheduling**
  - Raw material, production & delivery scheduling and resources are complex and prone to change
  - How do we reallocate resources to handle business and production changes?

- **Activity Monitoring**
  - Complex production and supply process with multiple actors
  - How to measure and action Key Performance Indicators?

Relevant event of interest:
- Product location change
- Resource, requirement change
- Process data change
Associated Events

- **Positive Events**
  - Product item X arrives at Production station S from Store T
  - Production worker Y arrives at Production station S
  - Production contract for item Z by time T is posted

- **Negative Events**
  - Product item X has been in transit to Store T for >15 minutes
  - Subcomponent Y hasn’t arrived at the Production station by the ETA
  - Delivery of contract Z has not taken place

- **Sets of Events**
  - 5+ items of Product item type Y failed to arrive at destination
  - Supplier Y was 5 mins late for 1 delivery, but made it early to the next
  - Return rate on component Z exceeds SLA %
Significant features of these Events

- **Time Sensitivity**
  - A thief may leave the building at the same time as stolen product
  - A product should take 40 minutes to travel a given production line segment

- **Distributed Event Sources**
  - A series of produced items fails at various QA stages, and their common attribute was a storage location
  - Multiple suppliers for a subcomponent are reporting delivery delays
Defining an “event”

- Change of state in some entity
  - Customer call
  - Bank debit
  - Aircraft movement

- Observation of some entity
  - CRM record of a customer call
  - ATM report of debit transaction success
  - Radar plot update of an aircraft

- IT Message
  - Queued point-to-point message
  - Publish / subscribe message
Event examples

- **SOA service requests**
  - time, destination, payload

- **Scans (parcel, baggage, RFID, production line...)**
  - location, time, payload

- **Web requests**
  - source IP, destination, payload, frequency

- **Messages / packets (telco, smartgrid)**
  - source, destination, time, location

- **Data streams (data feeds)**
  - payload, time, source
Where Rules fit in

CEP
CEP used for Situation Awareness

I DON'T THINK I HAVE YOUR FULL ATTENTION.

IT'S ASOK'S TURN TO LISTEN. IF YOU SAY ANYTHING USEFUL, HE'LL SEND US AN INSTANT MESSAGE.

HE'S ASLEEP.

HE'S EMPLOYING HEURISTICS.
Pattern Matching against events

- Filter events
- Join events
- Events can be across time
- Events can be aggregated
- Events can be ordered

- Queries, rules
- Event Store, State
- State
- Collections
- OO paradigms / facts
- Queuing etc policies
CEP, a “technology”

SOA Services
BPM Processes
ERP & Other Apps
Users

Event Cloud

Event Processing
Event Storage

Information
CEP = various technology components

- Event definition: events and concepts
- Entity lifecycle: states
- Event processing: rules and queries
- Decision processing: decision tables
- Relationship rules
- State transition rules
- Pattern matching rules
- Reaction / decision rules
Rule =

- `<conditions> → result`

- Logic: `<conditions> → inferred fact`
- Constraint: `<conditions> → constraint satisfaction fact`
- Data relationship: `<ownership> → relationship fact`

- Production: `<conditions> → action`
- ECA: `<event conditions><conditions> → action`
- State model: `<state><event><conditions> → new state`
- Query: `<conditions> → resultset`
- “CEP”: `<event><state><conditions> → new state`
Rule types: per RuleML as used in CEP

query + callback

rule with event declaration

function
Constraint (also event pattern constraint): A Boolean condition that must be satisfied by the events observed in a system.
  
  Examples:
  - A service level agreement limiting the time taken to complete a mortgage transaction from the time an application is received.

Rule (in event processing): A prescribed method for processing events.

Examples:
  - Whenever three timeouts have happened send an alert to the network manager.
  - If more than ten shopping carts have been active for more than five minutes then activate the website reaction time monitor and display an amber alert on the dashboard.
  - Whenever IBM trades 2% above its 1 hour VWAP and then within 15 minutes trades 5 points below then buy 1000 shares IBM.

Notes: Event processing rules may be prescribed in many different ways, including by finite state machines, activity diagrams, Java code, SQL code, ECA (event-condition-action) rules or reactive rules that are triggered by event patterns.

Event pattern triggered reactive rule: a rule that prescribes actions to be taken whenever an instance of a given event pattern is detected.
CEP = a process involving rules

Event and Data Model(s)

- Aggregation rules
- Behavioural rules
- Relationships, properties, inheritance rules
- Rule execution algorithms
- Subscriptions

Event and Data Process Model(s)

Event Processing Engines
Example: Rete-driven Production Rules

- **Scope / declaration**
  - Classes / Events relevant for the rule

- **Conditions**
  - Declarative
  - Performance
  - Filters on declarations
  - Joins across declarations

- **Actions**
  - Scalable...
  - Inference = knowledge
  - Decide
  - React

- **Inference**
  - Event-by-event but not set semantics
What do CEP rules require?
CEP Rules need to handle temporal logic

Kasparov beats "Deep Blue" in one move
CEP is a Stateful process

- Continuous identification of event patterns
- CEP: complex event processing
- State store
- Guaranteed Delivery
- Failover support for CEP engines
- State persistence
Example Rule Types

- **Basic:**
  Condition-Action

- **Triggers:**
  Event-Condition-Action

- **Timers/schedulers:**
  TimeUp-Action, TimeInterval-Action

- **Event lifecycle:**
  TimeToDie-Action
... also Low latency, Scalability

CEP: complex event processing

Rules

State store

Event performance is dependent on minimizing RTC times
Example: fraud event processing

Source Event definition

Event definition: Fire n’ forget
### Basic event processing

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### Event history processing

- Temporal history
- History points

### real time analytics

- Temporal history
- History points
Alternatives to rules in CEP?
Some things are not meant to be
Patterns in CEP: event lifecycles via states

Event-driven State Changes

- **State Model** for lifecycle modelling via states and state transition rules
- **State Machine** for state execution via rule engine

Continuous identification of event patterns

CEP: complex event processing

Event store
State Model advantages

1. Visual modeling metaphor
   - State diagram / flow diagram is simple to follow

2. State / flow transitions can be time-related
   - Can model missing events through time-outs etc
Example: state of rule management...
Example Rule Types (continued)

- **Basic**: Condition-Action
- **Triggers**: Event-Condition-Action
- **Timers/schedulers**: TimeUp-Action, TimeInterval-Action
- **Event lifecycle**: TimeToDie-Action
- **State transition**: Event-StateChange, Timeout-StateChange, StateEntry-Action, StateExit-Action
Patterns in CEP: continuous queries against streams

Event-stream Windows

- Queries for aggregations and statistics
- Continuous Queries for aggregations across time, numbers of events, etc

Continuous identification of event patterns

CEP: complex event processing

Event store
Query advantages

1. Query language
   - Usually SQL-based – familiar to DB users
   - Result can be a derived event for other queries, rules etc

2. Continuous operation
   - Extensions support time windows for the query to operate over
Example Rule Types (continued)

The mystery of Ireland

Details of how police in the Irish Republic finally caught up with the country's most reckless driver have emerged, the Irish Times reports.

He had been wanted from counties Cork to Cavan after racking up scores of speeding tickets and parking fines.

However, each time the serial offender evaded justice by giving a different address.

Query:
Query-ResultSet-Action,
Event-Query-ResultSetChange-Action
CEP in Rules?
Events are key to business rule enforcement / evaluation

- Business rules drive process definitions
- Business rules drive decisions made in business processes
- Mapping from business rules to processes and decisions is easier from an event perspective

New Order event  Change Order event  Change Currency / exchange rate event

e.g. An Order over $1000 must not be accepted on credit without a credit check

Change Rule Condition event  Rule applies to “order” process...  Change Limit (Rule Parameter) event
Per Analysts, a Hot Topic

Pattern-Based Strategy Core Technologies

The Difference between Complex Event Processing and Business Rules

Keynote: BRMS at a Cross Roads: The Next Five Years

“Saved my 401K by identifying an economic pattern via the metric of counting railway trucks”

“Future of business rules is CEP”

“DM platform needs data preparation and decision refinement and also state ie combining with CEP ...

Why not bring them together in active on/always on rule processing?”

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Final Remarks
Summary of Basic CEP Rule Types

Common Event Processing Models and Languages in 2009

Key:
- = EP graphical model;  = EP language;  = Code level;  = Transform

Note: imperative code / scripts subsumed into Production Rule or Engine concepts.
Concluding remark: Decisions are Event-Driven

'Dumb' American criminals attempt robbery with ‘permanent marker pen disguises’

Two hapless robbers in America, Matthew McNelly and Joey Miller, have been arrested with the "worst disguises ever" after trying to hide their faces with permanent marker pen

By Andrew Hough
Published: 9:25AM GMT 30 Oct 2009

Matthew Allan McNelly and Joey Lee Miller were caught in Iowa with permanent marker pen scrawled over their faces.  Photo: AP