

**ADVANCED SEMANTIC  
BUSINESS PROCESS ANALYSIS:  
COMBINING KNOWLEDGE ENGINEERING  
AND COMPLEX EVENT PROCESSING**

**CARLOS PEDRINACI  
THE OPEN UNIVERSITY**

# ACKNOWLEDGEMENTS

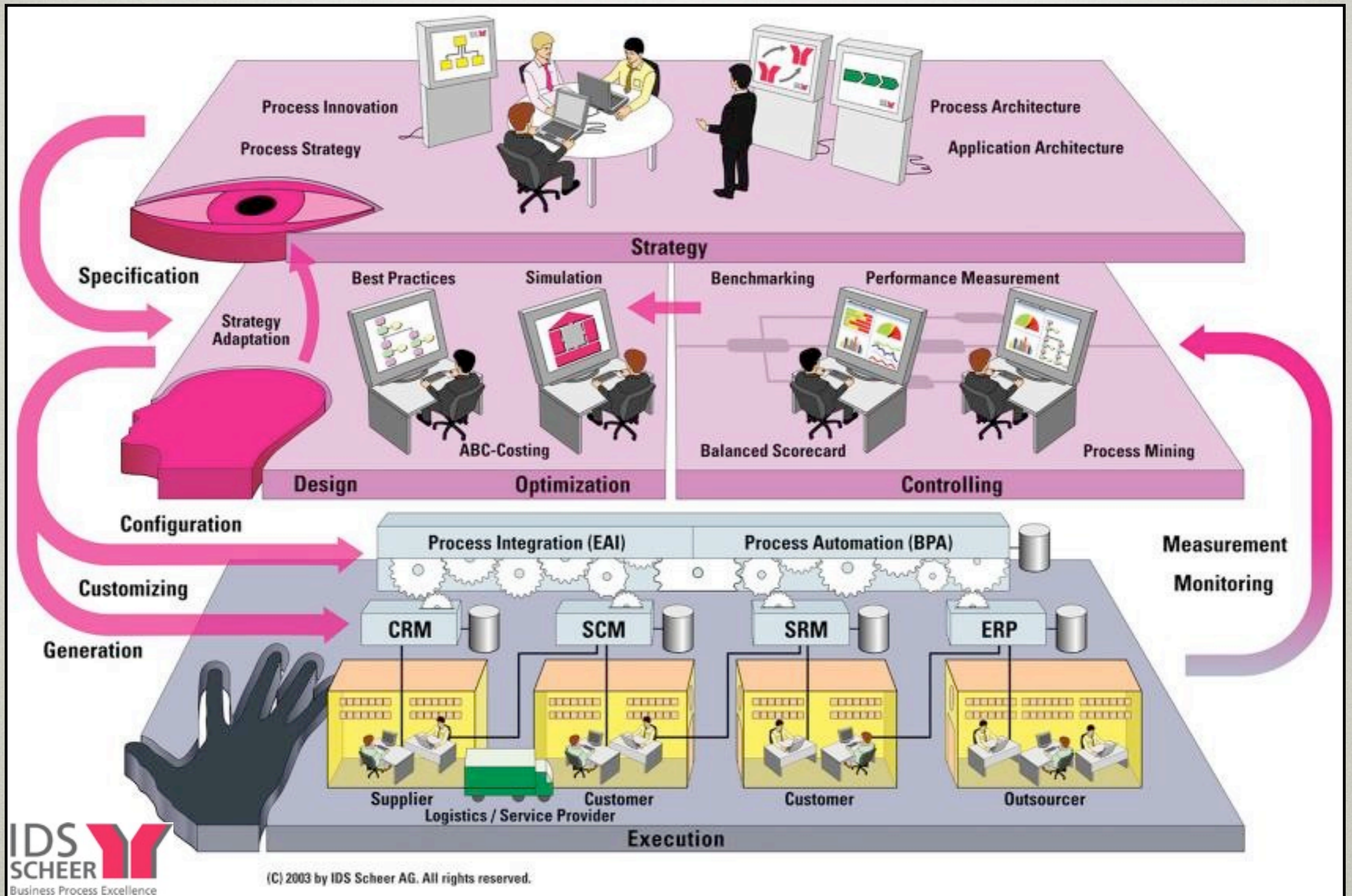
---

- Dong Liu, John Domingue and Enrico Motta (OU)
- Ana Karla Alves de Medeiros, Wil van der Aalst (TUE)
- Ivan Markovic (SAP)
- Lucesar Cekov (Ontotext)
- Michael Oppitz, Gernot Zeissler (IBIS)
- SUPER Project

# OVERVIEW

---

- Business Process Analysis in Context
- Semantics for Data Integration and Analysis
- Semantics for Generic BPA Components
- Lessons Learnt
- Concluding remarks



“In which of our food manufacturing machines are we processing meat or raw eggs?”

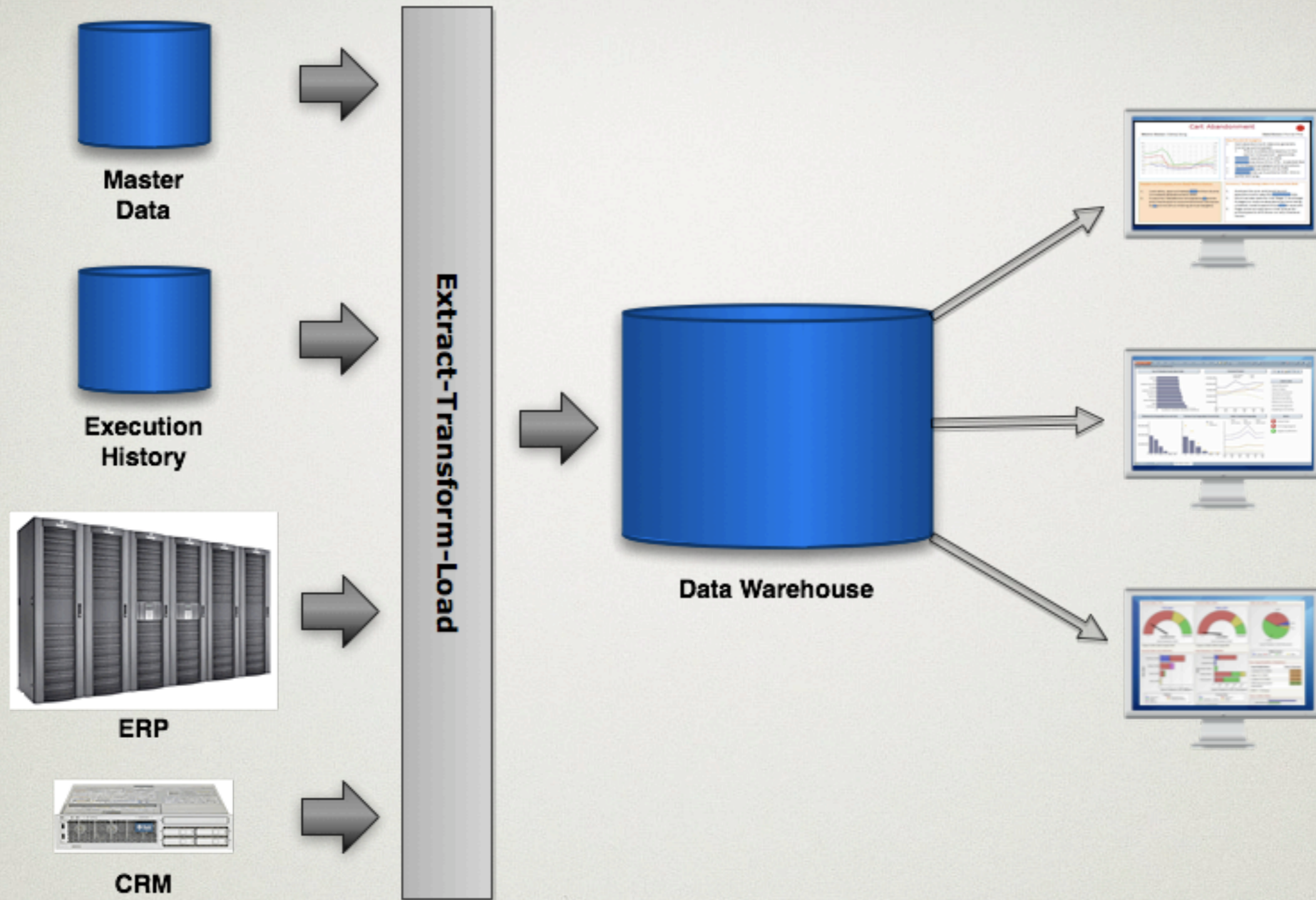
“Do we have a cost approval process for items below \$ 200?”

“How many inventory management methods are currently in use?”



# BUSINESS PROCESS ANALYSIS

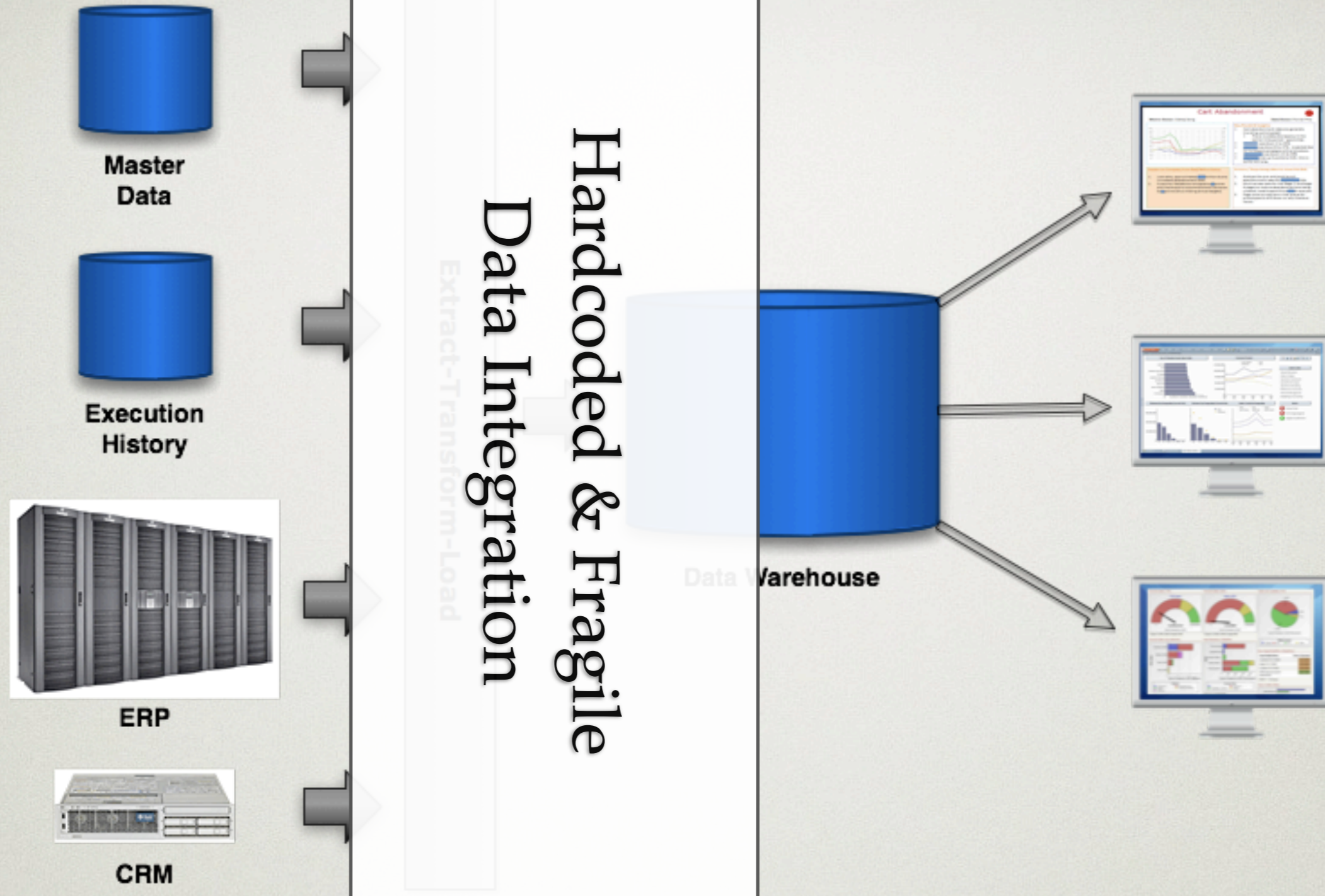
Mining  
Monitoring  
Reverse-Engineering



## TRADITIONAL BUSINESS PROCESS ANALYSIS

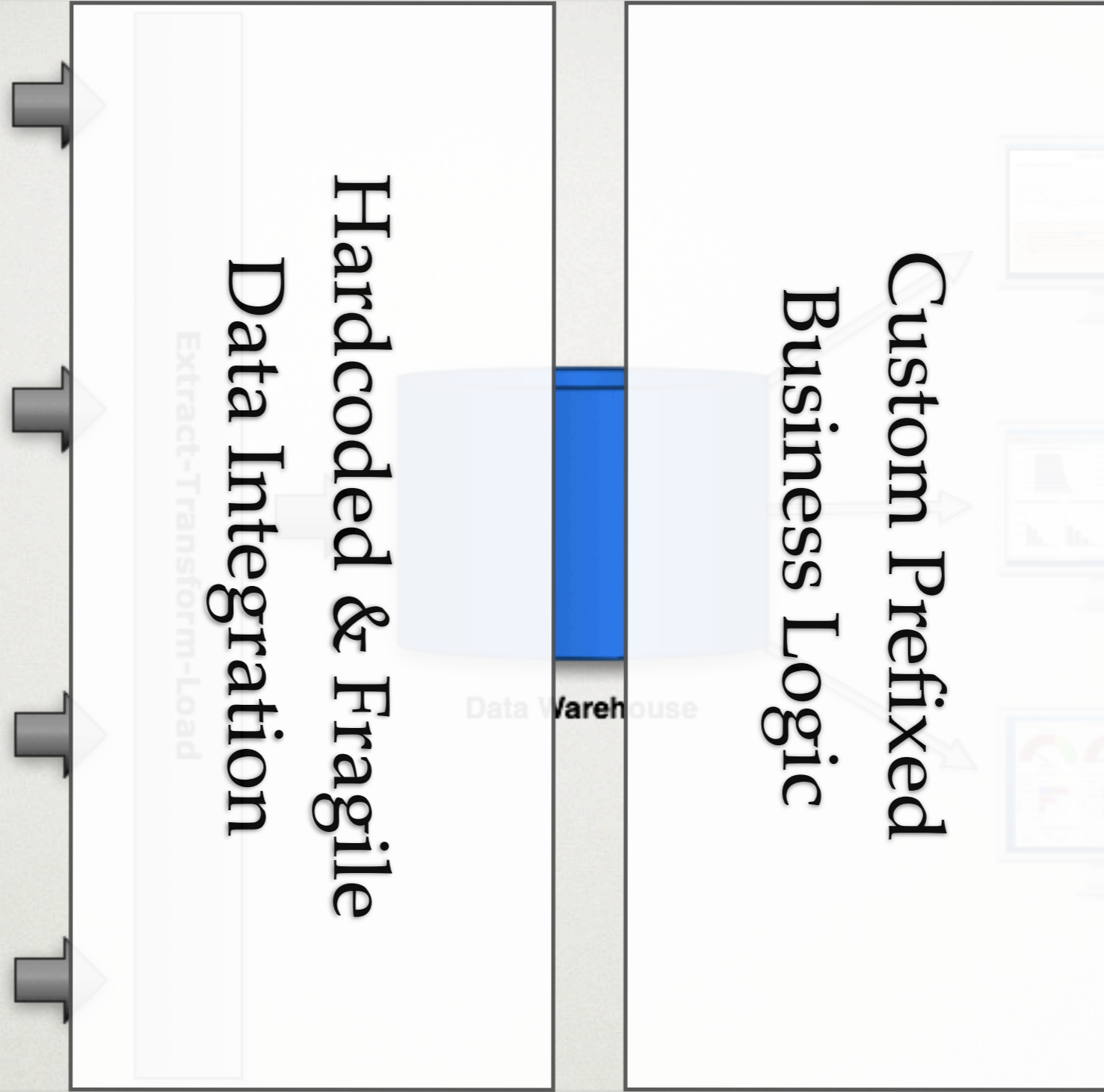
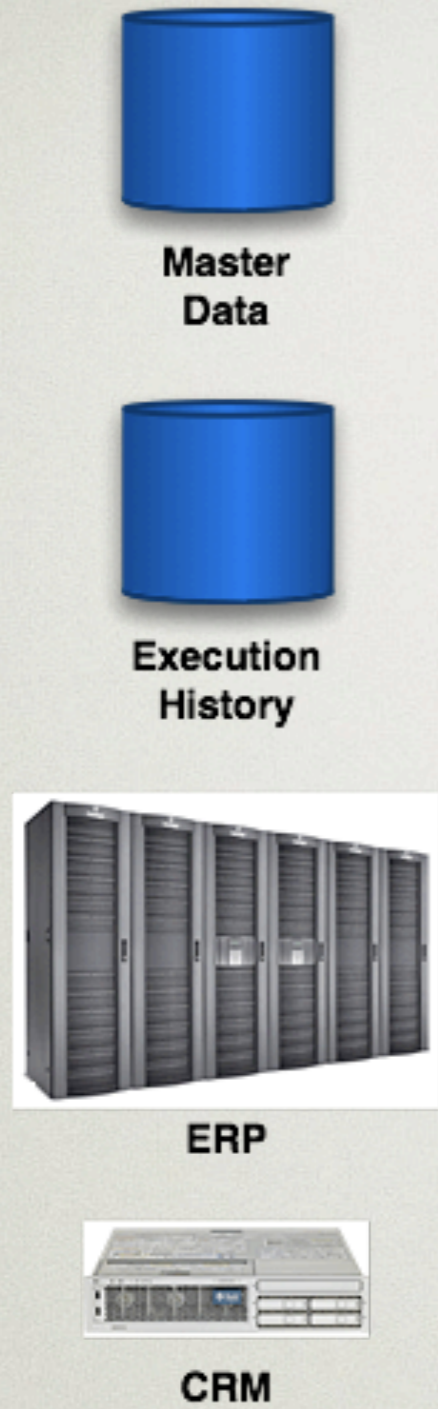
Manual & custom-tailored setup  
 Requires expensive adaptation for

- Changes on the underlying systems
- Changes on the objectives/goals



## TRADITIONAL BUSINESS PROCESS ANALYSIS

- Manual & custom-tailored setup  
 Requires expensive adaptation for
- Changes on the underlying systems
  - Changes on the objectives/ goals

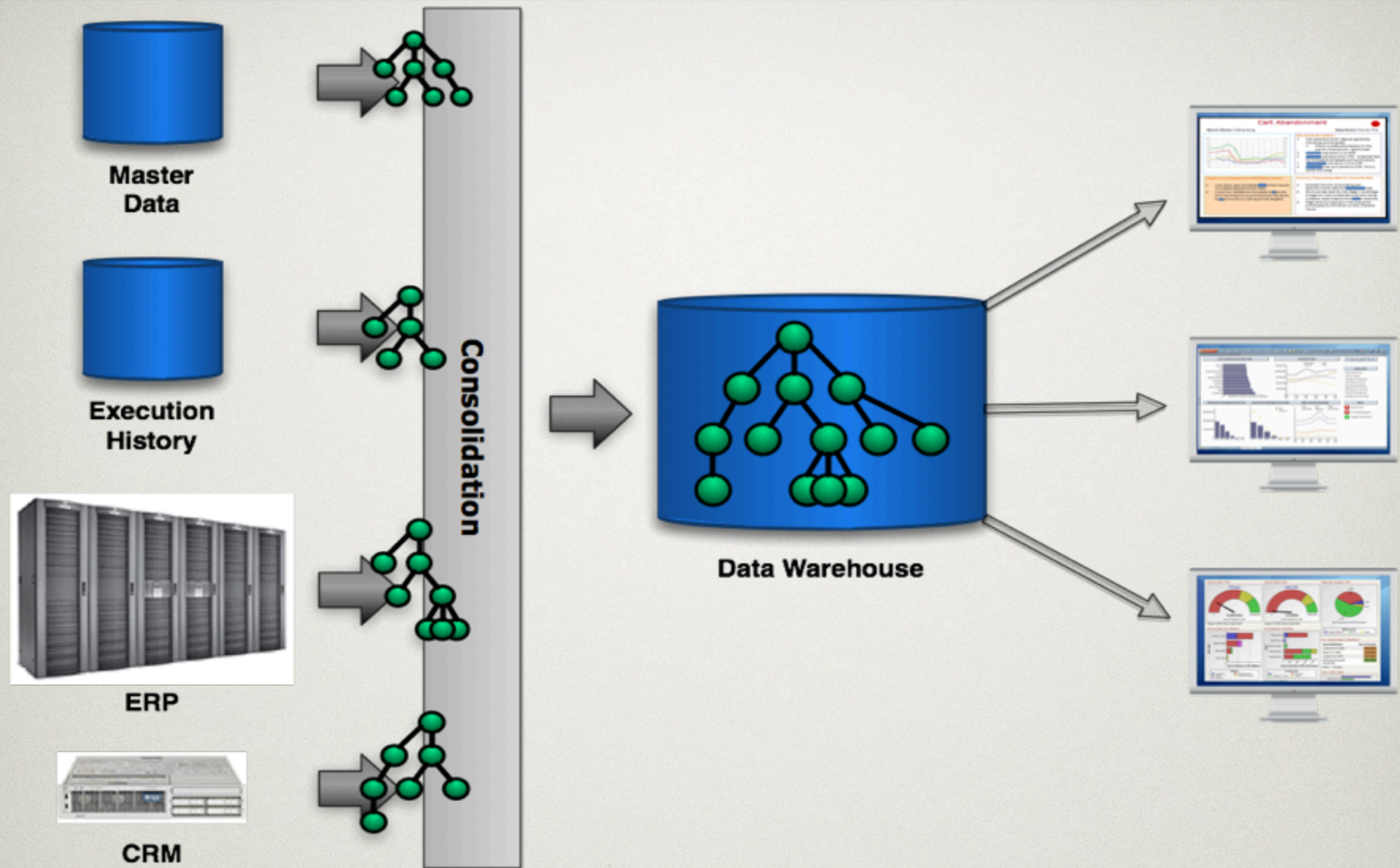


# TRADITIONAL BUSINESS PROCESS ANALYSIS

- Manual & custom-tailored setup  
 Requires expensive adaptation for
- Changes on the underlying systems
  - Changes on the objectives/ goals

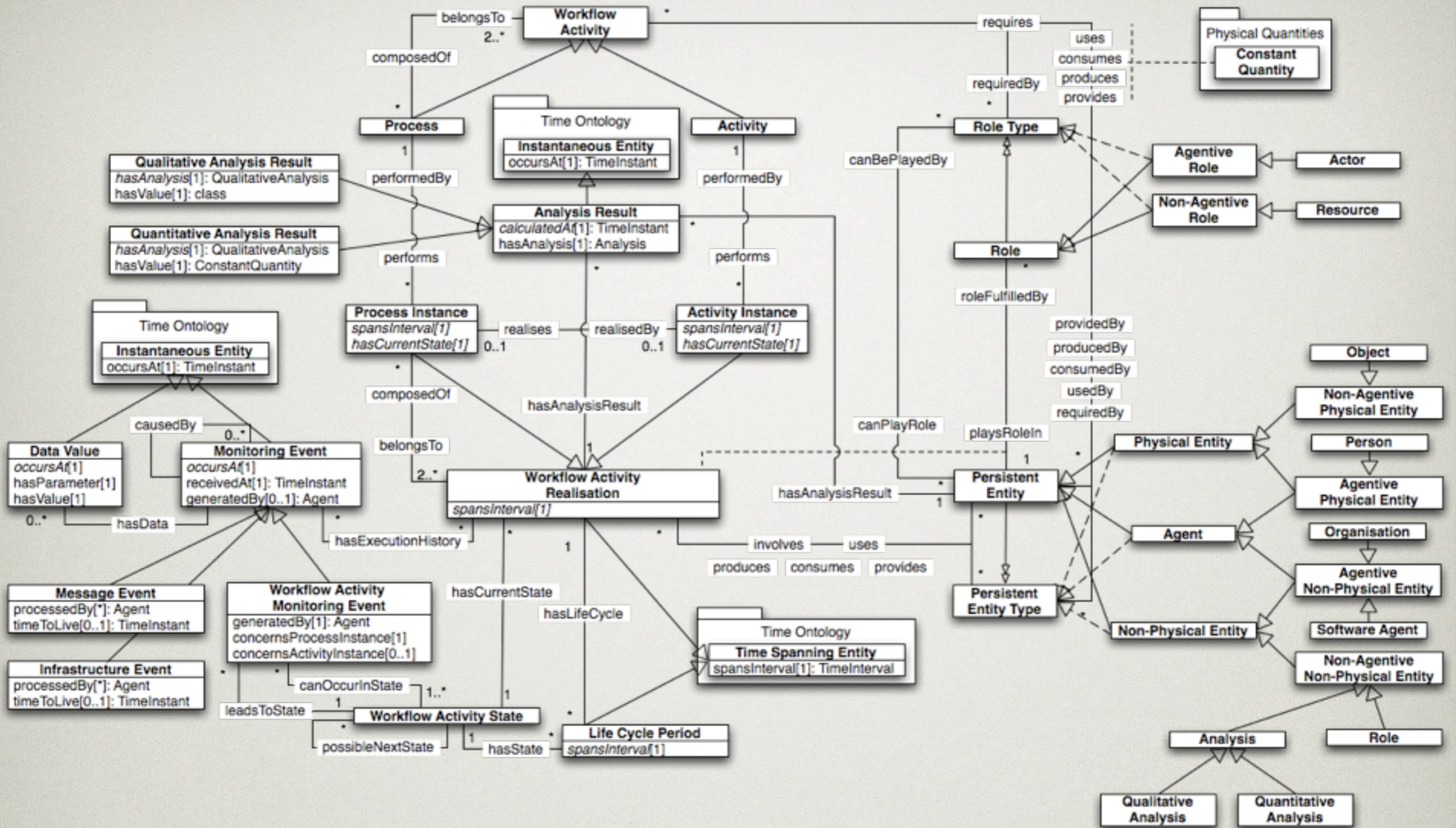


**... IMPROVING DATA  
MANAGEMENT WITH  
SEMANTIC TECHNOLOGIES ...**



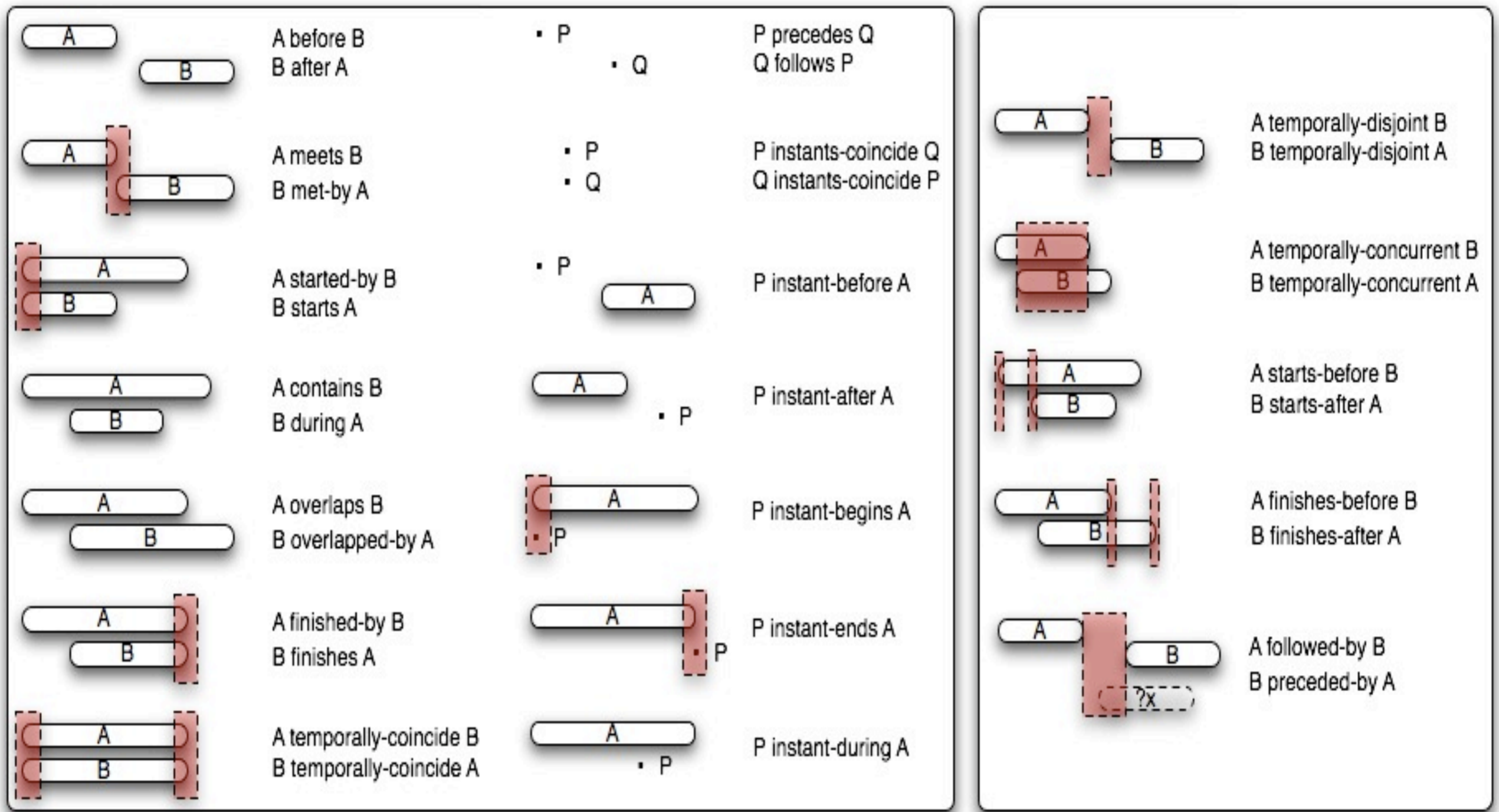
# DATA INTEGRATION: USE SEMANTICS

- Providing
- integrating views over data
  - enhanced querying support
  - automated derivation of knowledge



# COBRA ONTOLOGY

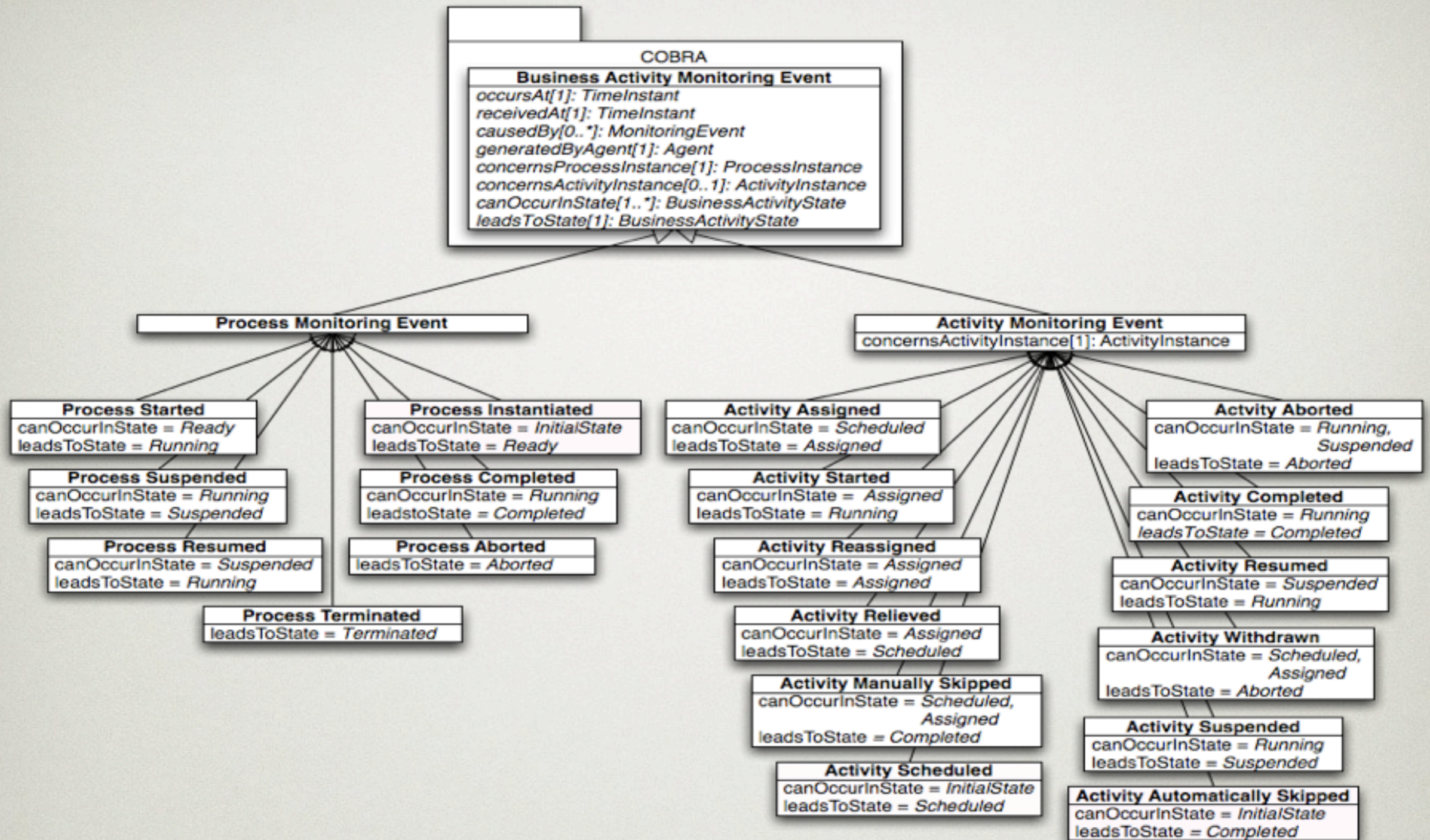
Core ontology for BPA  
 - Extensible along specific domains  
 - Providing a basic upper-level ontology for the development of generic software



# TIME ONTOLOGY

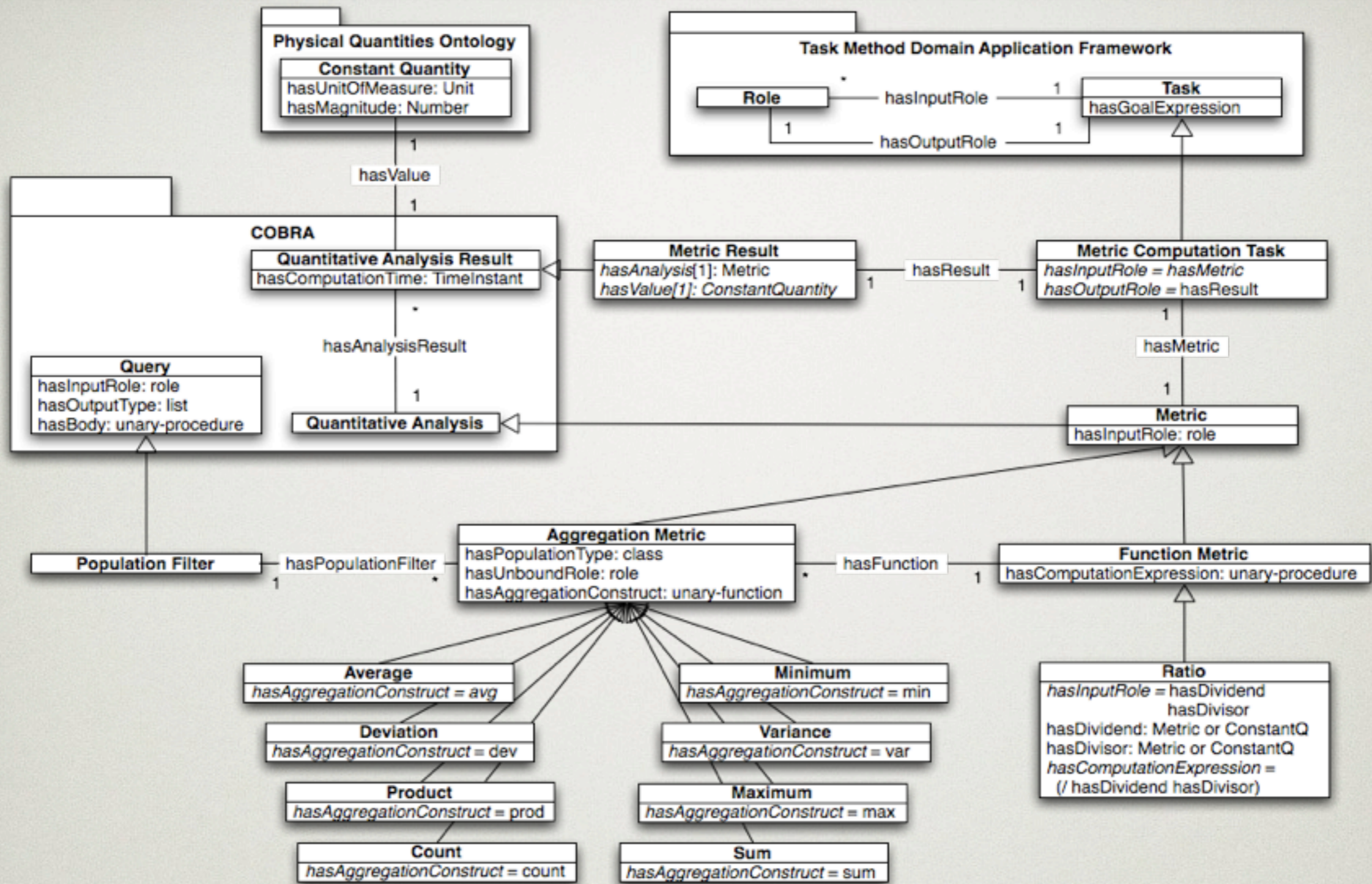
Assertion and reasoning about time  
 Based on Allen's algebra  
 Extended with some additional convenient relationships

**...AND FURTHER  
ONTOLOGIES**



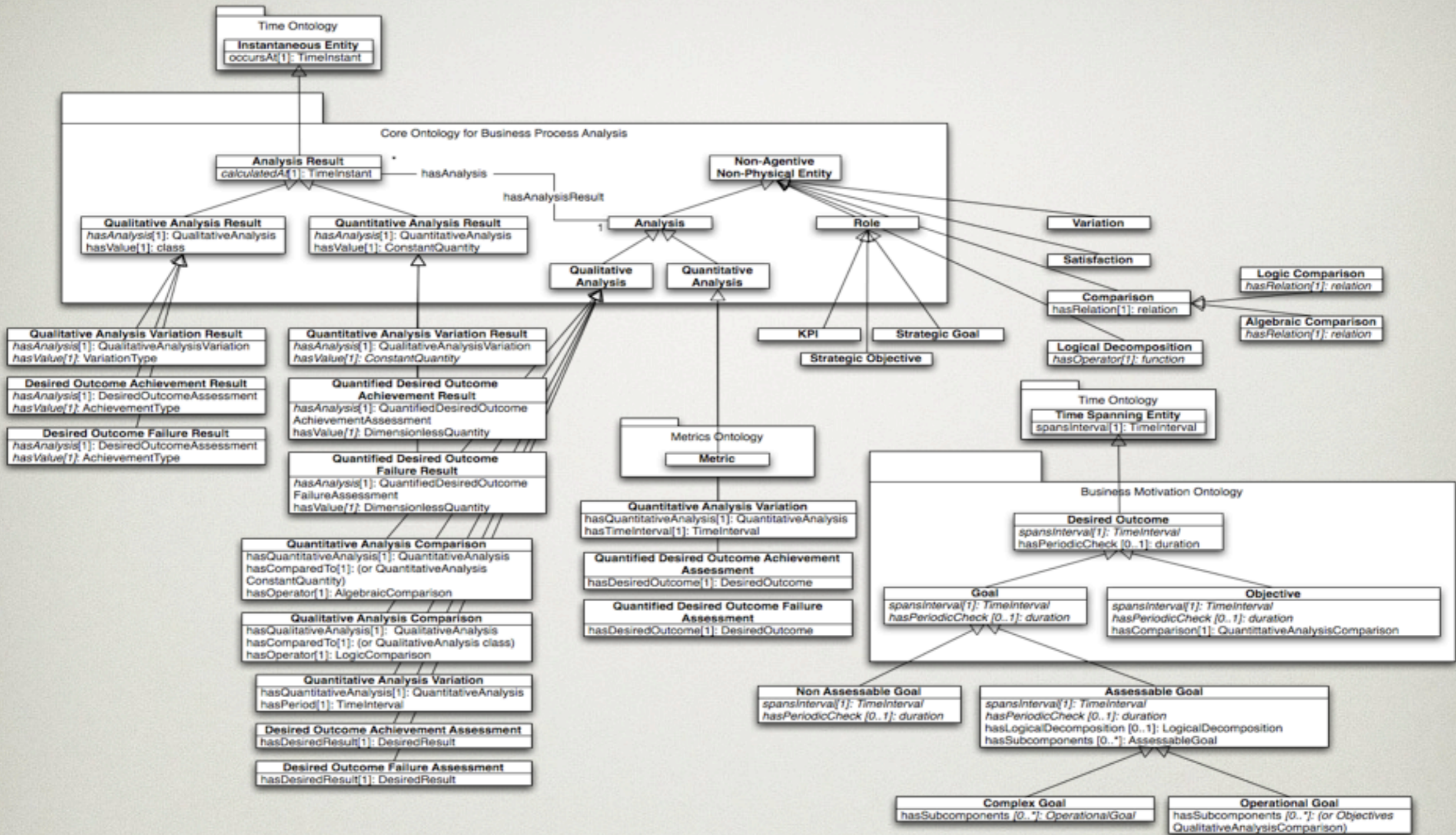
# ...AND FURTHER ONTOLOGIES

Capturing events within BPM systems



# ...AND FURTHER ONTOLOGIES

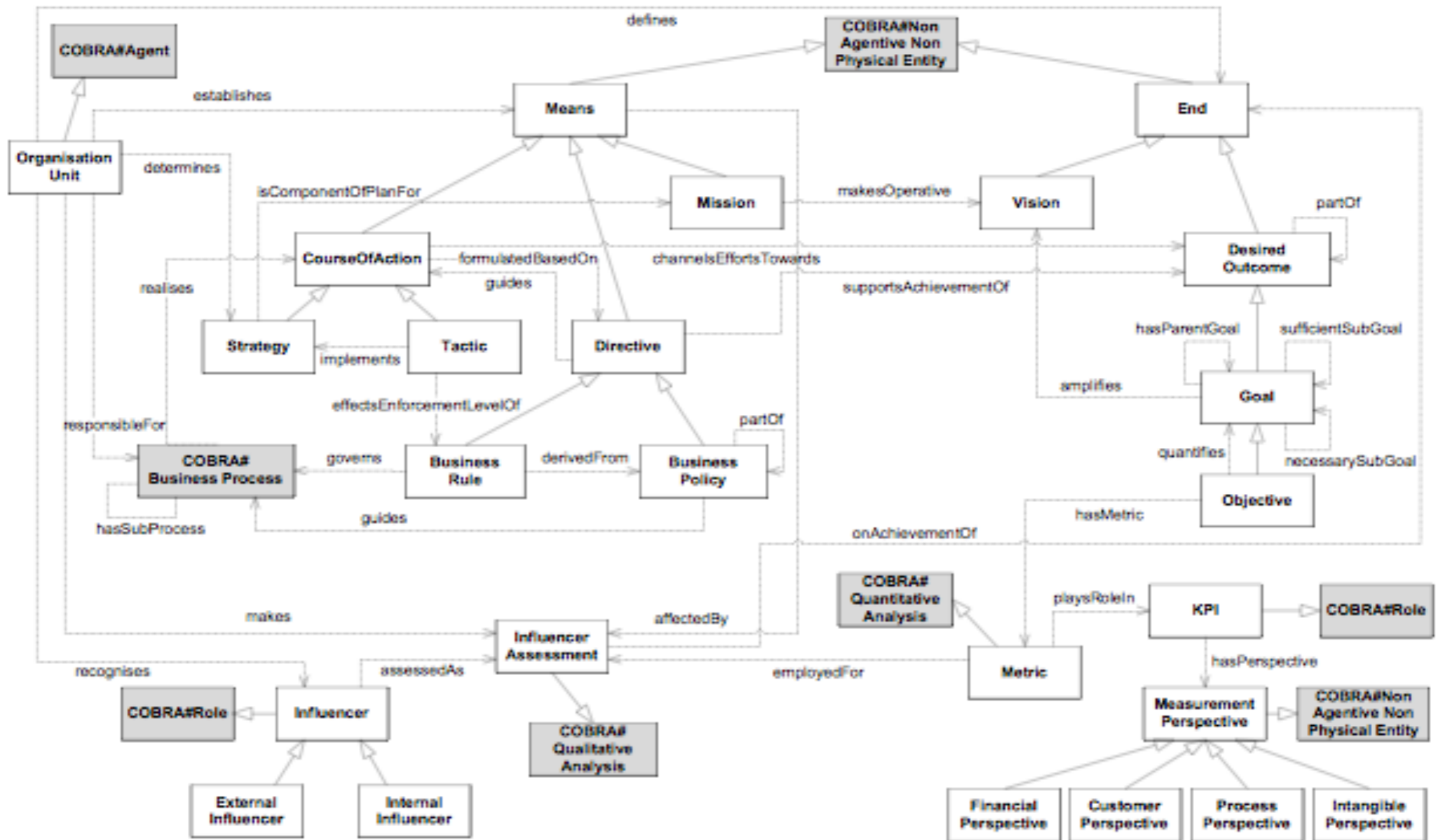
Capturing events within BPM systems  
Definition and computation of metrics



# ...AND FURTHER ONTOLOGIES

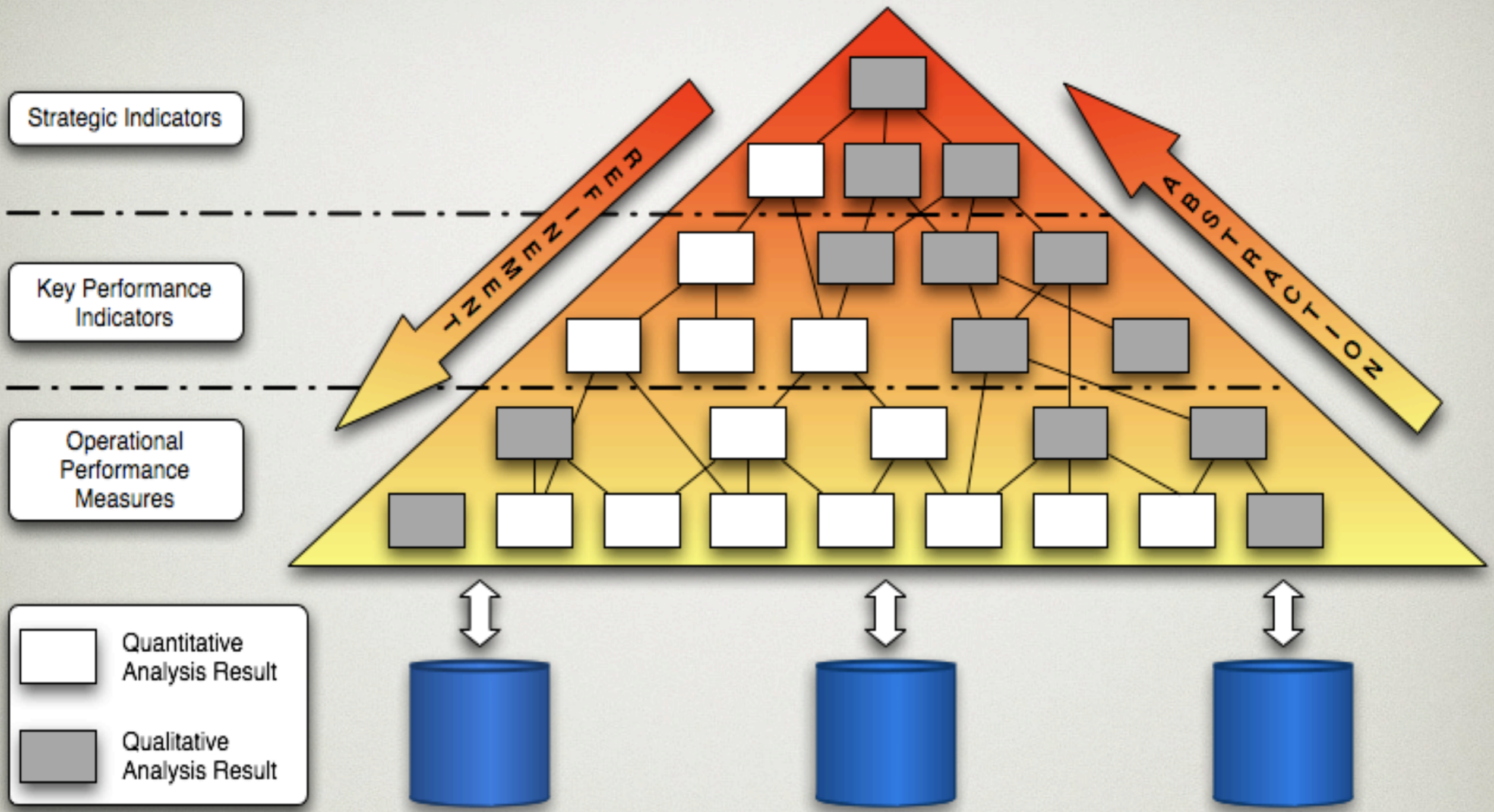
Capturing events within BPM systems  
 Definition and computation of metrics  
 Goal-driven metrics





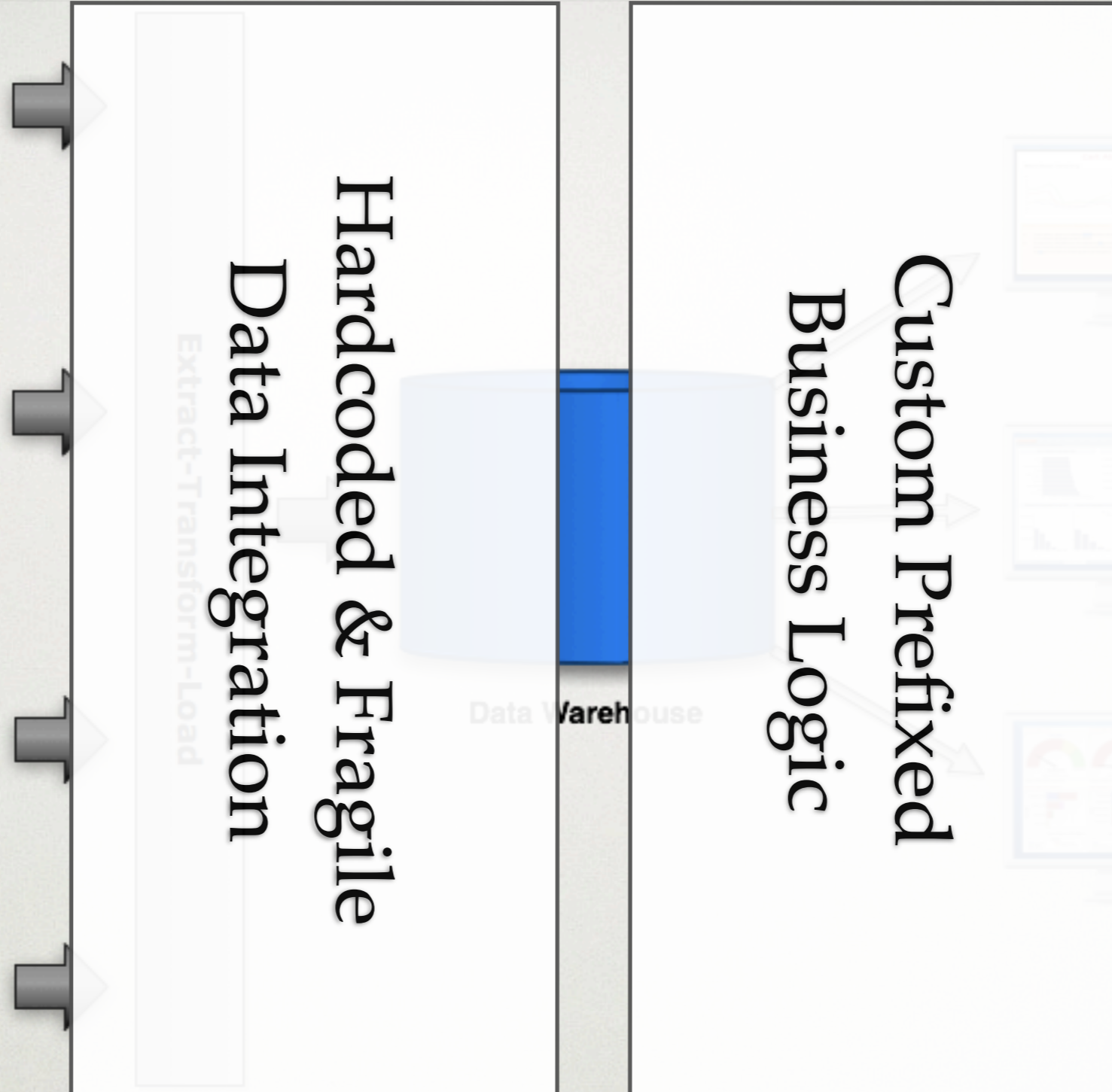
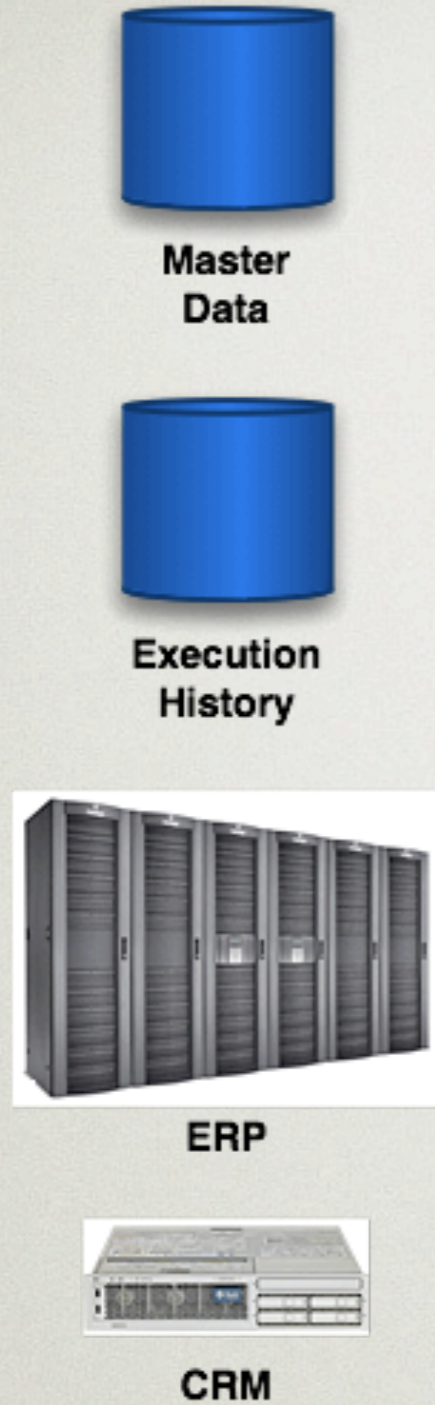
# ...AND FURTHER ONTOLOGIES

Capturing events within BPM systems  
 Definition and computation of metrics  
 Goal-driven metrics  
 Strategic analysis



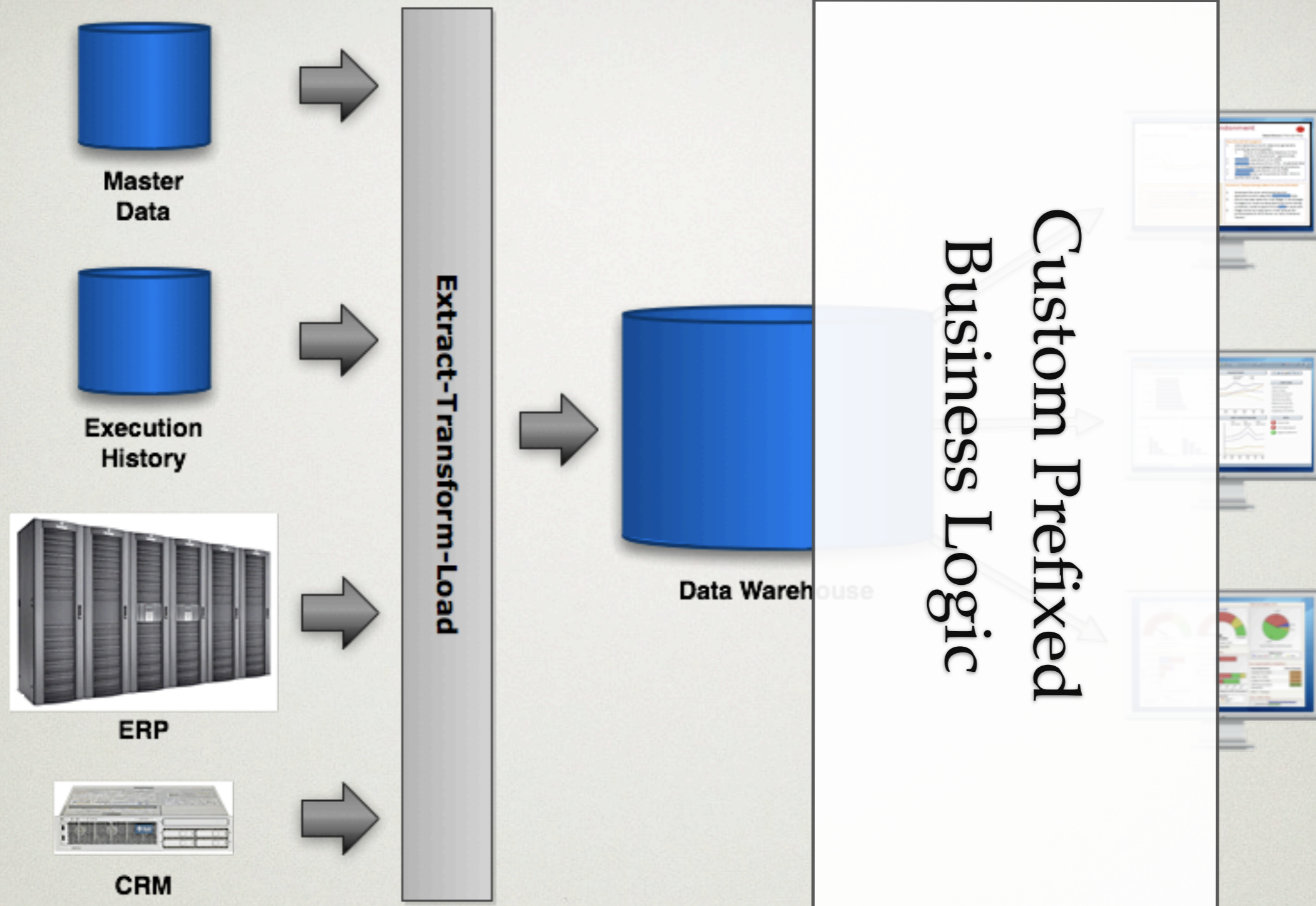
# SEMANTIC DATA WAREHOUSE

Continuously populated  
Incremental reasoning and knowledge  
derivation in generic terms for its analysis  
and decision making



# TRADITIONAL BUSINESS PROCESS ANALYSIS

- Manual & custom-tailored setup  
 Requires expensive adaptation for
- Changes on the underlying systems
  - Changes on the objectives/ goals



## TRADITIONAL BUSINESS PROCESS ANALYSIS

- Manual & custom-tailored setup  
 Requires expensive adaptation for
- Changes on the underlying systems
  - Changes on the objectives/ goals

**... PROVIDING GENERIC AND  
SMARTER ANALYSIS ENGINES  
WITH SEMANTIC  
TECHNOLOGIES ...**

# PROBLEM-SOLVING METHODS

---

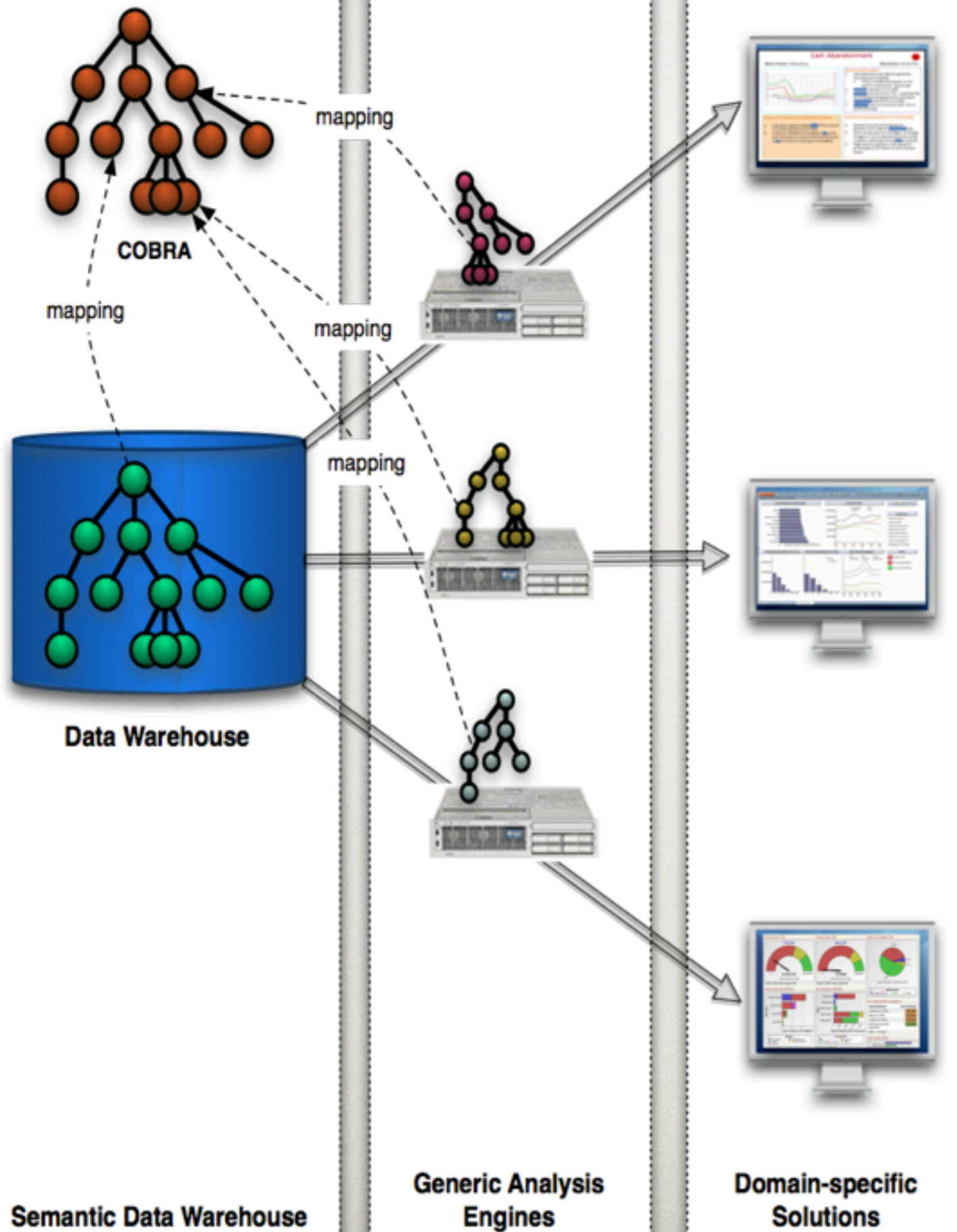
“Problem-solving methods describe [this] control knowledge independently from the application domain thus enabling reuse of this knowledge for different domains and applications. It describes which reasoning steps and which types of knowledge are needed to perform a task”

(Fensel & Benjamins, 1998)

# PROBLEM-SOLVING METHODS

---

- Effort was devoted to covering concrete tasks (configuration, diagnosis, etc)
- Creation of a library of PSMs
- Creation of frameworks and methods for their definition and development, e.g., CommonKADS, UPML, TMDA



# TASK-SPECIFIC YET DOMAIN-INDEPENDENT BPA ENGINES

Application of PSMs principles  
Based on the use of task-specific ontologies  
Anchored on COBRA as integration point



# **GENERIC SBPA TOOLING**

File Mining Analysis Conversion Exports Window Help

ProM

Analysis - Semantic LTL Checker (3)

Select formula :  
activity\_A\_is\_done\_by\_person\_P\_and\_Q

Check formula

Results - Fuzzy Miner on Filtered NexcomSLA\_configuredNotebook.mxm

Fuzzy Model Toolkit

Transformer Editor Unary Metrics Binary Metrics

Analysis - Execution Times Using Availability Based on Hours Per Shift

Execution Times Using Availability Based on Hours Per Shift

Hours per Shift 6 Use task ontology Calculate

Graphical View of Execution Times Originator vs Task Task Statistics Originator Availability

NexcomActivities

Filtering Only include elements selected below

Originators

- Originator
  - Jonh
  - Tony
  - Alex
  - Mary
  - Paul
  - Lisa
  - Susan
  - Phil

Automatically select all parents / deselect all children

Expand Collapse  
Select Deselect  
Update  Automatic

Ontology A visual representation of the ontology

Numbers The raw numbers for each element

Name	Total	Average	Frequen...
AbortD...	0:00:00	0:00:00	162
BestEff...	0:45:30	0:00:31	86
BillingT...	15:54:00	0:00:23	2426
CloseR...	0:00:00	0:00:00	1000
Confir...	0:00:00	0:00:00	838
Contra...	0:00:00	0:00:00	44
Contra...	0:00:00	0:00:00	1676
Custom...	35:48:06	0:00:15	8250
Custom...	19:54:06	0:00:17	4000
Decisio...	2:13:00	0:01:46	75
Escalat...	2:13:00	0:01:46	75
Estimat...	10:07:57	0:00:36	1000
Gold	3:44:00	0:00:37	359

Colors based on: Total

Number format: General time (...)

48:23:53  
38:43:07  
29:02:20  
19:21:33  
9:40:46  
0:00:00  
— No statistics available

Zoom: 50 %

# GENERIC SBPA TOOLING

Enhanced mining algorithms  
Enhanced conformance checking

**semantic Reverse Business Engineering**

**Analysis results**

The list below shows all selected Business Questions and their analysis results according to the configuration. You can also display the concrete LOG instances.

question	result	
<input checked="" type="checkbox"/> Ratio of still open router orders	12%	
Formula - ((Started Router Orders - Finished Router Orders) * 100) / Starte		
aBQ - How many router purchase orders were started?	31	
aBQ - How many router purchase orders were processed?	27	
<input checked="" type="checkbox"/> Ratio of delayed router orders	3%	
<input checked="" type="checkbox"/> How many router purchase orders were processed with delay (more than 7 day	1	
<input checked="" type="checkbox"/> How many router purchase orders were processed?	27	
<input checked="" type="checkbox"/> How many router purchase orders were started?	31	
<input checked="" type="checkbox"/> How many account requests were received?	2	
<input checked="" type="checkbox"/> How many SIP registrations were processed?	0	
<input checked="" type="checkbox"/> How Many Responses Were Prepared?	1	
<input checked="" type="checkbox"/> How Many Parameters Are Received?	2	
<input checked="" type="checkbox"/> How many router purchase orders were started? GroupBy	31	
R0 - STEFANO	2	
R1 - SBPELEE	28	
R2 - STEFAN	1	
iBQ - Which router purchase orders were started?		instances available
<input checked="" type="checkbox"/> How Many Account Infos Were Replied?	2	
<input checked="" type="checkbox"/> How many DNS services were invoked?	2	
<input checked="" type="checkbox"/> How many router purchase orders were started? (with user restriction)	31	

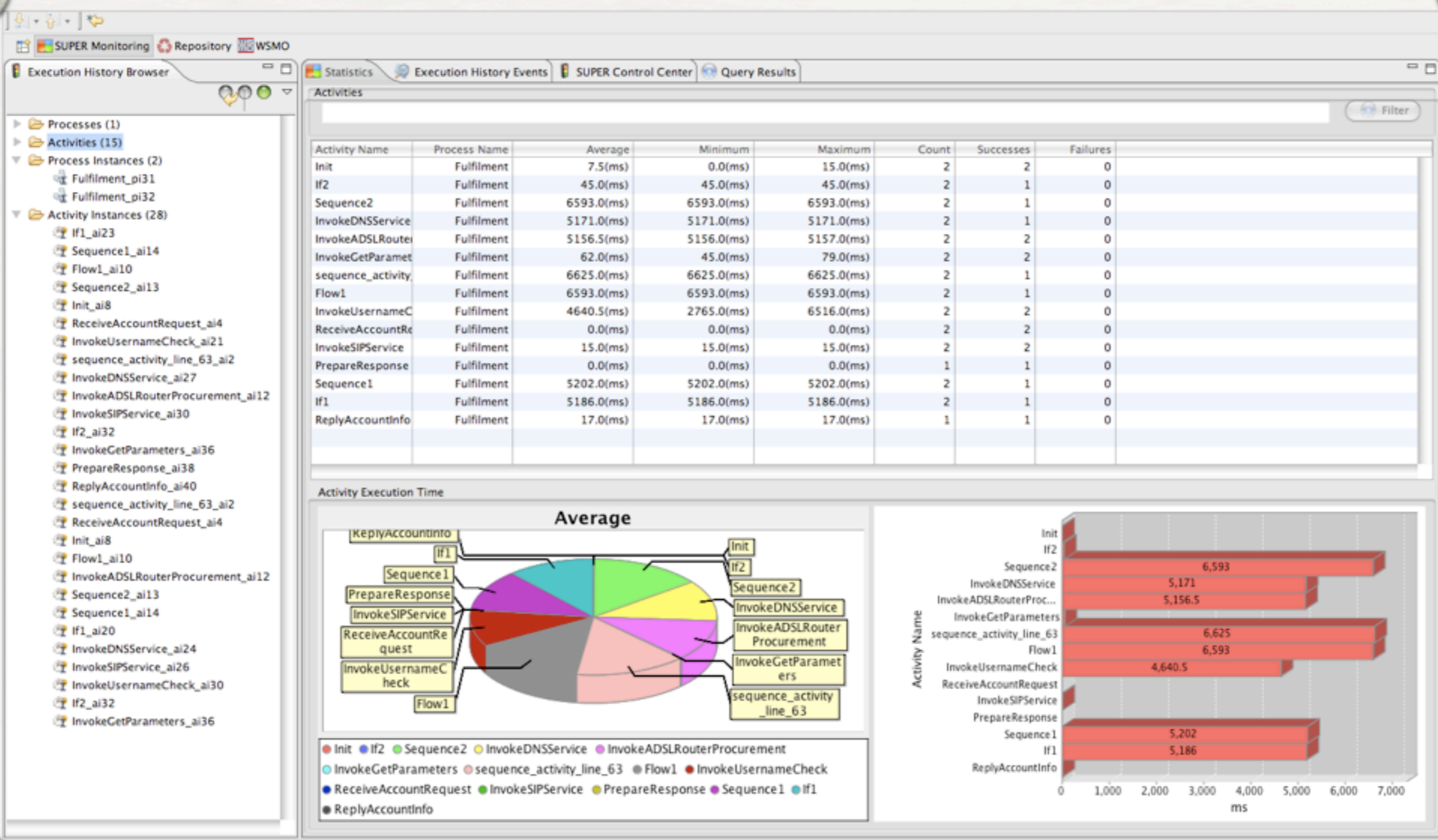
Show instances

Export results

< Back    Next >    Finish    Cancel

# GENERIC SBPA TOOLING

Enhanced mining algorithms  
 Enhanced conformance checking  
 Enhanced reverse business engineering



# GENERIC SBPA TOOLING

- Enhanced mining algorithms
- Enhanced conformance checking
- Enhanced reverse business engineering
- Enhanced monitoring

... A RETROSPECTIVE VIEW ...



# ONTOLOGY ENGINEERING

---

- Integration is based on comprehensive and expensive ontology engineering
- Considerable solutions available (TOVE, SUPER, etc)
- Although many of those solutions disregarded the operational aspect
- Convergence and establishment of some core models is necessary

# KNOWLEDGE REPRESENTATION

---

- The framework and technologies adopted has a fundamental impact
  - Expressivity
  - Processing Time
  - Scalability
  - Maturity



# DATA INTEGRATION

---

- Systems adaptation has to be gradual
  - Wrappers over existing formats
  - Views over existing DBs
- Knowledge needs to be embedded *in the core* in many cases
  - ▶ Adaptation of engines, e.g., BPEL engine

# LESSONS LEARNT

---

- Plain RDF(S) (with some bits of OWL) is expressive and scalable enough for enterprise data integration
  - ▶ Linked Data principles and technologies are a good option
- Procedural knowledge needs to be captured and this is beyond “just” rules

# LESSONS LEARNT

---

- Reasoning is expensive
  - ▶ Fine tuning when/how it takes place is essential: most of it “at night”
- Efficient queries over distributed datasets is challenging as of now
  - ▶ Minimise joins across datasets
  - ▶ Tradeoff between localisation and scalability

# MONITORING VS ANALYSIS

---

- Monitoring is a kind of BPA but in reality very different from the rest
  - Decisions need to be real-time
  - Little reasoning can take place
  - Decisions are limited to a time window using background knowledge

# REAL TIME VS BATCH ANALYSIS

---

- Real time and batch processing are complementary and this should be exploited
- Computations done in real-time can be avoided in batch processing
  - Summarisation & incremental processing
- Results from batch processing should be compiled into actions for real-time
  - Rules, decision trees, etc

# CEP AND SBPA

---

- Monitoring is often approached as CEP
- Objects detected are often of a transient nature
- From a holistic perspective CEP should be approached in an integrated BPA framework as both knowledge acquisition and situation detection

**SENTINEL**

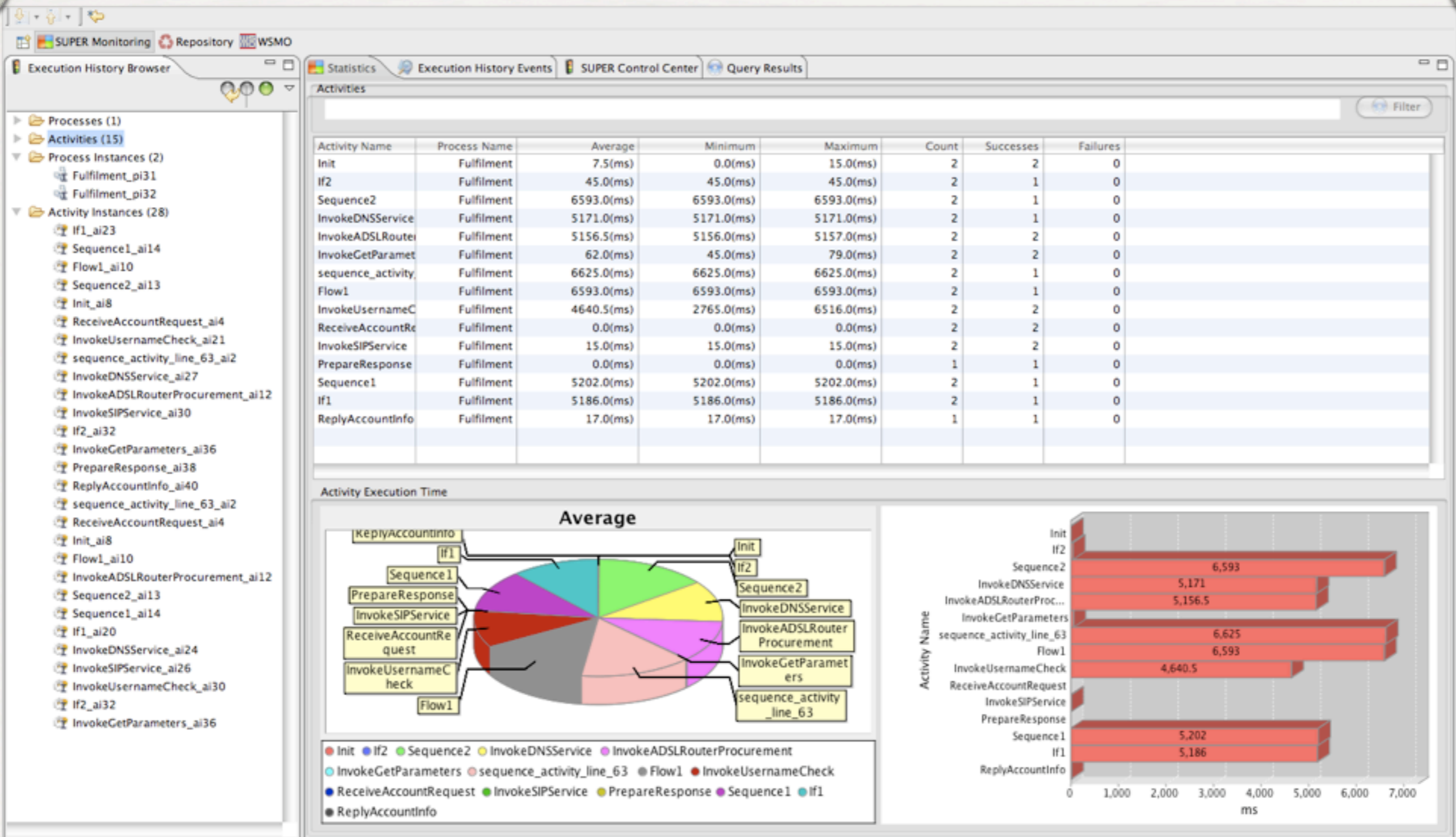
# SENTINEL

Semantic Business Process Monitoring tool

Integrating

- PSMs for execution analysis
- CEP for stream processing

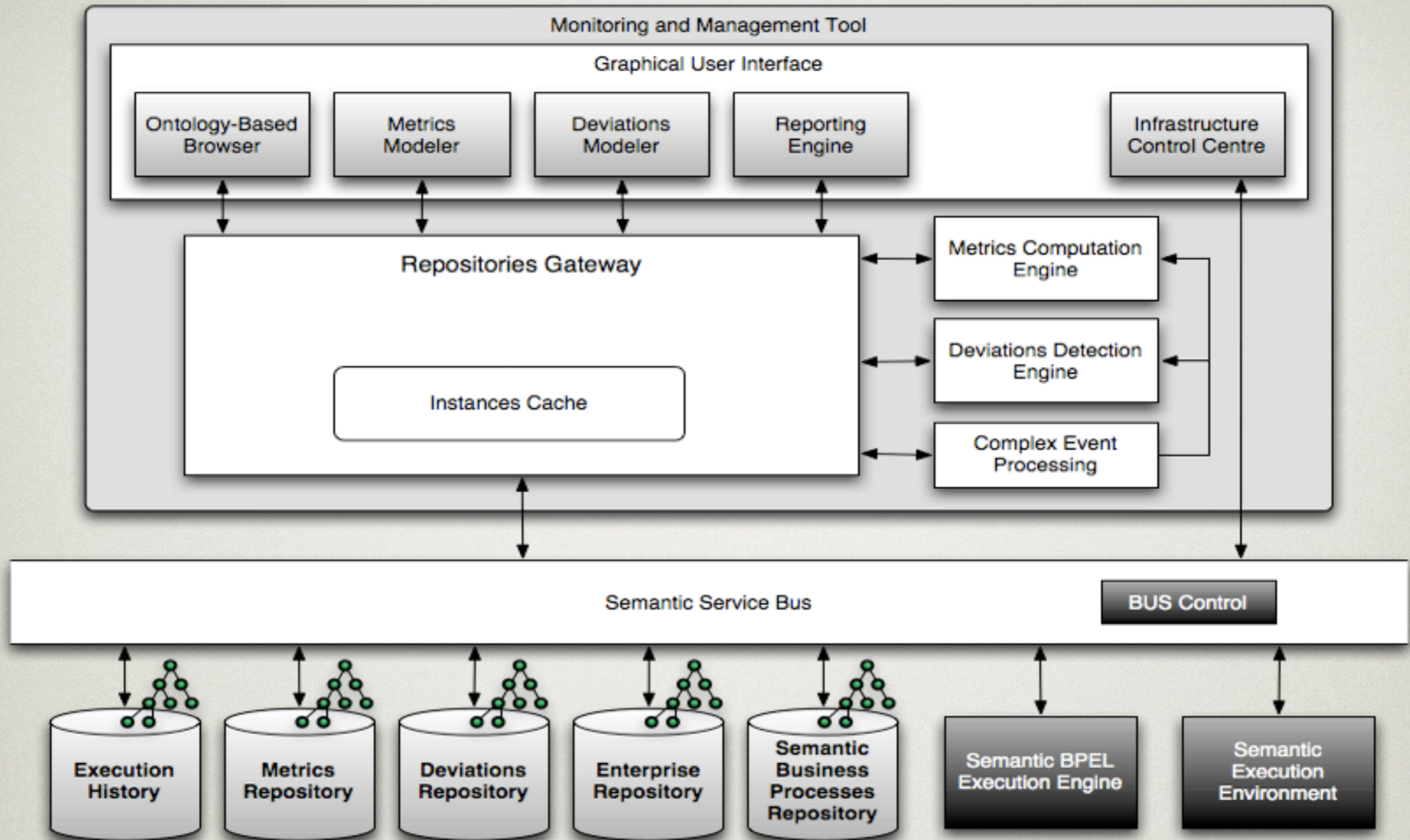




# SENTINEL

Semantic Business Process Monitoring tool  
 Integrating

- PSMs for execution analysis
- CEP for stream processing
- Semantics for data integration/processing



## SENTINEL IN CONTEXT

Semantic Business Process Monitoring tool  
Integrating

- PSMs for execution analysis
- CEP for stream processing
- Semantics for data integration/processing

... CONCLUSIONS

# CONCLUSIONS

---

- Semantic technologies can be highly beneficial within the BPM domain, notably in BPA
- Their exploitation isn't without challenges and requires combining a number of techniques (ontologies, rules, machine learning, etc)
- Performance is still a limiting factor

# CONCLUSIONS

---

- BPM is gradually moving from rigid solutions towards more flexible options where semantics can pay more
- Preexisting idiosyncrasy is however a very strong opposing force
  - ▶ See reluctance to Declarative Workflows

**THANKS FOR YOUR  
ATTENTION**