A Survey of Complex-Event Processing Models

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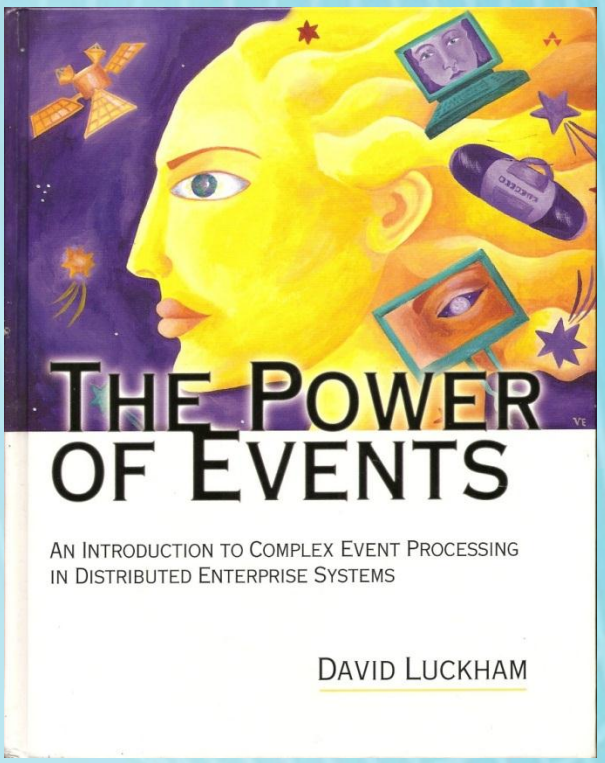
Agenda

- Understanding CEP
- CEP Technologies
  - Event Stream processing
  - Exploiting Rete for CEP
- Event Processing Networks

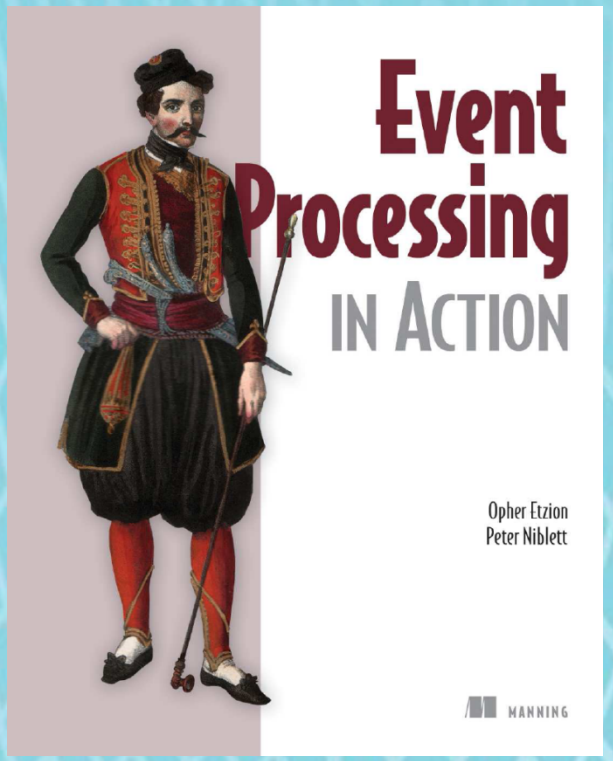
Books

David Luckham



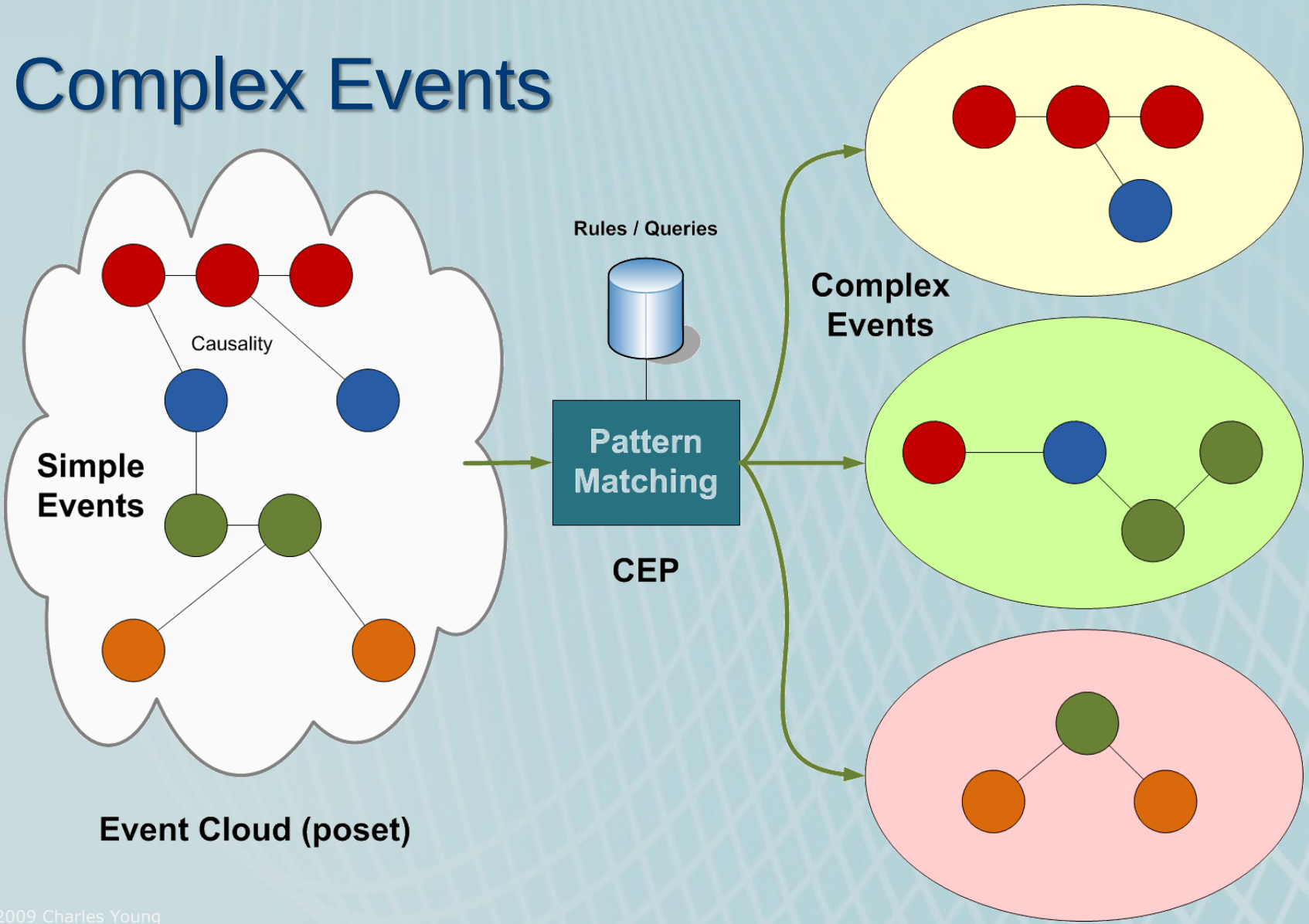
http://complexevents.com/

Opher Etzion
Peter Niblett
Target publish date: April 2010



http://epthinking.blogspot.com/

Complex Events



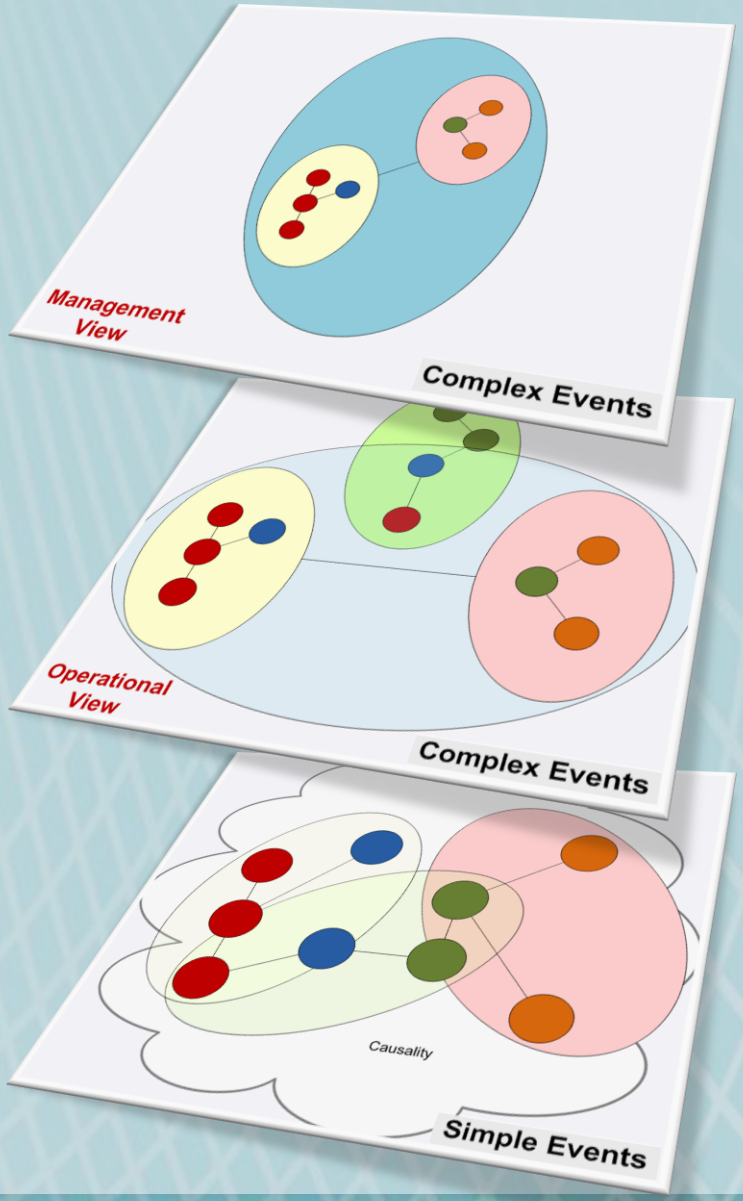
CEP Applications

- Multi-sensor Data Fusion
- Sense and Respond
- Situational Awareness
- Predictive Analytics

- Observe-Orientate-Decide-Act (OODA)
- Fraud Detection
- Intrusion Detection
- Algorithmic Trading
- RFID Processing
- Regulatory Compliance
- Diagnostics

Event Abstraction Hierarchies

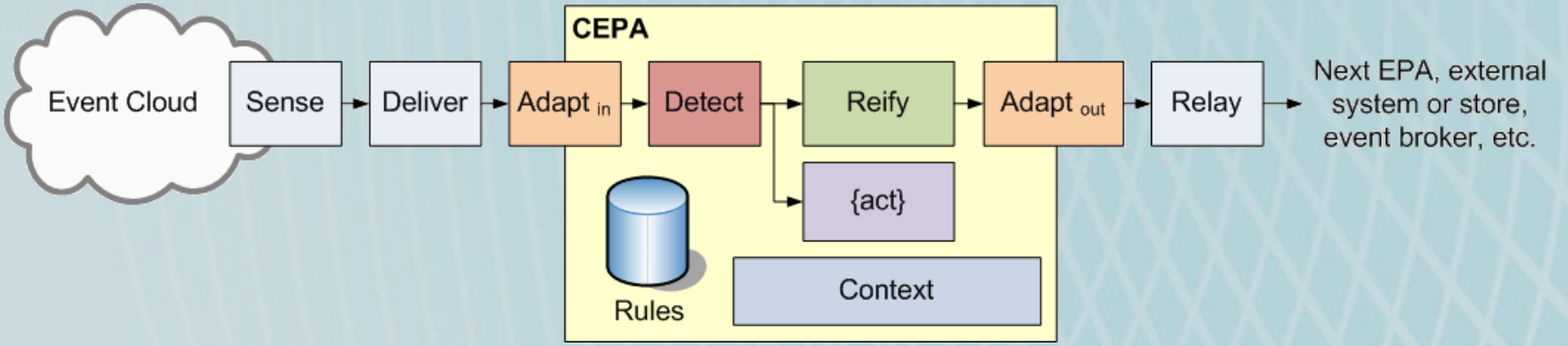
- Map from simpler to more complex events at multiple levels
- Provide views for different personas



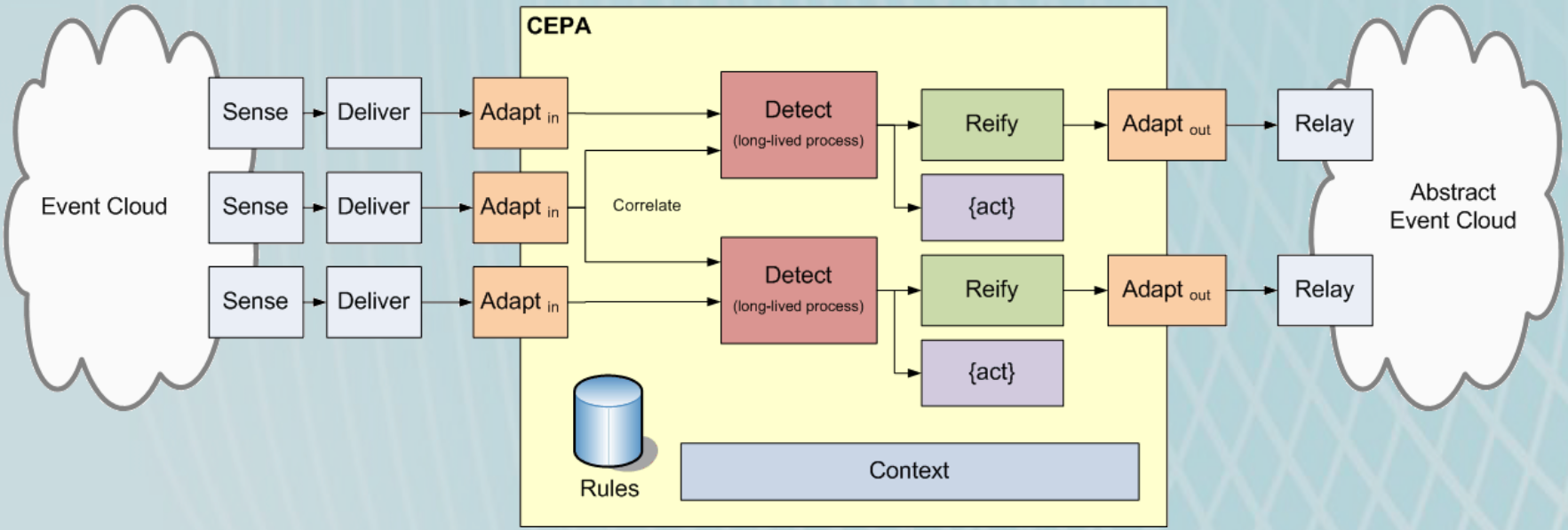
Requirements for CEP Technology

- Interaction with Event Clouds
  - Event sensing and observation
  - Event representation
  - Pattern matching
  - Event correlation
  - Continuous processing
  - Event semantics
  - Temporal reasoning
  - Event abstraction hierarchies
  - Low latency
  - Reasoning under uncertainty
  - Situational awareness and visualisation
  - Decision management
  - Parallelism
  - Simulation
  - Insight & debugging
- Event Pattern Recognition
- Event Aggregation
- Performance & Scalability
- Tooling
  - Sustainable throughput
  - Distributed processing

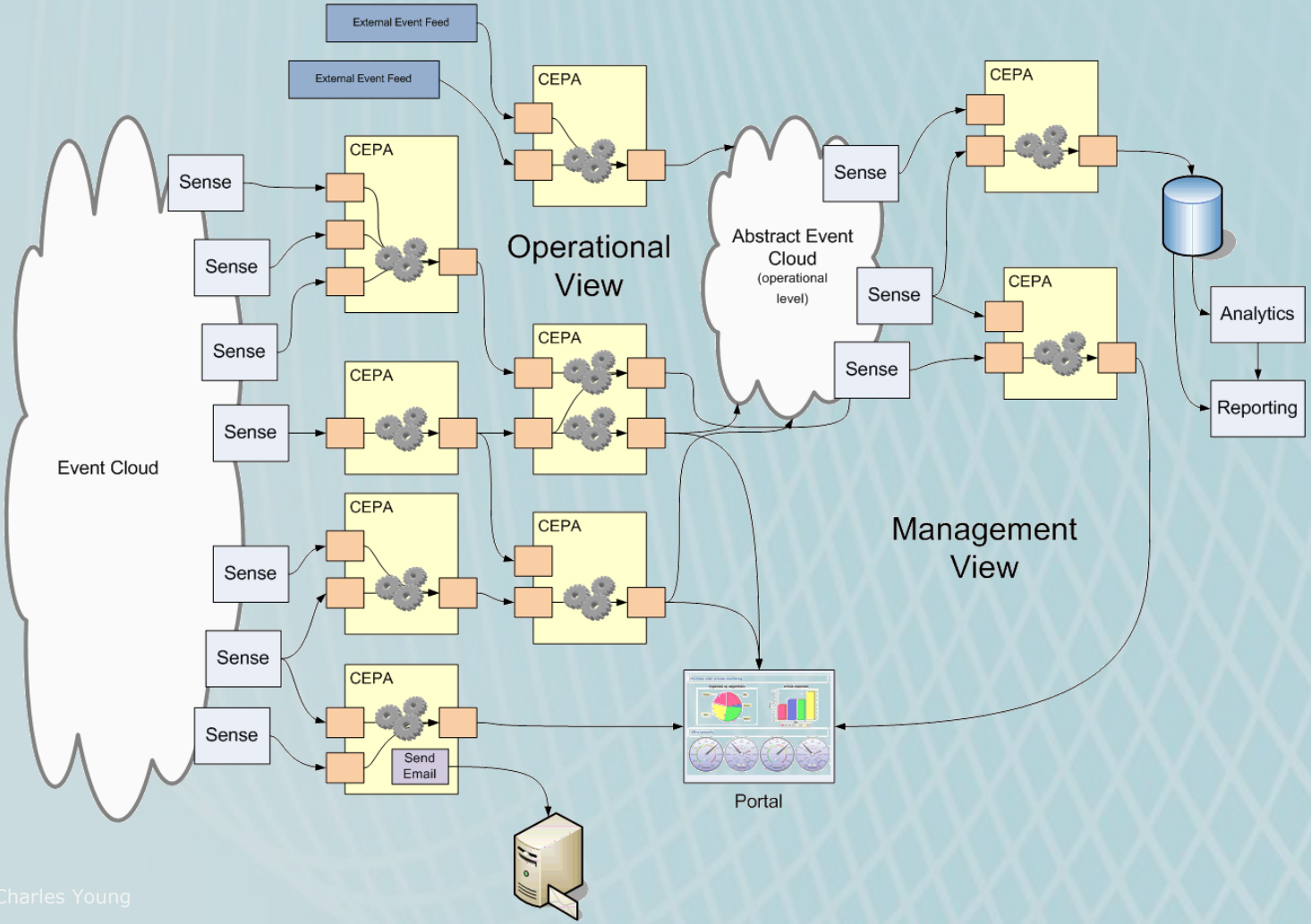
CEP Agents



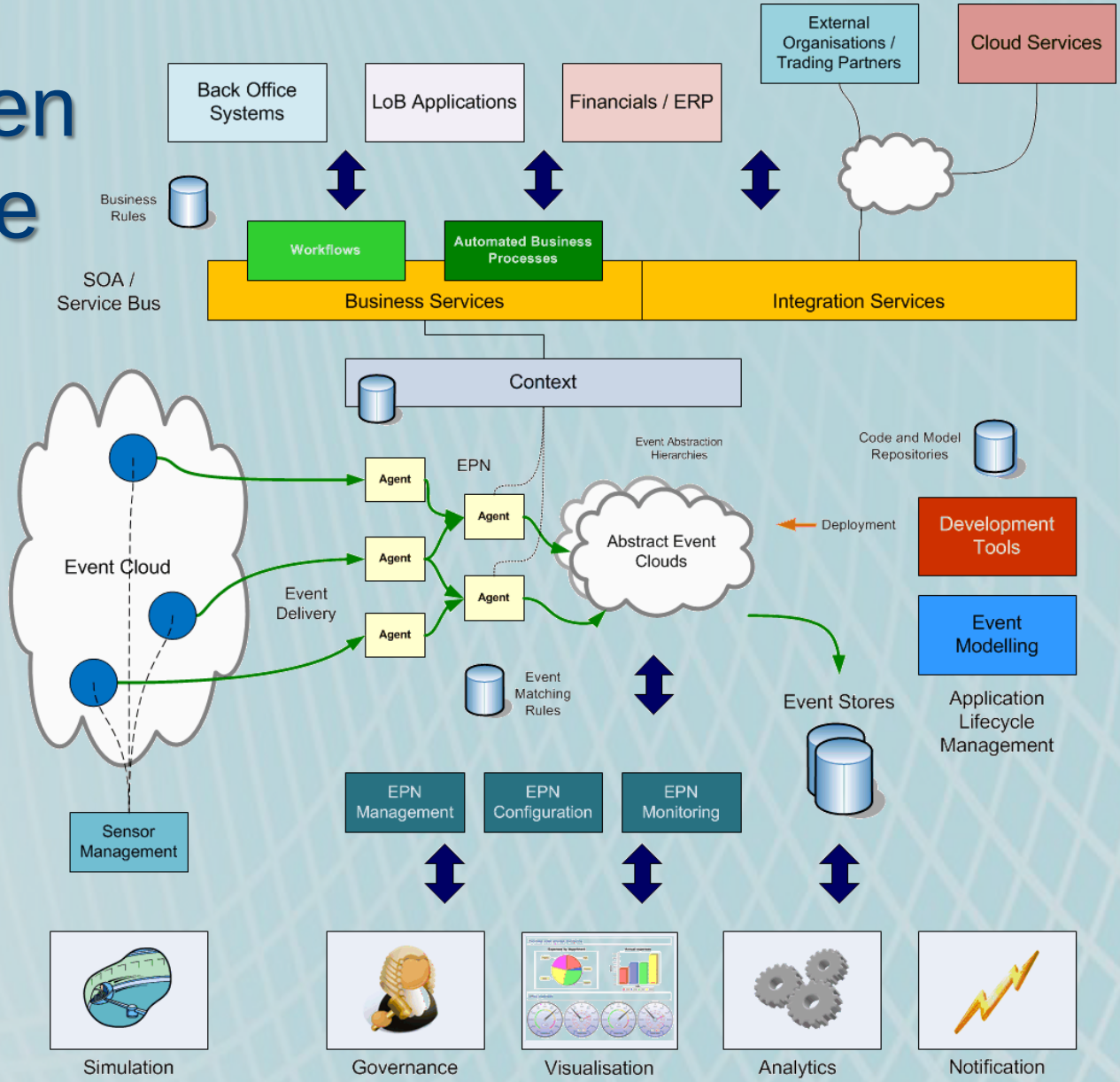
CEP Agents



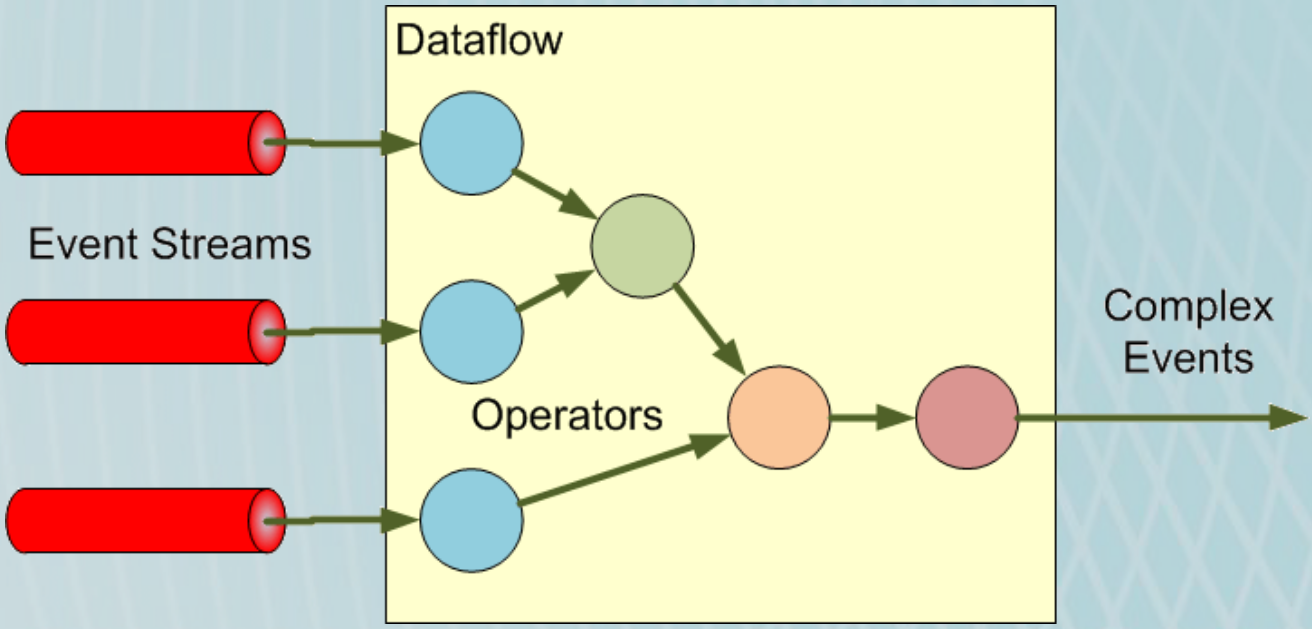
Event Processing Networks (EPNs)



Event-Driven Architecture

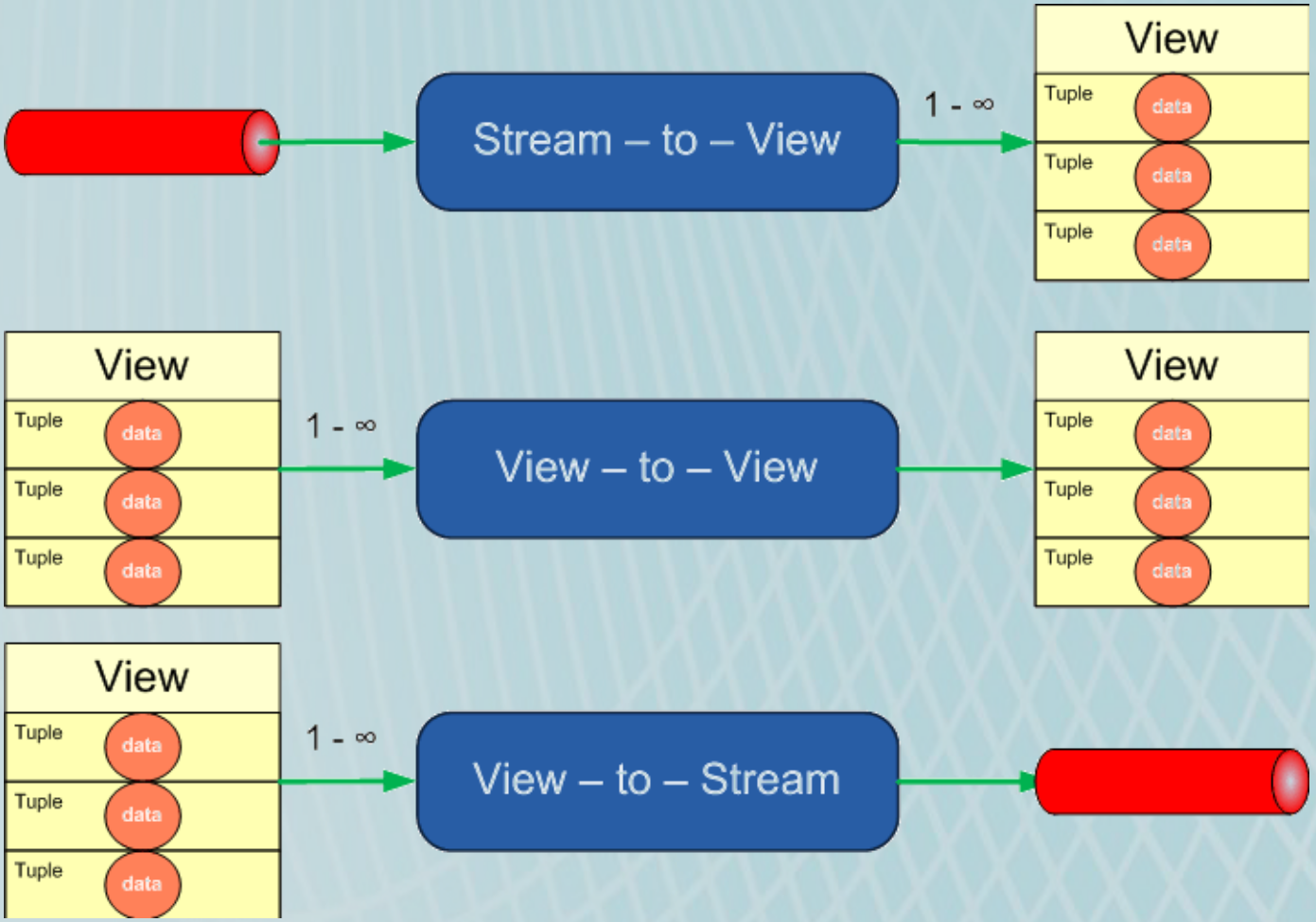


Event Stream Processing

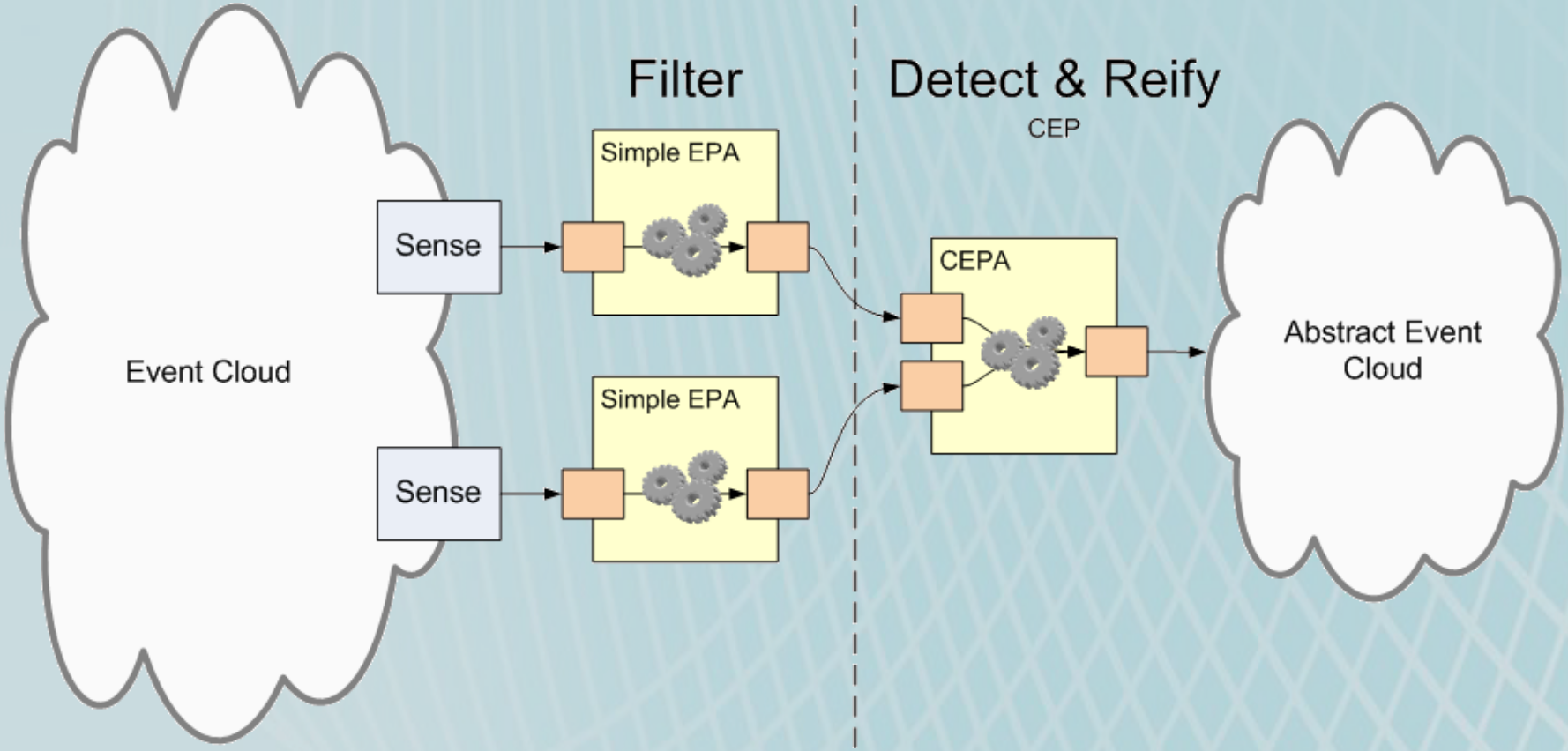


- Stream-Orientated
- Set-Based

Set-Based Operators

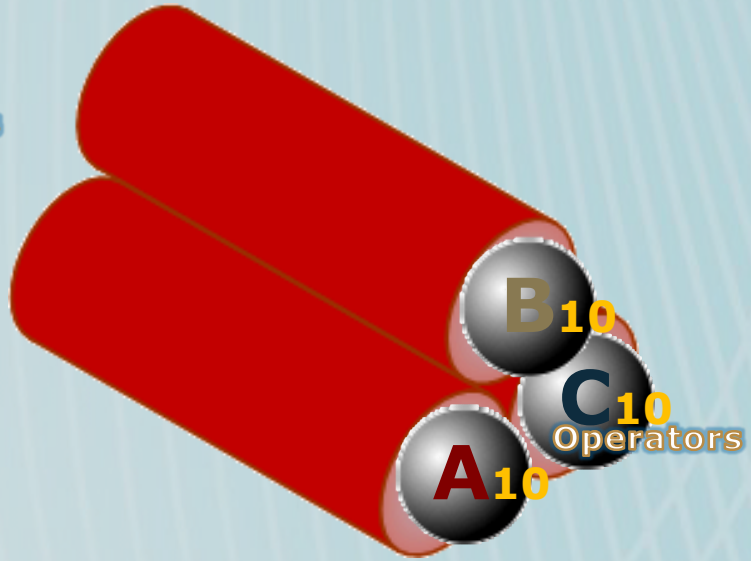


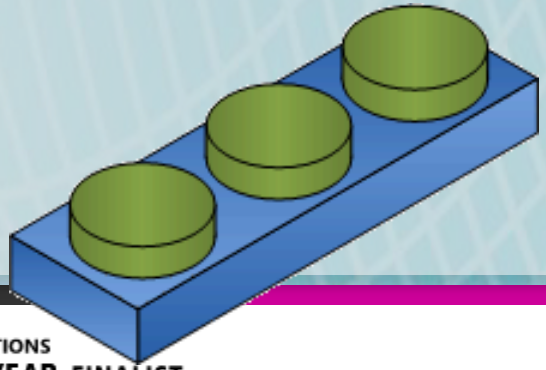
Simple Stream Processing in EPN



Select and Consume

- Context
  - Timestamps
  - Temporal Windows
  - Template Instantiation

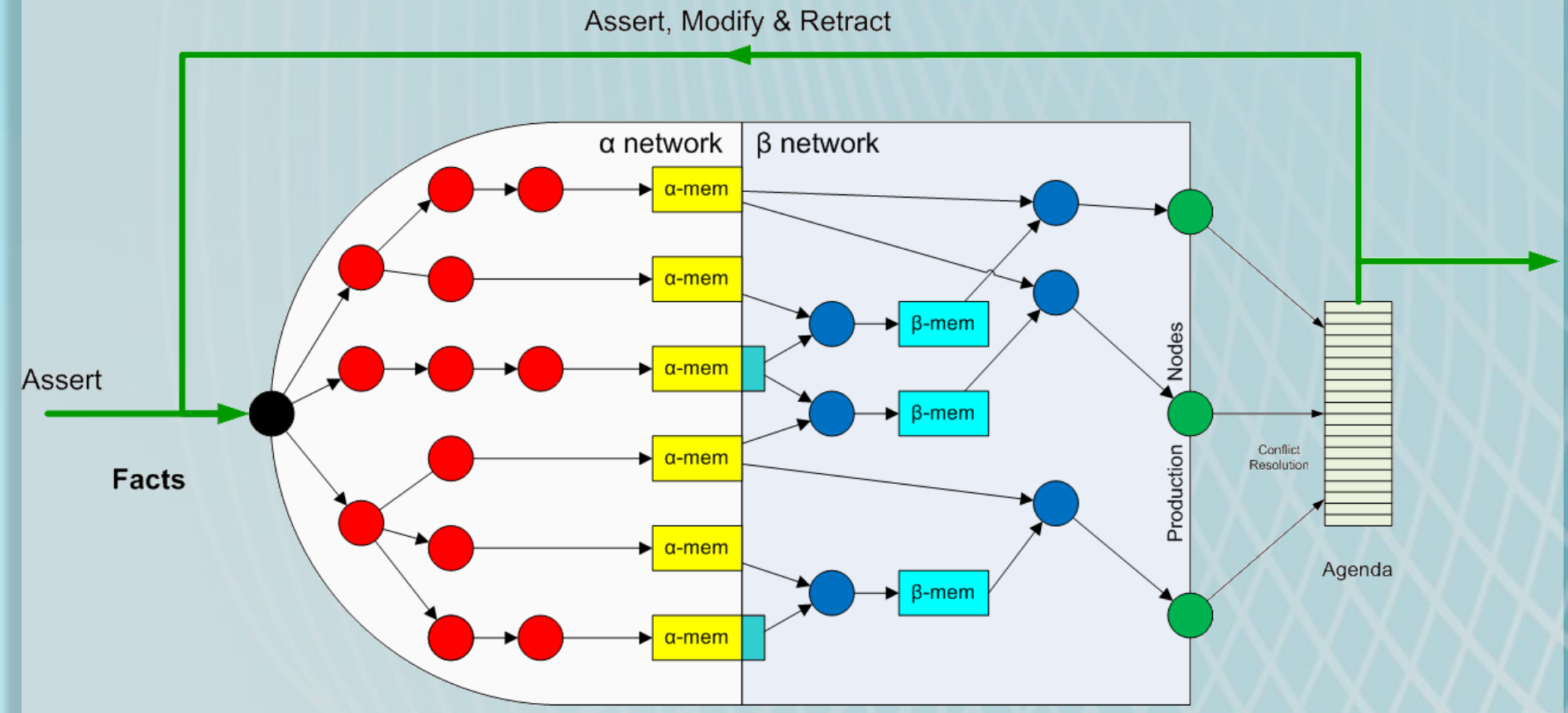




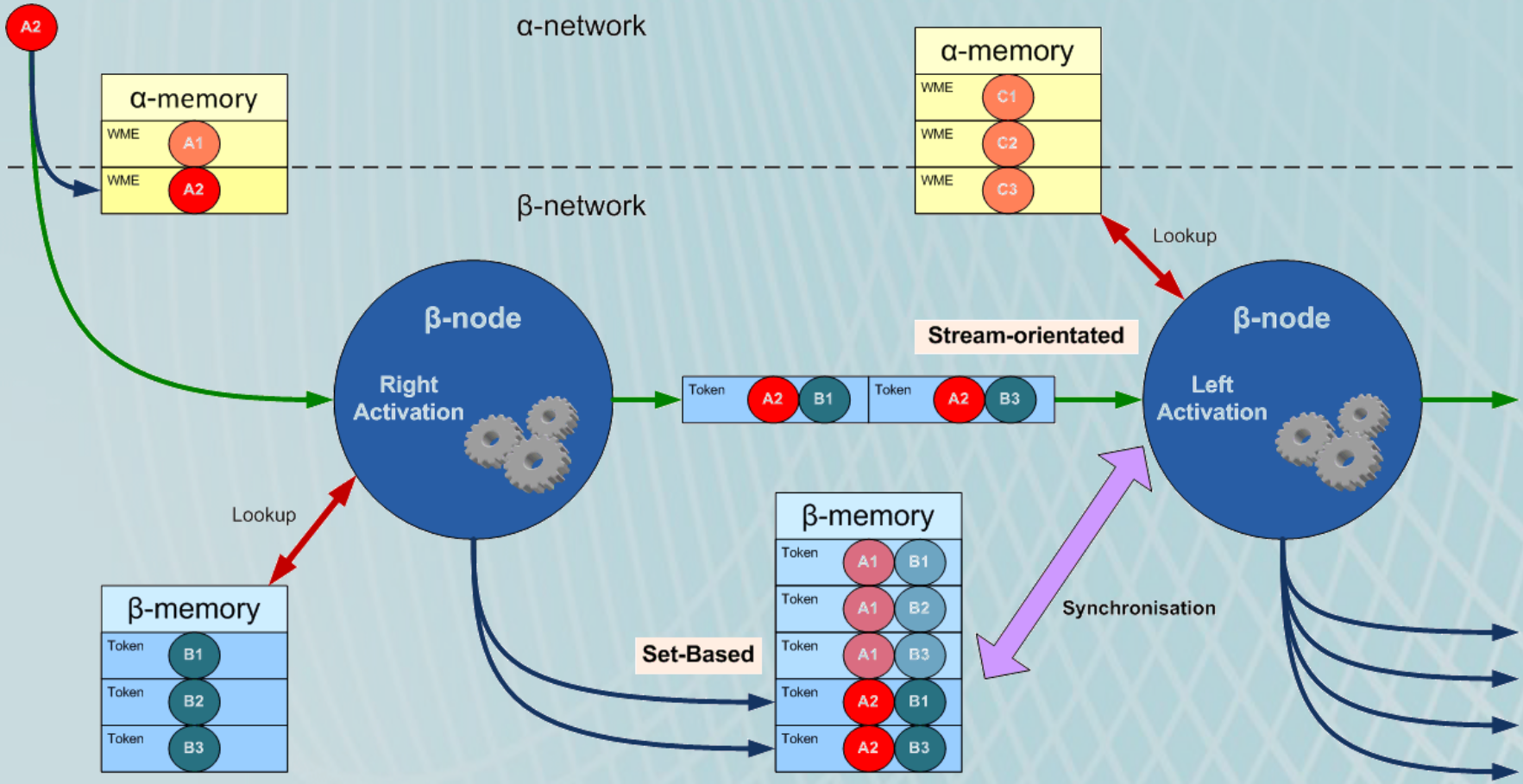
Event Pattern Languages

- Production Rules
- ECA Rules
- Dataflow DSLs
- Extended SQL
- Script / GPL
  - Imperative
  - Declarative (functional)

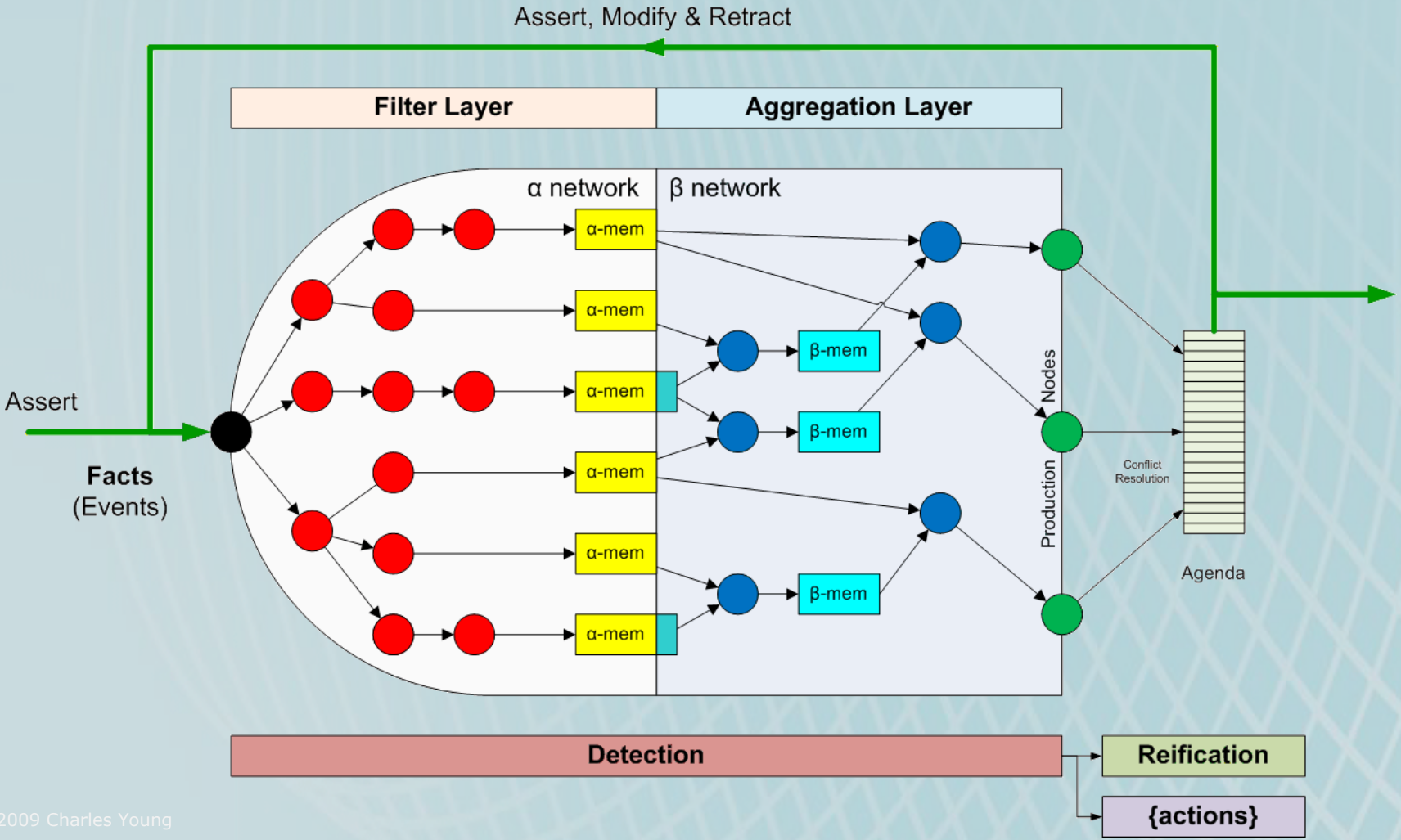
Production Systems: Rete Networks



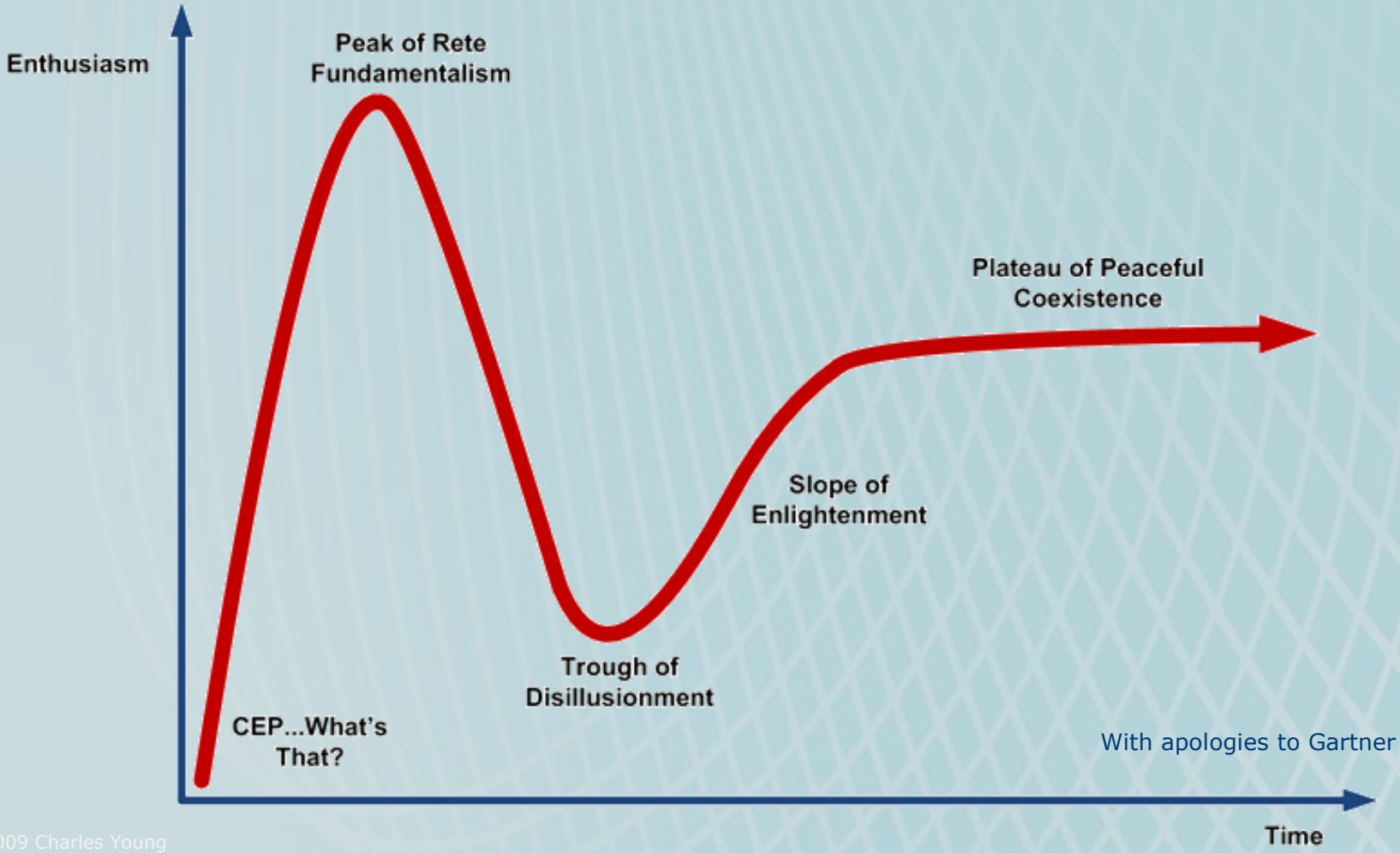
Rete: Stream vs. Set



Rete as CEP Agent

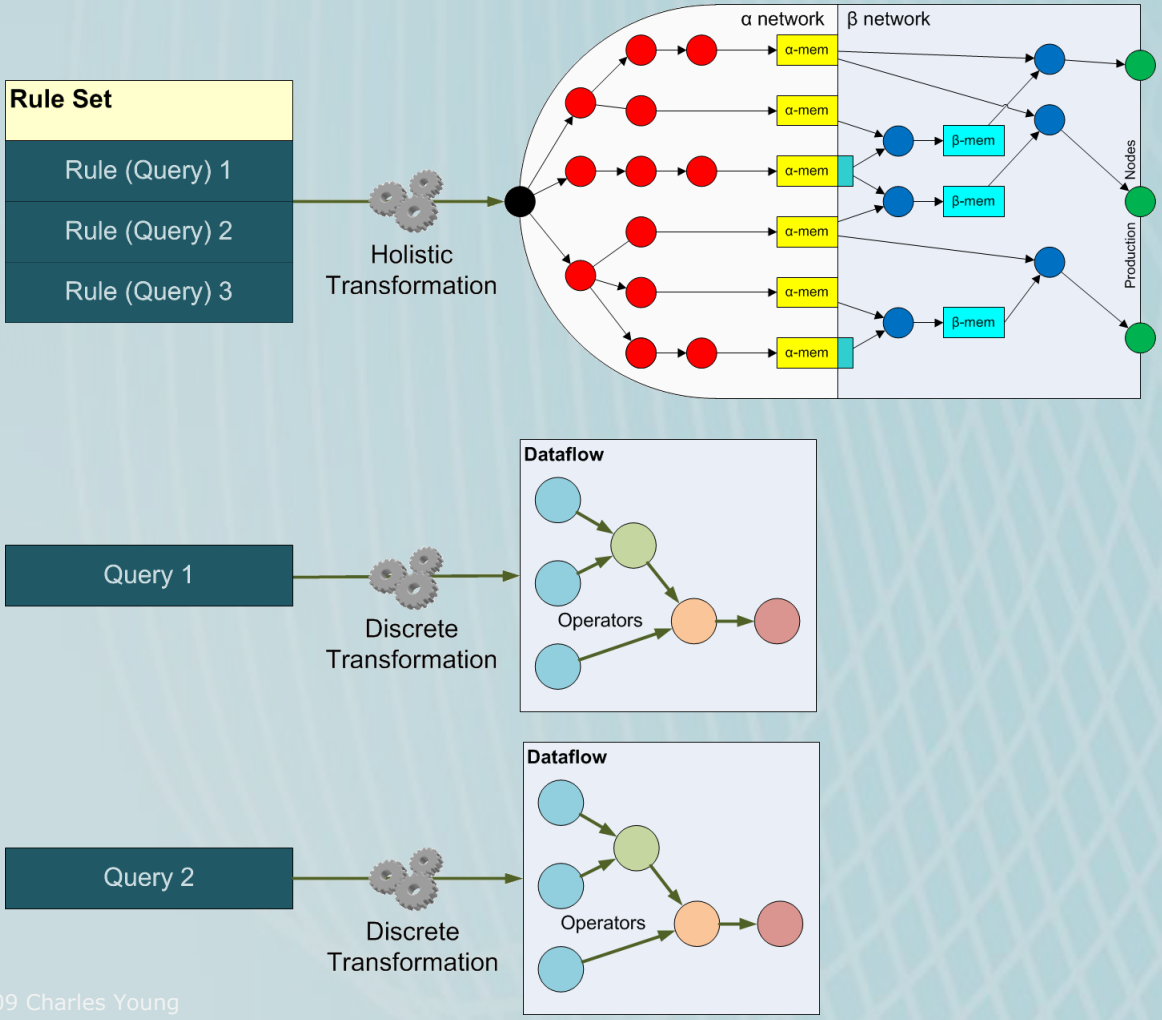


Journey of Enlightenment



With apologies to Gartner

Rete and Event Stream Dataflows



- Maximises redundancy elimination
- Hard to change continuous queries dynamically
- Many synchronisation points
- Reduced benefit of parallelisation

- Minimal redundancy elimination
- Easier to change continuous queries dynamically
- Easier scaling through parallelisation

Other Issues

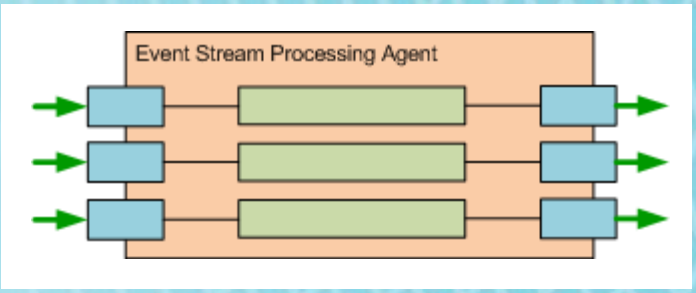
- Event semantics
  - Immutability
- Temporal Logic
- Selection and Consumption
- Handling out-of-order events
- Reasoning-under-uncertainty

Why use Rete in CEP?

- Stream Reasoning
  - 'Downstream' processing
  - Inference over events AND context data
  - Compute Event Abstraction Hierarchies
- Bridging the gaps
  - e.g.,
    - Event processing → Business Processes
    - Event processing → Analytics

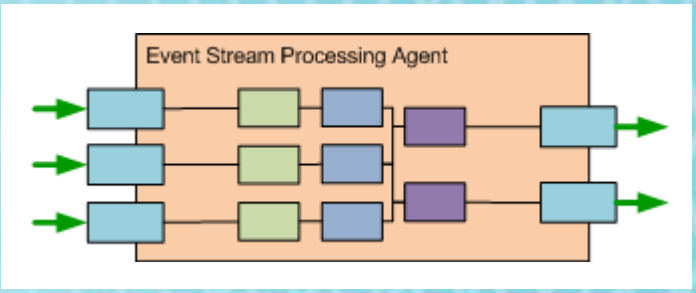
Single Agents

- Event Stream (Simple)
  - Filtering events
  - Use close to event source



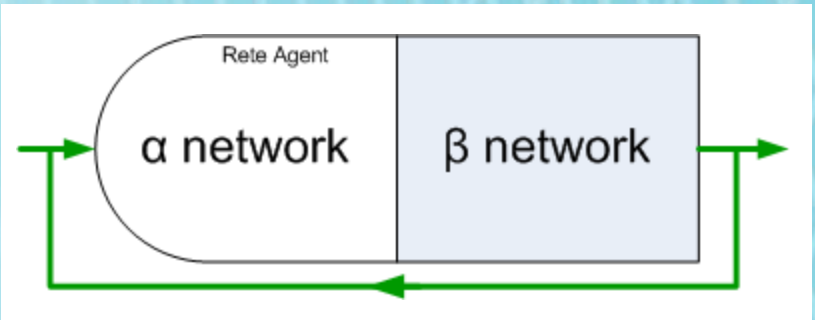
Single Agents

- Event Stream (CEP)
  - Ultra-low latency
  - High-throughput



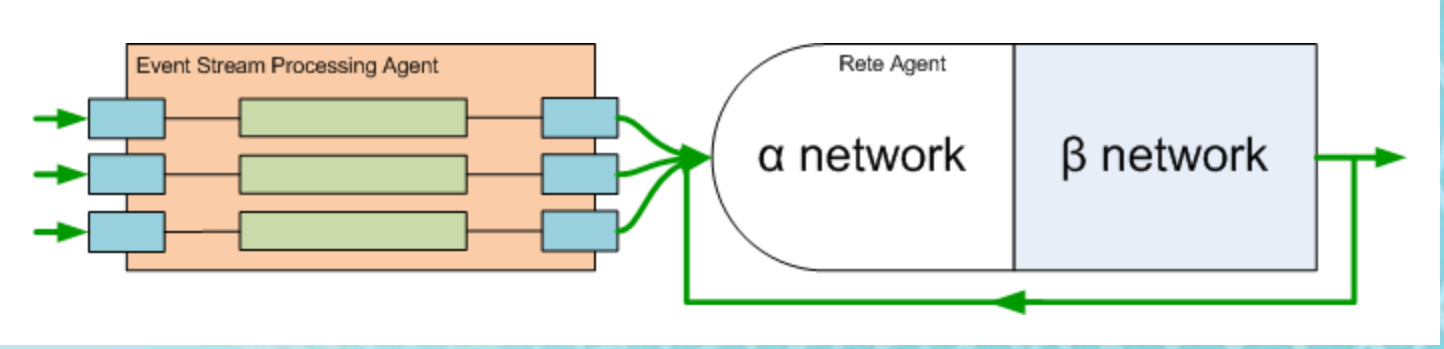
Single Agents

- Rete
  - Inference over events and context
  - Use downstream of event sources
  - Parallelisation challenges



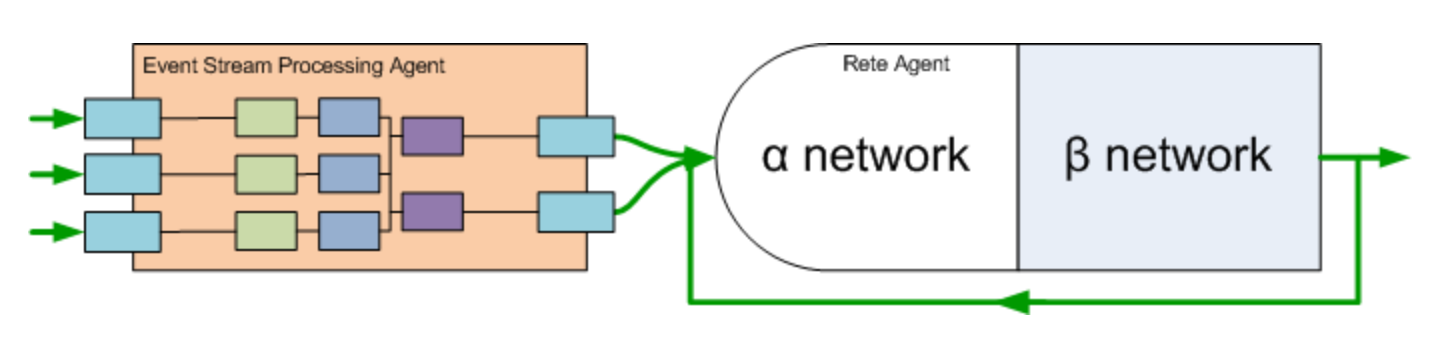
Combining Agents in an EPN

- Simple Event Streams Passed to Rete
  - Filter in Event Stream Agent
  - Aggregate & React in Rete Agent
  - Simple ECA model
  - Semantic Transformation



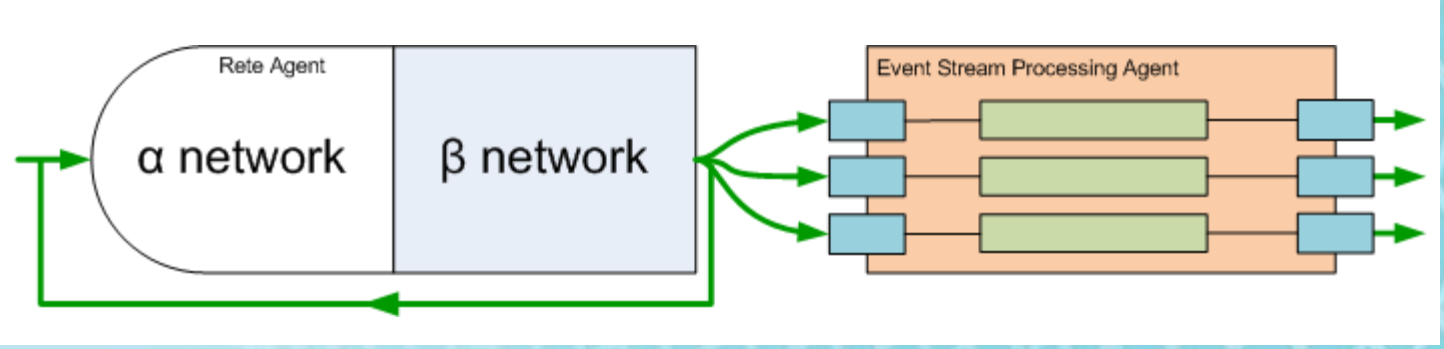
Combining Agents in an EPN

- Complex Event Streams Passed to Rete
  - Reduces Load on Rete Agent
    e.g., inference-only
  - Rete acts as 'bridge' to EDA



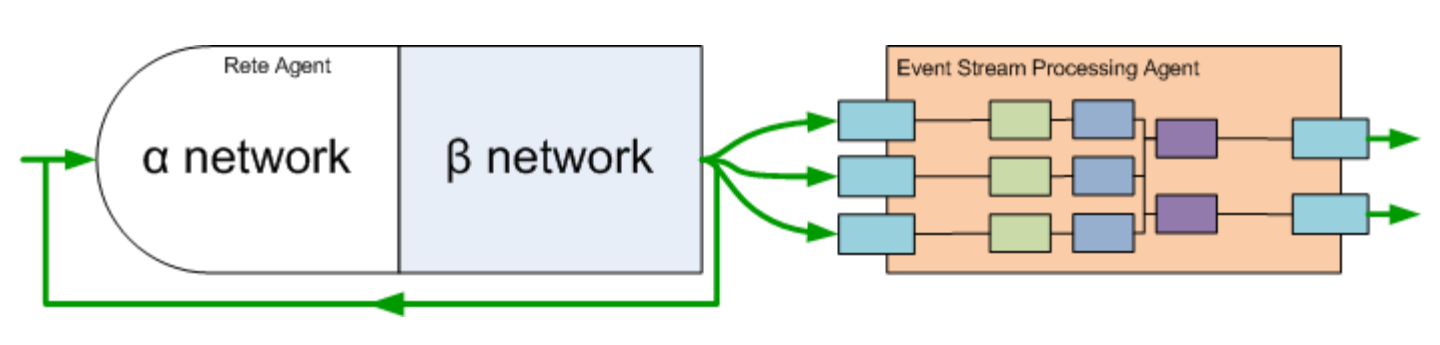
Combining Agents in an EPN

- Filter Events Inferred by Rete
  - Limited Applicability
  - Filtering historic events
    e.g., for simulation



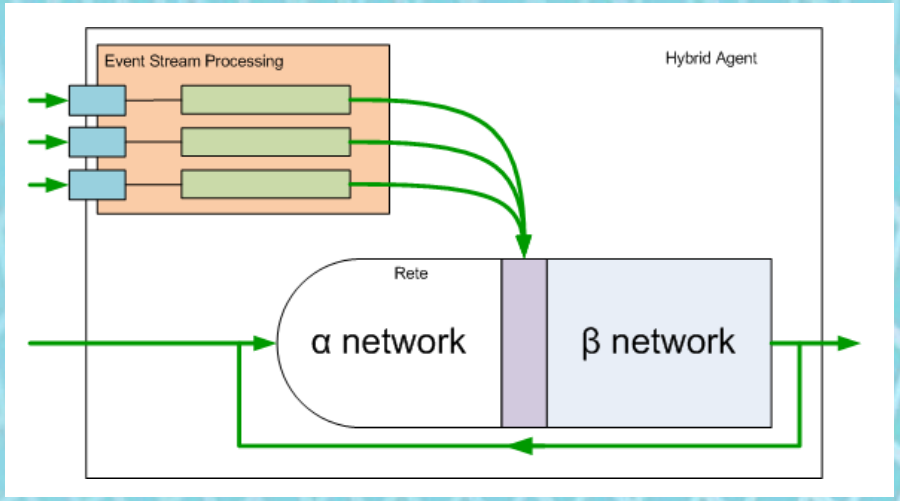
Combining Agents in an EPN

- Detect Complex Events Inferred by Rete
  - Limited applicability
  - May be useful in analytics over historical data



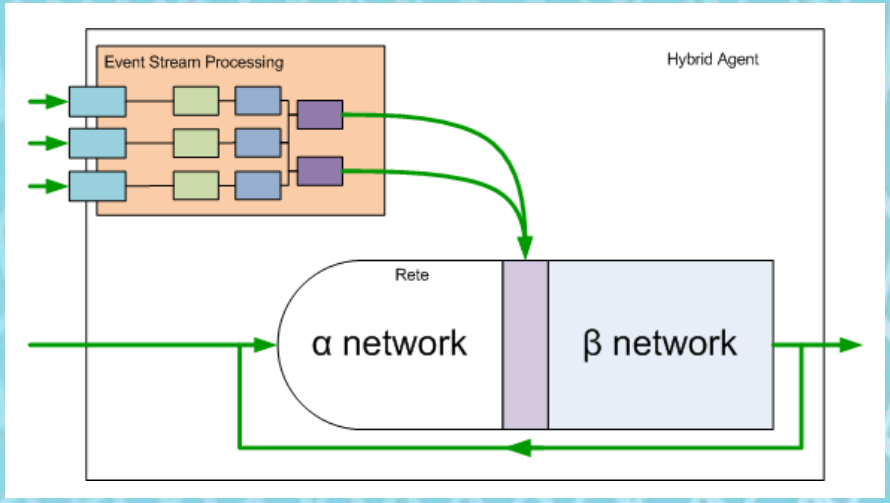
Hybrid Agents

- Rete with Extended α-network for Event Stream Filtering
  - Supports parallelisation for filtering
  - β-network sync
  - Garbage collection
  - 'Unrestricted'
  - JBoss Rules



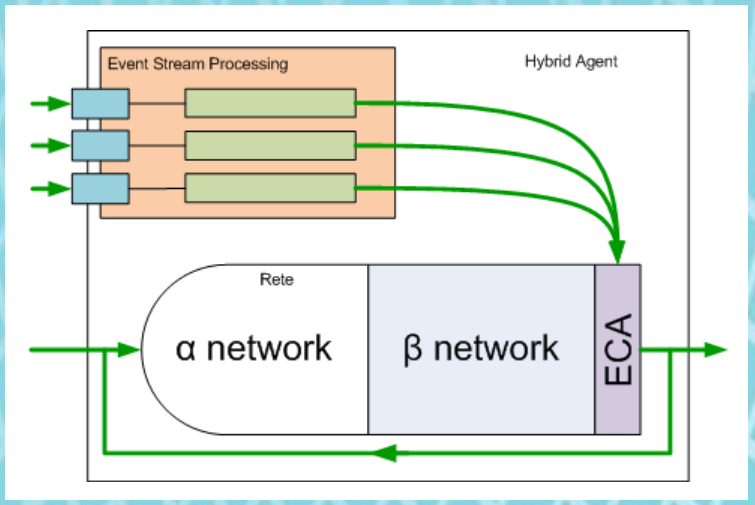
Hybrid Agents

- Rete with CEP Detection Parallel to the α-network
  - Supports parallelisation filtering and aggregation
  - Maintain semantics
  - Complex high-level language design
  - Any benefit over separate agents?



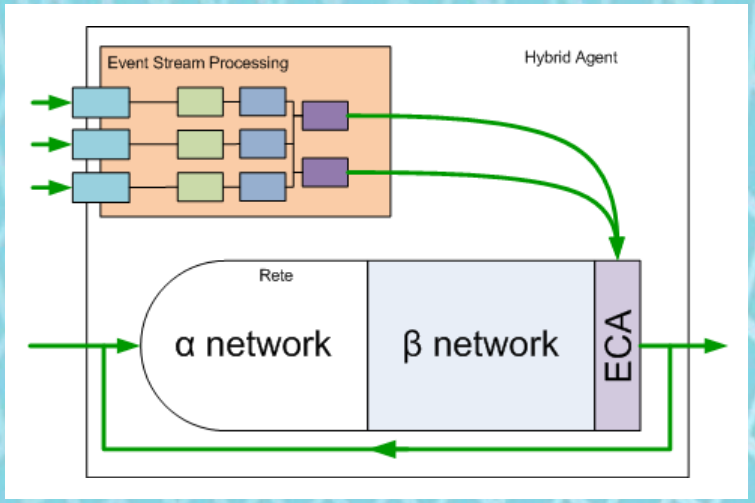
Hybrid Agents

- Rete with Simple ECA Extensions
  - Limited applicability
  - No direct support for CEP!
  - Inversion of ECA
    - CEA?
    - No lazy-eval in Rete
  - Event → Activations
    1- ∞



Hybrid Agents

- Rete with Complex ECA Extensions
  - ECA model with semantic separation (CEA)
  - Ultra low latency, lazy-eval CEP
  - Temporal restrictions on Rete
  - Complex language design
  - SAP Research, FZI



EPNs and ESBs

- Shared concerns
  - Common distributed ‘fabric’ and architecture
  - Centralised administration
  - Dynamic configuration and deployment
  - Platform and technology agnosticism
  - Dynamic routing and itineraries
  - Mediation
  - Adaptation
  - Monitoring

A Survey of CEP Models

Questions?

A Survey of CEP Models

Thank You