Chapter 6.
Summary, Conclusion and Recommendations

This chapter summarises and assesses the findings of research on the proposed Operational BI system. The title of the thesis is “A Novel System for Operational Business Intelligence” that extends business intelligence functionality to operational level decision making in current time. This thesis consists of six chapters. In addition, this chapter concludes with recommendations and highlights limitations. Finally, the future research of the present research study is presented.

6.1 Summary

The epitome of the present research study of the proposed Operational BI system is envisaged as follows.

In Chapter 1, introduction covers definitions, objectives, scope and functionality of Operational BI system. Moreover, literature review covers the relevant work reported on Operational BI. In addition, review findings have been reported which helps us for research problem identification and formulation. Finally, research objectives are listed.

In Chapter 2, the key features of the proposed system are presented which are low latency and reduced action time, access to lowest granularity data, real-time alerts, faster query response, ad-hoc querying capability, configurable operational parameters and performance measurements, flexible to integrate the existing business processes and workflows, detailed and timely information and Streaming SQL. Mapping between the key features of the system with their equivalent functional modules are presented. In addition, a holistic view of Operational BI system is presented. The functional architecture of system is envisaged from the identified key features. A methodology for developing business requirements of the proposed system is presented.

In Chapter 3, the major components of the proposed system are presented which are business performance management, event monitoring and notification, operational analytics, operational reporting and portal. Three major components of the proposed system are modeled which are business performance monitoring, event
monitoring and notification and incremental mining. The functionality of Check algorithm is presented and explained how this algorithm monitors SLAs and KPIs of an organization on real time basis. Envisaged how the proposed components of the system will improve business value of an organization.

The architectural design of the proposed system is presented that uses Model View Controller Model 2 architecture of J2EE which is a well proven and industry accepted architectural design pattern. The multi-tiered architecture of the proposed system is presented which provides reuse of functionality, higher performance, scalability and maintainability to the proposed system. The loose coupling between these layers facilitates to configure different levels of security to the components deployed on different layers of the system. The flow of user request and system response, sequence diagram, generic objects, system and deployment architectures of the proposed system are presented. Finally, the advantages of the proposed multi-tier architecture of the system are presented.

In Chapter 4, an algorithm for Association Mining for $K^{th}$ frequent ItemSet in short as AMKIS is designed and implemented. The structure and functionality of AMKIS algorithm is fundamentally differ from Apriori and FP tree algorithms. The AMKIS algorithm generates $K^{th}$ itemset directly from the transaction data without generating any previous itemsets. The experimental results of AMKIS algorithm are compared with Apriori with similar itemset generation and found that AMKIS outperforms Apriori for 2-itemset to 5-itemset. The AMKIS algorithm is tested for scale-up experiments for large data sets whose transactions volume ranges from one million to several millions and found satisfactory results. The proposed AMKIS algorithm has several advantages over other frequent itemset pattern algorithms which are one time scanning of transaction database, no massive candidate generation, extracts missing knowledge that is lost during pruning process of support count thresholds, uses limited main memory resources, uses simple data structure and does not use any support criteria.

In chapter 5, two incremental association mining algorithms are presented. The first algorithm is Incremental mining for $K^{th}$ frequent itemset generation for update database, in short INK, which directly generates the required $K^{th}$ frequent itemsets from transactional database without generating any lower values of frequent itemsets for update case. This proposed INK algorithm uses simple binary concepts for generating $K^{th}$ frequent itemsets. The previous mining results of original database
are updated with the extracted knowledge inorder to provide updated knowledge
database. The performance of INK algorithm is higher as compared with Apriori and
found satisfactory results over wide range of transactions that is linearly scalable with
database size. The speedup ratio of INK algorithm ranges between 2.35 and 11.07 for
2-itemset and 5-itemset respectively.

The second algorithm is Incremental Frequent Itemsets Mining for
maintenance of frequent pattern mining and is named as INFRIM. The performance
of INFRIM is significantly faster than mining the updated database from scratch. The
INFRIM algorithm has the following salient features: uses previous mining results,
works dynamically, avoids re-computing large itemsets that have already been
discovered, focus on newly inserted transactions thereby greatly reduces number of
candidate itemsets which intern saves computation time this results increases
execution speed, uses a simple check of 1-itemset support count of incremental
database and then generates the required frequent itemsets thereby the computation
time of large itemset generation reduces greatly. The speedup ratio of INFRIM
algorithm ranges between 1.2 and 3.1 for 2-itemset to 5-itemset as compared with
Apriori.

6.2 Conclusion

The study was to set to explore the possibility of extending business
intelligence functionality to the organizations for operational use. The following
conclusions are made from this research study which meets the set research objectives.

1) The nine key features of Operational BI were presented.
2) A holistic view of Operational BI system was presented.
3) The functional architecture of the proposed system was presented.
4) A methodology for developing business requirements of the proposed system
   was envisaged.
5) The five major components of Operational BI were presented.
6) The business performance management component of the proposed system
   was presented and explained performance measurement of the configured
   parameters on real time basis with the help of the Check algorithm.
7) Event monitoring and notification component of the proposed system was
   envisaged and explained generation of real time alerts.
8) Incremental Mining System (IMS) architecture was envisaged which is one of the major components of operational analytics of the proposed system.

9) Enterprise architectural design framework of the proposed system was presented using Model View Controller (MVC) Model 2 architecture of J2EE which includes multi-tiered architecture, generic objects, sequence diagram, system and deployment architectures.

10) An algorithm for generating $K^{th}$ frequent itemset in short AMKIS is designed and implemented. The performance of AMKIS is higher as compared with Apriori.

11) The speedup ratio of INK algorithm ranges between 2.35 and 11.07 for 2-itemset to 5-itemset generation as compared to Apriori.

12) The speedup ratio of INFRIM algorithm ranges between 1.2 and 3.1 for 2-itemset to 5-itemsets generation as compared to Apriori.

Finally, this is to conclude that from the key features to functional architecture, from identified components to conceptual architecture, from layered architecture to design of the proposed and the proposed association algorithms such as AMKIS, INK and INFRIM provide decision making information to the users in current time. Thus, the proposed Operational BI allows the user to make decisions based on what is happening now rather than past.

### 6.3 Recommendations

In the light of the title of this study, "A Novel System for Operational Business Intelligence" and on the basis of the above findings and conclusions, the following recommendations are made:

1) The proposed functionality of BI can be extended to operation level users of an organization for their decision making in current time. Thus, the proposed Operational BI system can be considered in developing low level decision making tool that helps operational users for their decision making to run day to day business operations smoothly.

2) Operational BI system provides a complete view of BI of an organization in current time that supports decision making information to strategic, tactical and operational users. Moreover, Operational BI system consists of conglomeration of knowledge mining algorithms which extract knowledge from operational data sources as well re-uses previously extracted knowledge
from historical data sources. Thus, Operational BI can be known as hybrid business intelligence system.

3) The proposed key feature of the system are highly generic based on these features new products / applications can be considered for developing Operational BI applications/ systems.

4) The proposed methodology for developing requirements for Operational BI is unique, level wise and focuses on business context of the organization which facilitates to study the requirements by multiple analysts simultaneously.

5) The proposed functional architecture of the system is based on software design principles that supports modularity and highly scalable because loose coupling between modules. The identified components of the system provide improved business value to the users in reduced the action time which re-uses previous mining results. Thus, the proposed system will provide knowledge in the present time as well as past knowledge as compared to traditional BI system. The architectural design of the proposed system uses Model View Controller Model 2 architecture which is highly scalable that supports enterprise applications because of loose coupling between various layers interms of presentation, business logic and data access layer. Hence, the proposed architecture framework can be considered as reference architecture for developing Operational BI system.

6) The proposed AMKIS algorithm is efficient to extract the required ($K^{th}$) frequent itemset patterns in large databases directly without the use of generating lower value of frequent itemset.

7) The proposed INK and INFRIM algorithms provide timely update of mining results to operational users of an organization for their decision making on continuously growing database. Hence, INK and INFRIM algorithms can be used in maintenance of data warehouse and business intelligence projects.

8) Operational BI is an extension of BI functionality to operational level of the business which is gaining immense popularity in these days. The use of Operational BI find in all most all organizations including but not limited to HR, CRM, ERP, stock market, sales, insurance, financial, medical, airlines, news, supply chain management, and telecommunications for decision making in current time and continue its demand for few more decades.
6.3.1 Limitations of this study

This study has noticed the following limitations that are acknowledged as follows. The proposed algorithms AMKIS, INK and INFRIM are designed, implemented and tested for large datasets for generating $K^{th}$ frequent itemsets. However, these algorithms are found suitable for frequent 2-itemset and 5-itemsets generation of database having smaller number of items. These algorithms can be extended further to improve the efficiency for longer itemsets generation of database consists of large number of items. Moreover, the proposed algorithms use binary data as inputs and do not work for other data formats. The itemset generation function in the proposed INFRIM algorithm uses recursive function call hence this may not be efficient for frequent itemset generations of larger $K$ values.

6.3.2 Future Research

Based on the preceding discussions on the present research study the following conclusions can be drawn for further research:

1) The proposed functional architecture of Operational BI system can be implemented as prototype.

2) The proposed methodology for business requirement development of Operational BI system can be extended to one or more business verticals.

3) The proposed event monitoring and notification system does not discuss Quality of Service (QoS) functionality that can be further studied.

4) The proposed AMKIS algorithm can be further improved to support databases having larger itemsets. The AMKIS algorithm uses a simple item mapping scheme for encoding which can further studied to develop an efficient dynamic mapping scheme. Further, this can extend to find Top - $K$ frequent itemsets.

5) The proposed Incremental mining algorithm for $K^{th}$ frequent itemset (INK) for update database can be further extended into insertion as well as deletion cases. Further, this algorithm can be extend into a generic incremental mining $K^{th}$ frequent itemset for short and long frequent item patterns in large databases.

6) The proposed INFRIM algorithm can be further extended to various minimum supports and problems of generalized incremental frequent itemset pattern generation.
7) Further, the proposed algorithms AMKIS, INK and INFRIM can be further extended to mine frequent patterns for multilevel association rules, clustering association rules and constraint based association mining.

8) One more interesting direction of future work is to develop software methodology for Operational BI system.

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