Complex Event Refinement by Statistical Augmentation Model

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ABSTRACT

The uncertainty of decision making in event hierarchies of CEP can be due to unreliable data sources, lack of conformance that the event which is reported has actually occurred. Also the Complex Event models which are used to define complex events are inaccurate. When the uncertain event is used for deriving complex event, it propagates its uncertainty to a higher level of event hierarchy and causes uncertainty in reasoning. This paper proposes an event refinement model based on statistical approach to augment the events to minimize the error due to uncertainty for better decision making. The proposed augmented CEP (a-CEP) is found to perform better in terms of reduction in false alarm for continuous monitoring of patient in a remote health care application. The proposed model is implemented on Drools Fusion CEP Engine using Java and it is found that the proposed a-CEP gives better results in terms of accuracy.

Keywords: Augmented CEP, Complex Event Processing (CEP), Stream Processing, Uncertainty Handling, Uncertainty in CEP

1. INTRODUCTION

The big-data (Villars, Olofson, & Eastwood, 2011) is famous for its three attributes namely Variety, Velocity and Volume. Recently, Veracity has also become an important attribute in big-data meaning ‘data with doubt’. Both Velocity and Veracity are key ingredients of event processing applications. However, Complex Event Processing (CEP) (Academic/Commercial) (Luckham, David & Brian, 1998) takes care of ‘Velocity’ but not ‘Veracity’.

Most real time monitoring applications use CEP. The various applications where CEP is used are fraud detection (Bass, 2006), stock trading (Adi, Botzer, Nechushtai, & Sharon, 2006), security and surveillance (B(524,603),(995,997)

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making engine by most of the applications. However, these applications fail to consider precision in data while decision making.

The existing event processing engines such as Drools (Proctor & Mark, 2012), Esper (http://esper.codehaus.org), etc. provides framework for the development of application specific rules to detect abnormalities. Moreover, existing CEP systems considers the event stream received from the event sources is precise and certain. Also, application developers neglect the issue of uncertainty in the events. Hence, these applications fail to handle various types of uncertainties in the received events and also affect the complex events derived from them (Diao et al., 2009; Wasserkrug, Gal, Etzion & Turchin, 2012). But the issues related to event refinement still prevail and it is more severe in real time streaming data.

Event Hierarchy depicts the hierarchy of reasoning complex events from low level basic events. The event hierarchy has lower level basic events at bottom and higher level complex events at top.

The Complex Event model is defined by a function \( y = f(x_1, x_2, x_3, ..., x_n) \), where \( x_1, x_2, x_3, ..., x_n \) are parameters (basic events) to function which when applied to the function results into \( y \). The output of \( y \) is a complex event as it is associated with \( n \) parameters. Accuracy of complex event identification \( P(y) \) when the parameters are associated with uncertainty can be obtained with following assumptions:

1. Complex Event model is 100% accurate if the applied parameters are correct. Suppose each parameters \( x_1, x_2, x_3, ..., x_n \) are associated with certainty of \( u_1, u_2, u_3, ..., u_n \) then:

   \[
   \text{Maximum possible } P(y) = \min(u_1, u_2, u_3, ..., u_n) 
   \]

   \[
   \text{Minimum possible } P(y) = 1 - \sum_{i=1}^{n} (1 - u_i) 
   \]

2. Complex Event model is \( r \)% accurate if the applied parameters are correct. Suppose each parameters \( x_1, x_2, x_3, ..., x_n \) are associated with certainty of \( u_1, u_2, u_3, ..., u_n \) then:

   \[
   \text{Maximum possible } P(y) = \min(u_1, u_2, u_3, ..., u_n) \times r 
   \]

   \[
   \text{Minimum possible } P(y) = 1 - \sum_{i=1}^{n} (1 - u_i) \times r 
   \]

Since the maximum and minimum accuracy of Complex Event depends on certainty of the parameters and accuracy of the model used for deduction. In uncertain real environment it is difficult to identify 100% accurate models and parameters. To address the issue of uncertainty and false alarms in continuous monitoring applications, this paper proposes a simple & efficient event refinement model based on statistical approach for augmenting the events in CEP. The proposed data model uses overlapping window and statistical parameters to perform event refinement. This model is a layer within CEP events. Every event stream passes through this model in the hierarchy of events in CEP. The key contribution in this paper is the design of an event refinement model based on statistical reasoning to augment the existing CEP system. This paper presents an extended work of augmented CEP (a-CEP) (Pathak & Vaidehi, 2014) and compares the performance with traditional CEP in terms of accuracy and speed of event processing.
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