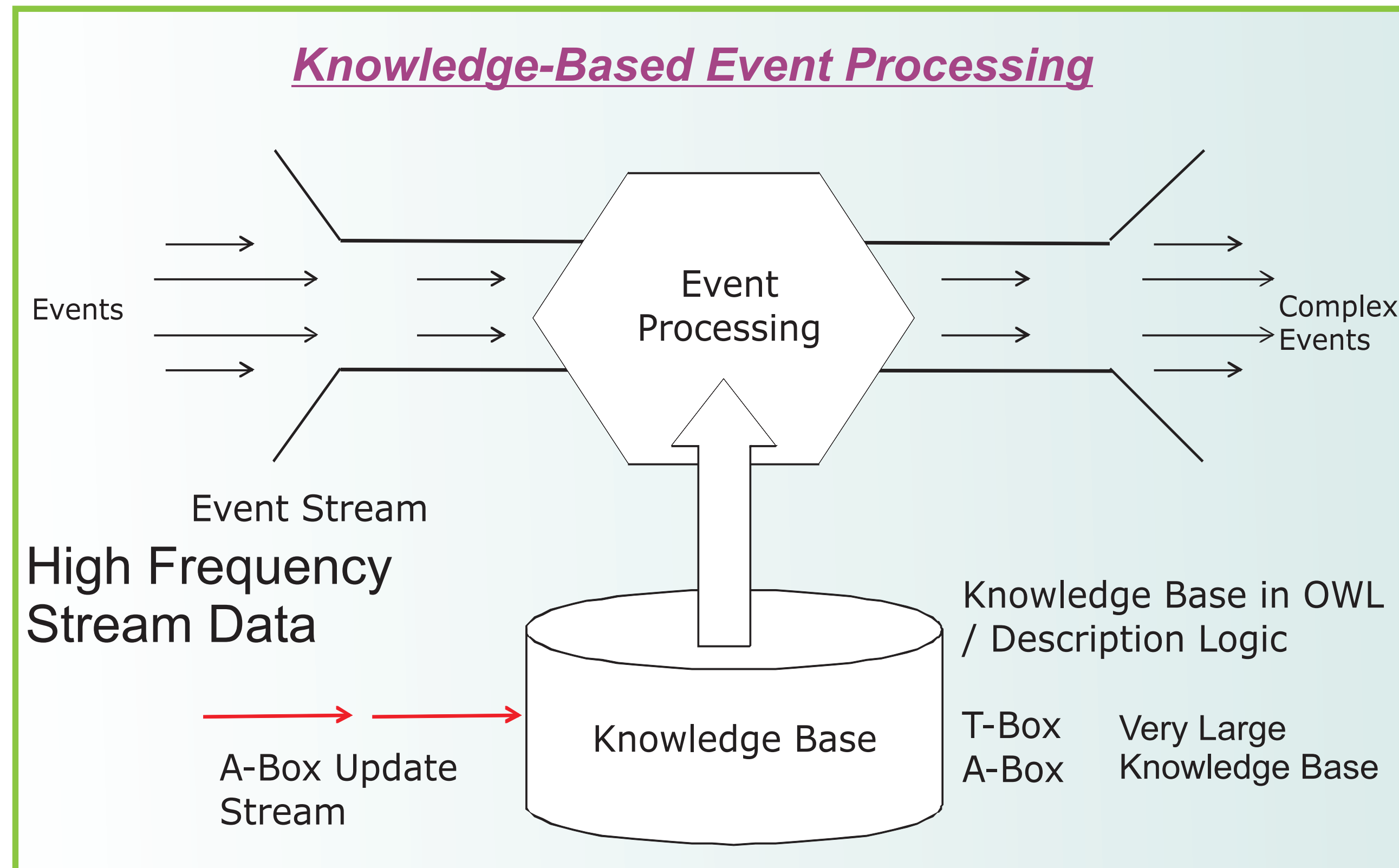# A Framework for Knowledge-Based Complex Event Processing

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Knowledge-Based Event Processing

Events

Event Stream

High Frequency Stream Data

A-Box Update Stream

Knowledge Base

Event Processing

Complex Events

Knowledge Base in OWL / Description Logic

T-Box
A-Box

Very Large Knowledge Base

Event Stream Erinchment

Derived Events: e3 e4 e3

Event Processing Network

Event Stream: e1 e2 e1

Raw Events

Semantic Enrichment

e1 e2 e1

Knowledge Base

Complex Events

Final Event Processeing on EPN

Raw events are enriched or new events are generated. In the next step the derived events can be processed by normal syntactic event processing. Enrichment process should be based on user complex query.

Event Query Pre-Processing

Event Stream e1, e2, ...

Event Processing Network

New rewritten queries generated from the complex query

Q
Complex Query

Pre-Processing

q1 q2 q3
q...

Complex Events

Knowledge Base

Final Event Processeing on EPN

e.g.   Q1 is equivalent to (q1 OR q2 OR q3)

The complex query of user can be rewritten into several simple queries.
The generated (or enriched) queries can be processed by several event processing agents on an event processing network to achieve high scalability.
Problem: updates on knowledge base should be handled in real time and new simple queries should be generated

Event Query Execution Plans

• Knowledge base queries might have different response time and costs.
• Different execution plans are possible when AND, OR and SEQ event algebra operations are used
• Optimal execution plan? Heuristic-based optimal plan
.

e2   AND e1 [within 5]

Sq2   Sq1

KB

Sq1 SEQ Sq2
Sq2 SEQ Sq1

Sq1 costs more than sq2 and has more response time

e2   e1

Sq2   Sq1

KB

• e2 is deteced based on results of e1
• No execution plan is possible because detection of e2 depends on results of Sq1

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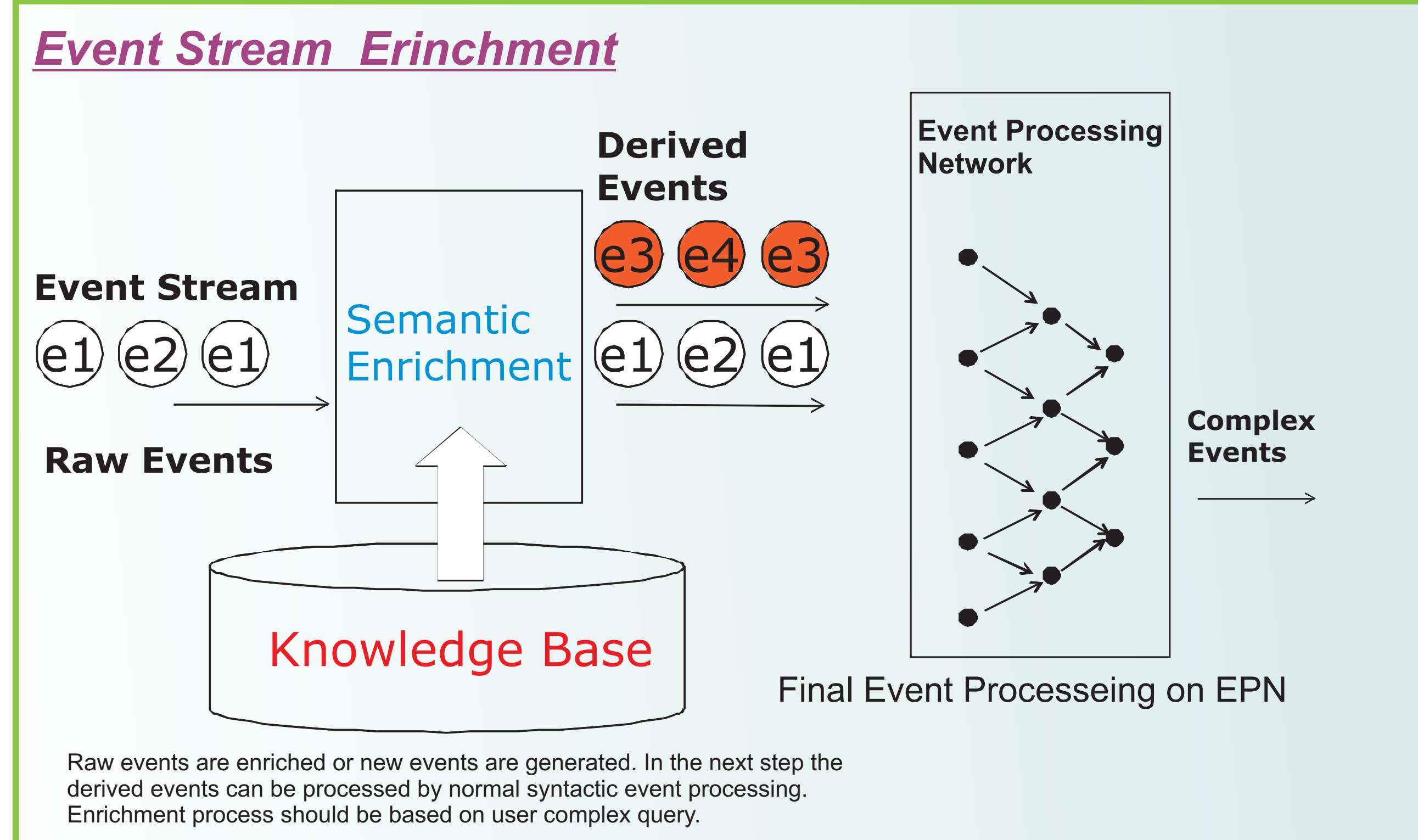kia@inf.fu-berlin.de

CSW Corporate Semantic Web

Fusion of Background knowledge and Semantic Events:

Real-world occurrences can be defined as Events that are happening over space and time. An event instance is an concrete **semantic object** containing data describing the event.
• Events have **relationships** to each other and to other objects in the application domain
• Syntactic information becomes **declarative knowledge** with underlying formal semantics
• Understanding the **temporal, spatio, habitual, .., relations between events, objects, states, activities, processes**
• Declaratively **process events and react to situations**
• Event Processing engine can understand what is happening in terms of events
• **Trade-off** between high expressivness (high complexity) and real-time processing of events

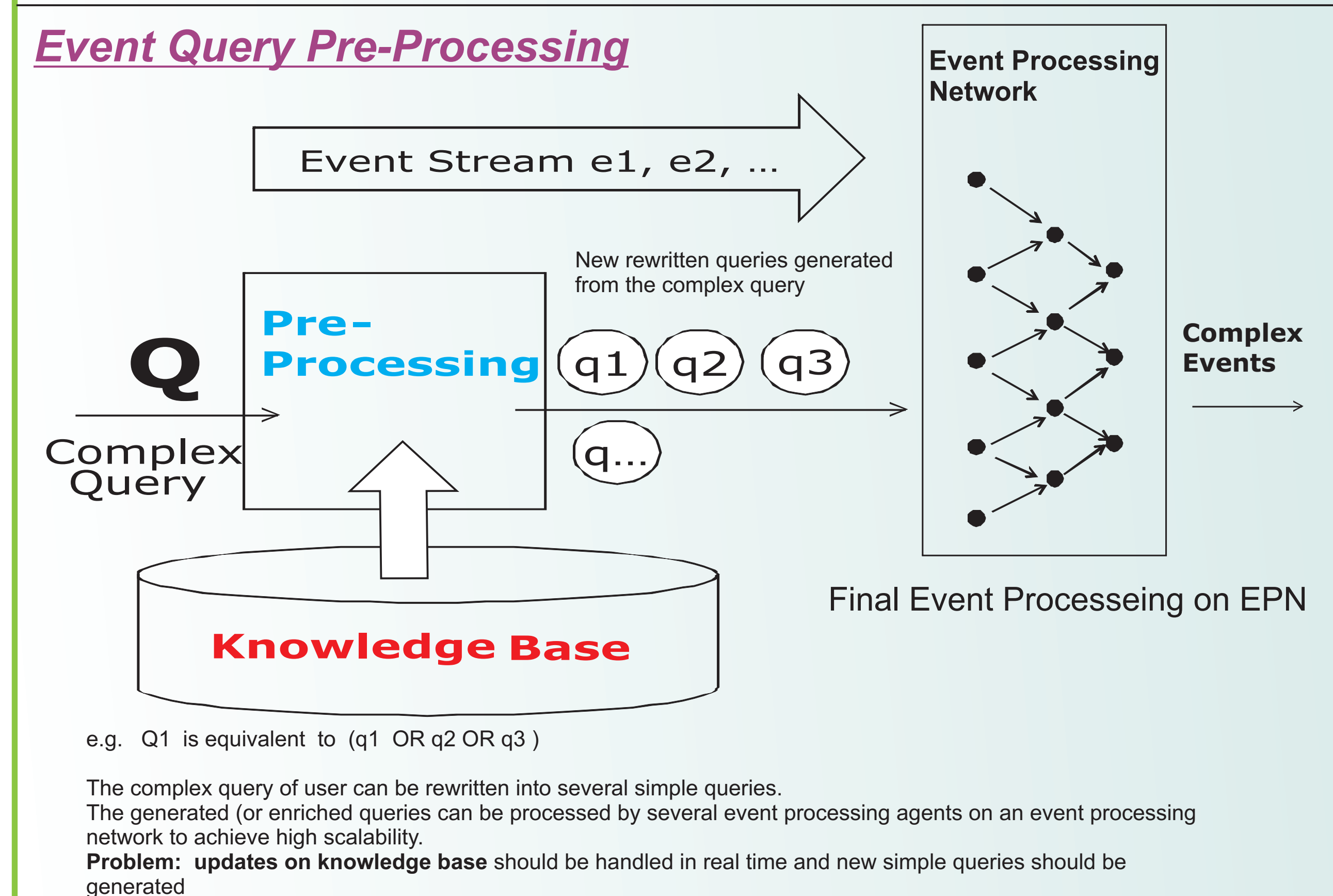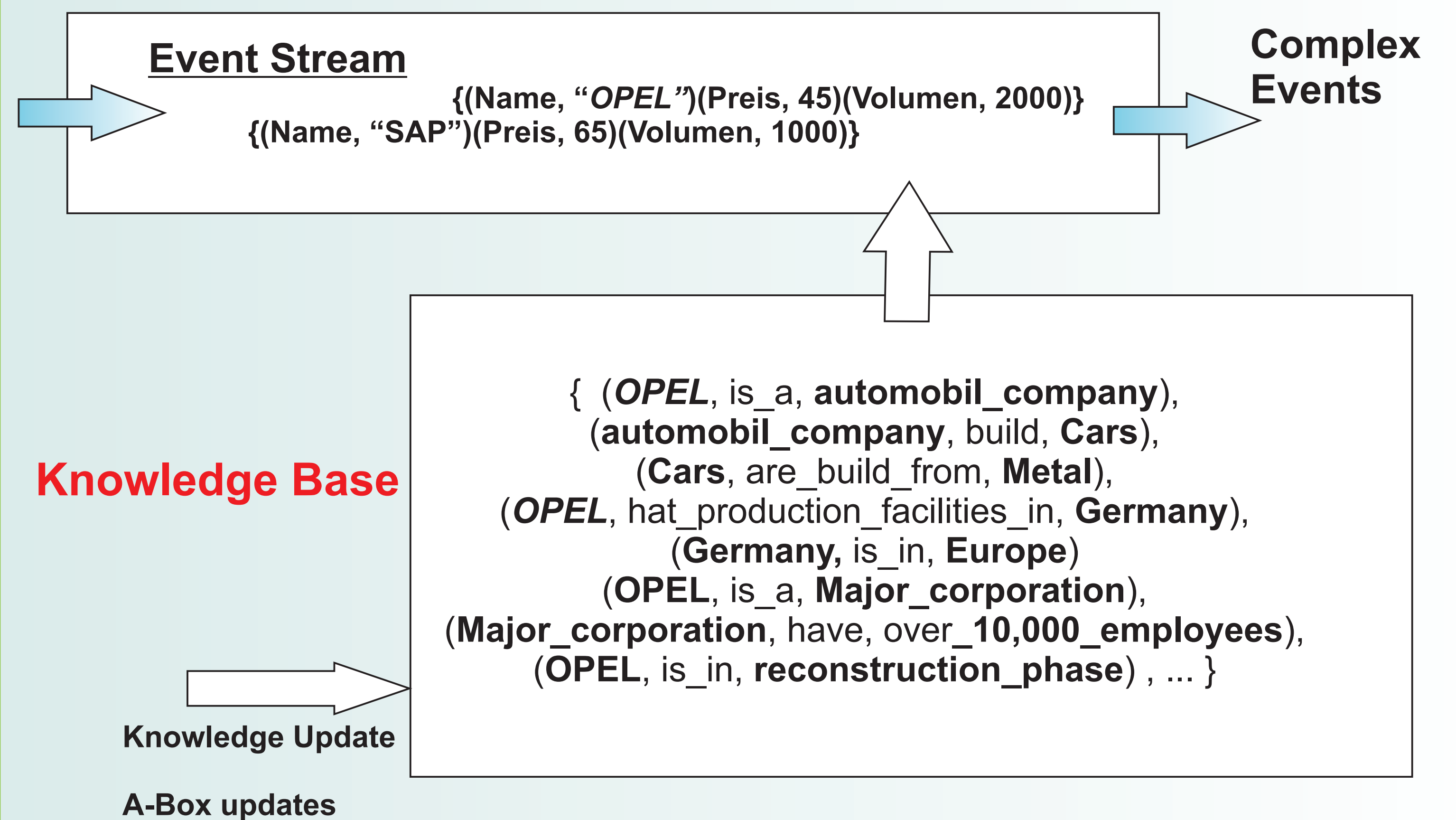The use of **Background Knowledge in Complex Event Processing (CEP)** offers:
• **Precise and expressive description** of complex events/situations and reactions,
• Enhancement of CEP systems to more agile systems and **improves flexibility to business changes**.
• **Simplicity** of event pattern rule definition

Example of Complex Event and Complex Event Pattern:

Event Pattern/ Event Query:

Buy Stocks of Companies,
who *have in Europe production facilities* **and**
produce products from metal and
have more than 10,000 employees and
are at the moment in reconstruction phase and
their price/volume increased stable
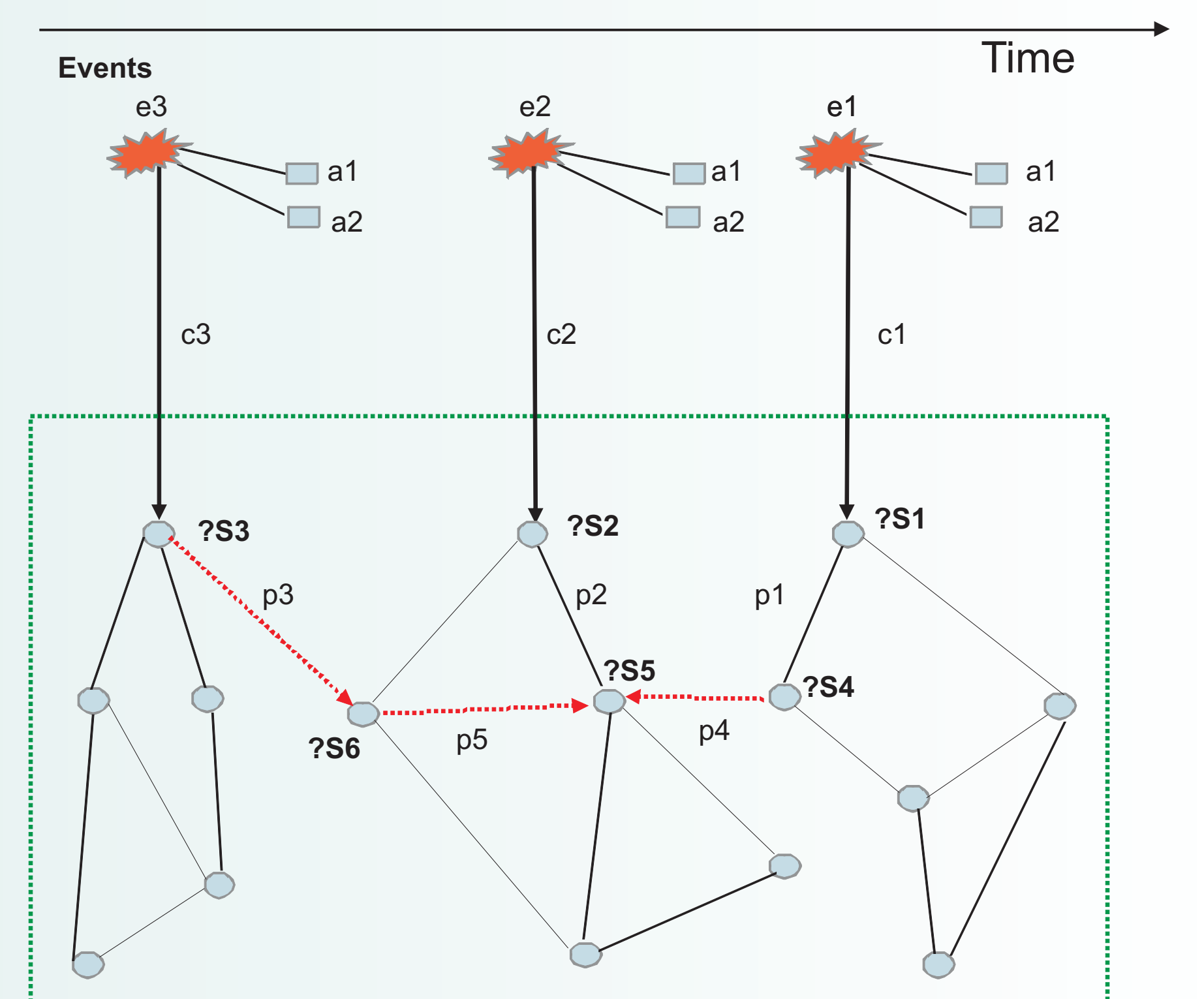**in the past 5 minutes.**

Event Stream {(Name, "OPEL")(Preis, 45)(Volumen, 2000)}
{(Name, "SAP")(Preis, 65)(Volumen, 1000)}

Complex Events

Knowledge Base

{ (*OPEL*, is_a, **automobil_company**),
(**automobil_company**, build, **Cars**),
(**Cars**, are_build_from, **Metal**),
(*OPEL*, hat_production_facilities_in, **Germany**),
(**Germany,** is_in, **Europe**)
(**OPEL**, is_a, **Major_corporation**),
(**Major_corporation**, have, over, **10,000_employees**),
(**OPEL**, is_in, **reconstruction_phase**) , ... }

Knowledge Update

A-Box updates

Example of Event Query

Events   Time

e1 SEQ e2 SEQ e3 [within 5 min]

{ (e1, c1, ?S1) .
  (?S1, p1, ?S4) .
  (?S4, p4, **?S5**) . }

{ (e2, c2, ?S2) .
  (?S2, p2, **?S5**) . }

{ (e3, c3, ?S3) .
  (?S3, p3, ?S6) .
  (**?S6**, p5, **?S5**) . }
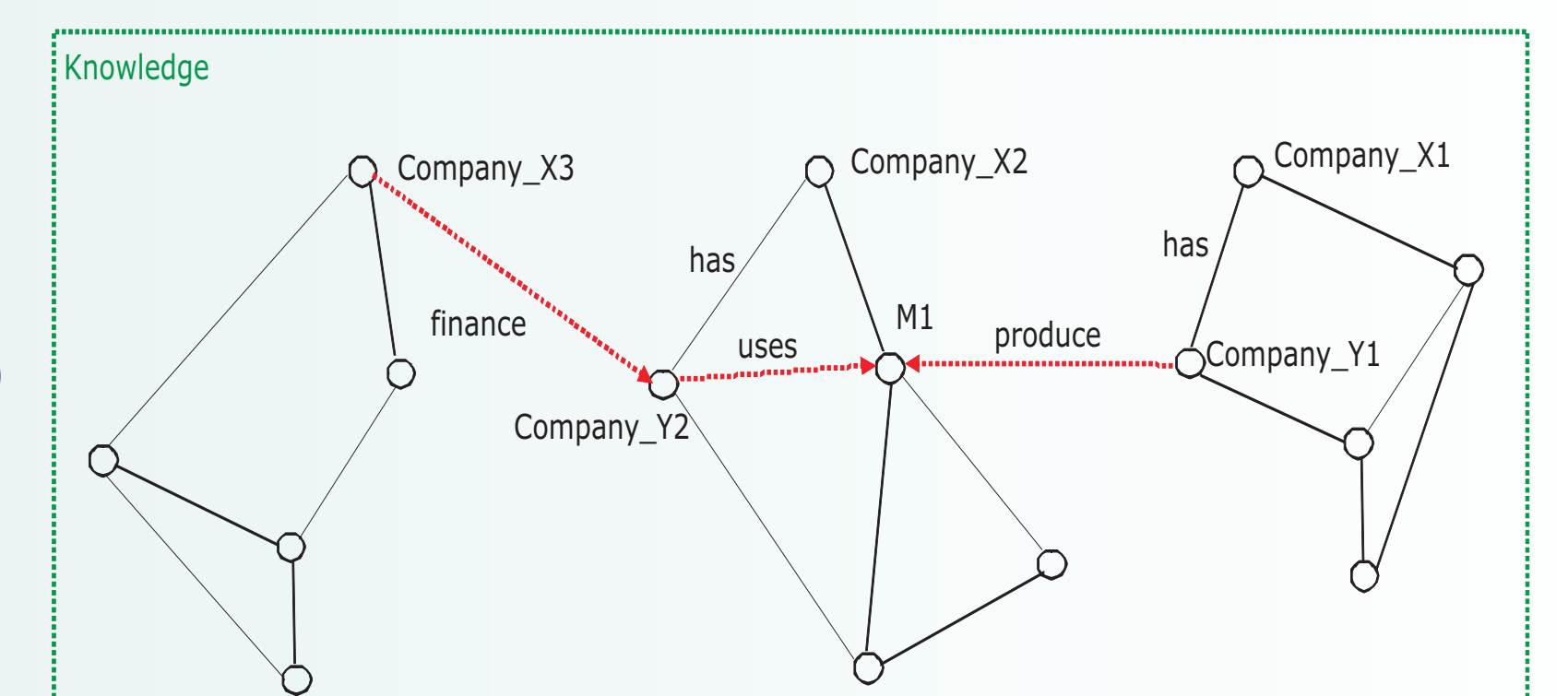
Knowledge Base

{ [(**e1** p:stockOf Company_X1),
  (Company_X1 p:affiliates Company_Y1)
  (Company_Y1 *p:supplierOf* **Metal**)]

; sequence   %(or other event algebra Operations)

[(**e2** p:stockOf Company_X2),
  (Company_X2 p:affiliates Company_Y2),
  (**Company_Y2** *p:hasResourcesDemand*   **Metal**)]

; sequence   %(or other event algebra Operations)
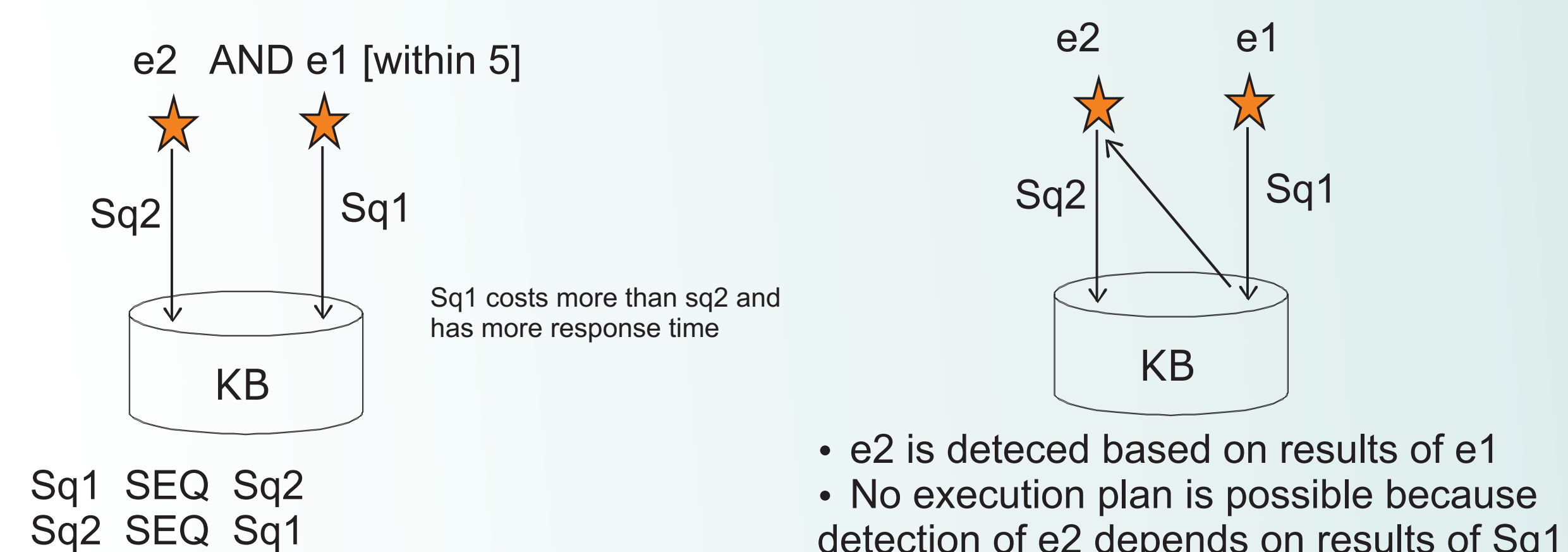
[(**e3** p:stockOf Company_X3),
  (Company_X3 *p:finance* **Company_Y2**)]
} {within 10 minutes}

New Knowledge is derived by inferencing on existing knowledge on the knowledge base and the results are used for event detection.