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Sudhanshu Rai, Suranjan Chakraborty and Suprateek Sarker

Department of Informatics  
Howitzvej 60  
DK - 2000 Frederiksberg

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*Working paper*

**By**

Sudhanshu Rai, Phd  
Post Doc  
Department of Informatics  
Copenhagen business school

Suranjan Chakraborty  
Assistant Professor  
YR424  
Department of Computer and Information Systems  
Towson University

Suprateek Sarker  
Professor, CAICT  
Copenhagen Business School

## Abstract

Requirement analysis RE has continued to attract attention among information system researchers. The inquiry into exploring how RE actually unfolds as an intellectual exercise is the central preoccupation of this paper. Here we identify requirement analysis as an inferential process, and go on to explaining how the inference unfolds during requirement analysis, then we argue that the IS literature calls an aspect of the RE process an intellectual activity. We think the term intellectual activity is much too broad and we want to explore what constitutes this intellectual activity. We identify the constitution of the intellectual activity as inference and then discuss instances of inference where problems might occur due to contextual diversity. We conjecture that the problem of inference is such that instances of the client's environment is not able to be transmitted in the same sense using the same logical consistency as the inferring themes might require to understand the concept along with the context. In order to address this problem we use the nature of inference in "Naiyayika" from the Indian logicians and argue that, this school allows for the empirical embedding of the context in the formal syllogism.

Key words, Indian logic, Requirement analysis, information system development

## Introduction

A fundamental and critical aspect of information system development (ISD) projects is identifying, interpreting and specifying the requirements for a proposed information system. These activities are traditionally considered to be the part of the requirements engineering (RE) process and have a significant impact on the success of the overall ISD project. Specifically, unsuccessful RE has frequently affected the downstream project phases, in terms of quality, productivity and budget (Curtis, Krasner & Iscoe 1988). An important pre-occupation of RE has been to understand how exactly the activity of successfully collecting requirements unfolds. Consequently there has been research that has looked into the *process of RE*. Such research is characterized by two distinct approaches. The first typically adopts a normative and deterministic perspective (e.g., Browne and Ramesh 2002; Deifel 2009; Hickey and Davis 2002; Sommerville 2007) and views RE as a sequence of tasks and activities. The second school (e.g., Pohl 1994;

Rolland 1998; Urquhart 2001) advocates a contextually situated, non-deterministic view of the process. A significant section of such research has adopted a behavioral lens, depicting process as a collaborative activity involving stakeholders with diverse world views, who understand and co-construct the requirements through the process of knowledge transfer and sense-making (e.g. Gasson 2006; Davidson 2002; Urquhart 2001).

The research on the RE process has been influential in increasing the cumulative understanding about this critical systems development activity. However, in our opinion, a possible limitation of this body of work is the fact that the research focus has been somewhat bounded by methodological (task based) and behavioral perspectives. RE is intrinsically an intellectual activity that involves substantial amount of analytical reasoning on the part of the stakeholders; a fact that has been implicitly acknowledged in research. For example research investigating important stakeholder skill-sets have repeatedly stressed on analytical capabilities, as well as proposing techniques that could assist such reasoning processes (e.g., Browne and Pitts 2004; Greene 1989). The behavioral viewpoint of the RE process has also assumed an underlying analytic reasoning process by predicating RE success on stakeholder sense-making. However to our knowledge there has not been any research that has explicitly attempted to understand the nature of such analytical reasoning.

In this article we propose that new insights about the RE process may be gained attempting to understand process of analytical reasoning underlying the RE process. We argue that this analytical reasoning process is best understood as a form of inference. We further argue that the “*naiyayika*” tradition of inferential reasoning within Indian logic serves as an appropriate lens for examining reasoning in the context of RE because of its commitment to the principles of empiricism. Finally we provide illustrative evidence from the exploratory analysis of our data to show that this tradition of inferential reasoning is a useful lens to understand the process by which requirements are formulated with RE

## **Understanding “reasoning” within the RE context**

### ***Development of shared frames of reference as a process of inference***

RE has been acknowledged to be a socio-collaborative process where system requirements are understood through intense interactions between the participating stakeholders (business users and systems analysts) (e.g., Urquhart 2001). An important characteristic of this process is that the participants bring into the forum diverse world views and perspectives about the proposed information system. Such world views or perspectives are essentially frames of reference that encapsulate their individual interpretations of their world. Goia (1986) suggests that such frames define an individual’s understanding of the organizational reality and includes “assumptions, knowledge and expectations, expressed symbolically through language, visual images, metaphors and stories” (Orlikowski and Gash 1994, pg 176).

In the context of RE, the two main actors, the business users and the systems analysts have frames of reference that are quite distinct. The business user’s subjective reality of the organization is couched in terms of business processes, their dependencies and related information elements. On the other hand the system analyst’s organizational frame of reference is far more technology centric, and bounded by a systems view of the organization. However research indicates that (e.g. Jarke and Pohl 1993; Orlikowski and Gash 1994; Urquhart, 2001) while there exists substantial differences in the frames of references of participants, a necessary condition for the success of RE is the development of shared frame of reference. Orlikowski and Gash (1994) terms such potential frames as *technology frames*. These frames represent the organizational actor’s assumptions, expectations and knowledge to understand the nature and role of technology as well as its application and consequence within the context of an organization.

The interesting question that then arises is how such a shared frame of reference is developed in the minds of the business user and the systems analyst? It is important to note at this juncture, a very important aspect. The development of the shared technology frame is facilitated and at the same time constrained by the frame of reference that describes the subjective reality of the organization these actors are embedded in (i.e. the business world and systems world). In other words the sensory inputs that inform the development of the shared frame are intrinsically linked to the organizational environment of the actors and consequently to their primary frame of reference. The second important aspect is that technology frame that is developed needs not only to be shared but also congruent (Orlikowski and Gash 1994). The implication of this is that the technology frame that is developed is distinct from the original frame of reference in that for both the actors, the frame of reference needs to incorporate elements of

frames of reference of the other (i.e. organizational context for the systems analyst and the systems context for the business user). Therefore both the actors participating in RE are forced to develop an interpretation of the organizational reality with unfamiliar elements that are not easily apparent in terms of what is known to them in the context of their immediate environment. As a result the reasoning that reinforces the technology frame in their mind contains elements of a “leap” beyond what is known. Urquhart (2001) indicated evidence of this in her research when she described the tactics used by the stakeholders in reaching a mutually shared understanding of the proposed system as *reframing* and *imagining*. In other words the stakeholders develop a shared frame of reference by attempting to derive an *indicative interpretation* beyond what is known, initially.

The capacity to say something more than what is known initially (as in the context described above); being able to provide reasonable prognoses of the context that is not immediately seen is known in general as *inference* (Matilal 1977b). Therefore based on the preceding discussion it will not be illogical to assume that inferential reasoning is the mechanism that allows the participants of RE to transcend the boundaries of their primary frames of reference. The original frames of reference play an instrumental role in the inference process by providing the business users as well the systems analysts initial premises on which to base the reframing of their interpretation of organizational reality (to better understand the nature of the proposed information system). For example the business user may assume that the inter-relationship of business process elements would remain invariant when instantiated within the information system. In a similar vein, the systems analyst may attempt to understand and categorize the business process elements in terms of the common systems viewpoint of *input-process-output*. The usefulness of any inferential conclusion is predicated on the validity of the underlying premises. Therefore the original frames of references may also undermine the inference process by rigidly reinforcing established assumptions that end up distorting the perception of reality when applied to technology frames and provide invalid premises to base conclusions on. In other words the business user’s attempt at understanding relationships in terms of business process relationship may be an invalid premise and result in erroneous conclusions about the nature of the system.

In the preceding discussion we attempt to establish how the stakeholders of RE formulate a shared frame of reference about the proposed information system through the intellectual process of inferential reasoning. There are two important aspects of the formulation of the shared frame of reference. The first is the formalism of the shared frames that is apparent as the changed subjective reality of the individual. The second is the process of empiricism that validates the premises of inference and leads to its formulation. Research has indicated that an important factor within the RE process is the intensive communicative interaction (or knowledge transfer) between the stakeholders (e.g., Urquhart, 2001). Such knowledge transfer provides the stakeholders with examples or empirical basis that informs the inference and consequently the development of a shared and congruent frame of reference. Therefore an inference based insight into the process of reasoning needs to be able to trace the underlying empirical foundation. This we feel is critical if inferential reasoning is to form the basis of a holistic understanding of the RE process. Given such a context, we propose that the inferential mechanism inherent in the “Naiyayika” school of Indian logic as an appropriate lens to understand and express the process of RE. In the next section we discuss the nature of inference within the naiyaika tradition.

### ***The Nature of inference in the Naiyayika traditions***

Our focus on the Naiyayika school is influenced by two reasons. The inferential mechanism in Naiyayika school is distinct and clearly elucidated, second, it lends itself to application in non Philosophical contexts. The key feature of the Naiyayika School is its commitment to empiricism, any inference one makes has to be grounded in some observation (or examples). These examples should be commonly accepted and can be both positive and negative examples as we shall illustrate subsequently, (Ingalls, 1951). The Nyaya's conceptualized inference as having two modes, First inference for self, second inference for others. Inference for self: This occurs when one sees smoke on a hill and then infers to oneself that there is fire on the hill. There is no further communication or need to convince somebody else about this inference. The other type of inference is called inference-for-others, which is an explanation of the inferential process to convince another person of the correctness of the inference. The two step process is grounded in intellectual relevance. For instance if a person is not convinced of the inferential conclusion he or she might find it difficult to explain it to others as to the validity of his/hers inference. To convince others the Nyaya's have developed a five step process; 1) the statement of the thesis of inference (2) stating the reason or evidence for this thesis (3) citing an example of a generalization supporting the reason and this example is such that

it is well accepted by others (4) application of the present observation to the generalization and (5) conclusion or assertion that the statement of the thesis has been proven, (Matilal 1977a).

<b>Table 1- 5 step inferential process of the Naiyayika tradition</b>	
Instance of an inference	Illustration of that inference
Proposition	There is fire on the hill.
Reason	For there is smoke
Example	(Wherever there is smoke, there is fire), as in the kitchen
Application	This is such a case (smoke on the hill)
Conclusion	Therefore it is so, i.e., there is fire on the hill

Inferential conclusions can have either a positive prognosis or a negative outcome; Positive prognosis is those which support the inference, such as a kitchen because in the kitchen we know that smoke and fire are seen to occur together. Negative examples, such as a lake, support the inference by looking at places where there is no fire. The fourth step applies this general principle to the case at hand and finally, the fifth step, states the conclusion as being established, (Hempel 1965). This five step process is an exemplar of Indian logic and is the Indian logic's 'equivalent' of Aristotelian syllogisms, (Heijenoort 1974). In the proceeding sections we provide details of our empirical investigation and provide preliminary illustration of how five steps of the "naiyayika" tradition can be used to understand process of understanding requirements for an information system

## **Methodology**

### ***Data Collection***

The data collection was done in two organizations -EduTech and CompuTech (both pseudonyms). These companies are based in two different regions of India, and have a fairly large software production base. Both have a similar management structure: software projects are handled by managers, with analysts and developers assisting the process. Both companies employ advanced methodologies for the software development process and employ fairly large developer community, approximately 100 in each firm. Both companies have a relatively limited number of analysts in relation to the developers, approximately 10 each. The main source of income in both companies comes from sales of software in the domestic market and the main activities of both the companies are client specific software development.

The primary strategy data collection based on semi-structured interviews. All interviews were conducted by one of the authors of this article.

The interviews were conducted on site, during the project with analysts, developers and managers, lasting for approximately 90 minutes. These interviews were initiated with the following three questions:

- a) What does requirement analysis mean to you?
- b) How do you share the contents of requirement analysis within your team members?
- c) How do you share your requirement analysis experience with other teams?

### ***Empirical Illustration***

In this section we present our very preliminary findings based on an initial exploratory analysis of our data. We would like to note at this juncture that this analysis is exemplary and this is simply the beginning of a long journey and that we have longer in depth representations to illustrate in the future.

Table 2 illustrates the reasoning process demonstrated by one of the systems analysts we interview during our data collection. The context of the conversation was the preliminary scoping process for a teaching tool. EduTech ( the

organization that employed this analyst) was trying to formulate a strategy for a teaching tool that they were planning to develop and market. The primary objective of the analyst was to understand the nature and objectives of such a teaching tool. As table 2 indicates, the systems analyst intrinsically felt that the important factor in teaching was not the tool but the quality of teaching; hence the proposition about seemingly archaic chalk and talk method. For the analyst the proposition was self evident because his experiences with good teachers (as demonstrated in the second row and the premise for the inference for the self). However this was not sufficient for him to convince the others. This brought forth the example of encyclopedia Britannica and an illustration of tools only being of value if they are used appropriately. This creates a generalized premise for the application and use of tools. The analyst further reinforces his argument by contextualizing to the present case and providing alternative example of when a tool may replace an individual and when it may not. He also uses the contextual application to define the objective of the teaching tool of enhancing the quality of teaching , through its role as a teaching aid. Finally all this is brought together by a conclusion that the aim of the tool should not be to replace a teacher at the secondary level.

While this analysis is indeed preliminary in nature, it illustrates how the steps of inference within the”naiyayika “ tradition may be used to gain valuable insights about the nature of reasoning that leads to understanding of system requirements.

<b>Table 2 – Empirical Illustration</b>	
Instance of an inference	Illustration of that inference
Proposition	“there must be something that is implicitly good in the chalk and talk method, after all everybody including me is a product of that”
Reason	“Quality of teaching”
Example	“An analogy was if I buy like 26 volumes of the encyclopedia, let's say Britannica and I pay for it, and then the publisher gets money. But I lock them up in a cabinet in the library, so value exchange is not fair. So there is no ... benefit that I get”
Application	“The role of technology is to improve the quality of surgery without replacing the surgeon. Then you have the role of technology as you see which is the ATM, which replaces the banking clerk in front of me. So that the quality of banking improves, I can actually withdraw and deposit whenever I feel like. So there is the replacement role that technology plays and both are ultimately playing the role of improving quality of what is being done. In one case technology is replacing the individual and in the other the individual is only being assisted with technology. So when we looked at teaching as our focal area in the schools and technology as the enabler, we had this question mark above us to assist the teacher or replace the teacher with technology”
Conclusion	“we thought that replacing the teacher, especially at the school level is neither correct nor should be attempted”

### **Contribution and Future Research**

An important preoccupation of research on RE has been to understand how the stakeholders understand RE. The predominant paradigm of such research has been to understand it in terms of methodological or socio-collaborative perspective. In this article we argue that new insights in RE may be gained by trying to understand the intellectual reasoning process underlying it. We try to establish this process as a form of inference and propose the “Naiyayika” tradition of inference in Indian logic as an appropriate lens to understand the how RE stakeholders understand requirements. Finally illustrate through an exploratory analysis of the empirical data how the “Naiyayika” tradition can provide insights into the intellectual process employed by a systems analyst to understand the nature of the requirement.

While this research is at a very preliminary stage, we feel that our primary contribution lies in proposing an innovative perspective with which to re-examine the RE process. Existing research (e.g. Urquhart 2001) has acknowledged that RE success is contingent on the stakeholders achieving a shared understanding about the proposed information system. We feel that our proposed approach may be instrumental in opening the “black box” of how exactly such shared understanding is achieved by explicitly examining the intellectual reasoning process of the participants.

In our current research we have found initial evidence of inferential reasoning in the way systems analysts understand requirements. Our future aim is complete the analysis of the data to provide a richer understanding of the nuances of such reasoning process. We also hope to extend this research by collecting empirical data from the other important stakeholder, the business user. Finally our initial exploration is embedded within an Indian context we would like to expand our research by including other cultural context to see if the traditions of Indian logic in interpreting system requirements is contextual to the sub-continental culture or is more universal

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