Event Processing Systems—the Way to Improved and Quicker Decision Making
Introduction

Cisco estimates about 50 billion devices and objects are likely to be connected to the Internet by 2020. This interaction will create new classes of applications. New generation applications will generate huge volumes of data depending on the type of interactions and sphere of operations. The data generated by these stream generators can be viewed as event streams, where events are the outcome of an interaction. Large amounts of data generated by these applications will be pushed to servers for real time processing. These applications will include sensor based monitoring, stock trading, web traffic processing, network monitoring, etc.

Stream based applications push data to the central or de-central system as unbounded sequence of event messages in various data formats. Since large volumes of data are produced by these systems, processing the information in real time is not possible with the traditional centralized solutions. Therefore, this has necessitated the emergence of new breed of solutions. Various organizations across the world are excited and are vying for a chunk in this space.

Current businesses look for new competitive advantages in their respective industry. One of the opportunities often identified is the ability to derive actionable insights from information faster leading to better ROI. Businesses that can make better and faster decisions in response to their customers or operations stand to gain market share by delivering higher levels of customer satisfaction, driving repeat business, and ultimately obtaining larger business share. The swift responses to business events in seconds instead of minutes or hours can yield significant revenue. By leveraging proven patterns and practices for deploying the capabilities, business can realize new value from their data. This helps in risk reduction across the board. HTC has been in this space observing and understanding this new breed of technology, which has the capability to change the face of future business. HTC has established a center of excellence and research division to work on the potential benefits of this new technology.
What are Events?

An event is the outcome of an interaction. Various data sources generate events. Events (for example, sensor readings) are produced by information systems, or generated by the Event Processing Engine (EPE). A collection of data sources represent the spectrum of systems that can generate events which are processed by analytics engine. Events may be generated from systems already in the cloud or from devices local to a person or piece of equipment. The events from systems may be delivered on time as they occur or batched with time to be delivered when connectivity is available. Event sources may generate their own timestamp. The generated events have enormous business value and the potential to alter the organization’s revenue stream.

Business events are the real business drivers of enterprises as they represent changes in the state of business. Most businesses actively monitor data streams and application messages to detect business events or situations and take the appropriate actions. The Internet of Things (IoT) has contributed to the swift increase in the number of event generators (data sources). The potential pace of event generation per sensor is increasing rapidly. These events need to be processed in near real time. Event Processing (EP) is an emerging technology that helps to achieve actionable, situational knowledge from large scale event streams in real-time.

What are the Types of Events?

It is essential to understand the variety of events one has to anticipate in a business scenario. Therefore, it is appropriate to categorize the types of events for clarity and better understanding. At a top level, events are grouped into primitive events or composite events. For the purpose of clarity, a primitive event is directly observed in the business system. A composite event is a derived event which is a specific composition of primitive events based on business use cases.

There is another view on event grouping. Events are grouped as simple or raw, as they represent direct observations of the environment activity. When more than one event is grouped to achieve a business outcome, they are denominated as complex, composite, or derived events, since they result from the composition of lower-level events.

For example, EPE responds to sequences of raw events such as Simple Network Management Protocol (SNMP) traps and ATM transactions based
complex event aggregation like a network invasion alert or a fraudulent transaction warning. Frequently, EPE is required to transform incoming events into high-level data first by performing one or more intermediate operations such as aggregations or correlations to make business sense.

**What are Event Generators?**

As mentioned in the earlier sections, sensors are stream data generators. When the occurrence of events are continuous in nature, business calls it as event streams. For example, the stock market ticks are classified as streaming events. An event stream is defined as an infinite sequence of events and are time bound. Factories use sensors for optimizing their process lines and are extensively getting deployed as a part of Industry 4.0. Digital factories take inputs from their process lines, analyze them, and adjust their business processes in real-time. Sensors are used by factories to monitor resource usage and optimize resource production based on consumption. Sensors play a vital role in different aspects of the value chain and provides end-to-end visibility with proper design. For example, Germany is spearheading the modernization of production by making its companies the leading providers of Cyber Physical Systems (CPS) where sensor driven production lines move as self-organizing factories.

HTC has shown keen interest in taking data analytics, a part of digital factory solutions. HTC’s good understanding of Industry 4.0 enabled us to implement Key Performance Indicators (KPI) management system for one of the largest computer hard disk drive manufacturers in the world to effectively manage their KPI life cycle that are triggered from production line data streams. The system was visualized as a change enabler to optimize workflow. The client was able to manage their KPI definitions in a centralized version and generate visualizations and reports from huge volumes of data.

**What are Complex Events?**

It is time to explicitly describe complex events from a business standpoint which can be mapped to real life situations. An event is any important triggered occurrence, and represents an activity instance. Organizations have witnessed a variety of events that occur at different time intervals. Some events can be related and others may not be related.

Organizations have many vertical and horizontal event streams flowing through their business units, which are partially getting captured through information
systems. These event streams are cross coupled and mapped to business outcomes. The events may trigger a chain of related events. The output from event processors may feed other event processors. The event processors in turn correlate multiple event streams to generate events that signal complex conditions. Such events are classified under Complex Event Processing (CEP) systems. CEP based systems continuously process events as they infer complex relations based on business context. This complex mix of event streams calls for data flow design expertise. HTC has been building on this expertise over the years grooming data consultants to address this industrial need. Consultants were not asked to look at individual events but were trained to look for the presence or absence of specific business event combinations (complex events) which are tied together leading to optimal business outcome. HTC had deployed data consultants across the globe to map complex interrelated events coming out of event streams towards business optimization.

**Value of Event Processing**

The basic principles of event processing have been widely used for sometime in application integration middleware and various forms of system software such as operating systems, network, and system management software. However, the increased value of event processing lies in recognizing the significance of an event from a business context, and identifying the right responses to associate with that event. In turn, this can allow a business to respond quickly to new opportunities and to competitive threats, disseminate relevant information in a timely fashion to the right people, enable active diagnosis of problems, and contribute to creating a real-time view of the general state of the business.

Event processing helps businesses to identify trends and threats, seize opportunities to mitigate risks, promote faster time to value, and enable rapid sense and respond to cycle times. Event processing has a growing market across various industries. For example, event processing helps:

- Traders in capital markets wanting to react to arbitrage opportunities
- Military or intelligence analysts assessing streams of satellite and sensor data to determine appropriate offensive or defensive actions
- Transportation and logistics businesses utilizing real-time vehicle-telemetry to manage vehicle fleets more effectively
• Bankers tracing transactions continuously to look for fraud, money laundering, or breaches of financial regulations

• Providers of communication services seeking to minimize the mean-time-to-repair of faults in the network

• Oil companies to dynamically determine the depth and breadth of drills, based on real-time operational data

• Automobile part suppliers utilizing complex manufacturing decisions to provide parts to manufacturers for "just in time" production

In all the above cases, there is an inherent requirement to handle large volumes of complex data in real-time, which is provided by event processing. The need for enterprises to move from batch processing to real-time processing for quick decision-making is another reason that is pushing the demand for event processing. The characteristics of emerging workloads also require close to real-time complex event processing, involving not only data events but also events that originate from non-conventional sources like voice and video. This view is echoed by industry analysts who state that events in several forms from simple events to complex events, will become much more widely used in business applications. There are enormous financial and strategic benefits to implementing event-driven business processes, because they suit the inherently event-driven nature of many aspects of the real world.

Event-driven business processes are not just traditional processes made to run faster; rather, they have specific characteristics that distinguish them from "business as usual." Event-driven applications allow processes to be modified rapidly and to respond to errors and exceptional conditions that disrupt conventional processes. As enterprises strive to cut costs and improve their responsiveness to customers, suppliers and the world at large, the concept of event-driven design is becoming more widely used. Enterprises benefit by implementing event-driven business processes as they suit the event-driven nature of business and provides competitive advantage in terms of cost and time to value.
Industry 4.0 Standard

What is Industry 4.0 Standard?

Industry 4.0 refers to the fourth industrial revolution.

- The first industrial revolution (starting at the end of the 18th century and ending in the mid-19th century) focused on mechanization of production using water and steam power. This marked a radical shift from agrarian economy to the introduction of mechanical production methods.

- The second industrial revolution (at the start of the 20th century) introduced the concept of electrically powered mass production based on division of labor, signified the advent of industrial production, birth of factory, and ushered in the age of affordable consumer products for mass consumption.

- The third industrial revolution (during the 1960s) brought the use of electronics and IT in industrial processes to automate production (for example, CNC machines, industrial robots, etc.) representing a new age of optimized and automated production.

- The fourth industrial revolution "Industry 4.0" / smart industry refers to computerization of manufacturing operations based on cyber physical systems to further automate production. This brings in the next wave of automation characterized by increasing digitization and interconnection of products, value chains, and business models.

Industry 4.0 originates from a high-tech strategy project of the German government striving to promote the computerization of manufacturing operations. The term "Industrie 4.0" was first used in 2011 at the Hanover Fair. In October 2012 the Working Group on Industry 4.0 presented a set of Industry 4.0 implementation recommendations to the German government. On 8 April 2013, at the Hanover Fair, the final report of the Working Group Industry 4.0 was presented.

Industry 4.0 brings together production and network connectivity in an “Internet of Things” environment with “Smart Production” where intelligent Information and Communications Technology (ICT) based machines, systems, and networks are capable of independently exchanging and responding to information to manage industrial production processes.
Characteristics of Industry 4.0 Environment

The characteristics of Industry 4.0 environment are:

• Digitization and increased integration – horizontal value chain and vertical connectivity - Industry 4.0 requires comprehensive digitization of the horizontal and vertical value chains

• Autonomous self-organizing production units, intelligent products actively support the production process, creation of new digital business models

• Strong customization of products under the conditions of high flexible mass production

• The required automation technology is improved by introducing the methods of self-optimization, self-configuration, self-diagnosis, cognition, and intelligent support of workers in their increasingly complex work

• Industry 4.0 provides the framework / vision

• The path to Industry 4.0 is an evolutionary process that will unfold at different speeds
A diagrammatic representation of Industry 4.0's Horizontal and Vertical Value Chains is given below.
Design Principles of Industry 4.0

The design principles of Industry 4.0 aims at supporting manufacturers to identify and implement Industry 4.0 scenarios for:

1. Interoperability: the ability of Cyber-Physical Systems (i.e. work-piece carriers, assembly stations, and products), humans and Smart Factories to connect and communicate with each other via the Internet of Things and the Internet of Services

2. Virtualization: a virtual copy of Smart Factory created by linking sensor data (from monitoring physical processes) with virtual plant models and simulation models

3. Decentralization: ability of Cyber-Physical Systems to make decisions on their own

4. Real-Time Capability: collect and analyze data and provide the derived insights immediately

5. Service Orientation: offering the services of Cyber-Physical Systems, humans or Smart Factories via the Internet of Services

6. Modularity: flexible adaptation of Smart Factories to changing requirements by replacing or expanding individual modules

Why Industry 4.0 and Critical Challenges to Industry 4.0

Global markets are demanding greater flexibility and productivity. Resource consumption needs to be minimized and optimized. The progress made in the areas of communication, sensor and production technologies opens up new sustainable and competitive ways of innovation, production, and consumption. More and faster information will optimize resource use, shorten lead times, increase productivity, and enable highly automated production.

The critical challenges to Industry 4.0 are:

- Inadequate skill-sets to expedite the move towards Industry 4.0
- Redundancy threat to the corporate IT department
- General reluctance to change by stakeholders
- Overblown expectations
Industry 4.0 Standards and Event Processing

An event is any identifiable action or occurrence having significance for the enterprise. Every event in an enterprise is significant because it can affect some other action. Event processing is the method of tracking, analyzing, processing streams of events / information / data about events that happen and deriving a conclusion from them / run-time decision making.

Industry 4.0 Standards is based on methods of self-optimization, self-configuration, self-diagnosis, and cognition. It therefore depends on events and events processing to monitor business process interactions and collaborations as business events significantly influence all aspects in enterprises.

The basic idea of Industry 4.0 Standards is that the product produces itself by built-in process models as a sequence of collaborating processes managed by domain or product specific models of event patterns and processes. These models are implemented in every single component of a product. An all-encompassing process will manage the whole supply chain of all the components needed to build the final product.

Role of Big Data and Analytics

Modern technologies (Cyber-Physical Systems, Big Data, etc.) will permit predicting the possibility of increasing productivity, quality, and flexibility in the manufacturing industry and therefore understand the advantages within the competition.

Big Data Analytics consists of 6Cs in the integrated Industry 4.0 and Cyber Physical Systems environment. The 6Cs consist of Connection (sensor and networks), Cloud (computing and data on demand), Cyber (model and memory), Content / Context (meaning and correlation), Community (sharing and collaboration), and Customization (personalization and value). To provide useful insight to the factory management and gain correct content, the data has to be processed with advanced tools (analytics and algorithms) for generating meaningful information. Considering the presence of visible and invisible issues in an industrial factory, the information generation algorithm has to be capable of detecting and addressing invisible issues such as machine degradation, component wear, etc. in the factory floor.
What are the Benefits of Industry 4.0 Standards to End-users?

Industry 4.0 merges real production with the virtual world by incorporating information technology into the production processes. It permits integration of processes and systems across sectors and technologies, revolutionizes production, services provision, logistics, and resource planning. All production systems communicate with one another in a new, intelligent way. The "internet of things" has brought a revolution to the entire industrial sector - confers new benefits to customers: shortened production cycles, customers' needs incorporated in real time, carrying out automatic maintenance, orders filled automatically, etc., resulting in "smart" factory.

Industry 4.0 will be the future of productivity and growth in manufacturing industries. It is set to transform the design, manufacture, operation, and service of products and production systems. As the concept of Industry 4.0 originated in Germany, most reports about its benefits are focused primarily on Germany and partly on the European Union. The key focus is to enable Germany gain the ground it lost to China and other emerging manufacturing hubs such as the BRICS nations, etc.

Industry 4.0 will bring in better connectivity and inter-connectivity among parts, machines, and humans. It will make production systems about 30% faster and 25% more efficient and elevate mass customization to new levels and help industries gain revenues, employment, and investment. Manufacturing operations will be transformed from single automated cells to fully integrated, automated facilities that seamlessly communicate with one another to improve flexibility, speed, productivity, and quality. For example, in Germany's advanced manufacturing scenario Industry 4.0 can:

• Push productivity gains of 5 to 8 percent on total manufacturing costs over ten years, totaling € 90 billion to € 150 billion
• Contribute a yearly increase of 1% to the GDP for 10 years
• Create about 390,000 jobs
• Add €25- billion to manufacturing investment (approximately 1 to 1.5% of manufacturers' revenues)

The full shift towards Industry 4.0 is likely to take about 20 years to reach maturity. The next 5 to 10 years will witness key advances and bring out the winners and losers.
The highlights of the above key findings of this PwC survey are given below. The findings focus on Industry 4.0 as the vital enabler of transformation of the entire value chain and allows the development of innovative products and services. The emphasis is on acting now to gain the lost lead in production.

1. Industrial internet / Industry 4.0, transforms the entire company and must be part of the CEO agenda. It not only comprises the digitization of horizontal and vertical value chains but will also revolutionize the product and service portfolio of companies with the ultimate goal of better satisfying customer needs. Its potential uses go far beyond the optimization of production technologies. However, exploiting these opportunities requires considerable investment. The topic therefore inevitably occupies a leading position on the agenda of directors and managers of industrial companies.

2. By 2020, European industrial companies will invest €140 billion annually in industrial internet applications. Over the next five years, the industrial companies surveyed will invest, on average, 3.3% of their annual revenues in industrial internet solutions. This is equivalent to nearly 50% of the planned...
new capital investments and an annual sum of more than €140 billion with regard to the European industrial landscape. These investments will have to be used along the entire value chain in order to achieve maximum success.

3. In five years, more than 80% of companies will have digitized their value chains. One quarter of the companies surveyed have already achieved a high degree of digitization of their value chains. However, it is mostly only individual units and isolated applications that have been automated and digitized thus far. The companies expect that 86% of the horizontal and 80% of the vertical value chains will have a high degree of digitization by 2020 and will therefore be closely integrated.

4. The industrial internet increases productivity and resource efficiency - an 18% increase in efficiency within five years. The industrial sector is required to produce ever larger quantities using fewer raw materials and less energy. The industrial internet allows higher productivity and resource efficiency and thus creates the conditions for sustainable and efficient production. The companies surveyed anticipate an average efficiency increase of 3.3% per year across all industry sectors due to the digitization of value chains. This amounts to a total of 18% in the next five years. They expect annual savings of 2.6% with respect to cost reduction.

5. The integrated analysis and use of data are the key capabilities for the industrial internet. Today the efficient analysis and use of data is of great significance for half of all companies surveyed. Moreover, 90% of companies believe that the ability to analyze data will be decisive to their business model in five years. These companies primarily focus on the efficient exchange of data within their own value chain, the digital labeling of the products, and the use of real-time data to steer their production.

6. Digitization of the product and service portfolio is the key to sustainable corporate success. Thirty percent of the companies surveyed have already digitized their products to a great extent and expanded their portfolio to include connected and automated services. A mechanically perfect product will no longer be enough to successfully withstand international competition. More than four out of five respondents - with the exception of the process industry - therefore expect that they will have achieved a high degree of digitization of their product and service portfolio within five years.
7. Digitized products and services generate approximately €110 billion of additional revenues per year for the European industry. Companies which have already digitized their product portfolio to a great extent have grown above average in the past three years. Half of the companies surveyed anticipate double-digit growth in the next five years due to the intensified digitization of their product and service portfolio. One in five companies even expects sales to rise by more than 20%. In total, this amounts to an average, incremental sales increase of 2.5% per annum. Compared to all industrial companies in the five core industry sectors, this is equivalent to an annual sales potential of more than €30 billion for Germany and reaches up to €110 billion of additional revenues for the European industry in total.

8. The industrial internet paves the way for new, often disruptive digital business models. The industrial internet will have a lasting effect on existing business models and will particularly also generate new, digital - often disruptive - business models. The focal point of this trend comprises increasing customer benefits through a growing range of value solutions (instead of products) and increased networking with customers and partners. The special quality of the digital change lies in the rapid acceleration of the speed of change. Disruptive innovations will also cause industry sectors like the information and communications industry to sustainably transform within a short period of time.

9. Horizontal co-operation allows for improved satisfaction of customer needs. About half of all companies surveyed are already convinced that closer cooperation with value chain partners — combined with increased horizontal interconnection - is of great significance. The importance of this will further grow in the context of Industry 4.0 in light of increased digitization — particularly where new, digital business models have to be established. More than 80% of the companies surveyed believe that closer co-operation and a more vigorous horizontal connection of value chains will play an important role in five years.

10. The industrial internet holds various challenges - policy-makers and industrial associations can help. Companies have to master several challenges on the way to becoming a Digital 4.0 champion. The main focus is on high investment levels and often unclear business cases for new industrial internet applications. Furthermore, sufficient skills to meet the needs of the digital
world must be ensured. Binding standards must also be defined and tasks in the area of IT security have to be solved. Policy-makers and industrial associations can help with these latter challenges in particular, by advocating uniform industrial standards at a European or international level and promoting efficient rules for data security and data protection.

“Event Processing and Kafka are the key enablers for businesses worldwide”.

- Practice Head - Big Data, HTC Global Services Inc

Acronyms

The acronyms used in this white paper and their expansion are provided below:

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<tr>
<th>Acronym</th>
<th>Expansion</th>
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<td>CEP</td>
<td>Complex Event Processing</td>
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<td>CPS</td>
<td>Cyber Physical Systems</td>
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<td>EPE</td>
<td>Event Processing Engine</td>
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<td>ICT</td>
<td>Information and Communications Technology</td>
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<td>IoT</td>
<td>Internet of Things</td>
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<td>KPI</td>
<td>Key Performance Indicators</td>
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<td>SNMP</td>
<td>Simple Network Management Protocol</td>
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About HTC's Big Data CoE

HTC's Center of Excellence for Big Data Management and Analytics brings in mature technologies and thought leadership. Our dedicated R&D team develops highly customized and cost-effective cutting edge solutions to enable clients manage and understand big data for improved and quicker decision making. This white paper was developed by HTC's Big Data CoE.