

# TACIT KNOWLEDGE FOR BUSINESS INTELLIGENCE FRAMEWORK: A PART OF UNSTRUCTURED DATA?

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## ABSTRACT

Idea to capture knowledge from different sources can be very beneficial to Business Intelligence (BI). Organizations need to collect data sources from type of structured and unstructured, including individuals' tacit knowledge in order to have the better output in data analysis. Therefore, the complexity of BI processes need to be explored in order to ensure the process will properly treat the tacit knowledge as a part of the data source in BI framework. Moreover, the linkage between unstructured data and tacit knowledge is generally consistent, for the reason that one of tacit knowledge characteristic is unstructured, which is difficult to capture, codify, estimate, investigate, formalize, write down, and communicate accurately. Cognitive approach is ideally suited for the capturing tacit knowledge as from among the massive data available these days. Typically, the organization must integrate multiple streams of data from several sources or other collaboration resources with the knowledge systems for making the decisions. This paper explores the possibility of tacit knowledge used in BI framework to perform data analysis for decision makers.

**Keywords:** *Business Intelligence, Cognitive Approach, Data Analytics, Tacit Knowledge, Unstructured Data*

## 1. INTRODUCTION

Raw data or information retains within the organization in the form of explicit, implicit and tacit knowledge with limited resources [1]. Several researches have been conducted in Business intelligence (BI) and Knowledge Management (KM) domain to solve the problem by using tacit knowledge for data analysis. Yet, the new information, knowledge, and un-structured data are used to improve the decision making. The raw data and information need to be processed to acquire knowledge through the use of the analytical approach, which is normally the analyst will use the descriptive or predictive analysis approach to produce results for making a decision.

The idea of taking knowledge from different sources can be very beneficial to BI, especially for tacit knowledge. The identifying content or “data” from authors or experts in the form of tacit and “know-how” knowledge is important to be used for data analysis. Currently, the use of BI applications for managing and analyzing the explicit knowledge is the major portion of the enterprise software of BI

for data analytics [2]. Therefore, the requirement of BI application that can support for managing the tacit knowledge is crucially important. This paper will start with a discussion on how the tacit knowledge can be part of unstructured data and later can be used for data analysis in BI framework.

Even though several models and frameworks have been proposed by many researchers, but the limited framework for BI system still needs to be explored. Additionally, the traditional method of BI framework can be enhanced by using the cognitive approach to handle the capturing of tacit knowledge sources. Tacit knowledge needs to be converted to either structured or unstructured data to being codified in the BI system. The proposed model for managing tacit knowledge is developed by using KID model and cognitive approach to capture and extract tacit knowledge, and develop a new data centric model that works with traditional structured data as well as unstructured data including video, image, and digital signal processing.

**2. LITERATURE REVIEW**

**2.1 Managing the Knowledge**

The complexities of knowledge have been growing drastically. The amount of data stored by the individuals and the organizations is growing exponentially with an added overload and complexity. The various formats of data are increasing the intricacy of searching and extracting the useful information from the knowledge management systems. As the technology grows, there is no Knowledge Management System (KMS) which integrates the evolving capacity of KM, while providing for a single storage. Hence, to design a more efficient KMS, it is mandatory to exploit the characteristics of the traditional systems and make it more flexible. These new KMS must support the next generation technologies, with heaps of data to analyze and assess [3].

**2.2 Tacit Knowledge versus Explicit Knowledge**

It is easier to document and share explicit knowledge. Moreover, the type of explicit knowledge is easier to replicate. Explicit knowledge can be obtained from sources such as a book, various types of documents, white papers, and in other cases, policy manuals among other forms. On the other hand, tacit knowledge is related to the knowledge that resides in the head of a person and not organized. However, this type of knowledge gets noticed whenever a person is faced with a particular situation or problem. This knowledge is personal in nature and its formulation is not easy.

**2.3 Cognitive Approach**

Usually, BI analytics use to manipulate the raw data, rather than supporting managers' decision making from the cognitive perspective [4]. BI with cognitive approach will reduce the needs of human factors as an analyst to analyze the various data format, especially for managing the tacit knowledge. Indeed, the new technique in cognitive approach is ideally suited for capturing the knowledge from among the massive data available these days. We argue, processing the tacit knowledge data for data analysis is a big challenge in BI framework. Therefore, a new framework for BI with cognitive approach need to be developed.

**2.4 Tacit Knowledge Capturing Techniques**

Techniques for capturing tacit knowledge are aimed to acquiring knowledge within a particular organization. Currently, several capturing techniques for tacit knowledge has been released after decades as shown in the *Table 1*. The nature of

tacit knowledge as one that is difficult to capture requires robust measures and approaches in capturing it.

*Table 1: Summary of techniques for capturing and converting tacit knowledge [5].*

Technique	Techniques	Explicit Output
Observation	1. Observing 2. Recording 3. Interpreting	Records
Brainstorming	1. Presenting the problem 2. Generating ideas from experts 3. Evaluating ideas	Ideas, likes and dislikes as text streams
Protocol Analysis	1. Verbalizing problem solution 2. Collecting and analyzing protocols 3. Structuring of eliciting information	Protocol to solve a problem
Consensus Decision Making	1. Present the problem 2. Generating ideas 3. Voting on the alternate solutions	Consensus about solutions
Repertory Grid	1. Conceptualizing problem using a model 2. Using a grid to facilitate capture and evaluation of models	A grid of entities and attributes filled with values
Nominal Group Technique	1. Given a problem and the alternate solutions 2. A list of pros and cons are compiled 3. Ranking Pros and Cons 4. Choose the "best" solution from the alternatives	The end result is a written report
Delphi	1. Sending the questionnaire for experts 2. Providing next questionnaire with regard to	Solving a specific problem

	repeated responses	
Concept Map	<ol style="list-style-type: none"> <li>Idea generation</li> <li>Statement structuring</li> <li>Representation</li> <li>Interpretation</li> <li>Utilization</li> </ol>	<ol style="list-style-type: none"> <li>Designed complex structures</li> <li>Generated ideas</li> <li>Communicate ideas</li> <li>Diagnosed misunderstanding</li> </ol>
Blackboarding	<ol style="list-style-type: none"> <li>Present the problem on the blackboard</li> <li>Contribute to solving the problem</li> <li>Continue until the solution reached</li> </ol>	Solution for a specific problem
Kinematic Analysis	<ol style="list-style-type: none"> <li>Recording process of motion</li> <li>Analyze the relative motion of the appendages and joints</li> </ol>	Physical actions concerned with decision making
Cognitive Map (CM)	<ol style="list-style-type: none"> <li>Formalisation</li> <li>Storing tacit knowledge in the case base</li> <li>Reuse of tacit</li> </ol>	Cases
Formal Interview	Asking questions in an iterative fashion, in at least two different interviews	Recorded idea

One of the proposed techniques [6] is the use of interviewing experts to capture tacit knowledge. This includes structured interviewing, open-ended questions, closed questions, relative listening, and stories. Structured interviewing is focused on the people and this technique useful in facilitating the interview and helping participants in sharing their knowledge in a more efficient and comfortable manner. This mode of capturing tacit knowledge renders tacit knowledge to a rather explicit type of knowledge.

In the case of open ended questions, a broad level of coverage is offered and there are few constraints. Here, free response answers are encouraged and the nature of the questions ensures that the interviewees can touch on different perspectives of the questions, which makes more knowledge available since there are no constraints to answer specific questions.

Moreover, the interviewee is given an opportunity of including knowledge that is widely related to the questions [7].

In contrast, closed questions are more limited in terms of the type, levels, and amount of information that can be given by interviewees. The aim of having this kind of knowledge capturing approach is to ensure that the organization gets specific details about a certain topic that the interviewee has expertise in.

### 3. SIGNIFICANCE OF STUDY

Organizations need to improve their data source from such structured and unstructured, including the individuals' tacit knowledge in order to have the better output in analytics. BI involves the gathering and processing required knowledge in the appropriate analytic method and delivering the results for decision making. Many researches have been conducted to solve the analytical problem in order to handle explicit and tacit knowledge to analyze according to the fact that current BI is only handle explicit knowledge as a structured data to analyze [8].

Unstructured data can be very challenging to document and govern. Most organizations focus on the quantity of knowledge captured rather than quality results with the manual capturing process. Manual capturing of the knowledge will need more effort for the analysts analyze the unstructured data. Likewise, the knowledge on unstructured sources can be very difficult to capture since the data in them are fuzzy [9].

Data collection could be empowered by step-by-step in close communication with users. The success depends on feasibility of data collection in daily practice and validity of outcome [10]. It can be solved by using the cognitive approach, since the cognitive system is designed to build a dialog between human and machine so that the best practices are learned by the system as opposed to the traditional method that being programmed as a set of rules [11]. Cognitive approach also suitable for the more-than-one hypotheses to be analyzed as it is a kind of decision support [11], [12].

On the other hand, cognitive has the capability to learn, remember, provoke, analyze, and resolve in a manner that is contextually relevant to the organization or to the individual user [11]. Cognitive approach will be able to gained the skills by practice and experience, where it is impossible to directly transfer the knowledge to other individuals by telling them how to do it [13].

### 3.1 Extract, Transform, and Load (ETL)

Currently, BI uses the Extract, Transform and Load (ETL) functions to integrate, transform, and store data in a Data Warehouse (DW) to analyze. Usually, uncaptured data will cause the problem in ETL process due to uncertainty of data structure [27]. It makes the data seem poor in the form of unclean data. This condition requires more effort from analyst to analyze the results to be reported to the decision maker. Moreover, BI analytics usually use the data manipulation techniques, rather than supporting managers' decision making from the cognitive perspective [14].

The cognitive model of the human memory system has been described with two basic components, which are: one (working memory) for current information processing, and another (long-term memory) for storing all the information acquired in the past, which might need again in the future [15]. It related to the structured, semi-structured, and unstructured data during the term of data analytics, where the data input comes from perception, make the unstructured data to be structured for long-term use, and the output may have a cognitive business as a new behavior. The cognitive business is the use of structured and unstructured data, which has the highly sophisticated analytical techniques to identify, evaluate, and recommend business courses of actions [16]. Furthermore, the problem with tacit knowledge as an unstructured data to be processed in ETL can be solved using the cognitive approach, and this need further study how it works in BI framework.

### 3.2 Cognitive Approach in Business Intelligence

The organization still needs the expert's knowledge in order to analyze the predicted outcomes from the analytical tool in BI. It also needs more effort from analysts to analyze the possible outcomes from un-structured and un-captured data or information. This condition caused by the lack of data capturing in the form of tacit knowledge and un-structured data in current BI tools. Hence, this research will explore the method to capture tacit knowledge to be used for data analytics in BI, to use a cognitive approach for managing tacit knowledge in BI framework, and to ensure that the cognitive-based BI framework can improve the accuracy of analytics results.

### 3.3 Business Intelligence Framework

BI analytics use the data manipulation techniques, rather than supporting managers' decision making from the cognitive perspective

[17]. Moreover, the managers' cognitive knowledge plays the important role in decision making. Basically, BI framework has 5 layers, which are data sources, integration services, data management services, analytical and reporting services as shown in *Figure 1*.

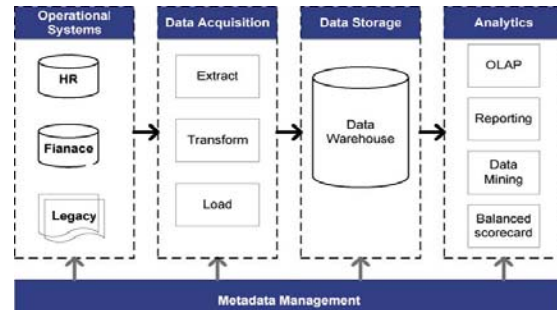


Figure 1 Current Business Intelligence Framework [17]

Several organizations, have implemented an optimum solution of BI in the term of knowledge acquisition, yet they ignore the important role of cognitive approach in the scope of gathering the data to perform the data analysis. The idea behind data capturing is to utilize the valuable knowledge resources and analyze it for further improves the analytical results. Thus, better data sources before perform the ETL processes can improve the data analysis result and has the potential to strengthen the efficacy and competitiveness of the business sectors. Yet, the importance of cognitive systems cannot be denied as this domain be a new role in achieving the efficiency of BI systems in the era of "Big Data".

### 3.4 Practical Implications

This research will aid the enhancement of BI framework with the cognitive approach for supporting the development of BI system for decision making. The BI framework would be benefitted to the users from the applied theories of the cognitive approach in human knowledge and using the current technology of cognitive tools. Thus, it will increase the BI system efficiency by performing a better data preprocessing and data analysis. The proposed model in *Figure 7* will guide the organizations to use their knowledge sources to scrutinize and analyze the tacit knowledge toward the unstructured and structured data, for further analysing process. The data analysis would help organizations have the right information at the right time for decision making. Thus, the enhancement of BI framework with cognitive approach would increase the capabilities

of an organization to make decisions based on tacit knowledge.

### 3.5 Limitation and Purpose

BI framework usually uses data manipulation techniques, rather than supporting data analysis from the cognitive perspective, although the users play the important cognitive role in performing the decision making [3]. The study is limited to the use of cognitive-based either for knowledge capturing techniques and analyzing the data. The main reason is because cognitive technology has the capability to learn, remember, provoke, analyze, and resolve in a manner that is contextually relevant to the organization or to the individual user [10].

Cognitive-based approach will be able to gained the skills by practice and experience, where it is impossible to directly transfer the knowledge to other individuals by telling them how to do it [10]. The purpose is to improve BI performance, because currently, most BI uses structured data to perform their integration process using ETL, and then store the final data into the data warehouse to be analyzed. On the other hand, un-captured data usually are a problem in ETL process due to uncertainty of data structure, and making data seems poor and un-complete. This requires some more effort from analysts to analyze the data to report to the decision maker [15].

## 4. METHODOLOGY

This research will adapt the hybrid methodology of qualitative and quantitative approach due to handling experiment with the human knowledge. This research has investigated the limitations of BI framework in capturing various data types to identify the problem in handling the tacit knowledge for data analysis. This has built the gap in this research and worth it to explore the solution for this problem. Several studies have been conducted in the field of BI and KM, but lacking of research work which has explored the solution for tackling tacit knowledge of data analysis in the BI system. Therefore, we argue must be a study to propose a method to handle the tacit knowledge and later can be used for data analysis in BI framework. The traditional method of BI framework will be enhanced by using the cognitive approach to handle the tacit knowledge of BI framework for data analysis.

### 4.1 Cognitive Approach

Authors [15] and [18] has clearly mentioned that the future of research in BI analytics research would be required to properly handle the structured

and unstructured data for analysis. The unstructured data are referred to human knowledge, which was important to be used for better data analysis. However, to simulate how a human brain works and processes the information is a real challenge that lies ahead. As [15] described the people observe or sense an object which is represented in the data; perceived as information once the data can be interpreted by memory retrieval and existing knowledge; then the information is applied to update the memory and enhance the knowledge, which may lead to the possible discovery of new knowledge. This phenomenon can be illustrated in cognitive models of human memory system as shown in *Figure 2*.

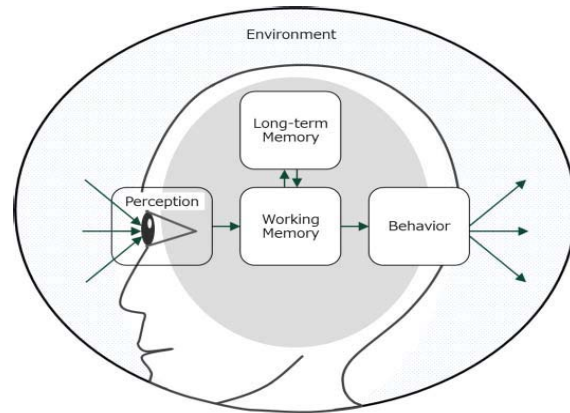


Figure 2 A Cognitive Model of the Human Memory System [15]

Human as individual construct their own knowledge during the course of interaction with the environment, and each interaction enriches a human's knowledge through the data-information-knowledge transformation process, as shown in *Figure 2*. [15] has stated that implies for the relations of data, information, knowledge and wisdom still lacks explicit and pragmatic approaches. Yet, tacit knowledge contains wisdom, where wisdom is solely owned by humans.

The model as shown in *Figure 2* stated that knowledge as the basic unit of wisdom, where wisdom is in state of probabilistic. As long as knowledge is probabilistic, it will always be influenced by human and social factors [19]. Here, the cognitive approach is suitable for the "more than one" hypotheses to be analyzed. Thus, as it is a kind of decision support that allows people to explain new opportunities, which has an impact in a positive manner [11], [12].

## 4.2 Cognitive Analytics

The best stream processing systems have been built with a data centric model that works with traditional structured data as well as unstructured data including video, image, and digital signal processing. This system has performed cognitive analytics as an advanced approach to capture and extract tacit knowledge as shown in *Figure 3* [20].

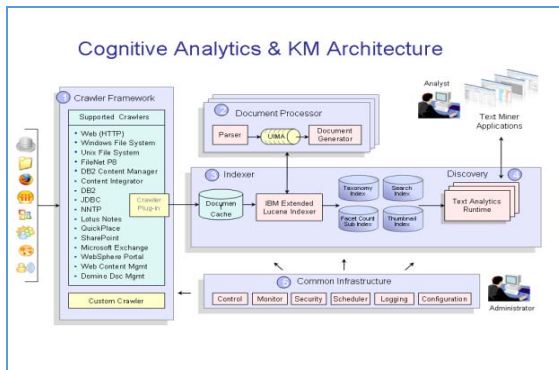


Figure 3 Cognitive Analytics Framework [20]

Even though several models and frameworks have been proposed by the researchers, but no framework for BI system, and thus need to be explored. Additionally, it is very much essential to consider the user's perspective (which in this case is a small size to large size organizations) before proposing a new framework or a business model. Therefore, based on the available literature review, the initial framework of data capturing of BI will be proposed to enhance the efficacy of business process and strategies.

## 4.3 Cognitive Mapping

Cognitive mapping technique and methodology focused on a set of way to capture, retrieve, and storing the expert knowledge in support of the design and development of intelligent information systems. Organizations as knowledge systems consist of four sets of socially enacted "knowledge processes" as follows [21]:

### 1. Knowledge application

Information technology can enhance knowledge application by facilitating capture, updating and accessibility of organizational directives.

### 2. Knowledge storage/retrieval

Knowledge residing in various component forms, including written documentation, structured information stored in electronic databases, codified human knowledge stored in expert systems, and tacit knowledge acquired by individuals.

## 3. Knowledge transfer

This can occur at various levels: transfer of knowledge between individuals, from individuals to explicit sources, from individuals to groups, between groups, across groups, and from groups to the organization.

## 4. Knowledge creation

Through social and collaborative processes as well as through the cognitive processes of the individual, knowledge is created, shared, amplified, enlarged and justified in organizational settings.

## 4.4 Approaches Evaluation

This research will assess the capturing process of the tacit knowledge since it is a part of situation awareness of what is going on around in the organization, and what the decision maker can be referred to as his/her understanding of the company situation (e.g., the internal and external environment, the past events, and the current state). The current famous current capturing process of tacit knowledge is by sensors and streaming process.

Cognitive maps are known such as graphical views or graphic representations that locate people to their information environments. In the other word, cognitive map is a visual aid in comprehending the mappers' understanding of particular, and selective, elements of the thoughts rather than thinking of an individual, group or organization. Cognitive maps are used as a set of techniques to identify subjective beliefs and to portray those beliefs externally as [21]:

### 1. Causal mapping

Used to investigate the cognition of decision-makers. A causal map represents a set of causal relationships (i.e., cause and effect relationships) among constructs within a system which shows that better sanitation facilities, causing an initial improvement in health, led to an increase in the city's population.

### 2. Semantic mapping

Known as idea mapping. Used to explore an idea without the constraints of a superimposed structure. A semantic map visually organizes related concepts around a main concept with tree-like branches, for example, is shown different types of transportation, organized in three categories: land, water, and air.

### 3. Concept mapping

A useful tool for organizing and representing concepts (events or objects) and their interrelationships in a particular domain. Each concept is designated by a label. The

relationship between two concepts in a concept map is referred to as a proposition; propositions connect concepts to form a meaningful statement. Relationships between concepts are associative, for example is there are two concepts of "plants" and "flowers" which associated via "may have" that form the proposition of "plants may have flowers". Describing complex structures with simple propositions improve quality of conceptual modeling in the development of information systems.

5. PROPOSED BI FRAMEWORK

The key of BI is to capture, analyze, and share such knowledge. The process of capturing knowledge with the cognitive approach might be useful in order to improve the predictive and prescriptive results BI framework. [15] and [19] shows the generated KID generated model that consists of three elements, which are: D, I, and K, and also Knowledge repository, named K-store as shown in Figure 4 and Figure 5. The capital D refers to data which represent the observable properties of objects in the external world. The capital I represent the information, as the result of data which being interpreted by existing knowledge which is referred to what human have said.

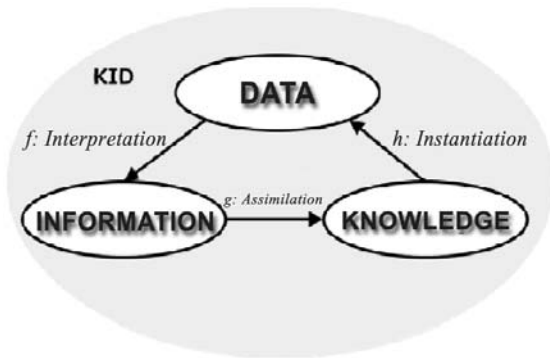


Figure 4 A Generic K-I-D Model [19]

The capital K refers to knowledge which is formed by assimilating the information into existing knowledge or derived from updating knowledge. D, I, and K are interrelated. Their interrelationships are defined by the three transformation functions. The KID model is a cognitive model, since data are is a cognitive process from data to knowledge. It adopts the results of psychologists' investigations, simulates human information processing and built based on our argument that any cognitive model can be built

with three transformation process from data to knowledge.

The implication for the relations of data, information, knowledge and wisdom still lacks explicit and pragmatic approaches [15]. Yet, tacit knowledge contains wisdom, where wisdom is solely owned by humans. From the model as shown as Figure 4 above, authors [15] and [19] stated that knowledge as the basic unit of wisdom, where wisdom is also probabilistic [22]. The cognitive approach is suitable for the "more than one" hypotheses to be analyzed. Moreover, as it is a kind of decision support that allows people to explain new opportunities, which has an impact in a positive manner [11], [23]. The key to BI is to capture, analyze, and share such knowledge. Thus, the process of capturing knowledge with the cognitive approach might be useful in order to improve the predictive and prescriptive results in BI applications.

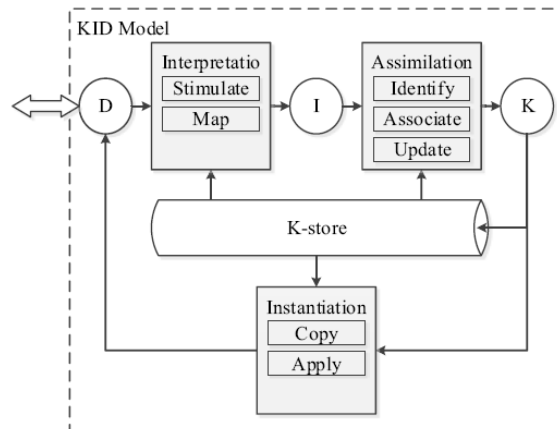


Figure 5 KID Model [15]

The generated KID model consists of three elements, which are: D, I, and K, and also a knowledge repository, named K-store as shown in Figure 5 [15]. The generated model provides three abstract functions, which are: *interpretation()*, *assimilation()*, and *instantiation()*, as described in the Figure 4. D refers to the data which are symbols that represent observable properties of objects in the external world. I refer to information which is the result of data being interpreted by existing knowledge, that is to say. K refers to knowledge which is formed by assimilating information into existing knowledge or derived from updating knowledge.

Typically, the decision maker must integrate multiple streams of data form information or other collaboration with the knowledge for making decisions [24]. The decisions may be based in

organizational politics or routines and decision makers may limit themselves to a few choices because of "bounded rationality" [25]. Author [20] has invented the use of cognitive as an advanced approach to capture and extract tacit knowledge by elaborating the predictive analytics, stochastic analytics, and cognitive computing. It was observed that although the importance of uncaptured data sources are aware by many researchers and organizations, there is a lack of models or tools that offers tacit knowledge capturing techniques by using a cognitive approach because the pros of one approach could be compensated by the cons of another approach. However, there is a huge research gap that calls for defining the new framework for integrating the KM into the BI approach, especially for managing the tacit knowledge as a data source to be used in BI analytics. Based on these literatures, this research proposes a new BI framework that supports the management of tacit knowledge as shown in *Figure 6*.

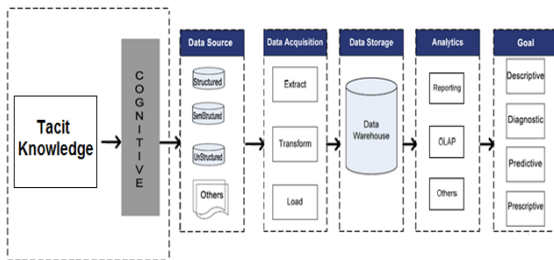


Figure 6 Proposed BI Framework: Data Management Using Cognitive Approach

Cognitive approach is ideally suited for the capturing knowledge as from among the massive data available these days. The decision maker typically must integrate multiple streams of information resources or other collaboration with the knowledge systems for making decisions [24]. Furthermore, decisions may be based on organizational politics or routines [26], and decision makers may limit themselves to a few choices because of "bounded rationality". The use of cognitive as an advanced approach to capture and extract tacit knowledge by elaborating the predictive analytics, stochastic analytics, and cognitive computing [20]. Thus, the new basic BI architecture can be drawn as shown in *Figure 6*.

In this phase, the importance of tacit knowledge in organizations will be captured and analyzed by using the appropriate methods. The tacit knowledge needs to be converted either to the unstructured or structured data to be processed using ETL in BI system. The proposed model for managing the

knowledge will be developed by using and modifying the KID model and cognitive approach to capture and extract tacit knowledge as shown in *Figure 7*.

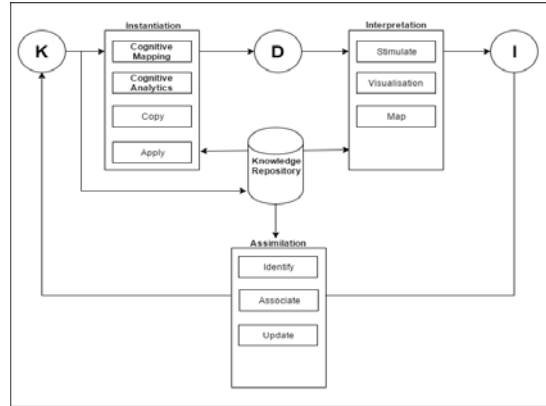


Figure 7 Proposed Model for Managing the Tacit Knowledge

## 6. CONCLUSION & FUTURE RESEARCH

The current trends for capturing process of tacit knowledge is by using sensors and streaming process. The best current processing systems have been built with a data centric model that works with traditional structured data as well as unstructured data, including digital signal processing, video, image, and cognitive analytics as an advanced approach to capture and extract tacit knowledge [20]. Furthermore, the use of generic method of KID model based on a cognitive approach [15] will be used to accumulate experience and gain knowledge by continually perceiving data, interpreting data into meaningful information, absorbing incoming information, and updating knowledge.

This paper has highlighted the importance of tacit knowledge in data analytic that perform in the BI system. Since managing the tacit knowledge required particular approach such as cognitive human minds, this is ideally suited for capturing the knowledge from among the massive available data these days, especially from the human mind. The use of BI systems for knowledge capturing is a major portion of the enterprise software technology that consists of intelligence of data analytics for explicit knowledge. However, the data from people or experts in the form of tacit and "know-how" knowledge is important for data analysis to produce better results. Therefore, this paper has proposed the new BI framework for supporting the managing of tacit knowledge base on cognitive-based approach such as cognitive analytic, cognitive map, and KID model. Further research will explore how



the propose model can be implemented and improve the results of data analysis in the BI system. The study of cognitive-based is used for knowledge capturing techniques so that the tacit knowledge can be converted either as unstructured or structured data to be analyzed in BI framework using ETL processes. As stated in the limited section that the main reason is because cognitive technologies have the capability to learn, remember, provoke, analyze, and resolve in a systematic manner that is contextually relevant to the organization or to the individual user [10]. Furthermore, the BI framework usually uses data manipulation techniques, rather than supporting data analysis from the cognitive perspective, although the users play the important cognitive role in performing the decision making [3].

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