Chapter 7
Application of Complex Event Processing Techniques to Big Data Related to Healthcare:
A Systematic Literature Review of Case Studies

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ABSTRACT

Healthcare is a growth area for event processing applications. Computers and information systems have been used for collecting patient data in health care for over fifty years. However, progress towards a unified health care delivery system in the UK has been slow. Big Data, the Internet of Things (IoT) and Complex Event Processing (CEP) have the potential not only to deal with treatment areas of healthcare domain but also to redefine healthcare services. This study is intended to provide a broad overview of where in the health sector, the application of CEP is most used, the data sources that contribute to it and the types of event processing languages and techniques implemented. By systematic review of existing literature on the application of CEP techniques in Healthcare, a number of use cases have been identified to provide a detailed analysis of the most common used case(s), common data sources in use and highlight CEP query language types and techniques that have been considered.

INTRODUCTION/BACKGROUND

With the rising popularity of the Internet and the digital world, information is shared instantaneously and businesses have become increasingly global. This has given rise to "Big Data". Big data is the measurement of large, complex data, specifically data that falls into the "4V's model"; high Volume, high

Velocity, high Variety and high Veracity resulting from sensors, cameras, social media, smart phones and other consumer and monitoring devices in use daily.

Big data is a perfect fit for dealing with the technology challenges faced by the health care industry. Health data generated by wearable sensor devices, Wi-Fi enabled scales and smart phones could provide a far more accurate picture of individual's health and the treatment(s) they receive.

In terms of big data for healthcare, *Volume* refers to the rapidly expanding size of the sets of data that is generated in every area of activity in a healthcare enterprise, from revenue, to patient data, to supply and operations. *Variety* includes the diversity of data collected. In a hospital, for instance, data includes patient records containing a variety of information like lab reports, scans, x-rays, prescription details and other medical data. Apart from having access to patient data relating to diagnosis and treatment, other data such as patient scheduling and workflow, data resulting from healthcare administration and hospital hygiene are also available. Exposure to such rich and contrasting elements of data is challenging and requires the use of special techniques to synthesise and process these large sets of data in a reasonable time frame. With the advent of sensor technology, Radio Frequency Identification (RFID), personal health monitors, wireless network of wearable devices and other healthcare monitoring devices, there is significant *Velocity* of incoming healthcare data. Finally, *Veracity*, data assurance and quality issues are of acute concern in healthcare as important decisions depend on having accurate information. The quality of healthcare data, especially unstructured data, is highly variable and needs utmost care.

Big data technologies deal with petabytes of records, files, transactional data either arriving as streams or in batches. The rise of technologies such as social and mobile are contributing to increase in unstructured and semi structured data. These datasets are so huge that they cannot be processed and managed using traditional methods like Relational Data Base Systems (RDBMS). Such data warehouses are not able to handle the processing demands of big data that need to be updated frequently or even continuously.

COMPLEX EVENT PROCESSING (CEP)

Complex event processing refers to the processing of representations of events possibly, thousands of events, in a form that is suitable for automated processing. An event is simply "something that happens" in real life. Event objects as these representations are called include data such as where and when the event happened, how long it took and if it was caused by other events.

Business enterprises are swamped by 100,000 to 100 million events per second, originating in their application systems, sensors, social applications, the Web and other sources. RFID readers, bar code scanners, and other devices detect the presence of objects and send events through Internet-based event-processing networks (EPNs) to CEP-enabled servers that maintain virtual representations for each object. Within healthcare, CEP engines can analyse events and related data which come from various sources (health sensors, environment sensors etc.) in real-time and provide insights for a better healthcare.

The CEP technology is aimed to provide applications with a flexible and scalable mechanism for constructing condensed, refined views of the data. It correlates the data (viewed as events streams) in order to detect and report meaningful predefined patterns, thus supplying the application with an effective view of the accumulated incoming data (events), and allowing the application to react to the detections by executing actions (Magid, Adi, Barnea, Botzer & Rabinovich, 2008).

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