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Learning Integrity Based Approach For Smart Business Systems' Cognition

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***Abstract*—The purpose of this paper is to show that how the information systems have moved from data integrity to information integrity to learning integrity and integrity of learned information. Since the smart systems are smart by virtue of being able to learn from the environment. In case decision making has to be done by the smart systems it is extremely important to evaluate the integrity (accuracy, consistency and reliability) of the process of learning by the smart systems i.e learning integrity and subsequently to evaluate the integrity of learned information,**

The approach adopted here is conceptual in nature and literature review of the relevant papers is also presented.

The paper proposes the concept of learning integrity and integrity of learned information. Also a framework for evaluating the two has been recommended. This framework will help to improve the cognition of smart systems.

The implications of this research is that it proposes to strengthen the decision making of smart systems in terms of improved accuracy, consistency and reliability.

It will have practical implications in terms of improved decision making by artificially intelligent businesses.

The society will undergo a change in terms of people and their lives and life styles as the new age smart systems become more accurate, reliable and consistent.

Key words: Data Integrity, Information Integrity, Smartdata Management Systems, Teaching Learning interplay, Improved Cognition

1.0 About Smart Systems

In a complex and changing environment Information Systems are described as an entity which continuously process information in a 'controlled' environment. Here controlled implied situation which entails continuous input, process and output of data with a view to achieve an objective, has an internal environment, external environment and works on an internal feedback loop [27] [12]

Data underlying such an information system is both normative and factual also should be processed on a continuous basis. This implies the data and hence these Information System should address open systems. This brings forth the question of what characterizes open and closed systems and how are they differentiated from smart systems.

Smart systems by definition are systems with special capabilities for sensing and control so that it is able to define and evaluate a state, and make choices based on the accessible data in a prognostic(predictive) or adaptive manner, thereby performing smart actions. In most cases the "smartness" of the system can be credited to independent operation based on control, energy efficacy, and networking proficiencies [1]. Thus it is apparent that these smart systems are actually based on data which is being continuously accessed from the environment, they also have a decision making ability under diverse situations.

Open systems on the other hand are defined as the one in which boundaries permit interaction with their environment. An example is a cell within the human body. The cell membrane quite clearly defines the boundaries of the cell, but it also enables nutrients and information (impulses from the nervous system) to enter and waste and information (impulses to the nervous system) to exit. As open systems at a micro level (cells) are enveloped in a more macro system (human body), they are referred to as nested open systems. A closed system does not export or import information, or material [22]

Thus comparing the two definitions above, it emerges that smart systems are essentially systems which are open in nature (as they exercise control similar to open systems) and have an additional ability to analyze for predictive and analytical choices in decision making which accounts for the cognitive capabilities of a smart systems.

2.0 Practices in Smart Systems and 5 C's

As described above all smart systems are driven by data which is collated from environment. Within the context outlined above, there is yet another issue - in addition to the uncertainty and judgmental factors at smart system-human interface [13] concerning the smart system design methodologies that start from user needs (requirements identification) to giving finished information systems and information there from for use by way of delivery of improved decision-making. Specifically, it makes data repositories deal with evaluative information items that are not only function of "source" (information in this form is normally termed 'data set') and at the most of "process" (which includes medium of communication) but also of "recipient", i.e., user with the objective of improved decision-making. This again introduces new types of data inconsistencies and errors in the data sets. Because the data set does not only have the data being entered and stored, it has also to account for information origination and evaluation and for the errors arising out of the data origination and evaluation, processing it through channels (medium) for entering it into the data set, and (for the errors arising) out of incorrect use of information [11][20]. The above discussion gives rise to the age old concern of data integrity for which many tools are being used to clean the data set like data scrubbing, extraction transformation and loading tools etc. [2],[4],[10] [38]

In fact, with increasing use of computing and communication technology in smart systems and with incessant use of computerized information systems for global operations, system environmental factors of Complexity, Change, Communication, Conversion and Corruption (5 Cs) [7] [22] have started impacting the smart systems and datasets, thereby introducing further data inconsistencies and information errors [27]. These system environmental factors are outside the logical environment of the traditional database design view and, hence, errors (as a result of them) are not amenable to control by data integrity mechanisms controls normally considered at the data design stage [34].

2.1 Complexity

Complexity factor signifies existence of many interdependent variables in a system. More is the interdependence of variables greater the system's complexity [8]. A system of variables is "interrelated" if an action that affects or is meant to affect one part of the system also affects other parts of it. This is because links between variables require attending to a great many features simultaneously, and that too concomitantly, which makes it impossible to address only one action in a complex system. This in turn leads to data errors not encountered in simple, non-integrated systems.

Great complexity places high demand on the information system's capacity to gather (i.e., originate or produce and evaluate) and store information, integrate findings, and process information, which is trustworthy or dependable for use (say, that in the form of improved decision- making). At a detailed level, these system's issues contributing to complexity can be identified in terms of: number of components (every new component, be it hard or soft, adds new interface in the system of business enterprise, and therefore new variables in the system and increases complexity), number of interfaces, number of types, volume, speed, frequency, span of time, number of steps, signal to noise (S/ N) ratio, standard deviation / number of branches (number and level of decisions), degree of interconnection, integration and interdependence, distance, momentum, velocity, quantitative vs. qualitative, subjective vs. objective, differences in way of handling information, etc. [14]

2.2 Change

A change could be in content or context. It might have been caused due to a number of factors, and, therefore, have multitude of origins and descriptions. For example software change, hardware change, organizational change, design changes, process change, regulatory changes, people, supplier, consumer, technology changes, economic change, societal change, time changes (decay), discrete change, continuous change, general change, conceptual change, operational change etc.

All business enterprises show dynamic behavior. That is, as time passes, the state variables by which one measures their condition (such as sales, profits, stocks, balance of payment and many others), fluctuate noticeably, sometime alarmingly as when cash reserves fall (and occasionally, of course, gratifyingly such as when profits rise). These fluctuations are because of input variations, which are contributed by pressures generated from within the enterprise, in turn leading to errors in data and information and hence in data sets [28].

2.3 Communication

Communication factor where "communication" stands for movement (transfer) of data/information across space and time. At a detailed level, Communication factor operating within and across enterprise is influenced by requirements of: languages, distance, protocols, transmission, receipt, signal to noise ratio, verifiability, medium, confirmation, asynchronous and synchronous communication, acknowledgement, etc. And it is this Communication factor that also provides a chance for error introduction in smart systems leading to inaccurate, inconsistent and unreliable information [28].

2.4 Conversion

Conversion factor, refers to the consolidation, decomposition or transformation of data. At a more detailed level, 'Conversion' can be seen to be influenced by requirements of: transformation, consolidation, decomposition, planning, format conversion, medium conversion, merging, splitting, translation, etc.

Whenever one converts data from one form to another, there exists a possibility of error introduction, resulting in information, which may be inaccurate. To explain, conversion covers the "processing" stage of smart systems. This stage transforming "data" into

"usable information" comprises machine operation, use of data files, use of systems and application programs and of processing operation itself. While machine operation suffers from errors caused due to incorrect and/or fraudulent operations, processing not on time, machine breakdown, etc.; in respect of data files errors caused are due to poor physical storage, lack of clearly defined responsibilities for data files, inadequate procedures, natural disasters and theft, fraud or sabotage, Against this, during the use of systems and applications software, errors caused are due to out of sequence programming, wrong algorithms, wrong programming instructions, poor documentation, lax security; resulting in incorrect solutions and unauthorized changes. And coming to the processing stage itself, perhaps the most significant cause for errors is carelessness in data processing; resulting in records lost and use of incorrect file. Finally, the "processing" stage through all these operations would also have human-smart system interfaces at various levels and they would contribute to errors in business information environment. [26].

2.5 Corruption

The 'Corruption' factor relates to human behavior (poor motivation, desire for personal gain, carelessness, actions of people) and to unpredictability (noise) of any kind leading to introduction of errors in the business information environment. At a more practical level, 'Corruption' factor can be viewed as resulting from accidental, erroneous, or malicious alteration, loss, or duplication of information. A comprehensive description of the 'Corruption' factor could be based on concepts of: accidentally, deliberateness, failure, alteration, loss, defects, context, data entry, duplication, etc.

All these aspects as contributed by 5Cs, then, lead to errors in business information environment corrupting it with noise, as a result of which the smart systems inherit errors as it processes data and information that are inaccurate, imprecise and unreliable.

Thus there is clearly a need for a data set, which offers normative and factual information with integrity, i.e., information, which is not distorted and noisy, i.e., information with accuracy, consistency and reliability alternately called as information with integrity. Thus on top of data integrity another level of integrity emerged which is referred to as Information Integrity [21]

Cognitive capabilities of smart systems [3] may alternatively be referred to as smart systems based on learning integrity, which is explained below

3.0 Learning Integrity based Smart Systems - Cognitively Capable Systems

When modeled as function of "source", "process" and "recipient" with the objectives of improved decision making for greater system effectiveness and economy, information acquires normative (evaluative) and factual components – a shift from information item requirement of mere factuality as in an existing database. Both these information items are critical to useful decision-making and impart requirement that information originated, evaluated, stored and retrieved for improved decision-making is sufficiently perfect (non-distorted) and full (complete) [17]

In smart system the capability to self-learn in wake of evolving data set and being able to take decisions with integrity (implying accuracy, consistency and reliability over a period of time) [29] is then defined as a function of inverse amount of distortion (imperfectness, i.e., loss of goal, direction, objective, or value) and noise (incompleteness) present 16]

Learning Integrity is thus concerned with the correctness and exactness of the information. It is dependability and trustworthiness of information and controlling it is a key factor for determining strategic business advantage by way of delivering improved design decision. Its attributes are accuracy, consistency and reliability of smart system and information there from [23], which encompass the data integrity and information integrity aspects as outlined above.

External as well as internal user aspirations – described through their respective environments - are becoming increasingly local and instant, requiring recognition of importance of environment as a major factor in decision making under complex and changing environment, [15]. This then calls for information origination and evaluation processes hitherto not considered. These processes (or rather absence of them) and uncertainties therein are contributing to ever-increasing need of Learning Integrity and its assurance.

4.0 Issues in Creating Dataset for Improved Decision Making in Learning Integrity based Smart Systems

Dataset must take into account the changes enterprises are going through as discussed above There is clearly a need for the databases to be open and adaptable to the changing needs of the organizations [18], [17].

The possibilities of data inconsistencies as a result of uncertainties on account of openness identified, bring in the issue of lack of integrity in the decision making of the smart systems, thus to improve in the cognitive capabilities of the smart systems it is imperative that lack of Learning Integrity is identified and improved in automated systems. [11]. The possible sources of introducing lack of Integrity are:

1. Data Origin Stage: Erroneous data origination and collection methodologies [15]

2. Communication Channel (Pre- and Post-processing stage): Communication noise introducing inconsistency in the data transmitted.

3. Processing Stage:

a. Data errors at this stage could be arising out of:

- Wrong programming instructions

- Erroneous software environment: The errors in the software environment could be arising out of errors in the operating system, database system, middle layer, front end etc.
- Lack of security authentication mechanism
- Usage of incorrect files in data processing
- Lack of documentation
- Natural disaster, theft etc.

4. Output Stage:

a. Thus at the output stage the database contains data which has been generated with possibly erroneous procedures and hence might be inconsistent giving rise once again to integrity issues in decision making [Linhua et al, 2015]

Thus errors in the information systems result in the loss of integrity at each stage in the information system, and thereby resulting in the overall loss of system integrity [11]. Since a dataset is centric to any information system, thus the loss of integrity in information system actually implies loss of integrity in decision making thus to improve the same, additional information acquisition and utilization [22] is required which means improving the learning ability and hence integrity of the system there by enhancing its cognitive capabilities and learning integrity.

5.0 Smart System View of Datasets – Smartdata Mangement System (SMS)

The analysis above has unequivocally brought forth the point that under the incessant requirement of system integration maximization and with the information technology for the same becoming a reality across the supply chain [19] and on the Net; our information systems and, hence, data sets are getting exposed to uncertainties arising due to the constantly changing environment. The environment, that is, external to the logical environment of traditional applications and data sets and which has never been the design concern. The data sets that we have today are not only limited to being accessed within one organization. There are actually open, complex systems which can be modeled as networked, distributed or embedded databases (specifically in industrial automation and IoT systems using sensors) [39] [5] covering data origin, processing and use stages as one is in a shared environment with users having access to stored data as designed by vendors. In other words, there is a change in IS and data set Design View as shown in Fig 1.0. It (fig 1.0) shows a static data set which has been integrated with in or across an organization, this integration is a function of communication and hence network, thus though the information process in the information system may be reliable but may not be accurate and consistent with the changing business environment. In fact, we are arrive at a view of the data set where it must be seen along with an acquisition, utilization cycle, and the context (i.e. environment) of its objective or goal [22], which can be referred to as **Smartdata Management Systems (SMS).** There is another perception of this statement, when we consider the data with its acquisition cycle, which has arisen out of an error situation than that acquisition is actually aimed at making the data set smart subsequently it is updated for enhanced cognitive capabilities that implies that there is an improvement in integrity of decision making thereby making the system smarter due to increased learning integrity (Fig 2.0).

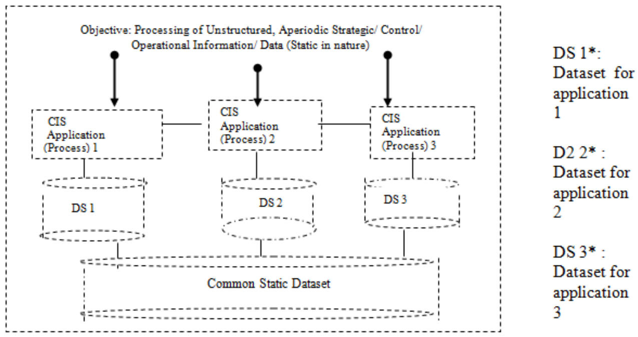
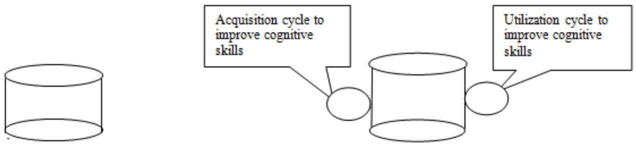


Fig 1.: Applications with emphasis on system integration maximization with static data set



i: Current static system view

ii: The proposed Smart data Management Systems view of the dataset

Fig 2.: Current and proposed dataset views

Smartdata Management System view based model [25], which has its analogy in the core Information System model. This is because like an Information system this model starts from the stage where the data originates and ends when the recipient receives the information. The earlier data set models were actually only considering the management of data residing in the system and were silent on the changing data sets as they were more akin to providing data set for decision making in static environment however now as the context for decision making is changing the data sets too need to add a continuous acquisition cycle shown on the left of the figure 2.0 ii and a utilization cycle shown on the right of Fig 2.0 ii to maintain the cognitive capability of the smart system.

6.0 Framework for Learning Integrity based Smart Systems' improved Cognition

From the above discussion it emerges that Smartdata Management Systems are a requirement for the cognition of Learning Integrity based systems (which is developed on the building blocks of data integrity and Information Integrity). To further delve into the aspect of decision making by the smart system; any decision making is a function of constructing improved knowledge (in the wake of 5

Cs, all pervasive internet and other data/information inconsistencies as outlined above) which is relative wherein some interpretations have greater relevance, thus knowledge is contextualized and situational and knowledge beliefs are justified probabilistically (refer Appendix I, figure 3.0)

The context and situation stated above represent the environment and the related environmental variables pertaining to the decision maker (here the decision maker may be the smart system which is expected to replace a human being or human being himself/herself). The environment is considered to be consisting of following layers [31]:

6.1 Integrating cognitive and intellectual capabilities with value creating framework

This implies the individual cognitive capabilities applied to decision making, these individual cognitive capabilities are a function of traditionally transferred beliefs, memory, problem solving and critical thinking capabilities, experiential learning based value creation at an individual level [30] [6]

6.2 Learning themes driven process centric instruction emphasizing coaching (mentoring/tutoring) learning interplay

This implies when the individual decision maker is exposed to a process in which the decision is to be made and each time the decision making context may vary then the decision becomes a function of an interplay between the teaching (coaching, mentoring, tutoring) system, this interplay may be between a team and group. The environmental variable which impact the decision making in this situation are identified as self-directed learning, independent learning, delivering learning outcomes i.e. learning to think, collaborate and regulate future decisions. [24][32]

6.3 Allocation of attention for sharp-end dynamic decision-making and endogenous learning

This implies a situation when the decision making eventually becomes a function of a larger group like an organization which exhibits management behavior. The environmental variable which are significant at this level of decision making are – prediction of future states, planning, scheduling and implementation of beliefs which actually translate into vision, mission and strategic objectives of the organization. The decision making thus is expected to be implemented through Teaching Learning System Performance Improvement processes in context of change implementation for the benefit of end beneficiaries, value creation and end performance desired for which it is imperative to recognize and redefine performance measures hence to originate information processes and information therefrom. [33].

6.4 A brain-like-connectome-structured [9] Teaching Learning Interplay platform performing a new instrument for "A Digital Process Choreography of Excellence" (DPCoE)

This implies a situation where the decision is to be made by an organization and the same is considered to be a network of several smaller groups. When this network of groups is encountered with a change from standard information nodes' structure relationship (in the connectome structured networked organization of information nodes) as a consequence of environment including local knowledge, strategic and attentional dynamics, factors for dynamic decision making at sharp end and endogenous learning interplay between constructive and destructive content, between contextualization(local context and individual situation of learning) and de contextualization (learning globally), between external (teacher directed) and internal (learner directed) regulation; all these become environmental factors which have to be applied synergistically to evolve the value of learning integrity. [Wiltz, 2018]

6.5 Decentralized and distributed information processing

This depicts a situation in decision making when the information processing is heavily decentralized and distributed more likely in a larger networked group compared to the mentioned in para 6.4, it could be the decision making at societal or cultural platform. This is expected to function through formations of connectome structured networked small-group organizations of information nodes by an ensemble of academic, professional and user communities which will be delivering brain like network processed informational work outcomes namely connecting to grow, pruning, maturing, reinventing, integration of logic and emotion, metacognition and with information nodes representing learner and teacher driven roles for improving learning integrity in future. [37]

6.6 Integrity of learned information contributing to higher cognition

In the Fig 3.0, Appendix 1 there are two crosses shown depicting 'Decision with low cognition' and 'Improved decision with higher cognition', the layers and environmental variables defined above are a proposed framework to move from 'Decision with low cognition' to 'Improved decision with higher cognition', the improvement in cognition for decision making is a function of learning integrity as explained above. Thus it emerges that just as Information Integrity is a measurable phenomenon [22] similarly integrity of learned information should also be measurable.

7.0 Conclusion

All business are open systems ,as they interact with the environment. Thus all Information Systems and hence data sets are also open systems . Open systems introduce lack of integrity at data origin,processing and output stages,due to their continuously changing nature.Thus the data once stored in the database is not good for future use, subsequently the concern of data integrity arose, which has been addressed through tools for data scrubbing, extraction, transformation and loading etc. Once the data is processed through these tools it is treated as information and it has been proven that there is a need to continuosly acquire information and utilize it. The utilization is done with a view to improve the decison making capability of systems in a changing business environment [22]. This is accomplished by attaching an acquisition ,utilization cycle to traditional data sets. Not only this , as the traditional databases become open they will also store factual as well as normative information with reference to the changing context [22]. The attachment of acquisition and utilization cycle to traditional static data set was meant to resolve the Information Integrity issue. The data set design had to be such that it catered to maximal and current data : both normative and factual. Thereby making the systems smarter and with higher cognitive capability due to increased learning integrity made possible by Smartdata Management Systems. This Smartdata Management Systems in order to improve the cognitive capability of decision making had to consider the achievement of learning integrity over and above the data integrity and information integrity.

The learning integrity helped in improved decision making through improved cognition of the smart systems. The improved decision making was an outcome of improved knowledge which is contextualised and situational in other words the improved decision by smart systems was a function of integrity of learned information. Integrity of learned information is proposed to be computed as a function of environmental variable which are to be captured through the framework comprising of five layers namely : integrating individual cognitive and intellectual capabilties with value creating framework, learning themes driven process centric instruction emphasizing teaching learning (T-L) interplay, allocation of attention for sharp-end decision making and endogenous learning, a brain like connectome structured T-L interplay platform perfoming a new instrument for ‘A Digital Process Choreography of Excellence’ (DPCoE) and Decentralized and Distributed information processing [36].

8.0 Further Research Direction

This paper explains the concept of learning integrity and integrity of learned information for improved cognition of smart systems. Learning integrity encompasses the earlier definitions of data integrity and information integrity ; integrity of learned information is applied on the process of learning integrity. Further reserach direction would be to derive the relationship between environmental variables described above in the paragraph 6.0 (on Framework for Learning Integrity based Smart Systems’ improved Cognition), identify the measurement criterion for the integrity of learned information and to derive a cost benefit analysis for the proposed framework.

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Decision-Making in Smart Service Systems: A Viable Systems Approach Contribution to Service Science

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