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# Semiotic notation principles for business process modelling

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# "SEMIOTIC NOTATION PRINCIPLES FOR BUSINESS PROCESS MODELLING"

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## Abstract

*Business Process Models use symbolic notations to represent business processes. Influenced by system engineering and mathematics, the application of these notations involves technical processes designed by engineers, undertaken by technically trained analysts for the use of largely technical people. However, the majority of business process stakeholders are non-technically inclined with a business or administrative background. While some notations are comprehensive, they can be visually and technically complex hindering effective understand. Others are arbitrary geometrical symbols where their intended semantics are unclear and confusing. While such representational constraints prevent effective communication of process knowledge, there is a lack of research evidence on theoretical principles justifying the choice and application of notations which can help to overcome the identified constraints. This paper proposes semiotics principles to overcome this deficiency in representing business process model. As the theoretical foundation for this proposal, it advocates the use of Peirce's semiotics triadic principles and Solomonick's principles on evolution of signs. A quantitative and qualitative comparative analysis confirmed that the proposed notation principles successfully identified the intuitively comprehensible notations and able to guide analysts to effectively model processes.*

*Keywords: Business Process Notations, Business Process Modelling, Semiotics, Effective Communications.*

# 1 INTRODUCTION

The importance of business processes to organisations (Phalp 1998, Warboys *et al*. 1999), purposes for modelling them (Huckvale & Ould 1995, Kueng & Kawalek 2003) and their generic constructs (Ould 1995, Katzenstein & Lerch 2000, Kueng & Kawalek 2003) have been widely discussed. In essence, with the use of symbolic diagrams, business process modelling (BPM) communicates the knowledge on the complex reality that existed or may exist within a business environment. These representations appraisals are deemed important for any business process improvement initiatives (Huckvale & Ould 1995). As reported in Melao and Pidd (2000), there are 25 different methodologies, 72 different techniques and 102 different tools in support of BPM. These approaches adopt numerous different sets of notational symbols to model their business process perspectives. Through critical literature reviews and comparative studies, this research revealed *a lack of scientific justification for choosing and applying specific types of notational symbols* by advocators of these main approaches (see Section 1.1). It could not find a theoretical principle that governs the choice on types of notational symbols nor how it should be effectively used in representing business process models. Seemingly, advocators arbitrarily select different notational symbols to represent objects within business processes (Jaffar 2003). These objects are any element that is directly associated to business process. This research also identified some common inadequacies among these above approaches that complicate effective communication between various stakeholders. Generally, these approaches address the needs and understanding of system engineers and technical analysts rather than the majority of business people, who are largely non-technical business process stakeholders.

Such absence in empirical evidence justifying advocated representational principles within existing "technocentric" BPM approaches could benefit from clear notational semantics that optimises our sensory experiences. In addition, appraising how intuitive natural sign hierarchically transforms into a more abstract sign; provides an insight on the various level of abstractness in signs representation. Since BPM uses symbolic notations to represent process abstraction, semiotics the science of signs (such as notational symbols) could provide insights in optimising the meaning inferred by such symbols. This research adhered to the semiotics fundamental positioning as advocated by Charles Pierce (1839-1914) and Morris (1946), and more recently by Stamper (1973) with his organisational semiotics in addition to Solomonick (2002) with his evolution of signs systems and its complexity in sign representations. The aim of this research is to propose a set of theoretical principles that govern the choice and use of symbolic notations for BPM. Its objectives are to appraise semiotics fundamental theories by these advocators, identify complimentary theoretical commonality and integrate them as a combined semiotics principles governing BPM symbolic representation. Subsequently, evaluates this proposed principle against existing sets of notations and finally, identify future work in balancing the social as well as technical considerations necessary in BPM for the purpose of process improvement initiative.

This research successfully introduced and validated semiotics notation principles that govern the choice and application of notations for BPM. Its application suggested that the principles are able to identify intuitively least abstract notations and guide analyst on syntactical rules for effective BPM. In support of these objectives, the following sections highlight the reasons why appropriate notations are important in BPM and the current lack of scientific justification in applying existing BPM approaches.

### 1.1 Reasons for justifiably notations

Katzenstein and Lerch (2000) extrapolation from the cognitive psychology in addressing limitations in modelling provided clear reasons for the *need to justify the choice of symbolic notations* for effective BPM representation. Others have raised similar concerns for the *need to elicit accurate semantics* from such representations (Phalp 1998, Robinson & Bannon 1991, Larkin & Simon 1987). Drawing attention to Semiotics (Morris 1946, Stamper 1973) allows this investigation to address the semantic

constraints in eliciting meaning of symbolic notations. Similarly, understanding how sign evolved from intuitively natural sign to a more abstract sign representation (Solomonick 2002), leverage in-depth understanding on how human interpret geometrically abstract signs.

Poor representation can affect *ease of understanding* a business process, particularly problems within the process (Katzenstein & Lerch 2000, Kaplan & Simon 1990). Larkin and Simon (1987) identified that *using graphical representation significantly assist in problem solving*. This is especially true when information is grouped together to enhance useful cognitive operations that *influence better inference making*. Solomonick (2002) raised similar findings in addressing the issue of complexity in signs representations.

Furthermore, Phalp (1998) reported that even a simple representation is sometimes too complex for certain users. He claimed that *users are not prepared to invest the time to understand complex models* or formal modelling approaches, which require technical experts to validate and appreciate them. The main problem is that the majority of *process stakeholders are non-technically inclined*. This led to the need for sacrificing rigor in order to facilitate discussion and understandability. Phalp (1998) also highlighted that the *type of audience must be identified* so that appropriate graphical diagrammatic notations with clear semantics are readily understandable. Such representation *uses a minimum set of intuitive and readily recognisable symbols* that must be easy to understand for the uninitiated. This observation is in direct contrast to the constraints to be discussed in section 1.2.

However, Curtis *et al.* (1992) claimed that it is difficult to establish a representational format which is universally understood. He suggested that representation models must be flexible, expressive and comprehensive. Robinson and Bannon (1991) acknowledged this dilemma, while addressing problems faced by ***semantic communities***[1]. Such communities adhere to individual ontologies, epistemologies and conventions. Robinson and Bannon also identified the problem of ***ontological drift***[2] while communicating with different semantic communities.

### 1.2 Existing notations lack scientific justification

This section appraises deficiencies in the use of symbolic notations to infer clear representational semantics, particularly leading to effective communication of process intentions as intuitively as possible. A key question that this research wishes to answer is why existing BPM techniques advocate the use of a specific set of notations to represent business process.

Despite numerous literature reviews and analytical comparisons on various existing BPM techniques conducted by this research, there seems to be an absence on the reason why majority of the current BPM techniques chose their existing sets of notations. In support of this conclusion, Katzenstein and Lerch (2000) claim of a lack of empirical evidence addressing the importance of representations in modelling processes. Hahn & Kim (1999) also observed that existing BPM techniques lack any theoretical framework, particularly for the cognitive processes involved in manipulating these symbolic diagrams. Users are left to choose diagrams without knowing which diagrammatic representation is more appropriate. Similarly, model designers have to devise cognitively compelling diagrams without any guidelines or theoretical principles to assist them (Hahn & Kim 1999). However, Warboys *et al.* (1999) claimed that debating which notation is best for modelling "in some absolute sense is fruitless" because "the exigencies of a given initiatives dictate the notation that are likely to be the most helpful". In contrast to this claimed, if one is to decipher some of the existing sets of notations (see legends in Figure 2a, 2b & 2c), all of them are intuitively meaningless. While this claimed may be true at one level, it may not invalidate deeper theoretical analysis in another. While

[1] Different groups of people who do not share similar jargons, norms and perspectives of the real world
[2] Lost of actual meaning when information is interpreted and further disseminated to others

some of these existing notations are commonly used symbols, others are merely geometric shapes to the uninitiated. Apart from the arrows, which may infer pointing in a specific direction, the different types of directional arrows will only confuse any initial understanding that one may have been established. These symbolic notations are arbitrarily assigned with meanings. Advocating intuitively meaningless and in some instances uncommon symbols to represent process elements, will only add to the complexity in communication and understanding of the intended representations. According to Moore (1993), "the biggest problem we have with communication is the fact that people use language to mean different things". This is true about the directional arrow if a set of notations is a form of communication language. In the following, weaknesses of 3 BPM techniques are outlined.

In analysing representational inefficiency within existing BPM techniques, Huckvale and Ould (1995) cited that Data Flow Diagram (DFD) suffered from limited notation representation vocabulary with imprecise details on activity sequence and concurrency. DFD notations focus on data objects and do not represent roles (people responsible for performing set of activities within a process), nor the interactions between these various roles. In addition, DFD notations express neither the dynamic behaviour nor the time dimension within a process (Barnard 1999).

In the case of Integrated DEFinition Suites (IDEF) by USAF (1981) and recently by KBSI (2001), while IDEF0 notations represent elements on behavioural and organisational perspectives, it adopts very much a data-oriented view (Huckvale & Ould 1995). IDEF0 "captures only a small variety of process features" (Earl 1994). It addresses process constraints and mechanisms, but it does not show social relationships among the latter (Huckvale & Ould 1995). Furthermore, IDEF0 strict hierarchical view of human activity is not realistic and may inhibit mapping of existing processes. IDEF0 is comprehensive but visually complex, particularly on its level of decomposition, which are cognitively difficult to navigate (Katzenstein & Lerch 2000).

Katzenstein and Lerch (2000) claim that the Role Activity Diagram's (RAD) set of notations are mere symbolism with no specific semantic intent. While its notations suffer from being highly abstract and hard to remember, its basic triangle shape is used to represent 2 different semantics in 2 different ways. RAD concurrent activity, represented by an upright triangle ($\triangle$), is reminiscent of the logical 'and' symbol and its business condition, represented by an upturned triangle ($\nabla$), is reminiscent of the logical 'or' symbol (Huckvale & Ould 1995). This will be confusing to some. Simultaneously, RAD only labels the interesting activity states that require attention (Huckvale & Ould 1995). While it reduces complexity in considering only those elements that are necessary, it exposes itself to the possibilities of overlooking a probable state that might be equally important. In addition, RAD business rules restrict its notation representation only towards diagrammatically representing the pattern of activity sequencing, decision-making and concurrent activity. It does not highlight the event that triggers such business conditions or the social behaviour that binds its roles to respond in certain socially acceptable ways. Neither does represent more than one business rule, which may be embedded within a single activity.

# 2 RESEARCH METHODOLOGY

The main problem this research needed to address was the absence of theoretical principles that governs the choice and application of symbolic notations for BPM representation. This research aimed at proposing an essential set of theoretical notation principles to overcome this inadequacy. The research objectives are to appraise semiotics theories (as advocated by Pierce, Morris and more recently Stamper and Solomonick), derive a set of notation principles governing BPM symbolic representation and validate this proposed set of principles against existing BPM techniques before briefly discussing its future work. Critical literature reviews and analytical comparative studies of existing BPM techniques formed the main thrust in this research investigation. Quantitative as well as qualitative analysis will be used to support the research findings. A comparison of two existing BPM approaches, IDEF and RAD as well as a newly developed Norm Process Chart (NPC) set of notations

based on the proposed semiotics principles (Jaffar 2003), will be used to evaluate the proposed theoretical principle.

# 3 THE THEORETICAL FOUNDATIONS

The essence from the above analysis revolves on the issue of communication to affect rigorous understanding in addressing a given BPM representation. The main concerns are with the target audience (mainly non-technical process stakeholders) within a typical organisation who use business models to appreciate their business operations. In addition, the content of the model, the type of notations to be used and their presentation formats will ensure effective appreciation by facilitating appropriate discussion to all business process stakeholders. BPM sets of notations are symbolic signs used to represent certain arbitrary meaning. Such purpose implicates *Semiotics* (the science of signs) as advocated by Charles Pierce {1839-1914} followed by Charles Morris {1901-1979} with *semiosis* a process which uses signs to produce meaning inferred by signs (Morris 1946). In-depth analysis is also drawn from critical appraisal on evolution of signs (Solomonick, 2002) from intuitively meaningful sign to highly abstract geometrical sign. In addition, theory of organisational semiotics (Stamper, 1973) provides a framework to establish the properties of signs. These various semiotics theories formed the basis of this research proposal.

### 3.1 Peirce's triadic semiotics model

Charles Peirce's definition of sign is "something which stands to somebody for something in some respect or capacity" (Chandler 1998). Humans associate intrinsic meaning to signs based on their past experience in direct relation to natural phenomenon (Chandler 1998). As humans evolved, they invented arbitrary signs to represent complex meaning (Solomonick 2002). Human associate dark sky (natural sign) to be night time and developed the complex arbitrary sign of $H^2O$ (conventional symbol) to represent water. In-depth discussions on Peirce's theory of signs and various sign classifications have been well documented (Stamper 1973, Chandler 1998, Lofting 1999 and Jaffar 2003). In brief, according to Lofting (1999), Pierce's triadic model of sign covers the process of "*deriving signs from our sensory experiences*". It is also based on the "*concept of hierarchical transformation*" from a concrete natural sign to a more abstract sign representation.

Process modelling is about abstracting the complexity of the real world and communicating it among its stakeholders through symbolic representations. Limitations in the human sensory system forces one to be *selective in generating significance* to individual stimuli in interpreting signs accurately. By organising stimuli into meaningful grouping to represent specific concepts will influence individual perceptions and eventually communication (Mullins & Hicks 1996). It is also important to minimise the amount and effort of information search in understanding and interpreting signs (Hahn & Kim, 1999). By increasing individual *computational efficiency*[3] will ensure effective understanding and communications of the intended representations (Larkin & Simon 1987). Similarly, increasing *cognitive processes effectively*[4] (Hahn & Kim 1999) through grammatical rules of *decomposition* and *layout* of the represented knowledge into meaningful units; not only will optimising the presentation space within a business model but also facilitate concisely clear representations (Hahn & Kim 1999).

Although Peirce's 66 different sign classifications (Burks & Weiss, 1945) encompass extensive results in sign usage, this research adopts Peirce's triadic principles of *Icon, Index* and *Symbols* classification of signs that relates to object (Marostica, 2001). However, unlike *Icon* and *Symbols* which directly associate its intended representation to an object, *Index* adhered to existential characteristics that inflict

[3] Refers to ease and rapidity of inference making by an individual
[4] Easy to perceive and reason with

a causal reaction from an object to generate its representational meaning (Burton-Robert 2001). Since *Index* is not directly representing an object of a business process (see Section 1); it is not suitable to be considered as a classification of signs for BPM (Jaffar 2003). A comparative study by Jaffar (2003) between Solomonick's evolution of signs and Peirce's hierarchical transformation of signs revealed a direct mapping in their classification of signs as well as signs' hierarchical positioning which addressed signs' levels of abstractness. These levels of abstractness are based on Peirce's hierarchical transformation principles of *Firstness*, *Secondness* and *Thirdness* (Jappy 2001 and Jaffar 2003), where *Firstness* is the least abstract as compared to *Thirdness*, being highly abstract. The study also highlighted a complementary relationship that supplements each other weaknesses. Solomonick (2002) provided detail decomposition of symbolic signs into *Natural Language*, *Notations* and *Mathematical* which is absence in Peirce. In turn, Peirce's hypoiconicity (Jappy 2001) of *Image*, *Diagram* and *Metaphor* reflects the breakdown of his Icon's classification that is not addressed by Solomonick. The integration of these decompositions (Jaffar 2003), as in Figure 1, paved for a new classification of signs that can be used to categorise BPM existing notations into their respective level of abstractness. Hence, helps to determine whether a BPM representation is intuitively meaningful or otherwise.

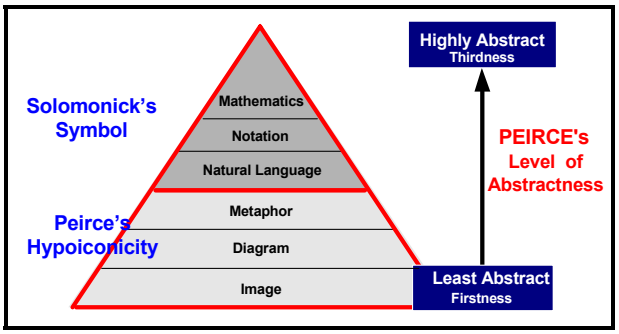



*Figure 1 Integrated BPM Classification of Signs*

### 3.2 Organisational Semiotics: Properties of notational symbols

Since BPM representations involve both technical as well as non-technical stakeholders, there is a need to introduce theoretical principles that emphasis the socio-technical aspects of using notational symbols for representing business process (Stamper 1973). This investigation adapted the organisational semiotics framework by Stamper (1973) to define the properties of notational symbols in representing BPM (see Table 1). It emphasised semiosis (Morris 1946) in determining the projected meaning by a notational symbol in representing an object within business processes.

| ***Technical Aspects*** | | ***Social Aspects*** | |
|---|---|---|---|
| ***Physic*** | Analyses the physical shape of the sign to be used. Base on arbitrarily geometrical symbols or natural iconic signs which are more intuitive in their meanings (Jaffar 2003) | ***Semantic*** | Defines the rules for eliciting the exact meaning from each sign used and their conformance to users' familiarity and acceptability |
| ***Empiric*** | Analyses the degree of abstractness in a sign. A geometrical sign is highly abstract as compared to intuitive iconic sign. It analyses the level of complexity in the various types of signs used | ***Pragmatic*** | Analyses the intention projected by a sign |
| ***Syntactic*** | Defines the rules for using the various signs. These include the categories of information to be addressed, the organisational layout of such signs on the diagram, relationship between signs and the target audience | ***Social*** | Addresses the social obligation in terms of acceptable norms that should be perceived from the interpretation of such signs |

*Table 1-Properties of Notational Symbols (Jaffar 2003)*

Collectively, *physic* and *empiric* are influenced by *syntactic* in order to project the *pragmatic* from the implied *semantic*, which in turn inflicts how an interpreter responds to their sign interpretation

(*social*). When aggregated together, an interpreter processes each division simultaneously during interpretation.

# 4 PROPOSING SEMIOTICS NOTATION PRINCIPLES FOR BPM

Critical appraisal on all of the above suggested various areas that require considerations when modelling business processes. As a result, this investigation proposes an amalgamated new set of theoretical principles comprising of **Suitable Notation**, **Presentation Layout** and **Effective Communication** for BPM (see Table 2). The **Theories** column associates existing semiotics principles as advocated by Peirce and Stamper. **Proposed Principles** classified existing theories to the proposed principles and the **Requirements** defines guidelines in applying the proposed principles.

| *Semiotics Theories* | *Proposed Principles* | *Principle Application Guidelines* |
|---|---|---|
| ***Human Sensory Experiences*** | ***Effective Communication & Suitable Notations*** | • Influencing individual stimuli with minimal symbols<br>• Organising stimuli into meaningful grouping |
| ***Minimising Information Search*** | ***Effective Communication*** | • Facilitating computational efficiency<br>• Effective knowledge understanding and reasoning |
| ***Diagrammatic Representation*** | ***Presentation Layout & Suitable Notations*** | • Ease diagrammatic reasoning to facilitate ease of perception and reasoning<br>• Simplifying diagrammatic decomposition<br>• Layout optimisation by positioning notations effectively |
| ***Physic*** | ***Suitable Notations*** | • Notational symbols must be intuitively simple |
| ***Empiric*** | | • Minimise level of abstractness; least abstract the better |
| ***Syntactic*** | ***Suitable Notations & Presentation Layout*** | • Group related information together<br>• Optimise layout to inflict better representational meaning<br>• Simplify expression of symbolic meaning |
| ***Semantic*** | ***Suitable Notations & Effective Communication*** | • Highlight intuitive meaning that is common |
| ***Pragmatic*** | | • Project intention easily |
| ***Social*** | | • Easy to inflict social obligation upon interpretation |

*Table2- Associating existing theories to the proposed BPM principles*

### 4.1 The Principle of Suitable Notation

**The principle**: Emphasised that different types of *symbolic notation must be minimal*, *graphically recognisable* and *visually less abstract* to all stakeholders. In addition, each notation must be *intuitively meaningful* in its individual as well as collective representation and easy for stakeholders to grasp the concepts that these notations are intended to prescribe.

Based on the adapted organisational semiotics framework, the choice of notations will address the socio-technical needs of all process stakeholders. The purpose is to minimise the learning curve and reduce the difficulties of appreciating new knowledge in representing process elements. Simultaneously, these notations must reduce the possible memory constraints in absorbing and storing the arbitrarily assigned meaning for such notations. *Similar basic symbols with different contextual meanings must be avoided*. The minimal number of symbols will facilitate the limited sensory systems to focus more effectively on deducing a given process knowledge. As far as possible, the shape of the notations must adhere to the principle of *Firstness*, closely associating to hypoiconicity rather than the highest level of symbolically abstract sign. The contention is to simplify stakeholders' cognitive inference making by facilitating qualitative reasoning with least abstract intuitive meaning, instead of straining them. Upon seeing a notation, interpreter is familiar with its meaning to deduce its projected intention and obliged with acceptable norm/s.

### 4.2 The Principle of Presentation Layout

**The principle**: Emphasised the *effective positioning* and *grouping of notations* facilitate clear and concise representation. It should *highlight logical flow* of process activities within and between different organisational sub-units (departments or sections within functional areas) and the various agents/roles performing these process activities.

The contention is to provide meaningful information by optimising the presentation space or layout within the model. The aim is to avoid cluttering of massive amounts of information together. Such decomposition will segregate specific information to be observed from different perspectives as well as "drill-down" to different level of abstractions, addressing activity multiple states or business rules that constrain its execution. Focusing on logical flows also highlight the interactions between the various activities and the associated roles. This 'process roadmap' can only increase interactions and productive negotiation between these roles. The purpose is to achieve cognitive knowledge on *what a process does*, the intuitive and tacit knowledge on *how the process works* or possibly does not work and also why a process operates as it does (Katzenstein & Lerch, 2000). The latter reveals the causal relationship between process entities, which will inflict greater understanding of the process complexity. As such, these considerations expand the model's content to include issues concerning the *logistic aspects* such as time and cost, the *psychological aspects* such as motivations and frustrations as well as sociological aspects in terms of relationships and conflicts (Katzenstein & Lerch, 2000). On the contrary, the logical sequences, constrained by conditional rules, can be used to highlight the execution timing for each activity within a process.

### 4.3 The Principle of Effective Communication

**The principle**: Emphasised factoring stakeholders' *limited sensory systems* through *optimising simple and very familiar graphical symbols* for representing process elements. Simultaneously, is to *contrast these stimuli* against pleasant background and placing them into meaningful groups.

The intention is to direct their specific attention to pleasant stimuli by increasing *computation efficiency* in interpreting process model through minimising o*ntological drift* across different *semantic communities*. Advocating such common symbols without changing their original intended semantics and usage would optimise stakeholders' previous experiences. Such stimulus will affect stakeholders' perceptions instantaneously. They will influence how these perceptions can be processed, understood and interpreted accurately by a given representation. The aim in contrasting different stimuli is to minimise the amount and effect of information searching within stakeholders' memory. Optimising such cognitive responses will only improve reasoning and manipulating of information by the individual stakeholder.

## 5 EVALUATING THE PROPOSED PRINCIPLES

NPC, RAD and IDEF sets of notations (see Figure 2) were used to model an Inter-Library Loan business process. Comparative analysis of these models against the proposed semiotics notation principles provided the qualitative evidence in substantiating the validity of the proposal. In addition, quantitative analysis was also used to measure the notion of sign complexity based on two measurement principles that compliment each other. Firstly, the ***least number of signs*** used in a representation is considered to be better or less complex and secondly, the ***least weighted value*** for measuring abstract signs in a representation is also considered to be better or less complex. The weight is logically assigned with hierarchical value that will reflect level of abstractness for each classification. With reference to Table 3, value 3.0 being least abstract is assigned to *Image* classification, with an incremental value of 0.3 for each respective classification within *Icon.* Another

value, for instance 6.0 is assigned to *Natural language* and so on within *Symbol*. The following sections discuss the findings of this evaluation.

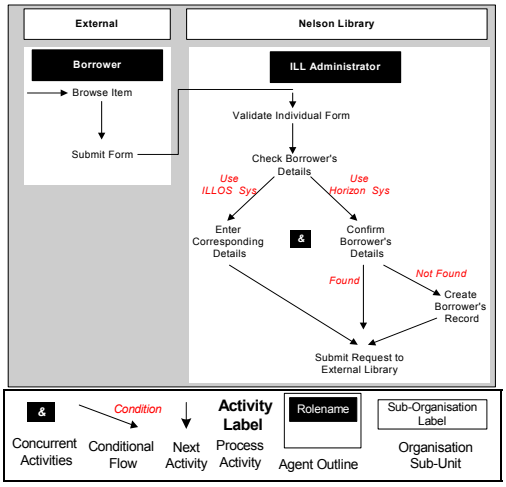



*Figure 2a - Inter-Library Loan Using NPC*

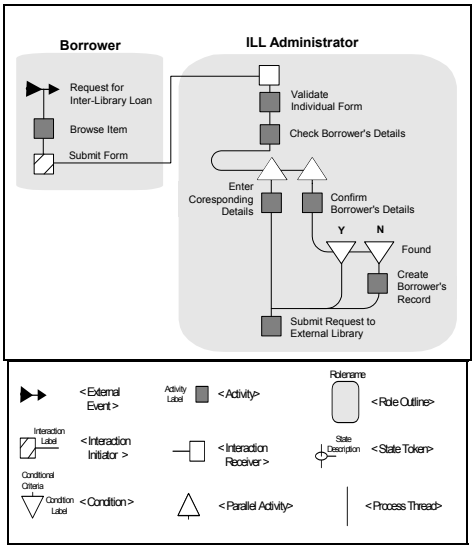



*Figure 2b - Inter-Library Loan Using RAD*

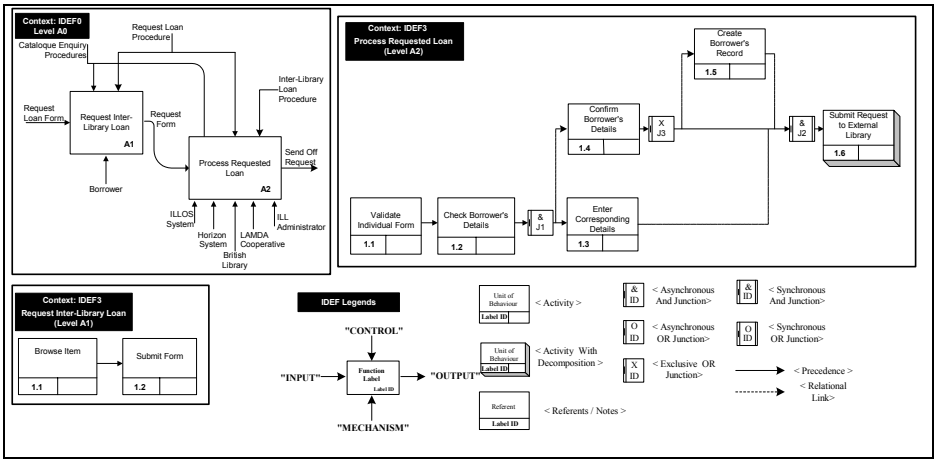



*Figure 3c - Inter-Library Loan Using IDEF*

## 5.1 Evaluating principle of suitable notations

The main issue is to emphasise intuitively meaningful symbols which are least abstract yet graphically recognisable in representing processes. Numerical calculation in Table 3 is based on *No. of Signs* (column Indv. No. of Signs) multiplied by the *Weight* value (Metaphor = 3.6) for each classification. In addressing the ***physic*** and ***empiric*** properties of Symbols based on *semiotics classification of signs* (Jaffar, 2003), based on the legends, Table 3 showed that not only does NPC use the least number of individual symbols but these symbols are also less abstract as compared to others. The arrows depicted least abstract metaphorically iconic symbol of indicating a direction as compared to the arbitrarily assigned symbolic notations such as natural language and the geometrical shapes of notations. Unlike others, RAD uses a line depicting process thread to highlight flow and sequence of activities. NPC and IDEF use arrows to determine logical flow of process activities. NPC uses merely natural language active verb phrases to project activity physical action. Others incorporate natural language within geometrical symbols of square or different types of rectangles to imply activity constrained by other

specific process technical conditions. NPC geometric notations are visually simple and commonly used as compared to RAD and IDEF.

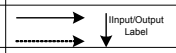
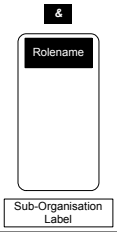
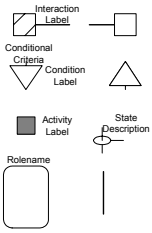
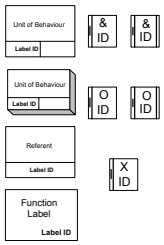
| Classification Of Signs | Types of Notations | | | Indv. No. Of Signs | | | Indv. Weight | | | Total No. of Signs | | | Total Weight | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NPC (N) | RAD (R) | IDEF (I) | N | R | I | N | R | I | N | R | I | N | R | I |
| Image (Weight = 3.0) | | | | | | | | | | | | | | | |
| Diagram (Weight = 3.3) | | | | | | | | | | | | | | | |
| Metaphor (Weight = 3.6) |  |  |  | 2 | 1 | 3 | 7 | 4 | 11 | 10 | 1 | 25 | 36 | 4 | 90 |
| Natural Language (Weight = 6.0) | Activity Label | Note: RAD activity label is attached to its greyed square box | Note: IDEF activity label is within its processes (rectangular box) | 1 | | | 6 | | | 8 | | | 48 | | |
| Notations (Weight = 6.3) |  |  |  | 3 | 8 | 9 | 18 | 50 | 57 | 5 | 29 | 13 | 32 | 183 | 82 |
| Mathematical (Weight = 6.6) | | | | | | | | | | | | | | | |
| Accumulated Results | | | | 6 | 9 | 12 | 32 | 54 | 68 | 23 | 30 | 38 | 116 | 187 | 172 |
| Least No. Of Signs | | | | ★ | | | | | | ★ | | | | | |
| Least Abstract | | | | | | | ★ | | | | | | ★ | | |

*Table 3. - Comparison Matrix Based on Semiotics Classification of Signs (Jaffar, 2003)*

In comparing Figure 3, the ***syntactic*** property renders RAD as confusing in deducing process logical flow to the uninitiated. Applying the norm of reading (as in English language) from top to bottom and left to right leads to complication at activity flow prior to "*Enter Corresponding Details*" as well as "*Submit Request to External Library*" (Figure 3a). In contrast, NPC (Figure 3b) with its directional arrows forces a reader the obligation of doing both entering and confirming details prior to submitting a request. While IDEF also uses arrows, evaluations on its physic and empiric properties are more complex than NPC. In Figure 3b, NPC maintains a better readability with explicit graphical visualisation that minimises ambiguity and abstraction in concept representations as compared to RAD (Figure 3a).

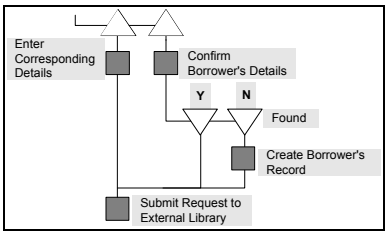



*Figure 3a - Misleading Representation*

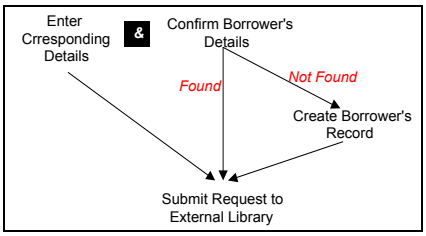



*Figure 3b - Definitive Representation*

***Semantically***, arrows in NPC and IDEF are indicative of its intention and expected obligation on an interpreter's part. However, its absence in RAD complicates representation without intuitively indicating which activity preceded the other. The arrows (bold and broken lines) in IDEF and triangular shapes (upright and upturn) in RAD, uses similar basic symbol but with different contextual meanings. While RAD upright triangle infers activities performed in parallel and the upturn triangle connotes branching due to a decision, their semantic representations arbitrarily inferred specific intent, which is far from acceptably common. Similarly, IDEF geometric symbols are neither intuitive nor comprehensive enough to infer a direct connotation to anything common in reality. NPC physical shapes are visually less complicated and graphically recognisable than others. While two of its notations fair no better than RAD and IDEF, its ampersand symbol adopts similar convention that

suggest association or relation of one to another. It implies the grammatical conjunction "and" in most of the natural languages. In contrast, IDEF usage of ampersand is more complex with the inclusion of various vertical lines within a square. In other instances, the letter "X" or "O" replaces the ampersand symbol implying an exclusive and alternative process branching, respectively. NPC is designed to reduce transformation rule (Stamper 1973) by retaining the meaning of symbols as they are commonly used. Hence, increase immediate comprehension of meaning leading to better and accurate interpretation of a representation.

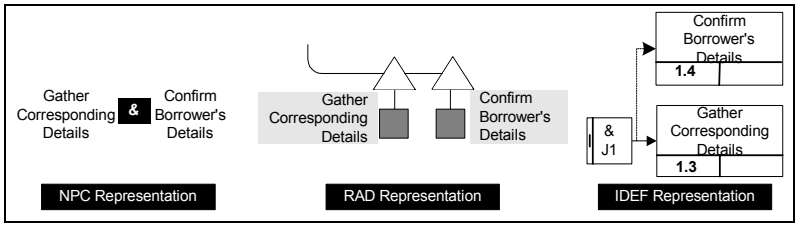



*Figure 4 - Comparing Conceptual Representation for Pragmatic Consideration*

In terms of collective representation (see Figure 4), NPC adhered to the ***pragmatic*** property more intuitively than others. "*Gather Corresponding Details*" and "*Confirm borrower's details*" cannot get simpler and clearer in its projection of its intended meaning. While in RAD such intention is cluttered with unnecessary symbols that do not add-value to its interpreter, IDEF cluttered all its representations with format layout and identifier to uniquely segregate one from the other. NPC optimises the use of existing common knowledge and shared assumption from the English language. In addition, NPC uses of conditional arrow with its variable value (see Figure 3b) provided additional information on the cause for process branching. Such application of pragmatic principle is absence in IDEF and vaguely addressed in RAD (see Figure 3a).

Within the ***social*** principle, RAD thread line does not implicate the same level of social obligation as in the use of metaphoric directional arrows. IDEF and NPC use of arrows enforce a definitive move towards a specific path that an interpreter is obliged to follow. RAD thread line implicates neither its starting nor ending point explicitly. Likewise with NPC conditional arrow as compared to RAD upturn triangle in conveying divergence of process flows. Similar effect can be expected of NPC ampersand symbol as discussed above.

### 5.2 Evaluating principle of presentation layout

In terms of the model structural layout, NPC and RAD group representations of activities performed by a role within the agent's boundary. These representations are integrated together within a single diagram. IDEF suites divide its models into 10 different separate diagrams for multiple purposes. Though IDEF may avoid information cluttering, NPC and RAD provided a single perspective without any loss of information. With reference to Figure 2c, IDEF presentation is visually more abstract, less appealing and not influencing cognitive stimuli. In addition, while RAD and NPC model incorporate roles performing processes, IDEF merely highlights the roles involved at a higher level of abstraction (in IDEF0) without describing which role explicitly performs the activities involved (in IDEF3). Unlike RAD and IDEF, NPC elevates the level of information further by grouping the modelled roles within their sub-organisations (departments). This facilitates an immediate focus onto a specific sub-unit or even a role within that sub-unit. NPC optimises cognitive knowledge by expanding the model's content to include not only the logical aspect of a business process, but also its psychological as well as sociological aspects.

While NPC maintains its directional arrow as activity sequence as well as interaction between activities, roles and sub-units (See Figure 2a), which are absent in RAD and IDEF. In the case of RAD, its representation for *Interaction* uses two additional notational symbols of an interaction

initiator and an interaction receiver (see Figure 2b). Additional symbols leads increase in the modelling complexity by introducing negative stimuli and congesting the limited sensory system with unnecessary representation. Similarly, IDEF introduces different additional symbols to provide in-depth process knowledge. Details such Exclusive OR ("X") segregated from its OR condition ("O"), identifier to all of its activities, activity synchronous and asynchronous may be necessary in modelling manufacturing process flows but such information is overwhelming when modelling business processes.

### 5.3 Evaluating principle of effective communication

Collectively, effective communication is directly influenced by the previous two principles. While suitable notations acted as the vocabularies of BPM representational language, presentational layout emphasises the language grammatical constructs. Analysis of the above two categories, clearly substantiated NPC capabilities in facilitating effective communication in BPM representations. With its minimal number of readily recognisable individual symbols that retained their originally common assigned meanings, NPC set of notations accommodate the human limited sensory system. Optimising familiar symbols from past experiences, NPC inflicts pleasant stimuli by organising its representation into a meaningful grouping backed by pleasant contrasting shades is its background. Such features ease interpreters' ability to cognitively focus their attention to intensely influence their perception of the representation effectively. The larger number of notations with uncommon arbitrarily assigned meaning and complicated syntactical rules by RAD and IDEF, lead to an overflow of the interpreter's limit sensory system. This will have adverse negative effect to the cognitive perceptual stimuli and hence, effectiveness in communication.

NPC presentation layout minimises information search by addressing not only the process's logical aspects but also psychological and sociological as well. These are catalysts to process knowledge computational efficiency by avoiding possible ontological drift due to misinterpretation among the different semantics communities (see Figure 4). Hence, NPC improve interpreter's cognitive responses facilitating their perceptions, reasoning and manipulating of information leading to rapid inference making and accurate interpretation and appreciation of the model.

## CONCLUSION

The absence of theoretical principles, governing the choice and application of notations for BPM, has been addressed with the proposal of semiotics notation principles which were comparatively evaluated against 3 sets of notations The introduction of NPC set of notations (which were developed based on the proposed set of principles) and its significant preferences against RAD and IDEF provided further evidence of the effectiveness of the proposed principles. The results showed that representational constraints preventing effective communication of process knowledge can be significantly reduced (if not eradicated). The findings overwhelmingly points toward simplicity, intuitiveness, and minimal representations which may sound trivial. However, the objective of ensuring accurate interpretation of signs leading to effective business process knowledge is distinctively more important than technically sophisticated models. Hence, inclusion of such a theoretical foundation promises to increase scientifically the value of BPM techniques.

Further investigation is necessary to validate the proposed theoretical principles. Similarly, Peirce use of operators in evaluating logic could be incorporated in comparing process notations. This might validate further the proposed principles. In contrast, while certain UML diagrams model business process, another initiative by Business Process Management Initiative (BPMI.org) has introduced a BPM set of notations, hailed to be the industrial standard that complies with US based Federal Information Processing Standards (FIPS). Comparing such industrial standards against the proposed principles can only improve the robustness of this semiotics notation principle.

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