An Introduction to Event Processing

Powering Real-Time, Intelligent Business Applications
# An Introduction to Event Processing

## The Business Driver—Real-Time Intelligence

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**The business driver—real-time intelligence**

The business driver for event processing technology is a need for organizations to monitor, analyze, and act on changing business conditions in real time—as events occur.

**What is an event?**

An event is a piece of data that represents that something happened in the real world. They flow in streams within every organization. Examples of events include:

- Financial market events: Buy 10,000 shares of IBM at $80.45.
- Supply chain events: RFID tag 121.19.1818 was scanned at 1:39 at dock door 10
- Security events: TCP/IP address 128.1.32.298 just accessed server 5

**What are Event Processing, Complex Event Processing (CEP), and Stream Processing?**

Different vendors use different terms to describe event processing technologies. The market is still coalescing around common terminology. Most agree, however, that event processing is a term that encompasses technologies such as Complex Event Processing (CEP), Stream Processing, and Event Stream Processing (ESP). Event processing is widely believed to be a key software technology to power more dynamic, real-time, automated business applications. CEP is the crucial key technology element in event processing. CEP allows applications to identify apply real-time intelligence to streaming data, by making it easy to identify “complex” sequences of events (A followed by B, then C) with temporal (within 5 seconds) or spatial (within 5 miles) constraints.

**What applications can leverage event processing and CEP?**

Applications that must process streaming event data and make low-latency, intelligent decisions in response to changing conditions reflected in those events are good candidates to use event processing technology. Examples include:  

**Algorithmic trading**—In capital markets, the use of algorithmic trading techniques has increased from less than 5% to over 20% in the last 4 years, and is estimated to rise to over 50% by 2010.

Algorithmic trading applies CEP by calculating complex algorithms on the fly that indicate when to buy or sell stock, such as: “When the price of IBM is .5% higher than its average price in the last 30 seconds, buy 10,000 shares of Microsoft every 3 seconds unless the average price drops back below the same threshold.”
All the world’s top-tier firms, including JP Morgan, Deutsche Bank, and ABN Amro, as well as buy-side hedge funds such as Aspect Capital are applying algorithmic trading. Many of these firms are using event processing as their technical architecture for algorithmic trading.

**Real-time supply chain**—In the retail and logistics industries, technologies like radio frequency identification (RFID) is creating an opportunity to automate supply chain operations by tracking, tracing, and moving items wherever they are, at any time, in real time.

CEP helps answer basic supply chain questions like (shown at left) “When a truck arrives, and all the items that were expected aren’t received within 60 seconds, then send an alert to the operations manager.” Once the supply chain is automated and this kind of basic decision making is in place, then advanced questions may be asked and answered in real time, such as: When the stock levels for the book “The Da Vinci Code” is within 10% of the minimum stock level given the last 10 hours of buying behavior; send an event to begin the re-stocking process to the distribution center.

A good example of a CEP-powered supply chain is Boekhandels Groep Nederlands (BGN), a Dutch bookseller and the first retail company to implement a complex event processing-based, item-level RFID (Radio Frequency Identification) tagging across its entire inventory.

For more examples of event processing use cases, see FAQ section of this document.
How is event processing different from traditional computing?

Traditional computing utilizes databases and data warehouses, which are designed to analyze static data. Static data is like a photograph in that it captures information about a moment in time. Static business data, for example, could be a table of customer data, transactions at retail stores, or shipments that have occurred within a company’s supply chain. Database-oriented computing helps applications answer questions like: “How many shoes did we sell in our New York stores last week?”

Real-time computing requires event processing that operates on streaming events. Streaming events are like a movie, where streams of images and sounds flow by your senses. Patterns within the stream of images and sounds can make you laugh, cry, or scream. Like a movie, streaming enterprise events allows a business to feel the pulse of operations as events travel through its arteries—the IT network. With event processing, a business can identify patterns and make instant decisions while they still matter: “When 4 transactions against the same credit card number from 4 different companies occur within one minute, deny the next request, flag the account, and send a message to the fraud detection dashboard.”

What is BAM and how does it relate to event processing and CEP?

Business activity monitoring, or BAM, has recently been defined by Gartner Inc as technology that provides real-time access to key business performance indicators (KPIs). End-users, who are largely business operations staff, application support groups and business executives, see BAM function through alerts and dashboards, but BAM systems can also trigger automated external processes with an alert message.

Event processing platforms that have rich, graphical dashboards are especially useful for BAM applications that require real-time visibility and decision making on patterns of events contained within streams of data, and the ability to both visualize and act on the patterns detected in these streams of events.
The Event Manager
Also referred to as a Correlation Engine, or Stream Processing Engine, the event manager is a CEP engine that identifies patterns within streaming events. Many event manager engines can process tens of thousands of events a second while concurrently analyzing thousands of event processing strategies. The value of the event manager is to provide performance and scalability, manageability and fault tolerance and failover for mission-critical event-driven systems.
**BAM Dashboards**

BAM dashboards provide real-time, event driven visualization of event driven applications. Dashboards allow users—from CEOs to operations personnel—to visualize events and automated action. Dashboards can be deployed as stand-alone “fat client” applications, in web browsers, or as part of a client portal.

**Data Stream Management**

Data stream management is a relatively new form of database that allows streams to be stored and replayed in real time, and in the order in which they were detected. Raw events (e.g. telemetry data), and derived events (e.g. flight re-routing decisions based on telemetry) can be stored in a DSM system. DSM helps application developers:

- Simulate the behavior of a new event scenario on history before deploying
- Perform “what happened” analysis, to drill-down and replay event history and identify the root cause of, for example, why a particular trading strategy made or lost $1 M in the last hour
The Elements of Event Processing Technology

- Identify historically recurring event patterns in data streams
- Audit the actual actions and behavior taken by automated CEP systems
- Capture and preserve system behavior for compliance purposes

CEP Development Platform

A CEP platform may contain as many as 4 components:
1. CEP language
2. Business analyst oriented development tools
3. Dashboard development tools
4. Event history / back testing / simulation tools

A CEP platform contains a **Complex Event Processing Language (EPL)** that allows applications to implement logic that identifies complex sequences of events (A followed by B, then C) with temporal constraints (within 30 seconds), and automatically take integrated actions (e.g. buy Microsoft).

Some CEP platforms support **graphical development tools** that enable business users—traders, risk managers, security managers—design their own event processing strategies through an intuitive drag and drop user interface. Graphical development tools allow real-time strategies to be created, managed, and evolved in hours, as opposed to in months or years involved in a typical IT project.
BAM dashboard development environment allows customers to fully customize dashboards with a drag and drop GUI development environment, with rich event-driven charts, graphs and dials. The value of BAM dashboards is to allow the end users of real-time applications—from CEOs to operations to traders—to visualize events and control the way automated actions are made.

Research, testing, and simulation tools—“TiVo” for event processing—allow applications to control and replay event history. Like a remote control for your TiVo at home, research tools allow application developers, administrators, and researchers run CEP logic through event history with graphical tools to control playback.

Integration Adapters and APIs
Event processing integration frameworks allow the event manager engine to connect with the outside world and contain technologies that connect the event manager to:
1. Event sources (e.g. market feeds, RFID readers)
2. Event sinks (e.g. email, SMS, alerts to a message board)
3. Databases (e.g. ODBC access for relational databases)
4. Other applications (e.g. an order management system)
5. General purpose middleware (e.g. JMS, IBM MQ Series)

Integration frameworks: Integrate real-time event processing with existing infrastructure.

Analytic Integration (“aka. SmartBlocks”)
The development of an event driven application includes interfacing with not just data sources, but also logic that implements CEP pattern detection, or statistical analysis. “SmartBlocks” is a term that has been used to describe the ability to encapsulate reusable CEP modules so that they may be used by business users to compose their own event processing strategies. For example, a complex fraud detection algorithm, designed by a fraud expert, can be “snapped in” by a business analyst to design custom variations on this strategy. SmartBlocks enable dynamic extensibility to the real-time applications—new algorithms can be introduced to the environment dynamically.
Algorithmic Trading
Algorithmic trading is a newer (since 2005) class of technique of trading where CEP algorithms are used to identify patterns within market data and identify opportunities to buy and sell securities in real-time based on patterns of price movements.

Business Activity Monitoring (BAM)
BAM is defined as providing real-time access to key business performance indicators. Examples of BAM applications include algorithmic trading, deadline management, and detection of compliance violations. End-users, who are largely business operations staff, application support groups and business executives, see BAM function through alerts and dashboards, but BAM systems can also trigger automated external processes with an alert message.

Business Activity Monitoring Software Platform
A BAM platform is defined by Gartner Inc as a separate and complete software product, designed and marketed to develop and deploy a broad set of BAM applications.

Complex Event
An event that is an abstraction of two or more events. Examples include:
- The 1929 stock market crash (aggregation denoting many thousands of member events, including individual stock trades)
- The 2004 Indonesian Tsunami (an aggregation of many natural events)
- A CPU instruction (an aggregation of register transfer level (RTL) events)
- A completed stock purchase (an aggregation of the events in a transaction to purchase the stock)

Complex Event Processing (CEP)
CEP is software technology that enables the detection of complex events. CEP is technology that allows applications to identify complex sequences of events, like event A is followed by B, then by C. These complex patterns of events can have temporal constraints (within 5 seconds) or spatial constraints (within 5 miles).
A dashboard is a graphical user interface that is event-driven, and monitors events and the state of the status of event scenarios that represent real-time analytics. An example of an Apama dashboard is shown at left which monitors in real time for loss and overcharge conditions in a mobile telecommunications application that provides on-demand, billable services to subscribers.

**Data Stream Management (DSM)**

DSM allows streams to be stored and replayed in real time, and in the order in which they were detected. Both raw events (e.g. market data), and derived events (e.g. trades) can be stored in a DSM system. DSM helps application developers:

- Simulate the behavior of a new event scenario on history before deploying
- Perform “what happened” analysis, to drill-down and replay event history and identify the root cause of, for example, why a trading event scenario had a profit of $1M in the last hour
- Identify historically recurring event patterns in data streams
- Provide an audit trail for the behavior taken by automated CEP systems
- Capture and preserve system behavior for compliance purposes

**Event**

An event is something notable that happens. For example:

- A financial trade
- An airline flight lands
- A sensor outputs a reading
- A change of state in a database, a finite state machine
- A key stroke
- A natural or historical occurrence such as an earthquake
- A social or historical happening, e.g., the abolition of slavery, the battle of Waterloo, the American revolution, and the Irish potato famine

The term event also refers to an object that represents, encodes, or records an event, generally for the purpose of computer processing.
Examples of events include:
- A purchase order (records a purchase activity)
- An email confirmation of an airline reservation
- Stock tick message that reports a stock trade
- A message that reports an RFID sensor reading

**Event Database**
See data stream management (DSM).

**Event-Driven Architecture (EDA)**
EDA is a type of software architecture in which some of the components are event driven and communicate by means of events.

**Event Processing Language (EPL)**
EPL is a generic term for a programming language that supports the detection of complex events.

**Event Stream Processing (ESP)**
See glossary entry for Stream Processing.

**Event Scenario**
An event scenario is a pattern of rules that can indicate a complex event is occurring. Event Scenario is not a standard industry term. An example of an event scenario used in an algorithmic trading application is shown at left. The scenario has a series of states, and each state can have one or more rules. Let’s examine these examples by beginning at the “start” state. This state begins to look for a pattern, initially triggered by a rule that matches a set of filter criteria. In this case, it’s looking for changes in stock prices on two ticker symbols. The first state checks for these price changes “Check Quantities”. After a price change is detected, the “spread,” or difference between the spread, is calculated. If the spread does not breach a buying condition, the scenario returns to the “wait for spread” state. If it does breach a buy or sell condition, the scenario transitions to the “Issue Orders” state, where it takes action—buying or selling—based on complex series of events.
Event Processing
Event processing is a name for the broad set of technologies that perform operations on events, including modifying, creating and destroying events, and complex event processing.

Stream
The word stream is typically used [e.g. stream processing, event stream processing, stream processing engine] because events that are processed in real-time tend to arrive in a stream.

Stream Processing
Stream processing, or event stream processing (ESP), is a term originally used in academia that refers to database-oriented techniques of processing streams that assumed that events arrived in order at the stream processing computing engine. As such, ESP is considered a subset of CEP, which does not assume events arrive in order.
What is the business value of event processing and CEP?
- Identify revenue opportunities in real time and capitalize in microseconds.
- Trade electronically in real time, quickly deploy, configure, and manage new services, price services in real time in response to changing market factors.
- Gain control over business operations through visibility. The ability to monitor the business through rich, interactive business activity monitoring (BAM) dashboards.
- Real-time automation—Detect and stop fraud as it happens, spot favorable market conditions as they arise, reduce errors as they are made and detected, monitor field devices, predict and fix outages before they occur.
- Reduce risk and ensure compliance in real time—Ensure SLAs are being met as they are delivered, monitor electronic payments and ensure they complete, ensure trades meet compliance guidelines before they are placed.

What is the History of CEP?
CEP was pioneered in the late 1990’s at Cambridge University in the UK, the California Technology Institute, and Stanford University. Apama was one of the first two CEP engines commercially available, and is based on the research carried out by Dr. John Bates and Dr. Giles Nelson at Cambridge. The prominent book on CEP is The Power of Events: An Introduction to Complex Event Processing in Distributed Enterprise Systems by David Luckham from Stanford University, published in 2002. Recently, companies like Progress Software have released commercial CEP engines. A full list of commercial CEP technology vendors can be found at www.eventstreamprocessing.com.

What is the difference between event processing, CEP, ESP, DSM, and BAM?
Different vendors use different terms to describe event processing technologies. The market is still coalescing around common terminology. Most agree, however, that event processing is the term that encompasses technologies such as Complex Event Processing (CEP), Stream Processing, and Event Stream Processing (ESP). Event processing is widely believed to be a key software technology to power more dynamic, real-time, automated business applications, CEP is the crucial key technology element in event processing. CEP allows applications to identify, apply real-time intelligence to streaming data, by making it easy to identify “complex” sequences of events (A followed by B, then C) with temporal (within 5 seconds) or spatial (within 5 miles) constraints.
How does CEP relate to BAM?
CEP provides a powerful analytic computing engine for BAM applications. BAM dashboards monitor raw events as well as the real-time decisions made by event scenarios.

How does CEP relate to RFID?
CEP is being applied broadly to RFID applications to process the event streams emitted by RFID readers that monitor for tagged item location and movement.

By industry, what applications are applying event processing technologies today?
Capital Markets
- Algorithmic trading
- Real-time risk management
- MiFID and RegNMS compliance
- Smart order routing
- Market making
- Market aggregation

Retail Banking
- Money transfer, SEP
- Fraud detection

Health Care
- Patient monitoring
- Fraud detection

Public Sector
- Electronic battlefield
- Surveillance
- Emergency response
- War fighter monitoring
- Security
- Net Centric

Travel & Logistics
- Flight logistics and operations
- Automated operations
Frequently Asked Questions

- RFID baggage handling
- Real-time pricing based on operational load and competitive analysis

Telecommunications
- SLA management
- Fault management

Retail and Supply Chain
- Automated supply chain
- Smart shelves
- Real-time point-of-sales analysis and one-to-one marketing

Energy
- Energy trading
- Pipeline monitoring
- Power grid monitoring and control

Web
- Click-stream analysis
- Real-time web page analysis
- On-line fraud detection

Entertainment
- Casino fraud detection
- Dynamic customer loyalty programs
- On-line gambling
Web Sites, Blogs & Wikis
- Mark Palmer’s Event stream processing web portal: www.eventstreamprocessing.com (includes full list of commercial event processing technology vendors)
- David Luckham’s web site on CEP: www.complexevents.com
- Yahoo e-group CEP community at: tech.groups.yahoo.com/group/CEP-Interest/
- Wikipedia entries:
  - CEP: en.wikipedia.org/wiki/CEP
  - ESP: en.wikipedia.org/wiki/Event_Stream_Processing
  - BAM: en.wikipedia.org/wiki/Business_activity_monitoring

Research & Articles
- Bill Gasman, Marketscope for Business Activity Monitoring Platforms, 16 August, 2006. Gartner, inc. ID Number: G00U2011
- Mark Palmer, Turning Service-Oriented Events into Business Insight, August 15, 2006 http://webservices.sys-con.com/read/250515.htm

Books

Industry Analysts
Analysts following the event processing, CEP, BAM are:
Gartner Inc (Roy Schulte and Bill Gasman), Bloor Group (Philip Howard, Robin Bloor).
Key algorithmic trading analysts are:
Tower Group [Rob Hegarty], Aite Group [Sang Lee].
References

1. Many analyst firms (Gartner, Bloor) cite CEP as the next wave of technology to have a major impact on the software industry, and companies like Progress Software, TIBCO, Oracle, IBM, and others are beginning to place a heavy emphasis on event processing technologies, including CEP.

2. AITE Group, Boston, Massachusetts.


5. Definition taken from the draft form of “the Event Processing Glossary,” by Roy Schulte, Opher Etzion, and the event processing community.

6. Many analyst firms (Gartner, Bloor) cite CEP as the next wave of technology to have a major impact on the software industry, and companies like Progress Software, TIBCO, Oracle, IBM, and others are beginning to place a heavy emphasis on event processing technologies, including CEP.

7. If you have a problem finding any of these documents, please email mdz@progress.com.
This brochure was compiled by Progress Software experts Mark Palmer and Michal Džmuráň.