Information Integrity Imperative for Competitive Advantage in Business Environment characterized by Uncertainty

Vijay V. Mandke
Research Leader
Centre for Information Integrity Research
Unitech Systems (I) Pvt. Ltd.,
B-64 (First Floor), Gulmohar Park
New Delhi - 110049, INDIA
E-mail : vijaymandke@satyam.net.in

Madhavan K. Nayar
President
Unitech Systems, Inc.
1240 E. Diehl Road, Suite 300
Naperville, Illinois 60563, USA
E-mail : mnayar@unitechsys.com

Abstract

The paper first develops the core IS view of business activity, which comprises informational and physical work systems and central to which is the informational work system delivering information decision for control implementation at the physical work system. Following this the paper delineates the 5Cs contributing to uncertainty in system environment leading to errors in business process IS view. It is within this framework and in the context of the reality of digital data as the medium for information flow throughout an enterprise, that the paper then argues the Information Integrity Imperative.

Key words: IS errors, Information Integrity, feedback control, Information Integrity Space.

Introduction

Till 19th century land was the key factor and it determined the strategic business advantage. In contrast in the industrial era, the power source, initially the steam engine and later the internal combustion engine or the electric motor, became the key factor in determining strategic advantage. Impetus for this change signifying a dramatic shift in decision making in economies came from the technological shift in the factors that produced strategic economic advantage.

However, the invention of the microprocessor in the early 1970s has led to a dramatic increase in the use of computers in business and in our daily life, to a point where computers now outnumber humans on our planet [1]. Further, from 1980s, real-time computer systems have become as common as batch systems; and the Net is a reality. All this has led to yet another technological shift, this time in the form of data-driven technologies.

Thus 21st century is poised to witness unparalleled growth in information processing and high speed telecommunications based business opportunities and industries. These would not be depending on energy-based technologies, thereby signifying yet another dramatic shift in decision-making in economies, wherein the dependability or trustworthiness of information, i.e. Information Integrity, will be the key factor determining strategic business advantage.

2. Informational Work System

Traditionally, with enterprise seeking to produce only ‘standard’ product in high volumes, control systems tuned to fixed 'data/information decisions' could ensure business objectives of operational optimization and cost efficiency, thereby giving the business strategic advantage. The enterprise did have computerized information systems (IS) developed in isolation, and there was no effort to optimize data or information for improved decision making. The requirement of the business enterprise, therefore, was in terms of automation of functions of 'hard 'components, i.e., of 'mechanical' or 'physical' work wherein physical variables or rather material was transformed or processed or converted so as to add value to the product produced.

However, with data-driven technologies keyed to the flow of digital data throughout an enterprise and on the Net and with pressures of achieving business objectives of effectiveness and efficiency through requirements of mass-customization, agility – focused on customer responsiveness, IT driven market differentiation, supply chain synchronization by integration maximization and financial optimization for strategic advantage, business enterprise has a further requirement for utilizing data/information decisions 'smarter '[2, 7].

This calls for automation of 'informational work' carried out by the soft components of the enterprise wherein 'data' is seen as raw material, 'data processing or transformation or conversion' as the system function and 'data product' or 'information' as processed data used to trigger information use (decision making stage included) so as to deliver 'information decision ' in the form of information to add value to the product. As can be seen, this is a networked, computerized information system and is characterized by (a) computing processes under system function that include microcomputer and telecommunication and (b) pre- and post-processing stage communication channels at various data/information processing nodes, that are people based and include data communication and transaction processing networks with world-wide reach.

This is an application of flexible automation accounting for product innovation, customer needs - (product requirements) and constraints of costs and capabilities - a structural variant from inflexible automation of 1950s. Specifically, the flexible automation is becoming possible due to (a) availability of on-line computers, (b) computers providing capability for moment by moment optimization of processes and decision-making, and (c) availability of system integration capability so as to yield a computer integrated system for attaining business objectives (Figure (1)). What makes it possible now to 'put it all together ' in a total production and delivery system is technological reality of digital data as medium of information flow across the enterprise [2]. Further, most importantly, such systems can be applied to both hard components of production like processes, machinery and equipment, and soft components like information flow and data bases --- the informational work systems.

3. The Core IS View of a Business Process

It is within the framework of this centrality of the 'informational work' in achieving agility in the enterprise's functioning and handling large and constantly changing variety of produced items, that a conceptualization emerges to model all business procedures as data processing procedures, i.e., they all process data in some manner to deliver information for use in decision - making. Taking the triple <e,a,v> to represent a data/information model, Mandke and Nayar [3] while studying information flow model for integrity analysis identify 10 data processing activities corresponding to the Data Origin Stage, Conversion Stage and Output i.e., Information Representation & Use Stage of the informational work system. Particularly as information emanating from the Output Stage gets used or transformed or converted into another information, now in the form of 'information decision' for control implementation at the physical work system stage, the informational work system acquires one more stage in it's operation, i. e, Decision Processing Stage [4].

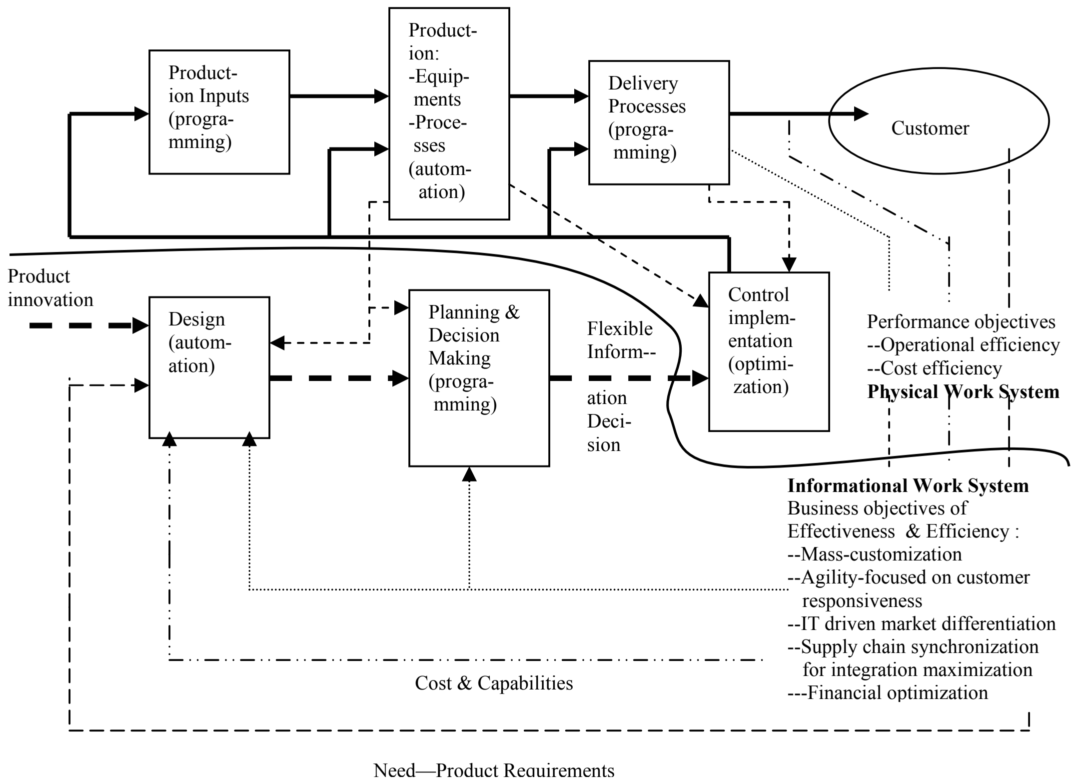
Delineation of information flow requirements for the decision processing stage as above and putting them together with data processing activities for data origin, conversion and output stages, then gives an IS View model for the Business Process (Figure (2)). It may be appreciated that in an actual enterprise function/activity/process such core models will be interconnected serially and in parallel in a number of ways.

4. Business Environment Uncertainty and it's implications on IS

And it is this IS view of the business process that is subjected to errors in data and information processed by it. Specifically, these errors in IS are caused due to business system environmental factors external to the IS application system and overlapping the user environment (here the term 'user ' includes designer, operator and direct functional user of IS). These system environmental factors are: Complexity, Change, Communication, Conversion, and Corruption (5 Cs) [5].

4.1 Complexity

Complexity factor signifies existence of interdependent variables in a system. A modern, real-world business enterprise is concerned with issues of size, speed, variability and measurability of the system, and has to work with a large number of



Figure(1): A systems representation of a business enterprise activities showing interrelationship between informational and physical work systems

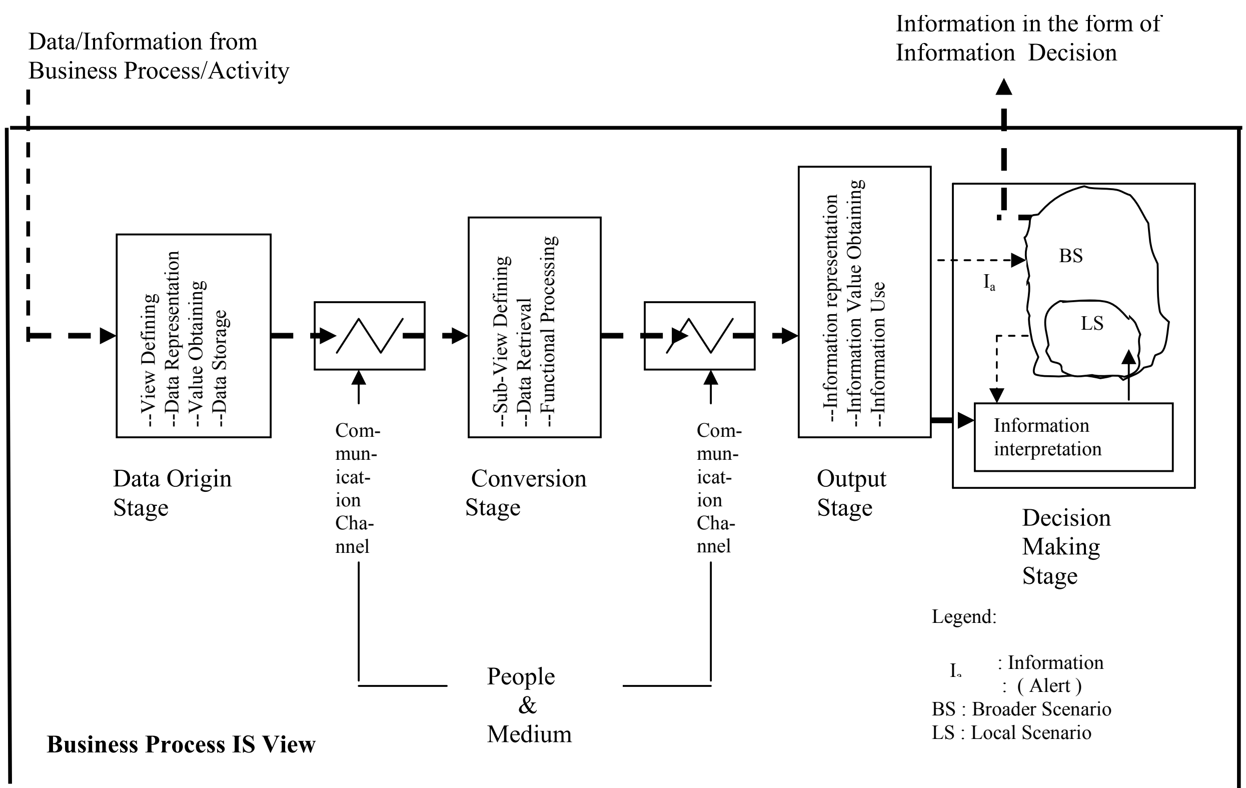


Figure (2) : Systems representation of the Core Business IS View

interconnected, interrelated and interdependent variables; rendering the business system complex in nature. 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.

In the face of Complexity, various factors like, (i) incomplete knowledge about system variables and about the structures governing their relationships (e.g., variables like competitor's information or governmental policy direction which are external to the system and are uncontrollable), (ii) variables to which, due to system non-transparence, one may not have direct access, i.e., unobservable or partially observable variables, and hence not exactly measurable (e.g., external variable like customer expectations, or internal like particular production process information), (iii) judgmental situations leading to 'what if' type problem solving - involving forecasting, evaluation and selection, i.e., decision , (iv) difficulty humans have in dealing with complex systems, make the business operate in an environment of uncertainty, both within and beyond it's boundaries, giving rise to errors in IS leading to data and information processed being inaccurate, incomplete, inconsistent and unreliable [3,5,6].

4.2 Change

Change factor pertains to the difference in the state of a system between two points of time. Thus the knowledge about change helps understanding system dynamics. 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 sometimes, of course, gratifyingly such as when profits rise. These fluctuations are because of input variations which fall on them from outside the business system, or are contributed by pressures generated from within the enterprise. Inhibiting the undesirable fluctuations, and/or promoting the beneficial ones, are objectives for the decision - makers concerned.

This decision making requirement makes it necessary to know dynamics inherent in the business enterprise, which in turn requires understanding of developmental tendencies in the business. However, in the face of Change, various factors, namely, (i) dynamics inherent in the system, thus making reality to some degree active, (ii) possibility of incomplete view of system state, (iii) inaccurate and incomplete perception of the 'reality model', (iv) inability to know all system inputs for all future times, (v) inability due to time delays to foresee effects of particularly minor changes and the fact of speed-accuracy trade-off (time pressure), introduce uncertainty in the understanding of the business developmental processes and, as a result, introduce errors in business IS implementation leading to data and information processed by IS being rendered inaccurate, incomplete and unreliable [5,6].

4.3 Communication

Emerging global, distributed business structures for competitive advantage and access to bigger markets are formulating business information systems as networked, computerized information systems. This brings in the Communication factor where 'communication' stands for movement of data/information within or across enterprise and it (the Communication factor) also provides a chance for error introduction in IS leading to inaccurate, inconsistent and unreliable processing of information.

Specifically in the face of Communication factor, a wide range of issues such as (i) communication noise, (ii) causes relating to physical structure of telecommunication, (iii) causes relating to logical aspects of data communication, (iv) business culture on the Net which values speed over quality in software development when software errors multiply geometrically, (v) acts of sabotage, incidents of accidental destruction and (vi) last but not the least, the very nature of the cognitive processes (at human - IS interfaces) which are error - prone, give rise to uncertainty in the business system environment resulting in errors in IS leading to data and information processed being inaccurate, inconsistent and unreliable [5].

4.4 Conversion

Conversion factor refers to the consolidation, decomposition or transformation of data. Whenever one converts data from one form to another, there exists a possibility of error introduction resulting in uncertainty and in information which may not be accurate and reliable.

4.5 Corruption

Finally, 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 uncertainty in system environment resulting in errors in the business process IS view leading to data and information processed being inaccurate, inconsistent, incomplete and unreliable.

5. Information Integrity Imperative

Mandke and Nayar [3] argue that errors in IS view can be modeled to include:

(i) errors with deterministic descriptions caused due to events singular in nature like software failure, denoted by $\eta_{sing,}$, and
(ii) errors with stochastic descriptions caused due to:

a) general causes like mechanistic failure, service disruptions, etc., denoted by η_g,
b) human judgmental factors operating at human-IS interface, denoted by $\eta_{j,}$ and
c) systems factors (external and internal to IS) like a merger, regulatory activity, legislative action, activity of a competitor, acquisition of a new software or hardware, etc., denoted by $\eta_{s.}$

Accordingly they suggest that applicable combinations of error types occur at various data processing activities under IS stages. For the purpose of the research investigation at hand, what is important is to recognize that it is these errors in IS view of the business process (that are made but not corrected in spite of application controls [5]) that then result in loss of integrity at the data origin, conversion and output stages and at pre - and post - conversion stage communication channels of the business process IS view model, thereby rendering data and information processed inaccurate, incomplete, not up to date and unreliable. And it is based on such low integrity information that the business IS view has a requirement for the decision maker to make information decisions on, say, product demand information; components, sub-systems and systems definitions' information; and on process definition information, which are 'smarter', i.e., which are optimum for control implementation for optimal processing of physical variables of business so as to achieve business objectives of mass-customization, inventory reduction and supply chain synchronization.

Once again there are additional constraints in the decision making process itself. Firstly, automation of informational work system reduces the supply chain time; thereby increasing in total business activity cycle time the proportion of time in which product is actually produced and delivered and reducing the proportional time in which information decisions are arrived at and that, too, based on uncertain information. And secondly, with automation of physical work system, if for any reason the product is not to customer requirements, only intervention possible in the physical work system, as product inputs are transformed into product, is till information decisions are fed in for control implementation.

If the first constraint adds to the implications of error components at data origin, conversion and output stages and at pre - and post - conversion stage communication channels by further increasing the risk of information decisions being incorrect, inconsistent and unreliable, the second constraint makes the procedures of the physical work system carry the possibility of incorrect and non-optimal implementation, as 'structured' physical work system has to operate under uncertain or incorrect information decisions; thereby rendering the product delivered sub-optimal or not to the customer requirements or incorrect. In other words, unlike when physical work was not automated, in the wake of data-driven technologies and the Net, second constraint carries a strong probability of resulting in business situations, more as rule rather than exception, wherein there is sub-optimal or incorrect product manufacture and delivery, and there is no alternative available at affordable price and in reasonable time.

And in a business with strategic objectives of mass-customization, agility and IT driven market differentiation which call for product carrying value added features based on customer specific information, this certainly means loss of competitive advantage in business strategy. This clearly brings out the central thesis emerging from the critical analysis so far of the workings of the informational and physical work systems under the business enterprise process characterized by uncertainty, and that is, with feasibility of data-driven technologies keyed to the flow of digital data throughout an enterprise and on the Net and faced with the strategic requirements of business objectives of effectiveness for competitive advantage, 'correct information decision' from informational work system is fundamental to physical work system delivering the correct product as per the customer specifications. That is to say the business process IS view characterized by errors due to uncertain business environment must ensure adaptivity in the form of feedback mechanism (a) to learn about errors made in processing information or information decision and (b) to correct them, so as to deliver correct information decision, i.e., information with integrity so critical for competitive advantage [5]. It is this information integrity imperative that then enunciates the dependability or trustworthiness of information, i.e. 'Information Integrity', as the key factor determining strategic advantage in business environment characterized by uncertainty.

6. The Experiment --- Reinforcing the Information Integrity Imperative

As argued earlier, shift in economy from energy-based to data based technologies is responsible for correct information decision, i.e. dependability or trustworthiness of information, i.e. Information Integrity to emerge as the key factor determining strategic business advantage. A critical look at the business objectives like mass-customization, agility implying customer responsiveness, and IT, i.e., information driven differentiation, in turn requiring flexible, i. e., adaptive informational work automation for competitive advantage tells that this shift in technology is proximating a business enterprise to a biological system characterized by demands of environment responsiveness and an self-preserving ability to undergo seemingly ‘sudden’ shifts in direction. And it is this visualization that offers reinforcement of Information Integrity Imperative from another angle.

Research in psychology reports a number of experiments demonstrating decision makers incapacity to deal with nonlinear time configurations [6]. This facilitates the conclusion that when dealing with Change factor, decision makers arrive at wrong growth information decisions (i.e., low integrity information decisions representing growth estimates) as they grossly under or over estimate the growth in time as it would actually occur. To study how a decision maker can gain insight in these developmental patterns (leading to ensuring integrity of information decision) in a system, at the University of Bamberg, Walpurga Preussler conducted a research experiment [8].

Specifically, drawing on the behavioral pattern of biological system, she designed a predator-and-prey system in which flocks of sheep (prey) suffer attacks from hyenas (predator). The experiment was built within it's own framework of the assumptions governing the ecological balance for the habitat in a hypothetical region. The decision makers' task was to predict (forecast) over thirty-five time units the curve that the predator (hyena) population would describe.

For the purpose of the investigation at hand, the most important aspect of this experiment was that while the decision makers were to predict for each time period the next value for the number of predators; after each prediction, they were immediately told what the correct value was. The results of the experiment studying decision makers' (participants') prediction performance were obtained in the form of time responses showing the development of the actual values of the predator and prey populations and the average values of all decision makers' predator predictions. Further, the difference between the actual value of the predator population at a given point of time and the average of the predator prediction by the decision makers at that point of time was used as a measure of the said decision maker group's prediction performance.

The conclusions of the experiment are quite revealing. To begin with, on average, the decision makers underestimated the initial exponential growth of the predators, their predictions being based on a linear model. However, the underestimates were relatively small because the decision makers were given immediate feedback on the correct value after each of their predictions. In the first cycle of twelve time units, the decision makers were also completely surprised by the reversal of the predator variable.

The continuation of the experiment through the second cycle from twelve to thirty-five time units, however, did improve the decision making. Particularly, the conclusions of the experiment report that as, after each prediction, all decision makers - representing the decision making process - received feedback on the accuracy or inaccuracy of predictions, i.e. on integrity of information decisions, and were told the correct value (of predictions thereby facilitating working towards improving integrity of information decision), by the time they came to the second time cycle the decision making process predicted the growth of predator population better than it did in the first cycle and the second reversal of the predator population did not catch it as much off balance as the first one, thereby demonstrating criticality of the information integrity for the purpose of improved decision making [6,8].

While discussing error reduction as a systems problem Moray [9] observes that, one of the major discoveries of recent years has been that even when all that is known about design of objects is applied to design, the probability of error cannot be reduced to zero . Moreover, further research of this type will never reduce error to zero. There are factors at work in a complex human - machine system, which the business process IS is, that have far greater potency for causing errors. Thus, it is a certainty that a business process IS view impacted by uncertainty and carrying error components at each of it's data processing stages will process incorrect and unreliable information decision.

Given this reality, the results of the research experiments in psychology and of Preussler's experiment described above then corroborate the earlier analysis of the working of the informational and physical work systems under the business process IS view leading to the construct of information integrity imperative. To elaborate, if the experiment is seen as a business activity, then information on actual predator population growth values is the information product desired, average of predator population predictions is information decision, and , as soon as the information decision is delivered, the physical work system of the activity instantaneously produces and delivers the product, as it (the product) is same as the information decision. Now, firstly, due to the unstructured character of the decision making process (constituting the informational work system), incorrect predictions are delivered, resulting in incorrect information decision and, therefore incorrect product delivery. And, secondly, when the informational work system is provided with correct value of prediction, thereby offering the opportunity to learn about the error made and to correct it, the value of the information decision (i.e. the working of the decision making process, i.e. the working of the unstructured informational work system) and, thereby, the product show improvement.

The above then reinforces the Information Integrity Imperative whereby the "correct information decision" from the informational work system , i.e. dependability or trustworthiness of information, i.e. Information Integrity, is identified as the key factor determining strategic advantage in business environment characterized by uncertainty. Sections to follow present a framework for defining Information Integrity and an introductory description of information integrity technology as a feedback control technology, followed by a concept of an information integrity space which unfolds a potential information integrity technology industry.

7. Information Integrity Definition Framework

Errors at various stages of a business process IS view result in loss of integrity at each of these stages as also in the loss of overall system integrity. Rajaraman [10] points out that integrity of the overall information system is ensured if the integrity of all parts of the system is ensured. This calls for a definition of integrity within the framework of a systems view of a business process IS incorporating error components and for an approach to study emergent integrity implications (Figure (3)).

Towards this, consider a core business IS model as in Figure (2), wherein with reference to data/information model given by a triple $< e, a, v >$, the view and data representation are given. Then to study integrity of information, one may study integrity of information on entity types and on relationships between them. Further, to study integrity of information on entity type, one may study integrity of information about attributes corresponding to entity type. Finally, to study integrity of information about attributes, one may

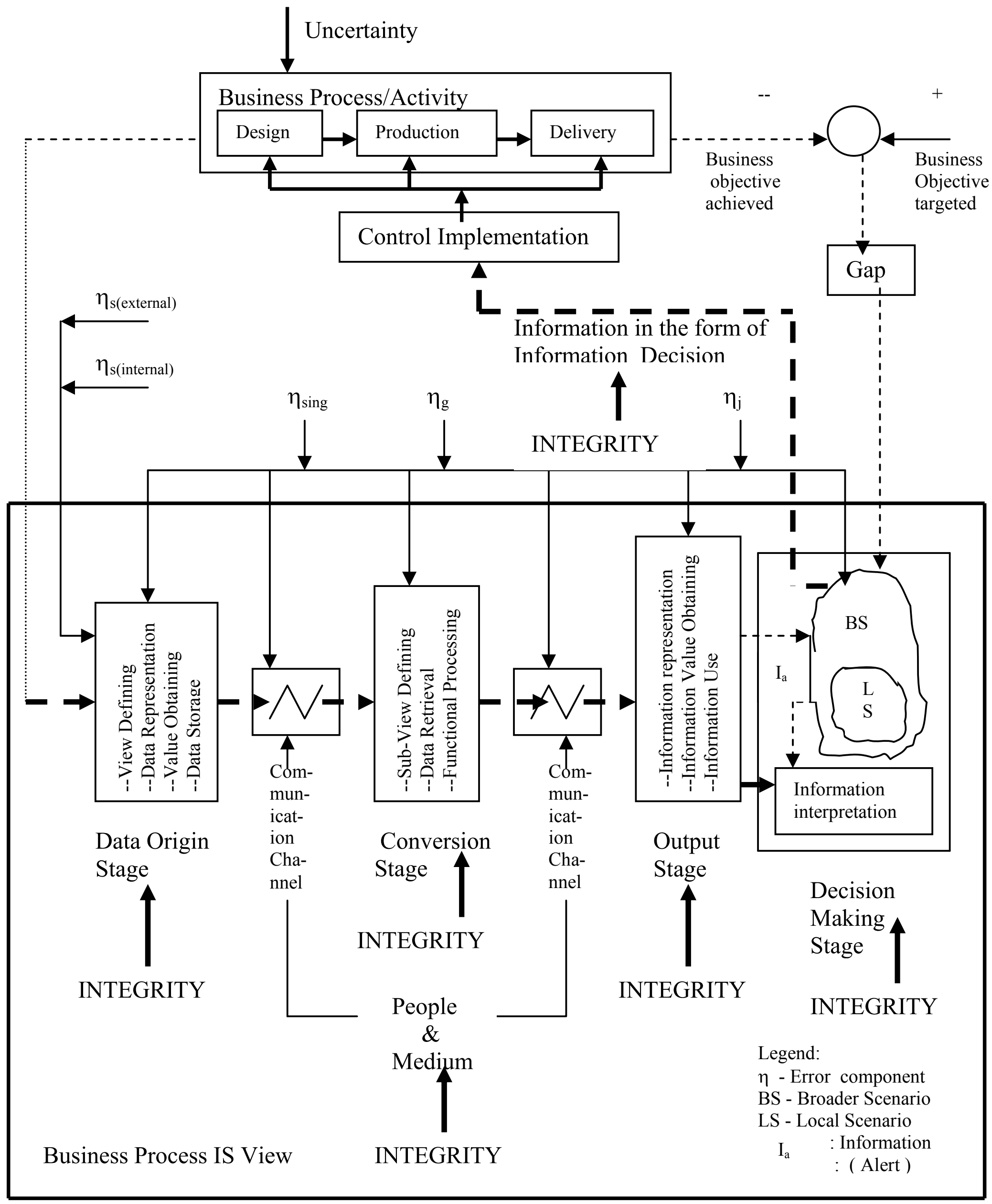


Figure (3) : Systems View of a Business Process IS View incorporating Error components and presenting emergent Information Integrity implications for a Business Process/Activity

study integrity of values of attributes, thereby making the exercise of studying integrity of information a viable one.

Within this framework, research investigations show that, irrespective of the nature of use of the information obtained from the information system, accuracy (includes completeness and timeliness),consistency (satisfying domains and constraints), and reliability (accuracy with which information item represents data item in whatever way information system processed it) emerge as intrinsic or basic or objective attributes of Information Integrity, while attributes of security (meaning confidentiality) and privacy are seen as extrinsic or subjective attributes. It may be noted that accuracy includes accuracy in spite of space or distance related changes. Further, requirement of security, meaning undamaged information, is understood to be analogous to accuracy [5].

Of course it may be mentioned that, what one is considering here is an IS model which delivers information for use. Therefore, depending on IS application area and industry standards, without reference to any specific user (decision maker), there may be different requirements/standards of information. Thus, even though accuracy, consistency and reliability emerge as intrinsic integrity attributes that an information system must demonstrate by incorporating Information Integrity Technology, depending on the application area, each of these intrinsic integrity attributes may satisfy different application area specific industry standards.

An IS comprises different data processing stages. Therefore, in a generic IS model as in Figure (3), Mandke and Nayar [11] suggest that what information integrity technologies will have to do is to follow data as it originates, moves over communication channel at pre- processing stage and gets processed or transformed or converted, and follow processed data, i.e. , information as it moves over communication channel at post-processing stage and gets used by user (decision maker), so as to detect where the error (s) occurs (at which field and what location in IS). Based on this, the information integrity technologies would then need to undertake 'integrity analysis' to decide at which location(s) and for which field(s) the integrity improvement opportunities are maximum and accordingly take corrective action(s) to remove error(s), so as to improve integrity, i. e., accuracy, consistency and reliability of information from information system stage(s) under consideration and from the entire information system. For a detailed discussion on Information Integrity definition framework and on design and implementation of information integrity technology as feedback control technology as here, one may refer to the literature [3, 5, 11].

This then presents information integrity framework conceptualizing it's definition and technology. It is submitted that the information integrity framework is encompassed by an integrity space covering different integrity dimensions and pregnant with contours of a challenging information integrity industry. Next section enunciates a concept of this information integrity space.

8. Information Integrity Space --- An Enunciation

As technology facilitates digital data as medium of information flow across the enterprise and as informational work system characterized by system integration application is put to work , due to the 5Cs every information movement in the business information environment runs a risk of loss of integrity, thereby harming the business capability for competitive advantage.

Business information environment, infested with risk of integrity loss at every information movement, is like a polluted water lake or like an atmosphere over a non - environment - friendly industrial township. Every water drop that human drinks, or every air particle that human breaths, must be pure, or otherwise over a time period a life, if not the entire species, can be under danger. Similarly, every information movement must deliver information with integrity, or otherwise, given a complex, real life business process information system, where it often is very difficult, if not impossible, to foresee the results of quite minor information pollution, over a period of time the business process IS view is in a danger of processing low integrity information decisions, putting business system out of control which in turn may lead to loosing customers, if not an entire market, and therefore loss of competitive advantage.

Requirement therefore is to ensure integrity of information at each information movement node (these include nodes where data or information changes form as also nodes characterized by transmission without change of form where loss of integrity could be due to difficulty in deciding the purpose of communication), as otherwise business runs the risk of working with low integrity (i.e. polluted) information environment. The universe of information movement nodes as defined here then offers a construct of the Information Integrity Space.

Seen from another angle, the Information Integrity Space generates integrity improvement business opportunities consistent with integrity requirements of parts or entirety of business process IS view. Based on current perception of business requirements, following Information Integrity Space dimensions are identified for developing integrity technologies :

- Prevention, monitoring, detection, verification, and correction of information errors.
- Security, audit, and control.
- Protection against corruption of information due accidental failures or deliberate fraud.
- Data scrubbing and cleansing in the creation of data warehouses.
- Design, development, operation, use, and maintenance of information systems.
- Conversion of existing systems due to mergers, acquisitions, and consolidations.
- Modification of existing systems to accommodate changes such as Y2K, new legislation, or new technology
- Information Integrity requirements of specific industries such as banking, finance, telecommunications, engineering, transportation, defense, etc.
- Information Integrity requirements of various data forms such as voice data, video, etc.
- Information Integrity Technologies in the context of information explosion, application integration, and zero latency enterprises.

Every enterprise performs a variety of activities in respect of above and spends a significant amount of resources to ensure the integrity of information it delivers to its manufacturing/production units and processes, customers, partners, suppliers, and shareholders. Specifically, for this purpose, most enterprises have systems and procedures to verify the integrity of information they receive from external sources and of information they produce and use internally. These systems and procedures are usually custom-developed, and unique to each enterprise. Further, many of the Information Integrity related activities are performed in all parts of the enterprise and are, therefore, often duplicated.

In other words, Information Integrity solutions as above are being developed and applied in isolated, unique and ineffective ways within most enterprises, even though the underlying requirements are the same, and could be addressed more effectively and consistently through an enterprise-wide approach. Consequently, many enterprises are paying an inordinately high price for the level of Information Integrity they are able to achieve. For example, even in a country such as India, where computerization is still at a nascent stage, one estimate suggests that India spent around USD 412 millions on Y2K related businesses; although the positive side is that one third from it was earned by IT industry fixing the problem [12].

Though there are no readily available studies about the total cost of Information Integrity related activities within an enterprise, many executives and industry experts suggest that such costs could be in the range of 1- 5% of revenue. Effective, enterprise-wide, and industry-wide approaches to Information Integrity using standards, best practices, and innovative Information Integrity Technologies while on the one hand can significantly reduce this cost, on the other hand they will open up the Information Integrity Space for new business opportunities in an unfolding Information Integrity Industry.

9. Conclusion

Not since the industrial revolution has technological advancement held as much promise and uncertainty as today, the beginning of the 21st century. Promise is due to shift in economies from energy based technologies to data - driven technologies triggering a new industrial awakening wherein technological innovation (e.g., the Internet, open systems) and business drivers (e.g., mass customization, supply chain synchronization through integration maximization) are forcing massive changes empowering business systems with a global market reach for competitive advantage based on seemingly endless access and processing of information. Uncertainty is because, due to the uncertainty in system environment, the information accessed and processed is fraught with risks of errors in the business information system. This brings in the issue of integrity of information system and of information processed by it which are key to the strategic business advantage in the presence of uncertainty.

Information Integrity is a pervasive universal issue, which impacts business, government, and society in many ways in this electronic information age. Today, the knowledge and understanding about Information Integrity is rudimentary, fragmented, and insufficient. On the one hand it has philosophical, sociological and economic aspects which are yet to be conceptualized, and on the other hand it has technical, technological and industry related requirements which only now have begun surfacing. Seen from this point, Information Integrity has potential for becoming a new discipline, a new science, even a new industry, very much like the environmental science and industry, which emerged as a result of society's concerns about the quality of air, water, and the earth.

The emergence of the new Information Integrity science, technology and industry will require the crafting and communication of clear, compelling, and consistent messages about the pervasive and key nature of Information Integrity, and the formation of a coalition of academia, thought leaders, professionals, practitioners, and organizations interested in Information Integrity.

REFERENCES

1. Storey N.,"Safety-Critical Computer Systems", Addison-Wesley Longman, England (1996).
2. Spectrum Series, "Computers and manufacturing productivity", An IEEE Press Book (1987).
3. Mandke V. V. and Nayar M. K., "Modeling Information Flow for Integrity Analysis", Proceedings of 1999 Conference on Information Quality, Edited by Y. V. Lee and G.K. Tayi, MIT, Massechusetts, USA.
4. Finlay P., "Introducing Decision Support Systems", NCC Blackwell (1989).
5. Mandke V.V. and Nayar M.K., "Design basis for achieving information integrity - a feedback control system approach", IFIP TC11 WG11.5 Second Working Conference on IICIS, Warrenton, Virginia, USA, November 19-20, 1998,Edited by S. Jajodia, W. List, G.W. McGregor and Leon A.M. Strous, Kluwer Academic Publishers, USA.
6. Dorner D., "The Logic of Failure - Recognizing and Avoiding Error in Complex situation", Perseus Books, USA.
7. "Supply Chain Management : Building the Agile Enterprise", Gartner Group Symposium, 11-15 October, 1999, Walt Disney World, Orlando, Florida, USA.
8. W. Preussler, "Uber die Bedingungen der Prognose eines bivariaten okologischen Systems", University of Bamberg (1985).
9. Moray N., "Error Reduction as a Systems Problem", Human Error in Medicine, Edited by M.S. Bogner, Lawrence Erlbaum Associates, Publishers, USA (1994).
10. Rajaraman V., "Information Integrity - An Overview", Proceedings of the JNCASR and SERC Discussion Meeting at IISc Campus, Bangalore on Information Integrity - Issues and Approaches, Edited by Rajaraman V. and Mandke V.V., India (1995).
11. Mandke V.V. and Nayar M. K., "Implementing Information Integrity Technology - A Feedback Control System Approach", Proceedings of the Third International IFIP TC11 WG11.5 Working Conference on IICIS, November 18-19, 1999, Amsterdam, The Netherlands.
12. "Tackling Y2K : IT industry proves its mettle" Report in Times of India, January 2, 2000, New Delhi, India.

0 - 0 - 0