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CAMEP - COMPLEX BUSINESS ACTIVITY MONITORING SYSTEM WITH EVENT PROCESSING

Govindasamy Vaiyapuri, Thambidurai Perumal

Original scientific paper
In today's world, complex global business environment is in a state of continuous change. Therefore, business organizations are looking for an innovative way to optimize and to support the performance of their business processes to meet out their market share in order to maintain a competitive edge. Usually, business processes are monitored in near real-time using Key Performance Indicators (KPI). KPI is in turn calculated from metrics from business processes. In the case of business outsourcing, the KPI calculation from the metrics of business process is to be carried out cutting across the inter-organizations boundaries and spanning multiple domains. This process poses several challenges in the computation of the KPIs. Some of these challenges include uncertainty in metric values, just-in-time KPI computation and scalability. To address the above challenges of business organizations, a four-tier Complex business Activity Monitoring system with Event Processing (CAMEP) is proposed. The performance evaluation of the proposed system is performed to demonstrate the effectiveness of the proposed CAMEP method by comparing with the existing BAM approaches. The proposed CAMEP is also analysed using the ANOVA and T test.

Keywords: *Bitmap Indexing and Data Imputation, Business Activity Monitoring, Complex Event Processing, Event Filtering, Heterogeneous Domain, Key Performance Indicators*

CAMEP - Sustav praćenja složenih poslovnih aktivnosti s obradom postupaka

Izvorni znanstveni rad
U današnjem svijetu, složeno globalno poslovno okruženje je u stanju kontinuiranih promjena. Stoga su poslovne organizacije u potrazi za inovativnim načinom optimaliziranja i davanja podrške obavljanju njihovih poslovnih procesa kako bi sačuvale svoj udio na tržištu i održale konkurentnu prednost. Obično se poslovni procesi prate gotovo u realnom vremenu pomoću ključnih pokazatelja uspješnosti (KPI). KPI se pak izračunavaju na temelju podataka iz poslovnih procesa. U slučaju poslovnog outsourcing, dobivanje KPI iz poslovnih podataka mora se provoditi prelazeći granice među organizacijama i obuhvaćajući mnoga područja. Ovaj proces postavlja nekoliko izazova proračunu ključnih pokazatelja uspješnosti. Neki od tih izazova su nesigurnost u metričke vrijednosti, just-in-time računanje KPI i skalabilnost. Za rješavanje navedenih izazova poslovnih organizacija, predlaže se sustav nadzora složenih poslovnih aktivnosti u četiri nivoa s obradom pojedinog postupka (CAMEP). Ocjenjivanje uspješnosti predloženog sustava provodi se kako bi se pokazala učinkovitost predložene CAMEP metode usporedbom s postojećim BAM pristupima. Predložena se metoda CAMEP također analizira pomoću ANOVA i T testa.

Ključne riječi: *bitmap indeksiranje i unos podataka, filtriranje postupaka, heterogeno područje, ključni pokazatelji uspješnosti, obrada složenog postupka, praćenje poslovne aktivnosti*

1 Introduction

The explosive growth in IT technology and Business Intelligence (BI) techniques pave way for the business enterprises to monitor and to analyse the business processes in real-time. This real-time monitoring is needed to trigger necessary actions in real-time for businesses to retain the competitive edge. Business Activity Monitoring (BAM) technology provides real-time access to critical business performance indicators which are in turn used to improve the speed and effectiveness of business operations [1]. Business Process Management [BPM] includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of business processes [2]. BAM technology enables continuous, near real-time event-based monitoring of business processes based on key business metrics. These key business metrics are known as Key Performance Indicators (KPI) [3]. In a large business organization, events originate from multiple domains. These events are to be processed in real-time to identify KPI in order to have a sustained competitive advantage. KPIs when introduced in the enterprise informatization framework can change the business process dynamically [3].

Collaborative business is the norm of the day. In order to maintain the competitive advantage, business organizations need to focus on their core area and to outsource their supporting area of business. The process of outsourcing leads to a cross-organizational process where business organizations delegate their process execution to other organizations for supporting the inter-enterprise cooperation. The provision of easy and real-time methodology to monitor the business process across the inter-enterprise cooperation is a complicated task. [4]. In order to achieve real-time decision support among the multiple organizations, BAM uses Complex Event Processing (CEP) to integrate multiple departments and organizations using a continuous and real-time event-based monitoring in business processes. Complex Event Processing (CEP) encompasses methods, techniques, and tools for processing events while they occur, i.e. in a continuous and timely fashion [5]. KPI is the most crucial factor for the success of the business enterprise to detect problems and to trigger business decisions. KPI is used to monitor the business process continuously at run time [6]. BAM is to select the suitable KPIs and to calculate the numerical values for the set of attributes in the KPIs to maintain the business process**.** KPI violations can be prevented by proper adaptations. Furthermore, derived KPIs are stored in a persistent database so that multiple users can access the KPIs without incurring the additional expense of recalculation. Due to the inter-enterprise cooperation of sharing of events from multiple organizations from multiple domains, there is a possibility of uncertainty in the data used to compute the KPIs. In the case of a single or intra-enterprise operation, the process of predicting the uncertainty in the KPIs is comparatively easier. However, for inter-enterprise cooperation, the process of handling uncertainty becomes difficult. The challenge is to convey the uncertainty of the Uncertain Key Indicator to the business analysts while keeping visual metaphors as simple and concise as possible [7].

To address these short comings, the CAMEP framework is proposed. CAMEP is an advanced, extremely fast and perfect platform for building Business Activity Monitoring solutions with the integration of Complex Event Processing. CAMEP supports high data cooperation from the multiple domains and business process/workflow management. In addition, a bitmap indexing scheme is introduced to perform the event filtering to filter out the exceptional or irrelevant events to improve scalability. In addition, the event drove logic addresses uncertainty through data imputation.

2 Related work

2.1 Business management with CEP

The Event-Driven Business Process Management (EDBPM) [8], Cordys BAM [9], and Ensemble BAM [10] approaches introduce the CEP in BAM to process the complex events effectively in a real-time manner.

EDBPM is a combination of BPM and CEP [8]. EDBPM approach establishes a first link between two different flourishing areas such as BPM and CEP. Moreover, a general reference model is introduced to integrate the main concepts of both BPM and CEP and to identify the new specialized operation of a business process. EDBPM provides the added value to detect possible errors within the business process. The reference model provides the visual representation using BAM in graphical dash-boards and meters. This business process deploys conditional decision and reaction logic to react automatically for detected errors. Furthermore, the feasibility and business value of EDBPM in three use case applications for the field of logistics, financial, and telecommunications is demonstrated.

Cordys BAM [9] provides a set of more comprehensive tools and capabilities to integrate Service Level Agreements (SLA) and KPIs in order to monitor the overall effective performance of the business process. Cordys BAM highlights the real time visibility about deviations in an enterprise performance through a centralized performance dash-board. In addition, a message filter has been used to monitor only the filtered attributes which are relevant to the business. The message filter improves the processing and also reduces the storage space. Cordys BAM offers a high level of agility and unique operational insight over the continuous improvement of the business organization in real-time. Cordys BAM can respond quickly in order to change the business situation from the current impending business threats based on the actual information.

Later, a top comprehensive BAM approach called as Ensemble was evolved [10]. Ensemble BAM provides a broad information base and the ultra-high performance necessary for the true Real-Time Enterprise (RTE) through the provision of alerts in the dash-boards. Ensemble BAM automatically triggers a sophisticated, programmatic real-time reaction according to Business Intelligence. In order to monitor real-time data streams, Ensemble BAM has a built-in primitive business process scheme called bit-mapped indexing that allows the processing of persistent data in the background.

In cloud-based service networks, the following abilities are crucial: (i) to define business rules dynamically and (ii) to correlate events from a variety of resources. The events are out-of-control for consumers. To regain control over remote resources, the Event-Driven Business Activity Management Architecture has been proposed for service networks [11]. The architecture is based on tri-partition CEP that serves as a blueprint for flexible business activity monitoring applications as well as closed loop service choreography control solutions.

BPM lifecycle has modelling, simulation and execution of the business processes, monitoring performance management and improving the process based on performance management outcomes. The BPM approach can also be combined with an RFID application. A state monitoring service integrates BPM with RFID for a health care system [12]. An architecture for event processing applications that manages business process of a health information system and BPM systems so as to improve the wait time of the patients utilizing CEP is presented [13].

The challenges in integrating BPM with CEP include Revised Events, Correlating Live Data and Archived Data, Correlating Streaming and Database Data, Stream Queries, Scalability and High Availability, Distributed Event Processing and Provence [14].

2.2 Cross-organizational BAM

Business Activity Monitoring (BAM) in a real-time business enterprise system is a subject of interest in many research fields. BAM provides the graphical virtual display of the overall performance of the business processes within a single company. BAM provides real-time information regarding the performance of the business processes by tracking pre-defined metrics. BAM systems enable business process analysis based on a data-centric approach rather than a process-centric one. In order to achieve BAM among various domains, a cross-organizational approach is proposed based on service BPEL4 choreography descriptions [15]. The cross-organizational approach provides the complex event specification to monitor the business process based on KPI and then, the abstract representation of choreography description is represented in the form of Choreography Instance Identifier (CIID). CIID is used to perform, to filter, to correlate and to aggregate events to order to infer the complex events across the inter-enterprise system. KPIs play a significant role to improve the operational performance of the enterprise system. However, in case of highly competitive and inter-cooperative business environments, it is extremely difficult to deduce KPI [15]. In order to overcome the difficulty, a suitable performance definitional model is proposed to deduce KPIs in [16].This definitional model is suitable even for the large enterprise systems where events come from the multiple numbers of companies of various domains. To handle cross-organizational business process monitoring, a Product-based Workflow Design has been proposed

[17]. The system takes care of capturing monitoring requirements. The optimization of monitoring requirements is based on Ant Colony Optimization heuristic.

The business process of today's world tends to be inter-organizational in nature due to outsourcing. When the business is spread across organizations, the process data also spans across multiple organizations. Due to multiple platforms, standards and culture prevalent in such a setup, impreciseness in process data is to a greater degree than when the business is limited to a single organization. Hence, there is a need for a framework to estimate KPI for Business Activity Monitoring in the presence of imprecise process data.

3 Research contribution

The outsourcing of business leads to an increased level of uncertainty in calculating KPIs. The KPIs are modelled as composite event queries. The composite events are derived from business process metrics that come as simple events from heterogeneous sources. KPI violations are to be monitored in near real-time. Thus, the processing time of composite events is a vital parameter. The research question is

- Whether the processing time of composite events is affected by the uncertainty caused by business process metrics originating from heterogeneous sources?

To answer this question, a CAMEP approach is proposed to process the large number of incoming events from the multiple domains based on the KPIs even under uncertainty. The main aim and contributions are:

(i) To present the application integration framework of a real-time enterprise using CEP as an event correlation engine in BAM.
(ii) To introduce an event filtering technique based on Bitmap Indexing.
(iii) To use Data Imputation through Inter-Transactional Association Rule (DIITAR) method for uncertain event processing.

4 CAMEP framework

The proposed approach is Complex Business Activity Monitoring with Event Processing (CAMEP). CAMEP combines two main platforms such as CEP and BAM into a single framework. CAMEP is an integrated end-to-end developer environment that performs real-time analysis on the input events under uncertainty and presents the results to recipients for immediate reaction. Figure 1 shows the four-tier architecture of CAMEP which consists of four layers: (i) Event Collection Layer, (ii) Event Filtering Layer, (iii) Event Processing Layer and (iv) Event Display and Delivery Layer.

In the CAMEP architecture, the first layer is the Event Collection Layer that collects a large number of metrics as events from heterogeneous sources such as Customer, Bank, Stock brokerage and Stock Market. The Event Collection Layer relies on an object oriented middleware layer to collect messages from heterogeneous transactional systems. The metrics from multiple domains are sent as event notifications to the CAMEP system. The second layer is the Event Filtering Layer, which uses a bitmap indexing scheme to filter the incoming events based on the KPIs provided by the expert. This layer filters the relevant metrics events which are needed to calculate the KPIs mentioned for the specified domain and discards the irrelevant metrics which are unrelated to the domain. The next layer is the Complex Event Processing Layer. The relevant events are entered into the Complex Event Processing Layer that deploys a Persistent Object Engine (POE) to perform Complex Event Processing (CEP) under uncertainty.

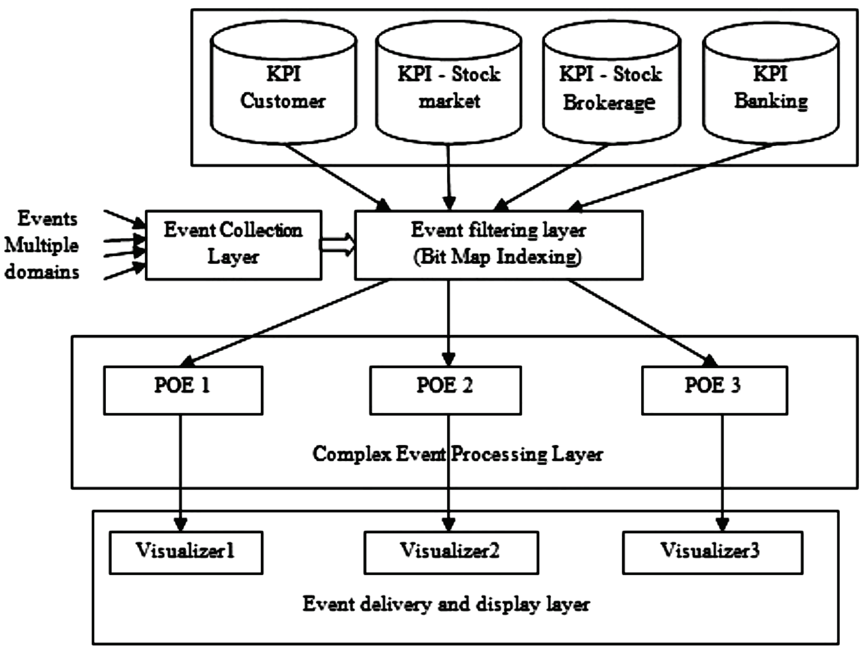

Figure 1 CAMEP in Real-Time Enterprise of Multiple Domains

The Complex Event Processing Layer identifies the divergence in the business performance according to the composite KPIs. The Event Delivery and Display Layer is the final layer which activates automated action to help Business Process Management (BMP) tools. In addition, the Event Delivery and Display Layer generate and communicate alerts via various communication systems to ensure the reactive action to improve the business performance.

4.1 Event Collection Layer

In the CAMEP model, the Event Collection Layer is responsible for collecting metrics as events from heterogeneous domains. Due to the heterogeneity in the incoming events, the following challenges have to be addressed:

- To handle multiple types of incoming events uniformly.
- To handle just-in-time events and to ensure that QoS parameters of the business are not infringed.

The Event Collection Layer is based on object oriented middleware. It collects events from heterogeneous domains. Adapter Design Pattern and Visitor pattern are used with the object oriented middleware in order to optimize against the above mentioned challenges. The incoming metric events are pre-processed into event instances, which are suitable for processing the events in the other layers.

4.2 Event Filtering Layer

Just-in-time KPI computation necessitates the filtering of irrelevant events. The events collected and pre-processed by the Event Collection Layer are Entered into the Event Filtering Layer. The CAMEP framework deploys an inbuilt analytical model called as transactional bitmap indexing for event filtering. Bitmap Indexing performs extremely fast filtering of the large number of continuously arriving events based on the expert specified KPIs. The reason for choosing Bitmap Indexing for event filtering is expert specified KPIs for a business domain does not change frequently. A Bitmap table is formed based on the KPIs formulated by the experts. The Bitmap table is modelled as a matrix. The number of rows in the Bitmap table specifies the number of KPIs and the number of columns represents the total number of individual metrics handled by the system. Each cell of the matrix will hold a value of 0 or 1 depending on whether the metric is used to compute the KPI. The events from the Event Collection Layer are divided into a window of size equal to the number of distinct metrics of the business process. Each window is considered to be an event vector which contains the metric values. Each event vector is normalized using a Normalization vector '***N***' which contains the lower bound of the allowed value range of the metric. The purpose of the Normalization vector is to filter out metric events that fall below the lower bound. The bit vector B is formed from the Normalized vector. An AND operation is performed between the Bit vector and all the rows of the Bitmap table. The number of KPIs specified in the CAMEP system is denoted by 'n'. The maximum number of metrics is represented as 'm'. The bitmap index is a matrix of size ($n \times m$) and is based on the KPIs. When a bit value in a row is set to 1, it indicates that the corresponding metric should be considered for the KPI. Figure 2 illustrates the algorithm for event filtering based on Bitmap Indexing. The incoming event vector $\boldsymbol{E} = (e_1, e_2, ..., e_m)$, where e_i ($1 <= i <= m$) is the value of i^{th} metric in a window of size m. The normalization vector will be $\boldsymbol{N} = (n_1, n_2, ..., n_m)$, where n_i ($1 <= i <= m$) is the lower bound of the metric. The normalized feature vector of $\boldsymbol{E}_k$ will be $\boldsymbol{L} = (l_1, l_2, ..., l_m)$ where $l_i = e_i/n_i$. The Bit vector of the incoming event vector will be $\boldsymbol{B} = (b_1, b_2, ..., b_m)$, where b_is value is given by,

$$\text{if } l_i >= 1{,}0 \quad \text{then } b_i = 1 \quad \text{else } b_i = 0 \tag{1}$$

```
// E is the vector which contains the metric values
// B is the Bit vector of E formed according to
     equation (1)
// BM is the BitmapIndex of size ( n × m)
// S is the candidate KPI set
Procedure BitMap Filter()
{
S=NULL;
For all BMj ( 1>=j>=n) in BitmapIndex BM do
rj = B AND BMj ;
If rj=1 then
Add j to S;
end for
If S is !NULL then
return S
```

Figure 2 Pseudo-code for Filtering using Bitmap Index

4.3 Complex Event Processing Layer

Complex Event Processing Layer accepts the filtered events from the filtering layer. The layer consists of Persistent Object Engines, which have two highly integrated components, a virtual machine and an object store that share the same memory. The object store maintains all the incoming metric events entering into the system persistently which in turn increases system reliability. The virtual machine deploys event-driven logic so that processes can react rapidly to the large number of incoming events from the multiple heterogeneous domains. Uncertainty is handled by Data Imputation through Inter-Transactional Association Rule (DIITAR) method. The set of event metrics that arrive at time 't' is considered as one transaction. The set of transactions is persistently stored in the object store. The closed frequent itemsets are identified using Inter-transactional Association rule mining. The algorithm used is Incremental mining for Closed Inter-Transaction Itemsets[18]. A dynamic tree structure is used to store the Closed Frequent Itemsets. The tree is constructed incrementally. When an uncertain metric event arrives, the data is imputed using the association rule generated by the corresponding closed frequent itemset. Using the imputed metric event, the pattern matching is done by the event logic deployed in the virtual machine.

The formal presentation of the above abstraction is as follows. The number of event metrics in the system is represented as '*m*'. $T_i = \{e_{1i}, e_{2i}, \ldots, e_{mi}\}$ is the transaction that represents the set of event metrics that happens at time '*t*'. Then, the collection of '*T*' represents a time series dataset of events. A subset of T_i is an itemset '*X*'. The function *f*(*T*) is a function that returns all itemsets in *T* and g(T) is a function that returns a set of transactions containing a given itemset *X*. An itemset '*X*' is said to be closed if *f*(*g*(*X*)) = *X*.

```
// Ti is a transaction or a set of metric events at time
    t
// e is a metric event
Procedure DIITAR()
{
T={};
For time t
{
            If Uncertain Event then
        Event e.val = Call Impute ( Event e.val);
            T= T + e;
}
Append T to Transaction Dataset;
Append T to Current Window CW;
 }
// F is the set of Closed Frequent itemsets
//D is the dynamic tree which holds the set of Closed
     Frequent item sets for the Current Window CW
Procedure Impute(Event e.val)
{
        Search Closed Itemset for Event e.val in
        Dynamic Tree D;
        Generate the Association rule from the
    Closed
            Frequent Itemset;
        Infer the missing data from the generated
            association rule for Event e;
```

Figure 3 Pseudo-code for DIITAR

Fig. 3 illustrates the algorithm for Data Imputation through Inter-Transactional Association Rule.

4.4 Event delivery and display layer

The Event Delivery and Display Layer are responsible for the notification of the impact and the severity of the events of the business performance to the recipients. The notification may be in the form of graphical display or alerts to the users about the deviation of the concurrent values in the KPIs of the incoming events. The values of KPI can be displayed on dash-boards via one or more meters and then, the corresponding actions are triggered to improve business operations and processes.

5 Performance evaluation

5.1 Experiment design

The proposed approach is implemented in open source Siddhi CEP engine that runs on a WSO2 Complex Event Processor. The hardware configuration consists of the processor Intel Core 2 Duo of 2,10 GHz with Memory 1,9 GB with the maximum JAVA heap size of 800 Mbytes. It is implemented in open source Java Enterprise Edition/Eclipse/WSO2. The system requires Java Virtual Machine version 5.0 or above. The proposed approach is implemented to monitor the large number of incoming events from the multiple domains. It can process more than 500 events/s on a dual CPU 2 GHz Intel based hardware. The performance of the proposed approach is evaluated using a Stock Brokerage system. The heterogeneous sources of events in the stock market case study are Customer, Bank, Stock Brokerage and Stock Market. One sample KPI to be calculated for this case study is Customer Order Fulfillment Time (COFT). The COFT is computed from three metrics. They are Customer Order Placement Time, Money Transfer Time and Stock Transfer Time. All the metrics have to be processed using Complex Event Processing to calculate the COFT. The event streams are of 10 000 incoming events. The overall performance of the business process is evaluated by monitoring the incoming streams in terms of KPI, which is derived by the technical experts in the corresponding domain.

5.2 Experimental results

5.2.1 Processing time

The average processing time taken to monitor the incoming large number of heterogeneous events from the multiple domains is evaluated. Fig. 4 illustrates that the proposed CAMEP approach outperforms the existing BAM approaches due to the integration of CEP in the BAM. In addition, event filtering is performed to filter out the irrelevant events based on the KPIs. Furthermore, the number of KPIs available for monitoring decides the elapsed time to monitor the incoming events. In case of the more number of KPIs, the average processing time required to process the incoming events gets gradually increased.

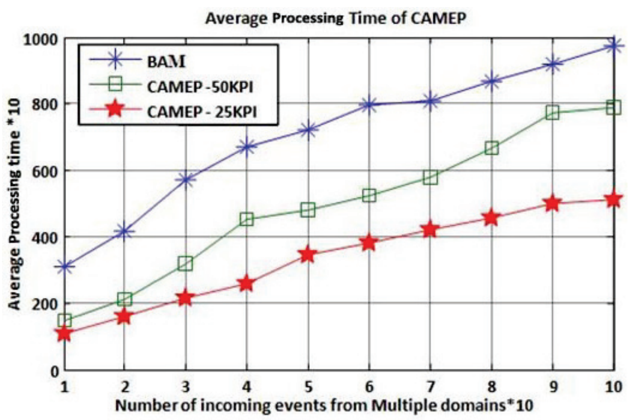

Figure 4 Average Processing Time of CAMEP

5.2.2 Efficiency

Efficiency is the unified performance metric that is effectively magnified with respect to average processing time, throughput and workload. Existing BAM approaches alone cannot meet the business requirements in the case of event uncertainty. BAM can provide the graphical display of information, but it does not have capability to indicate the business transitions by monitoring the event at all times. Hence, the proposed approach integrates CEP in BAM to manage the large number of incoming events under uncertainty and filters the irrelevant events to improve the processing speed. Fig. 5 illustrates that the proposed CAMEP approach outperforms the existing approach in terms of efficiency.

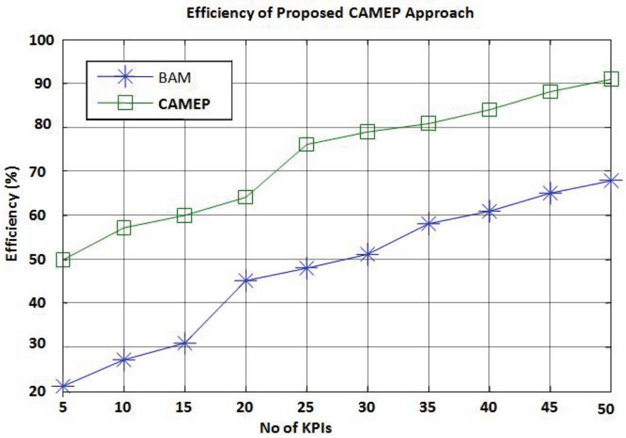

Figure 5 Efficiency of Proposed CAMEP

5.3 Statistical Analysis of Experimental Results

The favorability of the results is analyzed using ANOVA and T test. In order to compare the performance of BAM with CAMEP, the null hypothesis is formulated as:

H0: The Processing Time of composite events is independent on events from heterogeneous sources.

Similarly, the alternate hypothesis is formulated as:

H1: The Processing Time of composite events is dependent on events from heterogeneous sources.

The hypothesis is tested using the parameter - processing time. The experiment is carried out to compare the performance of the proposed CAMEP approach with the existing BAM approaches. The experiments are conducted in two modes: (i) CAMEP with 25 KPIs and (ii) CAMEP with 50 KPIs to test the scalability of the proposed method.

Table 1 ANOVA to compare BAM, CAMEP 25 KPI and CAMEP 50 KPI

Technique			Processing time	
I	II	III	Hypothesis	*p* value
BAM	CAMEP 50 KPI	CAMEP 25 KPI	H1	0,001

From the Tab. 1, it is concluded that the calculated significant difference in the level of the parameter – processing time of the three techniques namely (i) BAM, (ii) CAMEP 50 KPI, (iii) CAMEP 25 KPI always satisfy the condition (p value<0,05). Hence, the null hypothesis of H0 can be rejected.

In order to compare the performance of CAMEP 50 KPI with BAM, the following hypothesis is proposed and tested using T test.

<u>Null hypothesis:</u> H0 : P1=P2, where P1=BAM and P2=CAMEP 50 KPI. There is no significant difference between the two methods in terms of processing time.

<u>Alternate hypothesis:</u> H2: Treatment means are not equal for at least one pair of the treatment means of the factor P. There is a significant difference between the two methods in terms of processing time achieved.

Tab. 2 presents the calculated significant level of the parameter - processing time of BAM and CAMEP 50 KPI. The condition (p value<0,05) is satisfied. Hence, the null hypothesis of H2 is rejected. In order to compare the performance of CAMEP 25 KPI with BAM, the following hypothesis is proposed and tested using T test.

Table 2 T-test for BAM and CAMEP 50 KPI

Technique		Processing time	
I	II	Hypothesis	*p* value
BAM	CAMEP 50 KPI	H2	0,043

<u>Null hypothesis:</u> H0: P1=P2, where P1=BAM and P2=CAMEP 25 KPI. There is no significant difference between the two methods in terms of processing time obtained.

<u>Alternate hypothesis:</u> H3: Treatment means are not equal for at least one pair of the treatment means of the factor P.There is a significant difference between the two methods in terms of processing time achieved.

Table 3 T-test for BAM and CAMEP 25 KPI

Technique		Processing time	
I	II	Hypothesis	*p* value
BAM	CAMEP 25 KPI	H3	0,000

Tab. 3 presents the calculated significant level of the parameter processing time of BAM and CAMEP 25 KPI techniques. The p value obtained satisfies the condition (p value<0,05). Hence, the null hypothesis for H3 is not accepted.

6 Conclusion

This paper has proposed a four tier Complex Business Activity Monitoring with Event Processing (CAMEP) approach through integrating two leading platforms such as BAM and CEP. CAMEP performs efficient monitoring of events coming from the multiple domains based on Key Performance Indicators to trigger the necessary action for improving the overall business performance. In addition, event filtering is performed to filter exceptional events based on the set of attributes in the KPIs using a bitmap indexing technique. Further, CAMEP deploys a persistent object engine to process the large number of incoming events from the multiple heterogeneous domains even under uncertainty. The system handles uncertainty using data imputation method. The proposed system can automatically respond KPI violations to maintain the business performance. Performance evaluation is carried out to demonstrate the effectiveness of the proposed CAMEP method in terms of average detecting time and efficiency. Also, the experimental results are analysed using ANOVA and T test. The future work of our proposed approach is to evaluate the methodology in additional domains. The other possible future enhancement is to induce parallelization in the monitoring phase of the methodology.

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Authors' addresses

Govindasamy Vaiyapuri, Reaearch Scholar
Department of Computer Science and Engineering,
Pondicherry Engineering College,
Pondicherry 605014, India
E-mail: vgopu@pec.edu

Dr. Thambidurai Perumal, Principal and Professor
Perunthalaivar Kamarajar Institute of Engineering and Technology,
Karaikal, India
E-mail: perumal_thambidurai@rediffmail.com