Spatiotemporal Pattern Detection in Power Distribution Networks : From Data to Knowledge

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Flashback

Major power outage hits New York, other large cities

Thursday, August 14, 2003 Posted: 11:45 PM EDT (0345 GMT)

NEW YORK (CNN) -- Power began to flicker on late Thursday evening, hours after a major power outage struck simultaneously across dozens of cities in the eastern United States and Canada.

The outage occurred quickly and rippled across a large area. Cities affected included New York, Cleveland, Ohio, Detroit, Michigan, and Toronto and Ottawa, Canada.

In just three minutes, starting at 4:10 p.m., 21 power plants shut down, according to Genscape, a company that monitors the output of power plants.

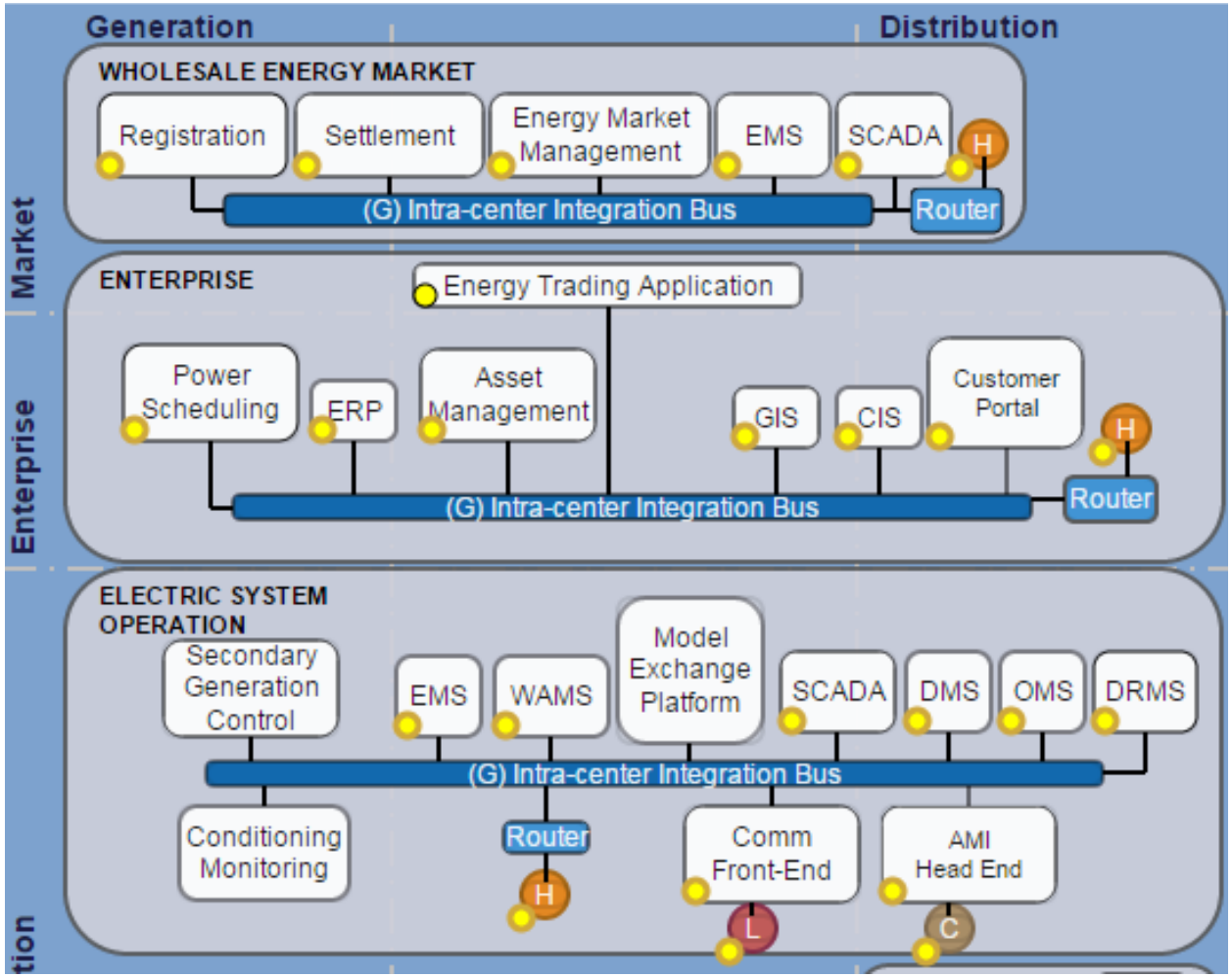
- Millions of houses affected
- Hundreds of flights canceled
- Nuclear power plants in two states shut down

Reasons

Electric Power Research Institute (EPRI) :

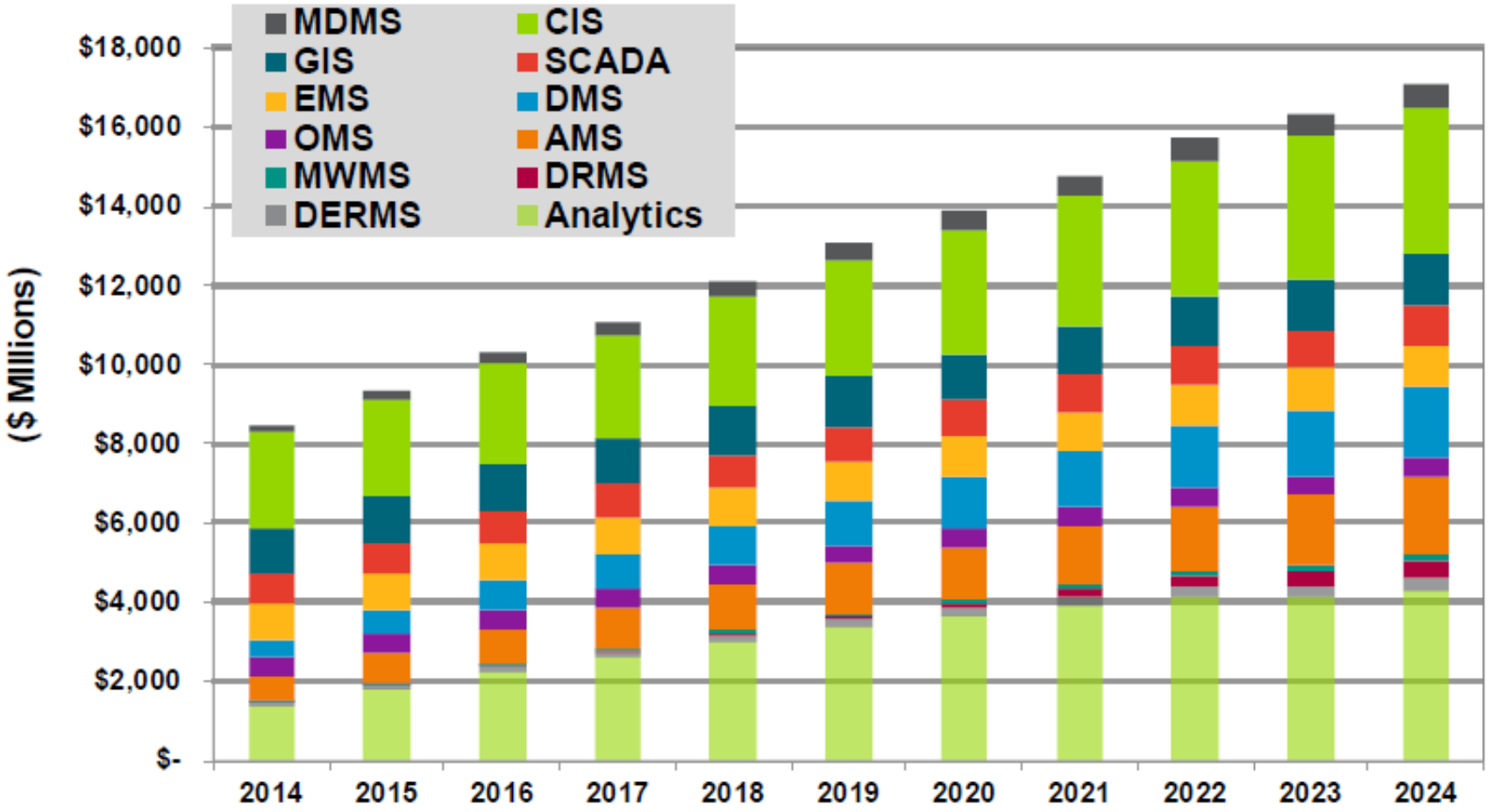
- Lack of real-time regional and interconnection-wide power flow models for anticipating changing flow **patterns** and the formation of new bottlenecks.
- Insufficient "visibility" of power flow conditions over the entire region, coupled with inadequate coordination, control and communication of the power system on a regional basis. That information is flowing from 27 distribution feeds, eight re-closure or safety switches and 4,192 transformers.
- Insufficient understanding of the potential impact on August 14, 2003 of new power flow **patterns** caused by increased wholesale power transfers resulting from industry restructuring.

The IEC Smart Grid Standard Map



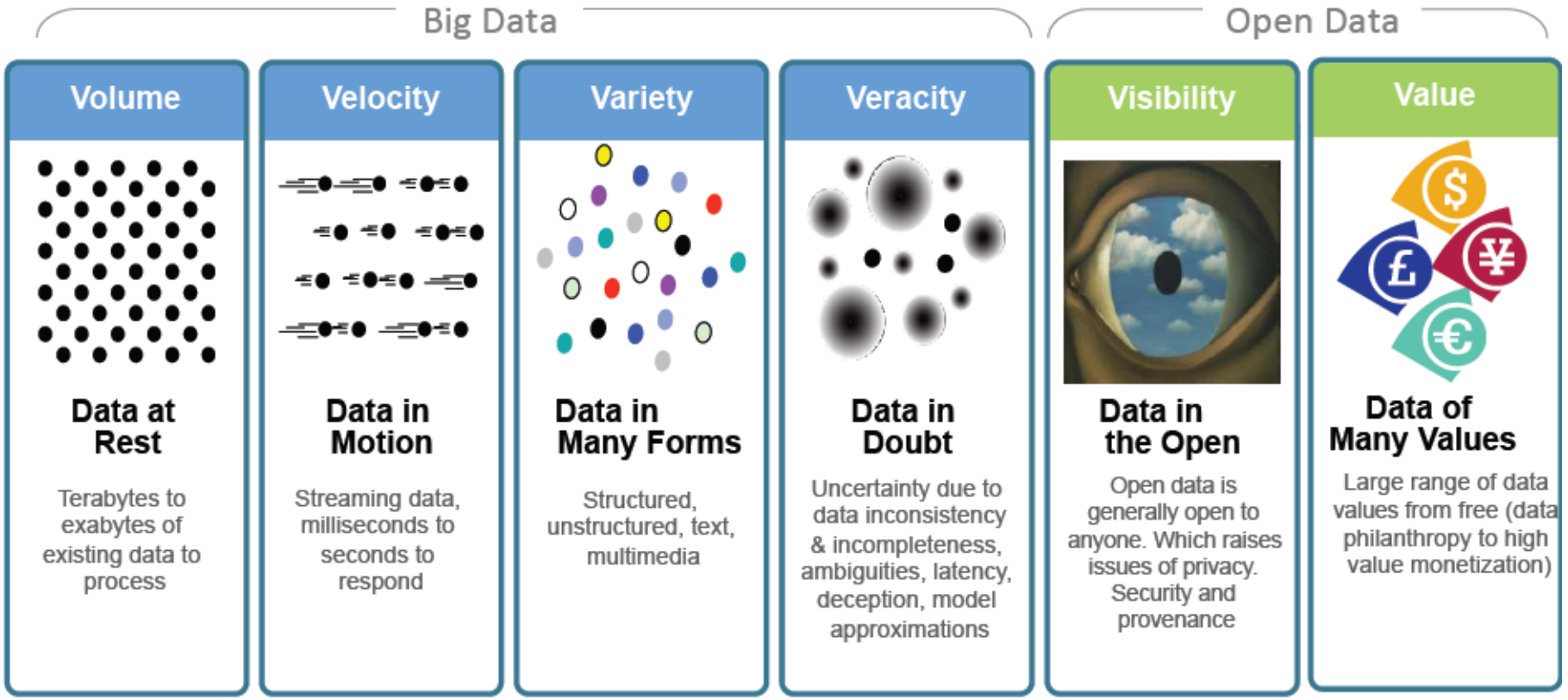
http://smartgridstandardsmap.com/

Smart Grid IT Spending by Application, World Markets: 2014-2024



Source : Navigant Research Q4 2016

What is « this » Big Data?



'Big data' is defined by IBM as any data that cannot be captured, managed and/or processed using traditional data management components and techniques

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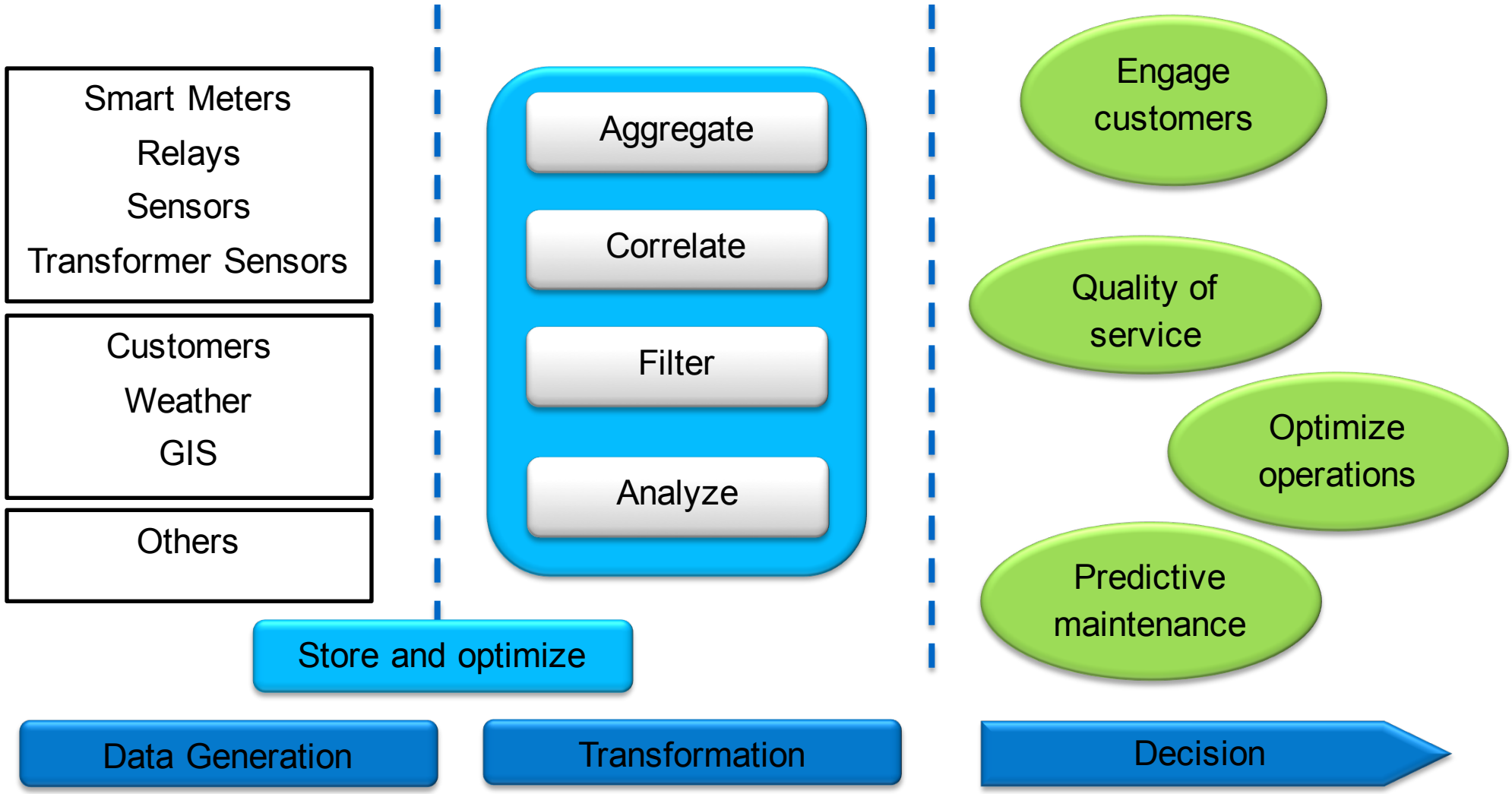
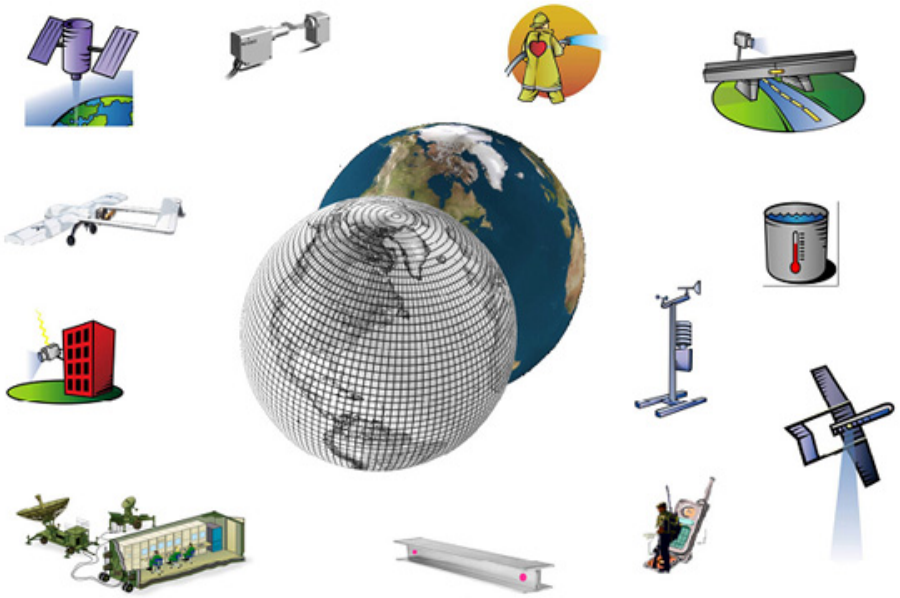
Why Big Data?



Data transformation: “event processing”

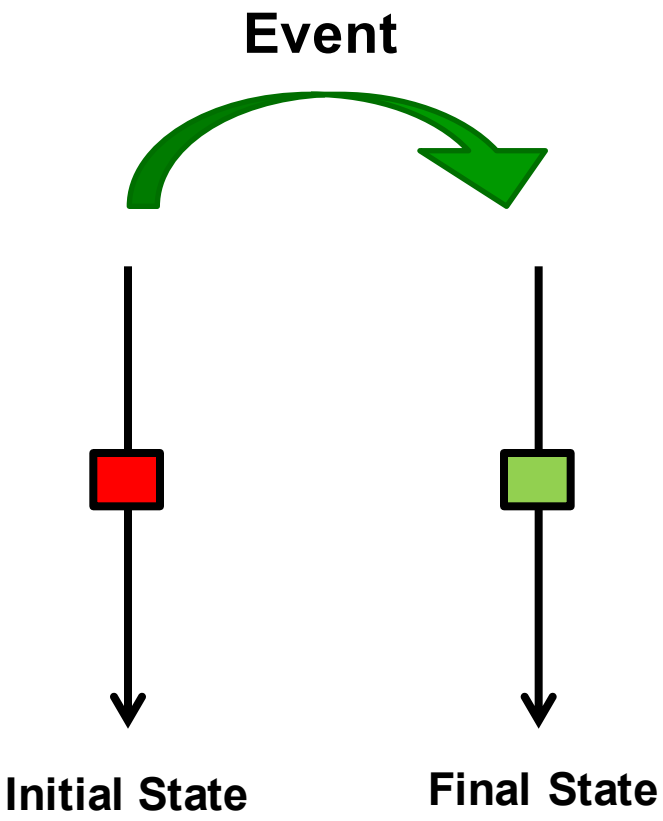


Event processing stands for a set of techniques, languages and tools to collect, analyze and interpret event streams.

- Speedy actions
- High volume of input events
- Analyze, decide and ACT!

What is an Event?

- *"An Event is something that happens"*



Events from a Smart Sensor

Signal	Current Value	Previous Value	Scale	Offset	Reported	Last Update Time
BatteryVoltage	0	0	0.001	0	☑	
ChargeCircuitryEnabled	0	0	1	0	☑	
DeviceTemperature	0	0	0.01	0	☑	
Fault	0	0	1	0	☑	
MomentaryOutage24hCount	0	0	1	0	☑	
NominalCurrent	0	0	1	0	☑	
OverCurrent	0	0	1	0	☑	
PeakCurrent	0	0	1	0	☑	
Power	0	0	1			
SampledCurrent	0	0	1			

- Source : Yukon Grid Advisor

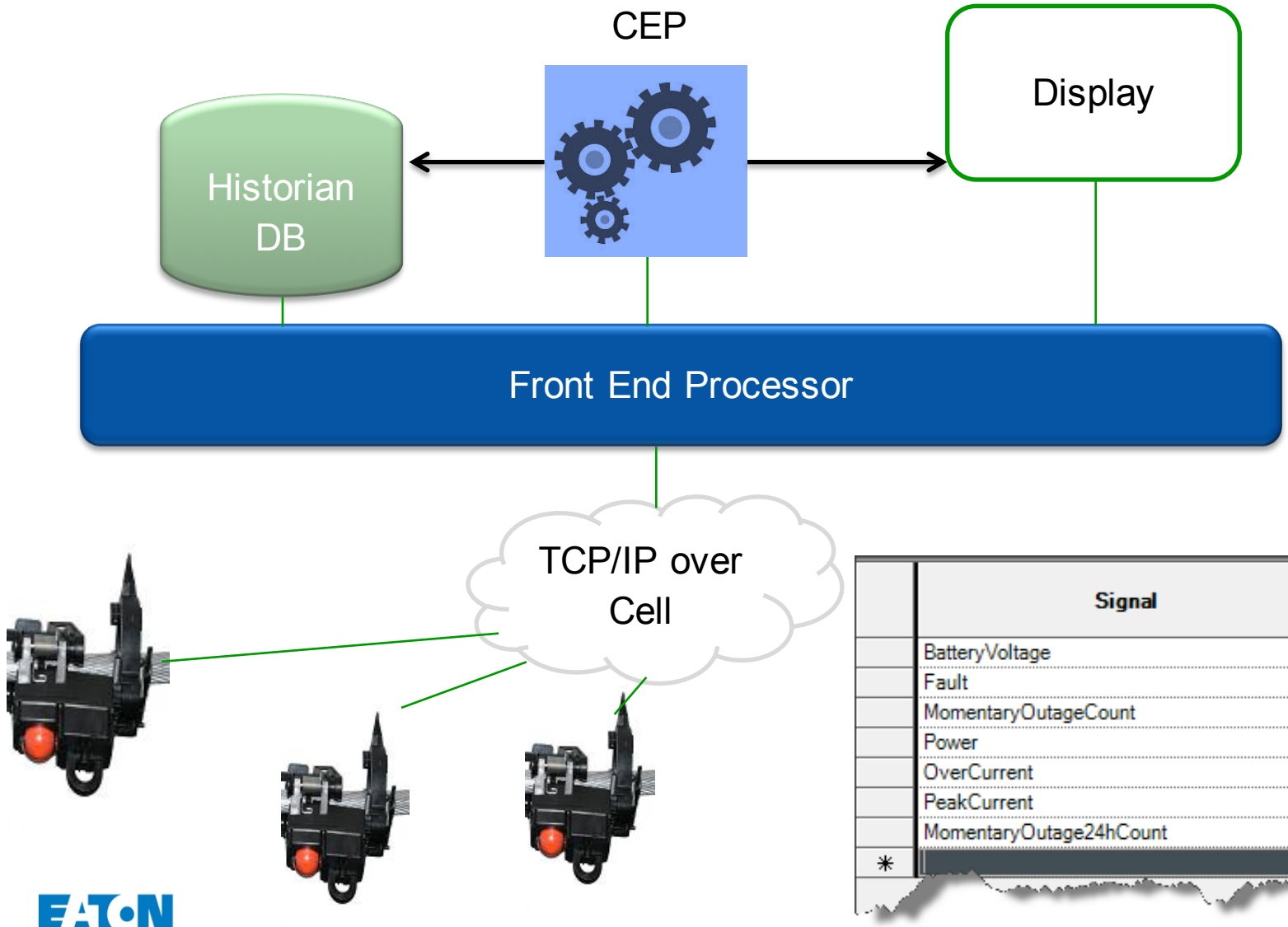
```
=>EVE 2 L
2  01/27/14 17:44:20.296 TRIG    100       0   59.99 1   2
eventInfo64=130353182602960000
eventTime=1390844660 296
eventAscii=01/27/14 17:44:20.296 +0
EVE 2 L

Relay ABC           Date: 01/27/14    Time: 17:44:20.296
Station XYZ


FID=SEL-351-7-R312-V0-Z005005-D20030714       CID=3057

                                                                  Out  In
      Currents (Amps Pri)            Voltages (kV Pri)            1357 135
    IA    IB    IC    IN    IG    VAB    VBC    VCA     VS Vdc Freq  246A 246
[1]
 -0.31 -0.14 -0.40 -0.00 -0.84  0.000  0.000  0.000  0.000   0 60.00 .... ...
 -0.25 -0.37 -0.04  0.05 -0.66  0.000  0.000  0.000 -0.003  -0 60.00 .... ...
  0.62  0.18  0.14 -0.01  0.95 -0.003  0.000  0.003 -0.003  -0 60.00 .... ...
 -0.23  0.02  0.30 -0.05  0.09 -0.003  0.000  0.003  0.000   0 60.00*.... ...
```

CEP on Fault Current Indicator



	Signal	Current Value
	BatteryVoltage	0
	Fault	0
	MomentaryOutageCount	0
	Power	0
	OverCurrent	0
	PeakCurrent	0
	MomentaryOutage24hCount	0
*		

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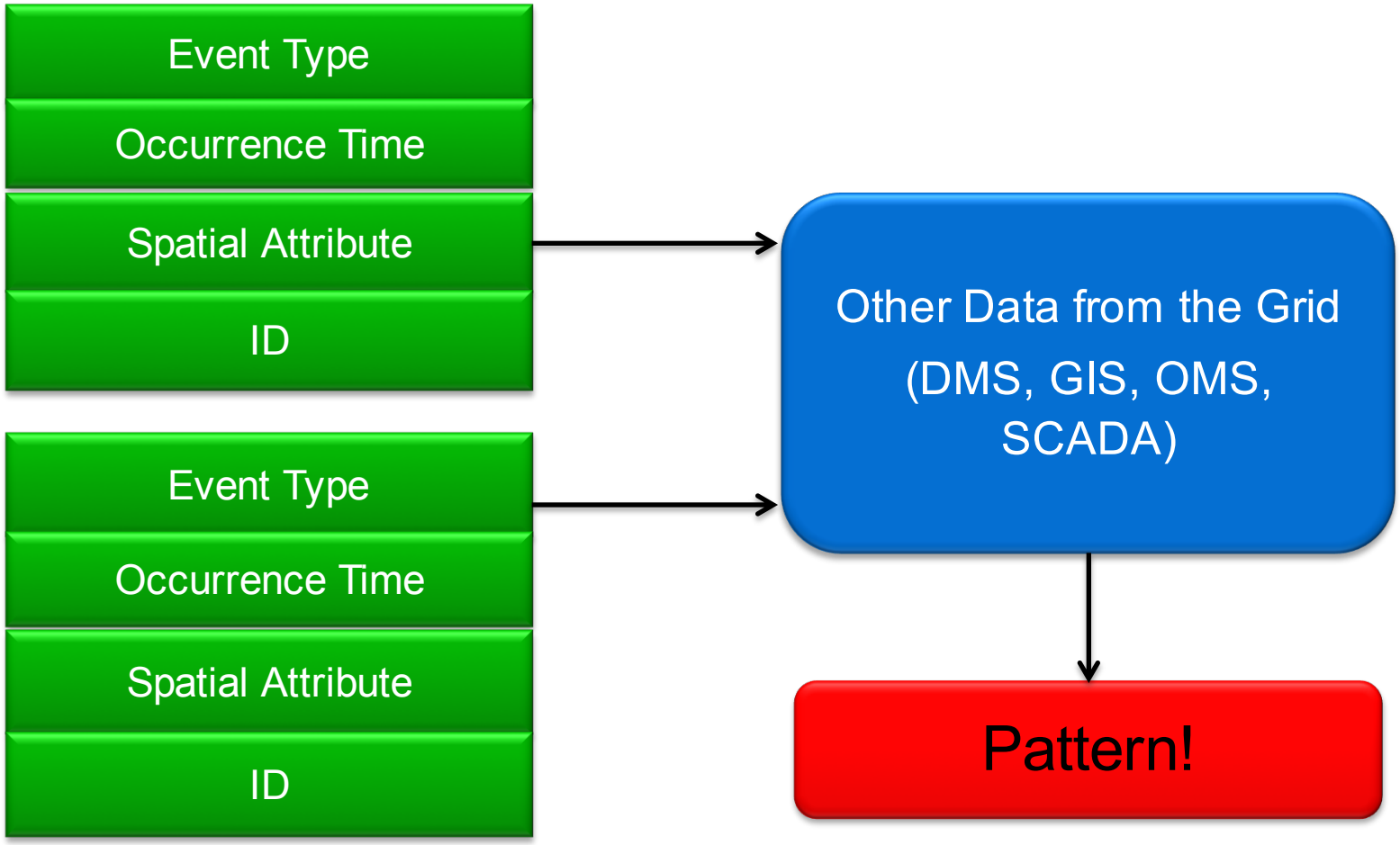
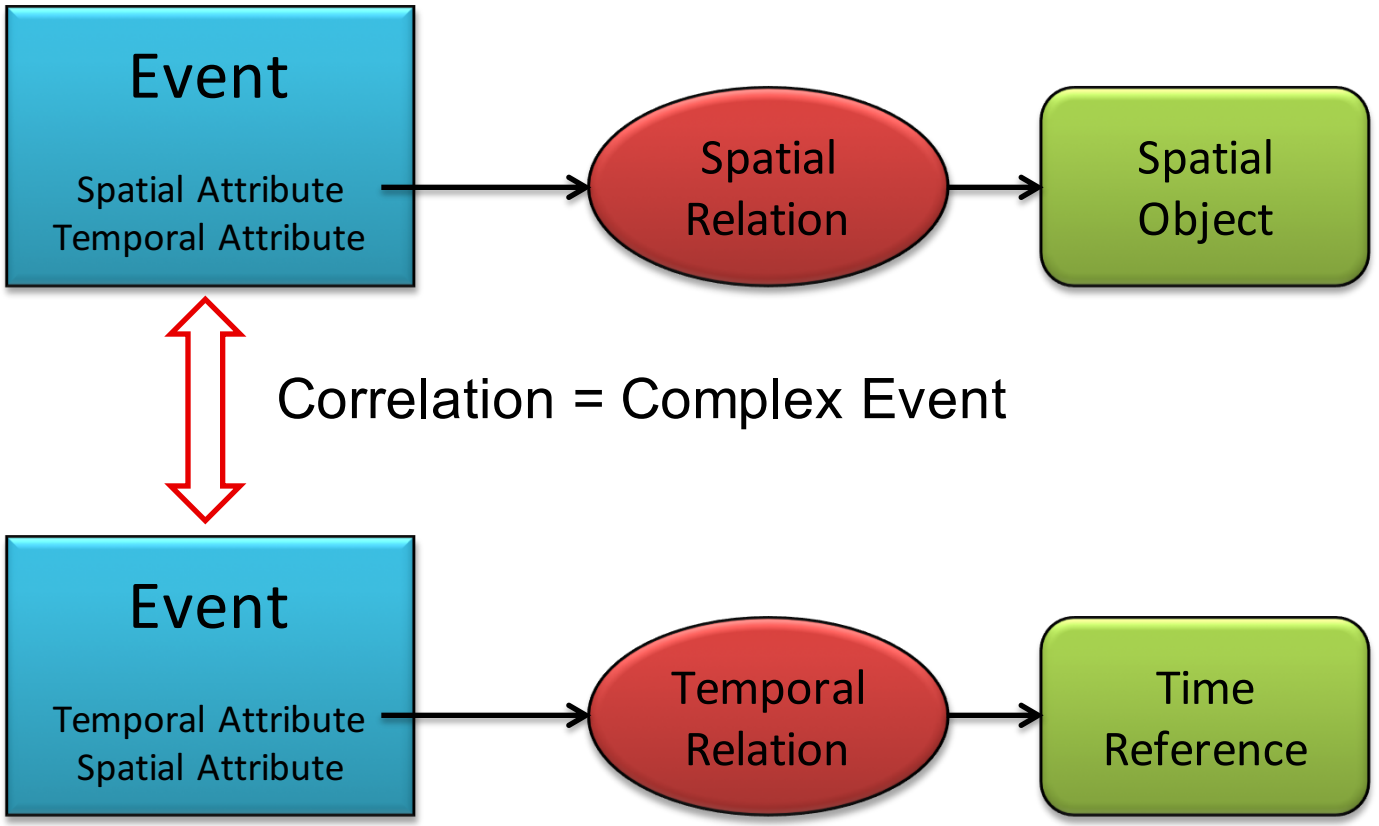
Event Representation

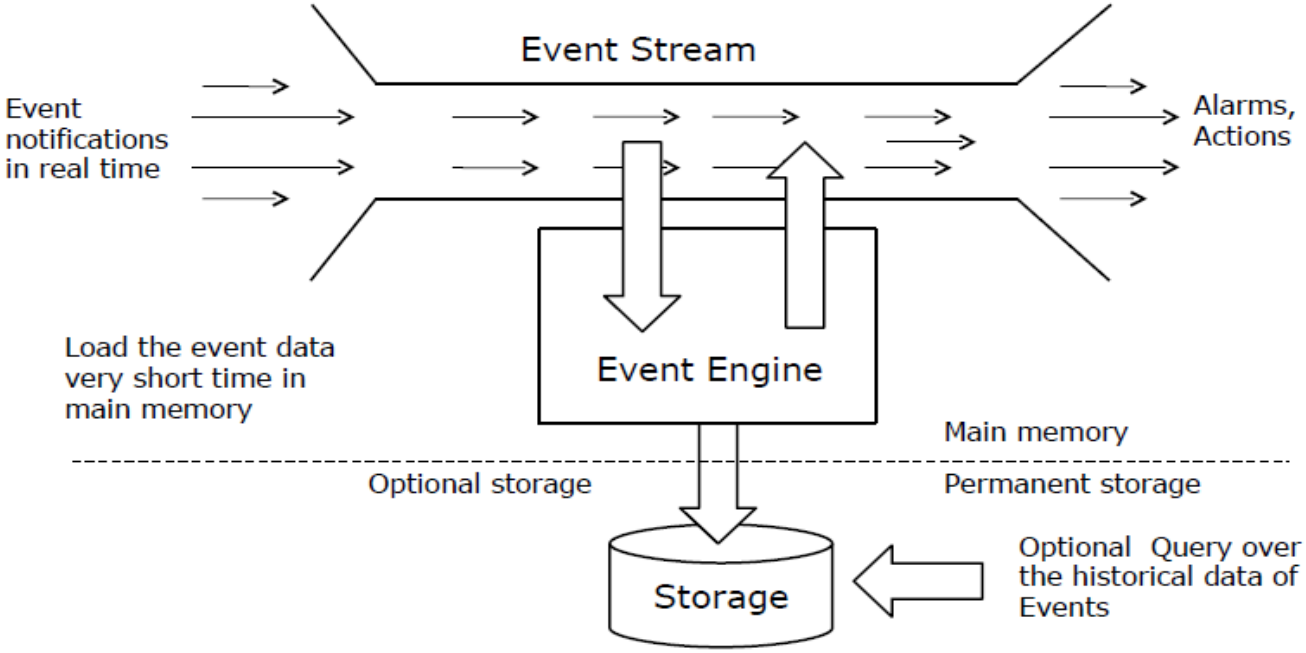


Patterns : complex event processing

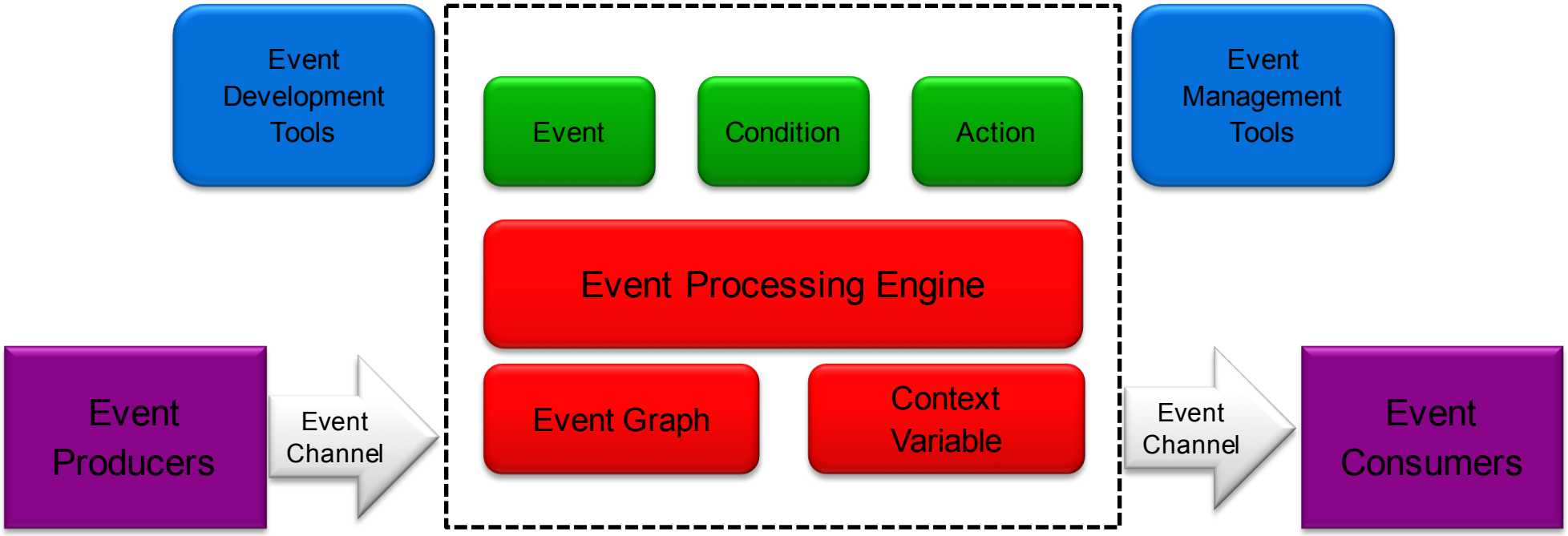


What is Complex Event Processing

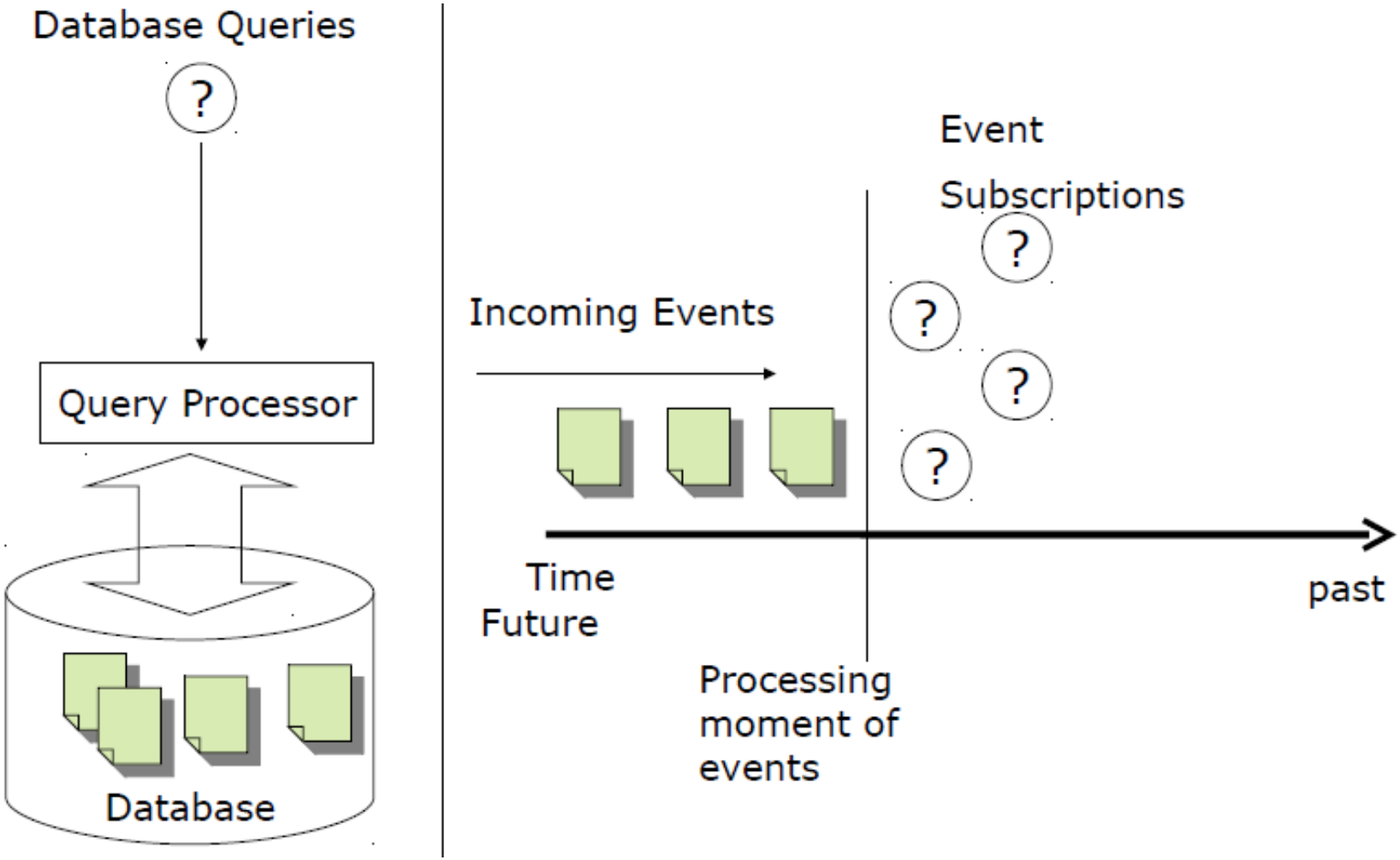
- Initially designed for finance industry in early 2000
- Definition and detection of patterns from a stream of events



CEP: Typical Architecture

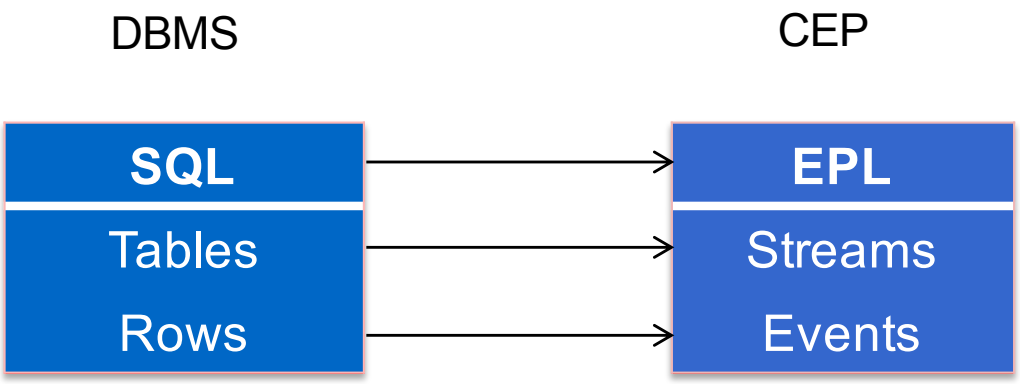


CEP VS DB



- From Store Now, Query Later, to Query Continuously!

CEP VS DBMS : turning DB upside down



Event Pattern Language

- A sample pattern that alerts on each IBM stock tick with a price greater then 80 and within the next 60 seconds:

“every StockTickEvent(symbol=“Etn", price>80) where timer:within(60 seconds)”

- A sample pattern that alerts when event A occurs, followed by either event B or event C:

“A -> (B or C)”

Some Examples (ESPER EPL)

- Outage Management System
  - **Every** OverCurrentEvent (Type1) -> OverCurrentEvent (Type2) **where Near(**OverCurrentEvent (Type1).Location, OverCurrentEvent (Type2).Location)

- ADMS (FLISR)
  - **Every** RecloserOpenEvent(Recloser1)**->** (RecloserOpenEvent(Recloser2) **where** Near(Recloser1.location, Recloser2.location)

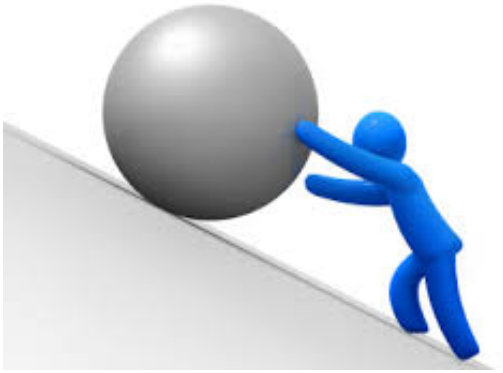
- Substation
  - **Every** TransformerRelayOpen(Device="Dev001") **where timer:within**(60 seconds)

CEP: How Smart a Utility Grid is?

- It can detect there was a power outage in one neighborhood 30 minutes before the first resident called the utility.
- Number of customer-voltage complaints — about either surges or drops — went from 50 to zero.
- It can identify a transformer that was overloaded and needed to be replaced — before it got fried.
- In the past, the utility knew to replace transformers when they blew and lights went out.

CEP and Big Data: Challenges and Opportunities

- Integration of various data sources from different departments
  - Static vs Dynamic
  - Security
  - More sensors/equipments
  - Configuration and Management



- Who will use these analytics patterns
  - Operation groups
  - Planning groups
  - Asset Management

CEP and Big Data

- Ownership: Where these applications will stand? (OT vs IT, or both)
- Yet antoher large software integration project!
- Applications: predictive maintenance, situation awarness, enhanced FLISR algorithms

Questions?

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