A Novel Model of Software Process Improvements for Small and Medium Scale Enterprises by using the Big Data Analytics Approach

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Abstract– **Most of the traditional organizations are not using the Big Data concept in the business process and other business activities but the rise of Big Data approach has been significantly transforming certain business enterprises. The majority of small software organizations are not adopting the existing models like CMM, CMMI, and ISO 9001 because they believe that these models are good for large organizations but fail to work in the SMEs. However, most of the software development companies around the globe are small and medium scale enterprises. The Software Process Improvement (SPI) has been recognized as an efficient way for firms to improve quality and productivity of the software they develop. Every software firm needs a well-understood and well managed software development process to improve the quality of their product. The problems with the traditionally SMEs is that they are using only internal data for decision making and other business activities like sale, inventory and shipments. However, to improve performance, we need to use data which is available inside and outside the organization. We propose the Big Data Analytics approach in our model to use data from different data sources to improve the performance of the business process in the SMEs.**

Keywords– **Business Intelligence, Software Quality, Small and Medium Enterprises, Software Process, Improvement and Capability Maturity**

I. INTRODUCTION

The small and medium firms have realized that improving their process and working methods are crucial for their business, but they are lacking in the knowledge and resources. Successful software process improvement implementation is a herculean task for these small and medium enterprises since they are not capable of investing in the cost of these programs. Software Process Improvement (SPI) has been recognized as an efficient and effective way for firms to improve the quality and productivity of the

software they develop. The existing process models do not support informational and behavioral aspects of the software development process [2]. To ensure the quality of the product, reduce costs and maximize productivity, software firms need a well-understood and well managed software development process. But due to some reasons the SMEs fail to do so because the majority of small software organizations are not adopting the existing standards. Models like CMM and CMMI have some problems moreover, these models are suitable for large organizations, and studies have shown that the negative perceptions of small firms regarding process model standards are primarily driven by negative views of cost, documentation and bureaucratic hurdles. But the majority of small and medium size enterprises are not adopting the existing models like CMM, CMMI, ISO 9001 etc. because some researchers believe that these models cannot be applied unmodified to small organizations [4], and we need some modification in it if we want to apply these models in small organizations. The third possibility was proposed to integrate CMM with the ISO 9001 and ISO 9000-3 models. But all these are the possibilities and the fact is that there is no ideal model available at the movement which is suitable for small and medium organizations. Moreover most of the SMEs and organizations are afraid of the initial expenses which they assume are large not only with regard to direct costs for process assessment, training and tools, but also due to indirect costs for personnel and time resources when implementing improvement actions. It is quite difficult for any SMEs to select an improvement approach, and to apply it in its organization without the external help from consultants. The quality of the product, price and productivity of the software in any organization depend on software development process; therefore every organization needs to understand and manage software development process. But the problem is that majority of small and medium enterprises (SMEs) are not adopting the existing standard, because they believe that it is suitable for only large organization.

On the other hand, the Big Data play a vital role in modern business phenomena and undoubtedly it is the need of every organization to collect data from different sources and use it in their organization for different business process and activities. It is fair to say that Big Data is rapidly maturing

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and evolving which provides significant data storage and processing power to our SMEs. To take advantage of this power of Big Data we need to collect and process very large amount of data with very high speed. Moreover, business organizations and enterprises demand the use of this Big Data approach in their organization for their business monitoring and management.

Big Data shifts business decision making strategies from conventional operation to electronic form of operation. There is an increase of 26% in performance where Big Data analytics have been applied [19]. Big organizations like Alibaba, Apple and Amazon have been delivering products and services speedily with a smooth user experiences. One of the latest business moves of Amazon is to take a patent to ship goods to the required organization before even the organization has made a decision to buy it, purely based on the predictive big data analytics [23]. Similarly Amazon has combined the strengths in data analytics and the instinct for patenting key features to obtain a patent for Anticipatory Shipping [11]. LinkedIn social website has created numerous data products, including people you may know, jobs, you may be interested in person or companies you want to follow etc. The Big Data is playing a very important role in an organization's operation and it can be applied in many compliance processes like audit and fraud risk management related discussions. In a study conducted by Vincent Walden (about Big risks require big data) about 72% of respondents believe that Big Data analytics can play a key role in fraud prevention and detection [20]. Analytics using Big Data for business intelligence within an organization are required to support critical operational process of an enterprise. Literature reveals that every organization generates around one third of the data they use internally, and are responsible to generate about 85% of the remaining two thirds of data from the customers interacting with their services. Every organization has various types of information systems to run basic business processes. Improving business process is very important in today's electronic marketplace; organizations must improve their business process to compete because the customers are demanding better products and services. The customers have a lot of options. If they are not satisfied with the quality or price of the product of any supplier, they choose another supplier. The business process improvement involves understanding and measuring the current process of organization and then making performance improvements accordingly. The organization wants to make good decisions and good decisions require data from a number of sources. Most of the traditional SMEs organizations are using only internal (in-house) data for decision making and other business activities like sale, inventory and shipments. But now organizations require analysis of external data for the customer requirements to gain new insights into customers' demands, needs, markets, supply chain and its operations.

To address these issues, we proposed a new software process improvement model (SPIM) which can be used in small and medium size enterprises. Our proposed model would be based on the traditional software process development models such as Capability Maturity Model (CMM), Capability Maturity Model Integration (CMMI), and International Organization for Standardization (ISO) and Software Process Improvement Capability Determination (SPICE). The model uses the Big Data Analytics concept for business process improvement in the SMEs.

II. LITERATURE REVIEW

In [24] the authors proposed a CMM model for engineering education system which is used to improve the education process and could help to enhance the overall education quality of education. The system is ideal for large organizations but for small and medium size organization it is not suitable because it is based on CMM and the CMM model does not specify a particular way of achieving these goals for SMEs. G.K Viju [25] proposed a model which could be used for small and medium size enterprises. This model is ideal for traditional SMEs enterprises but unable to fulfill the requirements of the SMEs which are working in the electronic workspace because it is mainly based on the organization internal (in-house) data. The organizations which are using the internal data only for business processes are unable in fraud detection, due to which some time their profit ratio is very low because this model is isolated from other sources of data.

In [27] the authors explain that small organizations can implement SPI as effectively as large organization and could achieve high organizational performance. They further point out that in order to implement SPI to work effectively like large organizations, small organizations should capitalize on their relative strengths in employee participation and exploration of new knowledge. In [28] the authors explain that the software development process is also very important for small project success as much as it is for large project due to the number of external dependences per team member of the project.

In [30] the authors explain that it is very difficult for any SMEs to choose an improvement approach to apply it in their own organization without the support of external consultants. Moreover, there are cultural issues like resistance to any changes from management or employee, who regard the extra workload for quality assurance as a useless and complicated burden on the developing team. In [31] the authors explain that the SME are afraid of the initial expenses which they suppose are large both with regard to direct costs for training, tools and process assessment. They are also wary of the indirect costs on time and personnel resources when implementing improvement actions. In [32] the authors explain the organizational level of CMMI-based SPI and conclude that organization are motivated by business benefits, either through increase in software quality or increase in productivity. They further point out that only 5-10% of CMMI-based SPI initiatives are motivated by human factors (for example knowledge, environment, motivation and leadership etc.). They explain that people related reasons are given by organizations and the impacts of CMMI-based SPI on developers are often overlooked by organizations which might be the main reasons for some of the SPI failures. In [1] the authors identified that the keys to software process improvements in SMEs are (1) Senior management support (2) Adequate staffing (3) Applying project management principles to process improvement (4) Integration with ISO

9001 (5) Assistance from process improvement consultants (6) Focus on providing value to projects and to the business. In [26] the authors identified seven small organization challenges: (1) Handling requirements (2) Generating documentation (3) Managing projects (4) Allocating resources (5) Measuring progress (6) Conducting reviews (7) Providing training. In [33] the authors conducted a case study investigating SPI model or techniques for software improvement in web software companies.

The researchers of [34] propose Software process improvement used AGILE method. In [35] the authors proposed Process Meta model. In [23] the authors proposed a model to combine the Big Data Analytics with business process and explained how to reengineer the business process in the existing organizations to improve the SPI for large organizations. The proposed concept is ideal but it could be run only in large organizations and the SMEs could not implement it so far. In [36] the authors explain reviewed literature on small organizations. In the [37] the authors used the ABC model to reshape software process according to the organization goals and objectives; they also evaluate the performance of software process accordingly. In [38] the Six Sigma process models are explained which contain theories and tools with software process to improve and produce high quality products after implementing continues improvement in SDLC. A gradual approach for software process improvement is also introduced to check various gradual assessments which allow gathering comprehensive knowledge depending on software in Small Enterprise Organizations (SMEs). In the [39] the author introduced the process quality measurement model which is used to analyze the quality of software used in organizations. The IDEAL model is proposed in [40] based on the experience of large organizations which also helps in the software improvement in small organizations.

III.   RESEARCH QUESTIONS

 i).   Which generic model provides the most reliable way to achieve these results?
 ii).   How can SPI be used for the organization's business goals?
 iii).   How can a software measurement be used effectively within the SPI program?
 iv).   How can we assess the effectiveness of the SPI program so that the management can see the return on their investment?

The proposed model will provide answers for all these questions.

A) Software Process

Software process is a structured set of activities required to develop software systems. A software process can also be defined as a set of activities, methods and transformations that people use to develop and maintain software and the associated products, for example, product plans, design documents, code, test cases and user manual [45]. A good software process can help organizations to improve their capability and maturity level throughout the business system

because a good quality of process will help the organization in standardizing software development, improve reusability and consistency of project teams, improve the quality of products, reduce cost and save time. Moreover, it is also very important to understand the goals of the business to start process improvement. Therefore companies should identify their process strength and weakness, improvement areas, risks and opportunities [44]. The goals of business processes which enable organizations to achieve improvements in performance measure are:

 i).   Increased responsiveness
 ii).   Improved customer satisfaction
 iii).   Reduced business and IT costs
 iv).   Increased profits
 v).   Improved quality of execution and decision making

B) Software Process Improvement

The software process improvement is a simple mechanism which is applied to give SMEs good results and which also changes the practices that cause the problems [42]. The idea behind the SPI in the organization is to achieve business goals and develop good quality products through a mature process. The main objective of the SPI is to set methods in order to improve the development process including work planning, risks handling, decision making, managing requirements and project management [43]. It is very important for every organization to analyze their structure and process and identify the main reasons of their failure and then work profoundly to improve their structure and process whenever they need. The software organizations are using SPI product suits, models and self-made techniques in order to improve process capability and are trying to advance from a pre-mature level process to mature level to improve and mature the process [41]. A number of software process improvement models have been designed which provide a good solution for software process improvement.

C) Software Process Improvement Models and Problems

A software process model is an abstract representation of a process. It presents a description of a process from some particular perspective. Several models have been developed to assist organizations to evaluate and improve their software development processes and capabilities.

The software process improvement and measurement is one of the main important mechanisms to solve the software crisis. The Software process measurement, which is also called software metric defines the process of software development, collection and analysis of data for the process of continues improvement. The standardized school of through of SPI is based on developing software in a more standardized form which generates high quality standard results within a given budget and allowed time schedule.

The following are some software process improvement models

Capability Maturity Model (CMM)

The CMM plays an important role in the software improvement efforts (SPI) of organizations worldwide. This

model was developed by the software engineering Institute at Carnegie Mellon to measure the maturity of organization and its ability to use software technologies. The main focus of this model is on managing the process and developing a process maturity framework to help an organization to improve its software process by using the initial, repeatable, defined, managed and optimized levels.

Limitations of CMM

i).   CMM is working only on repeating tasks.

ii).   CMM is goal. It is being used just as a stamp of approval.

iii). The main limitation of CMM that is the key practices describe "what to do" but do not prescribe "how to do".

iv).   CMM is concerned with the improvement of management related activities, without giving importance to the process related activities.

IDEAL Model

The IDEAL is software process improvement (SPI) model. It was designed by the Software Engineering Institute of Carnegie Mellon University in 1996. The goal of the model is to improve the development process of software. The IDEAL model is good for those organizations that initiate the SPI for the first time. The IDEAL model has five phases like Initiating Phase, Diagnosing phase, Establishing phase, Acting phase, Leveraging phase.

Limitations of IDEAL Model

The IDEAL is a continuous model, but it is a full method such that there is no recovery

Capability maturity model integration (CMMI)

The model was created by combining the CMM models SW-CMM V2.0, Integrated Product Development (IPD), and System Engineering CMM SE-CMM) [6]. The purpose of CMMI is that it helps to integrate the different organization functions.

Limitations of CMMI

i).   It may not be suitable for every organization especially for small and medium size organizations.

ii).   It may add overhead in terms of documentation.

iii). It may require additional resources and knowledge required in smaller organizations to initiate CMMI-based process improvement.

iv).   It may require a considerable amount of time and effort for implementation.

v).   It may require a major shift in organizational culture and attitude.

Similarly other models like International organization for standardization (ISO), Bootstraps and Software Process Improvement Capability Determination (SPICE) etc. also have some limitations.

D) Small and Medium Enterprises (SMEs)

The category of micro, small and medium-sized enterprises (SMEs) is made up of enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding 50 million euro, and/or an annual balance sheet total not exceeding 43 million euro. These organizations are considered as the back-bone of the world economy. More than 85% of the companies in US, China, India, Finland, Ireland etc. are small and medium scale enterprises in the year 2008 [13]. The SMEs have some characteristic which are shown in the following Table I.

Table I: Characteristics of Small Software Firms [2]

Characteristics	Approximately ratio in small firms (%)
Internal project meetings are held regularly	90%
Serve mainly regular customers	65%
Projects often last longer than planned	50%
Employees often work overtime	73%
Marketing is an important part of the company philosophy	75%
Investing in training of employees	78%
Quality management is important	87%
Continuous documentation of all Tasks	6%
Traditionally structured company	52%
Teamwork is important	99%
Customer involvement all the time	80%
Develop software for many different domains	50%
Always newest technology	80%
Dynamic and flexible company	94%
Customer support is important	95%
Often use new methods and techniques	75%

E) Six Sigma

The Six Sigma is an effective and systematic quality improvement approach to enhance an organization's performance based on the adoption of various statistical analytic techniques [46]. The primary goal of Six Sigma is to reduce variance in the processes by eliminating defects that interfere with customer satisfaction, and reducing the cost on the organization's development processes [48]. Six Sigma has been considered as the managerial strategy for quality improvement by quantitatively evaluating an organization's processes and reducing process variances [47]. The Six Sigma

has different problem solving methodologies such as DMAIC, DFSS and DMADV, but in our proposed system we are using the DMADV process (Define–Measure–Analyze– Design–Verify) methodology for the new process improvements which has five phases, such as Define, Measure, Analyze,

Design, and Verify. The advantage of the use of DMADV methodology is that it can be used to find problems in the new processes and fix them for improvements. We are using this Six Sigma in our proposed model for the software process improvement in the SMEs.
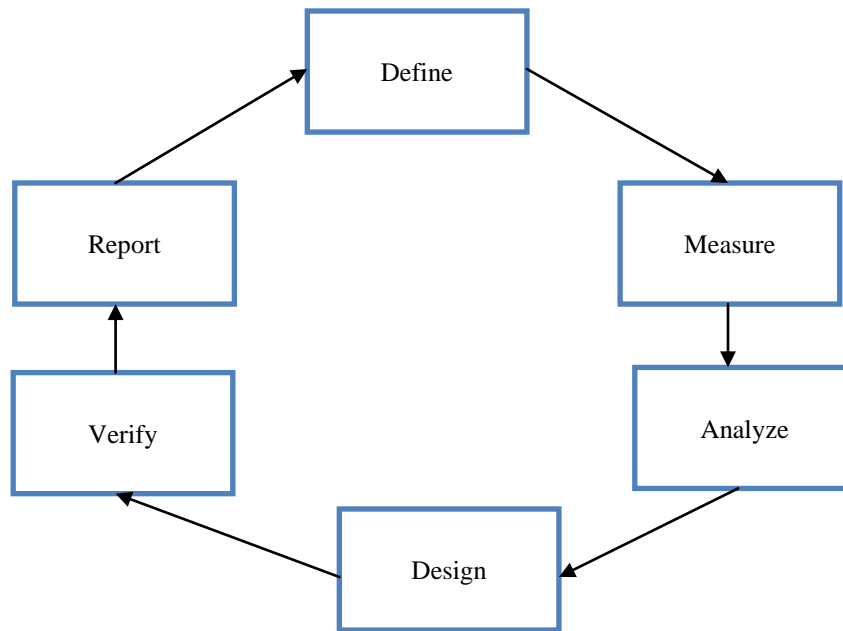

Fig. 1. Six Sigma activities for Develop new Business Process

IV. PROPOSED MODEL

After verifying all problems within the existing models, and looking at the advantages of the Big Data Analytics for the business processes in the SMEs, we proposed a new model for the SPI in the SMEs for the solution of these issues. Due to problems in the traditional models we are using a new approach in our proposed model and use the Big Data concept in our model for the SPI and other business activities in the SMEs. Our proposed model is based on the traditional software process development models such as Capability Maturity Model (CMM), Capability Maturity Model Integration (CMMI) and International Organization for Standardization (ISO), Software Process Improvement Capability Determination (SPICE) etc. we use the Big Data Analytics concept for SPI. Like other existing models our proposed model would also depend upon API success factors like economic factors, people issues factor, organization and implementation factors etc. In this model we collected information that we needed to change and to establish how to pursue the improvements in order to minimize development cost and maximize the quality of product.

A) Parts of the Proposed Model

Using the Big Data Analytics concept for business process improvement in SMEs

Most of the traditional SMEs enterprises or organizations are using only internal (in-house) data for decision making and other business activities like sale, inventory and shipments. However, to improve the performance in organization activities, the emergence of new technologies have shown an explosive growth in the types of data and information which is available to use inside or outside the organization. But now organizations require analysis of external data for the customer requirements to gain new insights into customers' demands, needs, markets, supply chain and its operations etc. Nowadays it is very easy to acquire data about people and objects through social media (Facebook, twitter, LinkedIn) and other sources. Many big organizations like Amazon and Apple are using social media for marketing and selling their products beyond their websites on Facebook, LinkedIn, twitter etc. When the customer is satisfied or unsatisfied with any product or service of any organization, they spread the information among their friends, and to the world at large through social media.

But unfortunately most of the SMEs have not adopted this practice so far. As such these enterprises are not able to achieve their goals properly. Moreover, the old way of business in SMEs is no longer effective and we need some changes in doing our business. To select the right business process for improvement to achieve their goals is a challenging task and we need to understand the impact of Big Data on the existing process in enterprises.

The traditional enterprises that are using only the in-house (internal) data for their business activities having the following problems: first they will improve existing processes and products that are on their way to becoming unprofitable. To make these business process and product profitable we needs to use not only the internal data, but the data from different external data sources need to be capture and use it. Second, using an organization's internal data only, some business process lost both performance and accuracy in the result. Third, some organizations required information for business process which is not available in the company internal database. Finally the organizations which are using the internal data only for business processes are unable to fraud detect, due to which some time their loss ratio is very high.

Creating the Data Warehouse for the Proposed Model

We are in the process of integrating Big Data sources for processing and analyzing so that business intelligence (BI) can be created. We are integrating the following external data sources of Big Data to create our local data warehouse and then analyze and process this data in our model.

Open Data: It is the main source of data from different government and private organizations. Open data set allow anyone to access data without any restriction [6].

My Data: It is the internal data of any organization or individual. This type of data is usually held securely with strict rules regarding access.

Little Data: Small business can also make use of data analytics across data that they have about their own business, similar to Big Data, but on a smaller scale [6].

Internal Enterprise Data: This is the data that is collected by an organization about its own systems and processes. This data may or may not be digital and can consist of both quantitative and qualitative information.

Web Logs: A Web Log, sometimes written as Web Log or Weblog is a website that consists of a series of entries arranged in reverse chronological order, often updated frequently with new information about particular topics.

Social Media: This includes websites and applications that enable users to create and share content or to participate in social networking like Facebook, twitter, LinkedIn etc.

Images and Videos: Today images and videos make up about 80 % of all corporate and public unstructured Big Data. In the present time the growth of unstructured data has increased. Analytical systems interpret images and videos as well as interpret structured data such as text and numbers.

Documents and PDF: The PDF which is portable documents format is a file format that has captured all the elements of a printed documents as an electronic image.
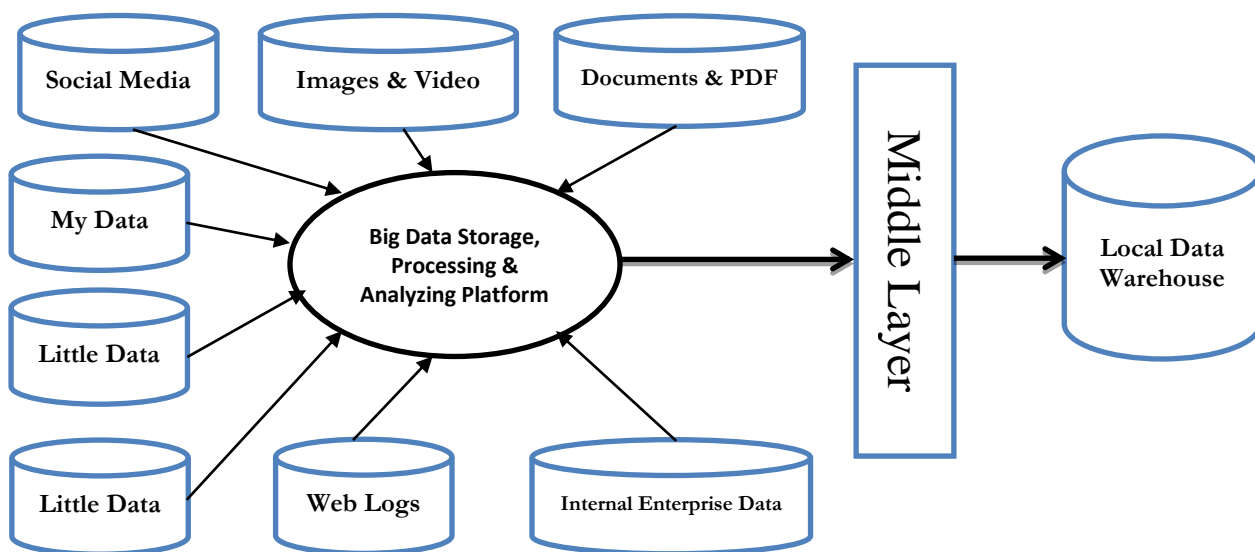

Fig. 2. Integration of Big Data Sources

Once the Big Data is collected, processed and analyzed, it can be stored in the local data warehouses from where data can be sued for business intelligence, reporting, online analytical process etc. Using the data from the internal data source is helpful to solve a number of business problems, but by working in isolation and applying analysis only to internal data might improve the exiting business process and product of the organization, which might be unprofitable. However, to make these business process and product profitable, we not only need to use the internal data but the data from different external data sources also need to be captured and used. Choosing the data from the right data source for decision making is very important because it improves performance of the business process in the organization. It is not only important to collect more data from different sources but also to understand in the variety of data being collected from

different sources for analysis. Therefore, first we need to identify which variables could improve the results of analysis.

Defining the Big Data Strategies

It is very important to define the Big Data strategies for the software process improvement, and we used the Six Sigma [22] activities for business process improvement in the SMEs in are proposed model to define the Big Data strategies. We are applying the following strategies in our proposed model.

i). Collect data from different data sources like internal, external, social media etc.
ii). Identify the business processes in the organization which are supporting the key tasks.
iii). Identify the critical success factors
iv). Identify the outcome
v). Identify the business factors that support the business strategies
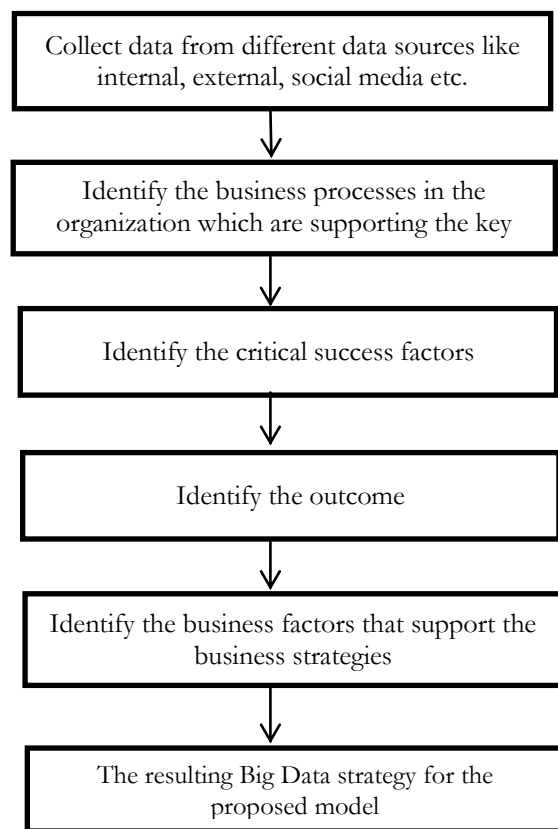vi). The resulting Big Data business strategy

Fig. 3. The steps for Big Data Strategy for SPI

Middle Layer

The traditional organizations process structured data and business processes generate more structured data, i.e. data in the form of database table. The data in the different data warehouses (sources) are historical data which is mostly un-structured or semi-structured data but we need the structured data for business process. We are using a middle layer which

is capable of converting the data from un-structured or semi-structured form into structured data form before storing into our local data warehouse. The data in our local data warehouse would be stored in the form of database table and we are using this data for process improvement and other business activities in the proposed model. The main advantage of our own data warehouse over the other datasets is to have structured data rather than un-structured and semi-structured data. Therefore, it should be very easy for every process in any organization to use this data without any extra effort; this will improve the performance of the business process in the organization.

V. PHASES AND WORKING OF THE PROPOSED MODEL

After verifying problems in the existing SPI models we came to the conclusion that the proposed model would help the small and medium enterprises to implement and improve their software processes. Since most of the SMEs are having the same and similar characteristics, after a careful review of literature we need to analyze and find the characteristics of the SMEs. Moreover, we also need to study and identify the problems of SPI success factors in the SMEs. We created the data warehouse by integrating different data warehouses and also defining the Big Data strategies for our proposed model (Phase 1). We are using the information from our local data warehouse wherever we need it during different phases. Once the characteristics of SMEs have been identified and the core issues of SPI critical success factors in the SME have been addressed then we discuss different software process improvement and development models to choose the near appropriate model for SMEs (Phase 2). After choosing the appropriate model we select the most suitable SPI traditional models like CMM, CMMI and IDEAL and compare these models with the selected SPI models and find out the missing activities (Phase 3). After selecting the right SPI model and address the missing activities in these models, we modify the selected software process model to achieve the selected SPI model (Phase 4). After modification of the selected model, we need to determine requirements of the new models, to address requirements of the new model we put administrative questionnaires to check whether the newly modified model fulfills the user requirements in the SME or not. (Phase 5) After receiving feedback from this questionnaire we made changes according to the user requirements and modified the model according to these requirements and chose the final SPI model. (Phase 6) It should be the final new proposed model. The flowchart of the proposed model is shown in Fig. 4.

VI. CONCLUSION

Small and medium size organizations are expected to utilize and benefit from our proposed model. It is a totally independent system which does not need the support of any other mode in the operations. Moreover, the proposed model is using the Big Data concept by using the data from different data sources for the business process improvement and other

business activities. The software process improvement deployment approaches require special concerns due to some constraints regarding material and human resources in the small and medium size enterprises. The adoption among small organizations is hard due to some size mismatches and to lack of experienced process engineers, which force organization to hire external consultants. Small and medium enterprises need to have suitable software process models that can achieve all the activities of a selected SPI traditional model. Our aim to address all these problems in our proposed model which compares the software process models and the characteristics of small software organizations and then developed the new model on the based on these requirements. Since the propose model is using the data from different data sources rather than using only the internal data for software process improvements and other business activities in the organization, therefore the proposed model would be more efficient than all other models and would be ideal for SMEs.
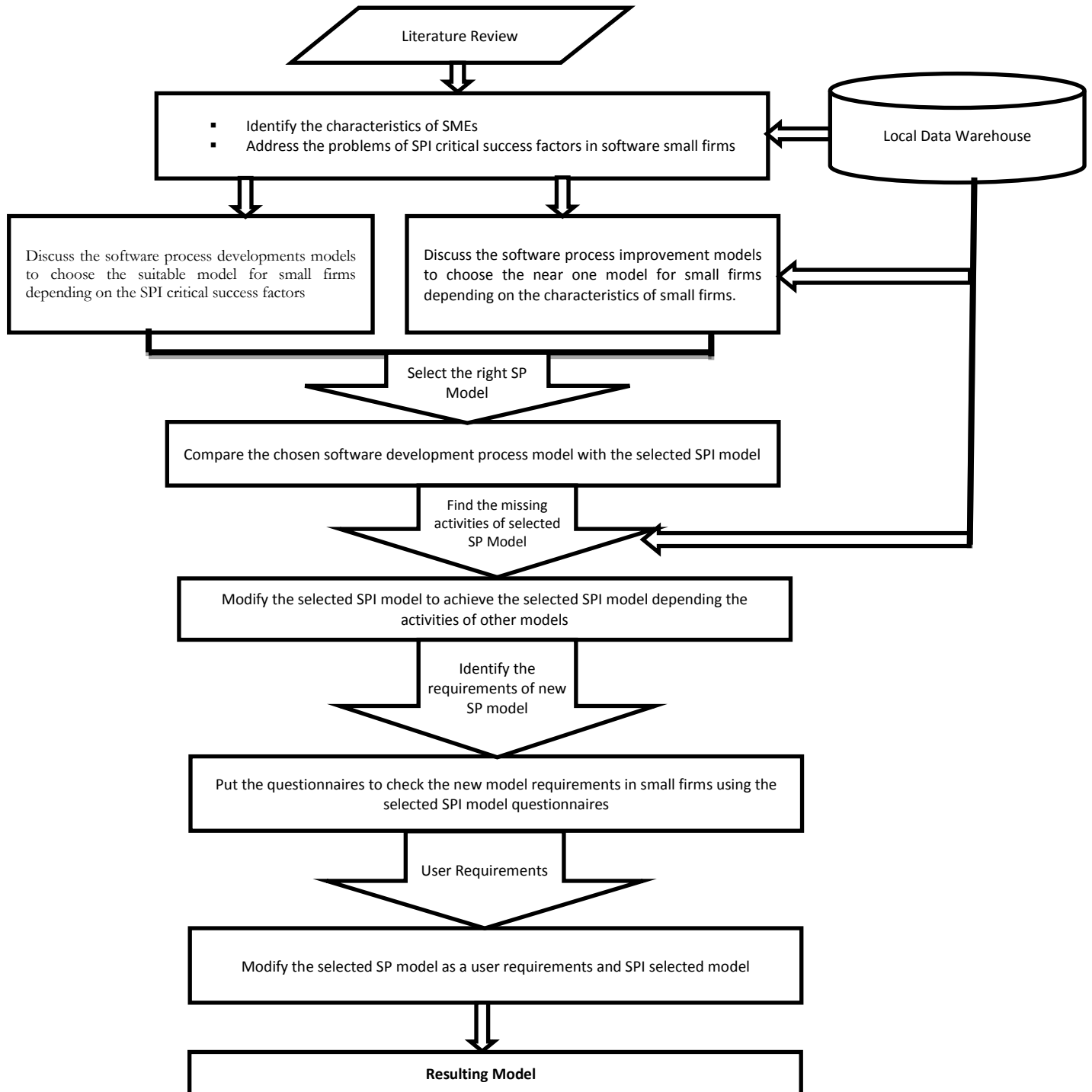

Fig. 4. Development steps of SPI model for SMEs

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