An Autopoietic View of the Concept 'Information System'

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Abstract: The system-theoretic concepts of autopoiesis, as a theory of living systems, are used to develop a metamodel for enterprise information systems. At the core of this model are two fundamental conceptual constructs. The first one is the "negotiated meaning" associated with each thing in the enterprise's cognitive domains. The second one is the concept of "situation" which "encapsulates" the data/information and behavioral aspects of the constituents of the enterprise universe of discourse together with the communicative processes needed to continuously conceptualize, maintain, and re-conceptualize them. In this model, enterprise information system is viewed as the realization of the enterprise's autopoieticity in the semiotic situational space. The dynamics of such system is represented through a modified version of an event-driven rule (WHEN…IF…THEN….ELSE). Some of the implications of this approach are discussed in this paper.

1. INTRODUCTION

An Enterprise Information System (EIS) phenomenon is a volatile one. This is because it is, by its very nature, an **"interference phenomenon"** that results from the superimposition of several waves, e.g., business waves, technology waves… Such volatility has revealed in the last few decades in several paradigm shifts in its conceptualization, i.e., function, data, and object-oriented paradigms, and consequently in the debate of what is the

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basic building block of what so called "Enterprise Information System", i.e., process, data entity/process and object.

Behind these paradigm shifts is the motivation of creating flexible and adaptable IS architecture that is capable to respond to the ever-changing business needs and user requirements. This motivation is usually expressed in different terms such as maintainability and re-usability. However, all of the methodologies based on these paradigms start its conceptualization/modeling process by assuming "snapshot", or "frozen" set of business/user requirements. Therefore, they neglect the dynamic processes needed to re-conceptualize/re-model the constituents of the ever-changing enterprise's universe of discourse. The result is a rigid information system architecture that is poorly coupled to its environment.

Therefore, in order to build an evolving and self-organizing information system, such architecture need not to have a fixed structure built solely by the designer but an evolving internal structure that can be congruently responds to environmental perturbations, i.e., structurally coupled to environment but at the same time "**conserves**" the "**very nature**" of an enterprise. Moreover, the building block of such architecture has to include in an explicit and organic manner the processes needed for re-conceptualizing the constituents of the universe of discourse. The characterization of such architecture as "*self-organizing*" one reflects its ability to re-configure its components structure in response to unexpected and contingent environmental changes (perturbations). The characterization of it as "*evolving*" one has two implications. The first one is the necessity of building-in "*learning mechanisms*". The second implication is the adoption of an "*open system architecture*" design philosophy.

In order to develop such architecture one needs a conceptual framework that:

i. provides common basis for modeling both an enterprise and its information system.
ii. provides a conceptual ground for structurally coupled information system architecture with the enterprise's environment. In other words, this architecture has to take into consideration "**second-order dynamics**" beside "**first-order dynamics**" that already taken care of by the conventional system development [17].

To this end, the main objective of this paper is to introduce the concept of "**situation**" as a building block for enterprise information system architecture. Such concept "encapsulates" the data and behavioral aspects of the constituents of the enterprise universe of discourse together with the communicative processes needed to continuously conceptualize, maintain, and re-conceptualize them.

In order to attain this objective the **autopoietic theory**, as a general form of system building using self-referential closure, is used as potential system-theoretic framework for self-organizing and evolving information system architecture.

In section **2**, the fundamental concepts of the theory of autopoiesis, as a theory of living systems, is introduced. In section **3**, the Luhmann's extension of the theory of autopoiesis, together with Winograd, Flora and Morgan views, have been used as a paradigm for a conceptual framework for modeling an enterprise and its information system as autopoietic systems. The case study provided in section **4** shows how this framework could be used. The paper is concluded in section **5** by discussing some of the implications of this approach together with suggestions for further researches.

2. AUTOPOIESIS SYSTEM-THEORETIC FUNDAMENTALS

2.1 Autopoiesis

In order to find what is the distinguishing feature of living (biological) systems, Maturana and Varela [10] coined the word **autopoiesis** (αυτοσ = self, ποιεσιν = creation, production) to describe this feature. In fact, the meaning of this word coveys the very nature of living systems as systems that maintain their identity through their own operations of continuous self-renewal. Moreover, these systems could only be characterized with *reference to themselves* and whatever takes place in them, takes place as necessarily and constitutively determined in relation to themselves.

One of the key concepts of autopoiesis, as a theory of biological living systems, is the distinction between *organization* and *structure*. On one hand, ***organization*** is the capability of a system to re-produce its identity by referring constantly to itself, through the alternate re-production of its components together with the component-producing processes, i.e., the capability of a recursive self-reproduction. In other words, organization is nothing more than *the mode of operation that maintains system unity* [10]. On the other hand, ***structure*** is the realization of a system's organization through the presence and interplay of its components in a specific realization space. In other words, organization provides the formal context within which components, of whatever kind, can interact and still maintain the system's unity, thus it specifies the limits within which structural changes may occur while system unity is preserved. An actual system requires, for its actualization, the unification of both of organization and structure. While **organization** is necessary to establish system unity, **structure** is necessary

because different spaces of its actualization impose different constraints on system's components [10]. By analogy, an algorithm for solving certain problem can be viewed as a description of the system's organization whereas the corresponding computer program can be viewed as the realization of this organization (structure) in a certain space (programming language).

In summary, autopoiesis; from dynamic point of view, is the process of maintenance and self-renewal of a systemic whole and, from static point of view; it is a kind of system **organization** which can be manifested, in principle, in indefinite number of different system **structures** but cannot be identified with any one of them.

2.2. Autopoietic Systems

An autopoietic system is defined by Maturana and Varela as "*a network of processes of production, transformation and destruction of components. These components constitute the system as a distinct unity in the space of its actualization and they continuously regenerate and realize, through their interactions and transformations, the network of processes that produce them.*" [10, p.135]

Among the distinct characteristics of the autopoietic systems, the most relevant ones are:

- **Autopoietic organization (autopoieticity)**, the capacity of autopoietic systems to *establish* and *maintain* their *unity* by means of their own autonomous processes (*autonomy*);
- **Invariance of autopoieticity**, since autopoieticity is the essential and defining characteristic of an autopoietic system, anything to change this would result in its destruction.
- **The simultaneous openness and closure**, Autopoietic systems are **open** with respect to structural interaction with the environment, i.e. *structural openness*, which is unavoidable consequence of the fact that system elements must satisfy the particular requirements of the physical (or conceptual) domain in which they occur, while they are **closed** with respect to their own organization, i.e. *organizational closure*. The recognition of *the simultaneous openness and closure* of autopoietic systems is in opposition to the tradition for which a system is one or the other but not both. This interpretation is possible only on the basis of a clear *distinction between organization and structure* [2].
- **Structural determination**, In spite of its structural openess, the behavior of autopoietic system is constrained by its structure rather than by direct influence of its environment, i.e., **structural determination principle**. The environmental perturbations could

trigger the system's structural changes but can never determine or direct these changes. In fact, the interaction between autopoietic system and its environment is an ongoing process of recurrent mutually congruent structural changes in both system and its environment, i.e., **structural coupling**. Such structural coupling has connotations of coordination and co-evolution.

3. AN ENTERPRISE AS AUTPOIETIC SYSTEM

3.1. Autopoietic Perspective of Enterprises

Enterprises such as companies and public administrations, and consequently their information processing machinery, are by their very nature, social systems. Moreover, "a*ny cohesive social institution is an autopoietic system, because it survives; its method of survival answers the autopoietic criteria and it may well change its entire appearance and its apparent purpose in process"* [10].

Metaphorically, an enterprise can be compared with the biological cell which *"is a complex production system, producing and synthesizing macromolecules of proteins, lipids, and enzymes, among others; it consists of about 10^5 macromolecules on the average. The entire macromolecular population of a given cell is renewed about 10^4 times during its lifetime. Through their staggering turnover of matter, the cell maintains its distinctiveness, coherence, and relative autonomy."* [22] Ontologically, *"an organization is a network of intersubjectively shared meanings that are sustained through the development and use of a common language and everyday social interactions."* [3]. Moreover, Winograd and Flora have viewed of enterprise as ***constituted from networks of recurrent conversations*** that are activated whenever it encounters requests and other external contingencies [20].

However, in order to extend the theory of autopoiesis beyond the realm of biological living systems one has to transcend the physical space of biological living systems into other conceptual spaces that can also meet its requirements. Among of these requirements is the homogeneity of processes and components of the autopoietic system, i.e. its processes and its components must belong to the same physical or conceptual space. To this end, Luhmann uses the formal aspects of the theory of autopoiesis to redefine autopoiesis as *"a general form of system building using self-*

referential closure." [7, p. 2] Based on this (re-) definition, distinction bas been made between two different modes of autopoiesis' realization, namely, life and meaning. **Life** is the mode of **living biological systems**, and **meaning** is that of **meaning-used systems** such as individuals (psychic systems) and societies. Meaning-used systems are further differentiated according whether they use **consciousness** or **communication** as a mode of meaning-based reproduction [7, 8]. Figure (1) shows the classification of systems according to this definition.

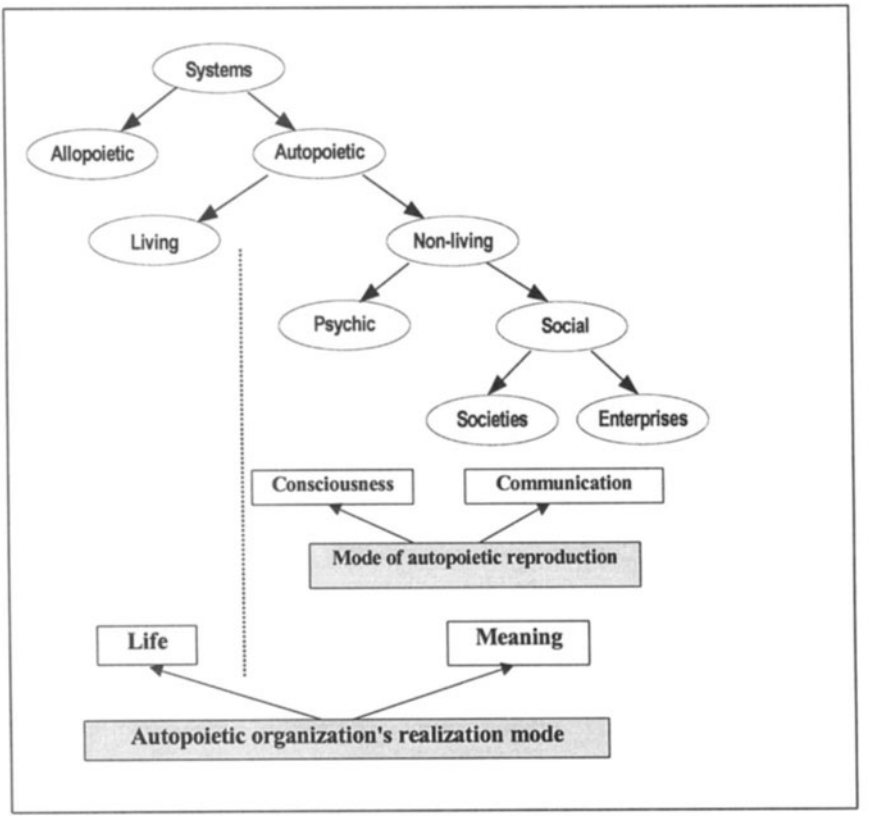

Figure (1): Autopoietic and Allopoietic Systems (revised from references 7 and 8)

According to Luhmann's theory, "*social systems uses communications as their particular mode of autopoietic reproduction. Their elements are communications which are recursively produced and reproduced by a network of communications and which cannot exist outside such network.*" [9] Such organizationally closed network of communication acts results in collective weltanschauung-context of meaning- that is continually sustained by further communicative acts. Moreover, this collective Weltanschauung,

includes among other things the system's self-description, defines the system's boundary (system' unity) in the symbolic social domain.

One of the implications of this view is the indispensable role played by meaning in establishing the system's unity. This is because its role in conjoining communicative acts. However, meaning is completely open self-referential structure that excludes nothing, even the negation of meanings. Therefore, meaning-based communication systems are both organizationally closed and structurally open [7]

3.2. An Autopoietic Model of Enterprise

In order to consolidate and formalize these perspectives and to develop a model for an enterprise and its information system as autopoietic systems, the following concepts are introduced. Examples from the case study of section **4** will be used to illustrate each concept.

Concept (1), Thing: A **thing** is the concept that is used to represent a concrete or abstract entity in an enterprise or in its environment toward which thought or action is directed or is communicated about by actors (concept 2) [13]. Enterprise's mission, objectives, policy, invoice, claim, driver, and accident are examples of the relevant things for an automobile insurance company. Each thing is characterized by its state and its behavior. The set of all relevant things is denoted by **O**.

However, the same thing may appear in different contexts, i.e., referential domains or relationships between it and other things. Hence, instead of dealing with *bare thing*, we have to deal with a **contexted thing**, i.e., a thing together with the context it appear in. A contexted thing can be represented as a pair $< o, c_o >$ where $o \in O$ and $c_o \in C_o$, and C_o is the set of contexts of the things. For example, a claim may appear in different contexts, i.e., in relation to a policy or in relation to accident type.

The set of all contexted things is denoted by **K**. In the autopoietic terminology, the set **K** together with the set of possible relationships between them represents the **enterprise's external cognitive domain** of an enterprise, i.e., "*the domain of all the interactions in which an autopoietic system can enter without loss of identity.*" [10, p. 119]. On the other hand, the set of all contexted things that represents the enterprise's self-image and self-consciousness (e.g., goals, the rules and relations guiding the entry of new components or the termination of component's membership, the rules guiding the associations, roles, functions and positions of enterprise's components, and rules guiding components transformations, i.e., training and organizational learning) is called **enterprise's internal cognitive domain**.

Concept (2), Actor (A): An **actor** is the concept of an active or responsive agent within an enterprise or its environment that is conceived as an ***executor*** of certain activities, a ***governor (decision maker)*** of their execution or as a ***provider/requester*** (***user***) of certain products/services. It could be human, individual or collective (e.g., manager, functional unit, enterprise, DBMS), or artifact (e.g., software component, IT-based system). In fact, an actor can be viewed as "a role that someone or something in the environment can play in relation to the business." [6]

In the case an automobile insurance company one can identify insurance agent, Claim Department and claim database as examples of the internal actors; and Police Department, Emergency clinics and Automobile Repair Shops as examples of the external actors.

Concept (3), Negotiated Meaning (NM): A **negotiated meaning** is the consensual interpretation (or shared point of view) which is constructed by at least two active actors in relation to the state, behavior of the constituents of the enterprise's cognitive domains or the relationship between them. In fact, this meaning is ever changing and has to be re-constructed de novo whenever a new context emerges or circumstance changes [21]. Therefore, networks of recurrent communication (conversation) are needed to establish and maintain the novelty of the enterprise's repository of negotiated meanings.

Figure (2) shows a simple model of the dynamic needed to construct negotiated meaning about a thing X in the enterprise cognitive domains. In this model, which is a modified version of the communication model between two human actors of Reference 5 [Fig. 3.5-1], the process of constructing negotiated meaning starts when each actor forms her/is conception of a thing X and utters its representation

$$R_0^{(j)}.$$

These initial representations serve as domains for the second iteration in which each actor interpret and represents her/is conception of the conception of the other actor, i.e.,

$$[a_j, R_k^{(i)}(X)] \rightarrow R_{k+1}^{(j)}(X)$$

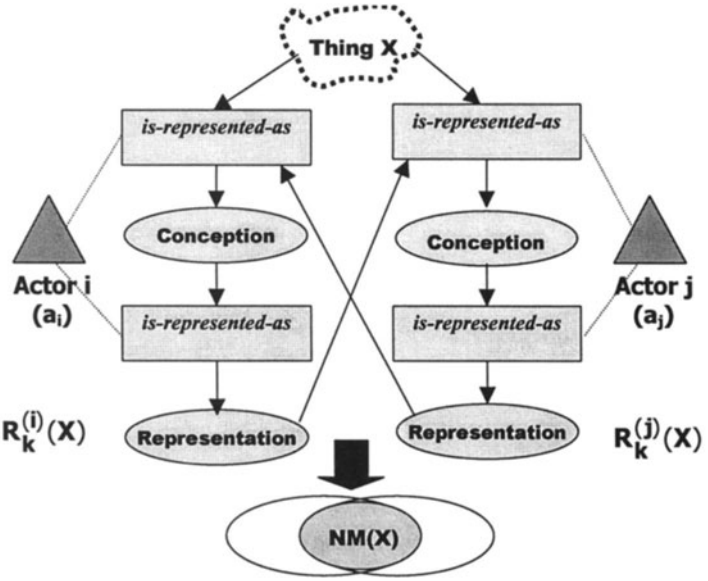

Figure (2): A simple model of the dynamic of constructing negotiated meaning about a thing X

This process will continue until both actors decide that the intersection between their representation can be considered as an agreed upon interpretation and representation of X, i.e.,

$$\mathbf{R_N^{(j)}(X) \cap R_N^{(k)}(X) = NM(X)}$$

The description of a negotiated meaning about a thing in the enterprise's cognitive domains is composed of two elements. The first element is the description of the data/information aspects of the thing. This element includes, for example, the thing's relevant properties, the applicable business rules and its context. The data/information content of a negotiated meaning can be represented in many different semiotic constructs and forms. It could be represented as a set of values of the thing properties, or as standard operating procedures, or as enterprise's data/object models, or any combination of them. The second element is the description of the communicative schema that is needed to construct and maintain it (see appendix A-1). Therefore, it can be represented as follows:

<Description of the thing's data/information content, Description of the relevant communicative situation(s)>.

For example, conceptual data model of an enterprise can be viewed as a representation of the description of the data content of negotiated meaning about the things enterprise's cognitive domains. Moreover, this represent-

ation is the outcome of a negotiation process between system owners/users and system developers.

Each negotiated meaning can be actualized through many situations (concept 5) depending on its state.

The totality of all negotiated meanings at certain point of time is an instant of an enterprise agreed-upon (negotiated) reality. This negotiated reality forms an organizationally closed space in which an enterprise is identified as a distinct unity. For example, the procedures of providing certain service have to conform (refer) to enterprise's objectives, goals and mission. In turn, enterprise's objectives, goals and mission have to adapt (refer) to the changes in the nature of this service.

Concept (4), Action: An **action** is the concept of the piece of work performed by an actor, or collection of actors, in relation to certain contexted thing and induces a change in the state of enterprise' cognitive domains. This change could be addition of a new thing, removal an existing one, or modifying its state or its context.

Actions can be classified according to two criteria: the realization space; i.e., *physical space* and *semiotic space**, and the nature of their outcomes (Figure 3). Based on the first criteria actions can be classified into two main categories physical actions and semiotic actions. **Physical actions** are deeds performed by an actor, or collection of actors, by means of some material resources. The set of all possible physical actions is denoted by $\mathbf{T}_p$. On the other hand, **semiotic actions** are the actions that handle the semiotic constructs that represent the things in the enterprise's cognitive domain.

Based on the nature of outcome, actions can be further classified into two categories, **performative actions** and **communicative action. Performative physical actions (PPAs)** are those, which change the physical state of a concrete thing (e.g., location, dimension, quantity,). **Performative semiotic actions (PSAs)** are those that generate new semiotic constructs or modifying existing ones to reflect the changes in the enterprise's cognitive domains. On the other hand, **communicative semiotic actions (CSAs)** are the actions of exchanging semiotic constructs that represent things in the enterprise's cognitive domains between, at least, two actors, whereas **communicative physical actions (CPAs)** are the physical arrangement for realizing them. The set of all relevant semiotic actions is denoted by $\mathbf{T}_s$. The set of all actions is denoted by $\mathbf{T}$ ($=\mathbf{T}_p \cup \mathbf{T}_s$).

* The space that composed of all kinds of sign used by human being to communicate and to store their negotiated meanings

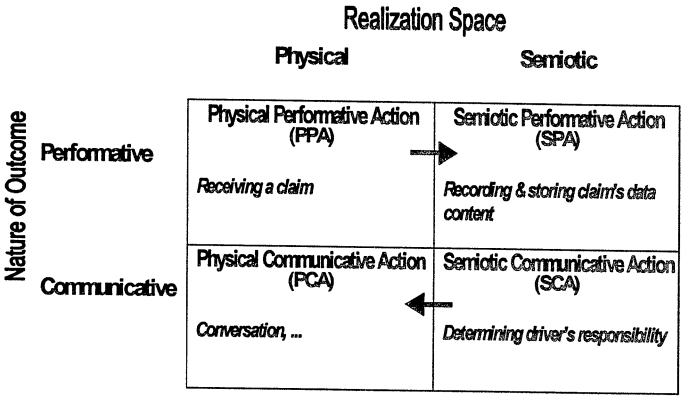

Figure (3): Types of actions

Concept (5), Situation: A **situation** is a dynamic construct composed of collection of actors that is configured and re-configured to actualize certain action. Situations can be classified according to the nature of the action they actualize. Therefore, one can distinguishes four types of situations: physical performative (**PP**), semiotic performative (**SP**), physical communicative (**PC**), and semiotic communicative (**SC**).

Configuring certain situation is based on whether there is a NM concerning the pertinent thing. **Performative situation** is the one that actualizes the existing NM concerning the pertinent thing. On the other hand, **communicative situation** is the one that has to be established to generate a new NM or to modify an existing one.

The set of all possible physical situations is denoted by Σ_p and the set of all possible semiotic situations is denoted by Σ_s. The union of these two sets is the **situational space** (Σ) in which the enterprise's autopoieticity can be realized in many different structures. In other words, an enterprise' structure is viewed as a configuration of situations which is continually re-constructed in response to environmental perturbations such as new market requirements.

A situation can be represented as follows (see table 1 and appendices A-2, A-3):

$$<\{NM(k_x), S\}, t_y, \{a_z\}, O>$$

where

$NM(k_x)$	is the associated negotiated meaning associated with a contexted thing in the enterprise's cognitive domains ($\in$ K);
S	the state of the negotiated meaning (e.g., complete, incomplete, to be modified,..)
t_y	is an action ($\in$ T);
a_z	is an actor ($\in$ A); and
O	is the outcome of the situation

Based on these concepts an enterprise can be modeled as a collection of interrelated and inseparable semiotic and physical situations. These situations are invoked by the events in the enterprise cognitive domains or by other situations. Many of the enterprise's situations can be a priory designed to respond to the expected environmental perturbations, i.e., **recurrent situations**. However, new situations can be promptly constructed to respond to unexpected environmental perturbations, i.e., **novel situations**. Such novel situations are characterized by their open set of actors, incomplete information about the relevant things and the proper action, and by the uncertain outcome.

Now the enterprise dynamics can be represented by the following event-driven rule:

WHEN <*occurrence of event in enterprise's cognitive domain (***K***) is identified*>
IF <there is NM concerning it exists>
THEN <configure the relevant performative situation>
INVOLVING <actors>
AFFECTING <thing(s)>
ELSE <configure relevant communicative situation>
INVOLVING <actors>
CONCERNING <thing(s)>

The WHEN part of the rule is compulsory and initiates the structure coupling mechanism between an enterprise and its environment. The precondition part (IF part) determines the kind of situation to be configured. The THEN part generally represents first-order dynamics of enterprise while the ELSE part represents its second-order dynamics.

3.3. An autopoietic model of information system

According to Pattee's semantic closure principle there is an autonomous closure (self-referent relation) between the physical (phenotypic) aspects and symbolic (genotypic) aspects of any autonomous, self-organizing and evolvable system [14, 15, 16]. In this context, it should be noted that for

natural symbols, one couldn't strictly separate their syntax from their semantics [18]. Therefore, there is irreducible complementarity between physical situations and semiotic ones which together realize the negotiated reality of an enterprise.

From autopoietic point of view, enterprise information system can be defined as **the totality of the possible semiotic situations that is configured and re-configured in response to perturbations (events) in the enterprise's cognitive domains**. Therefore, it can be represented by the following mapping:

$$\mathbf{EIS : \{events\} \rightarrow 2^{\Sigma_s}}$$

Based on the aforementioned general event-driven model of an enterprise, the dynamics of enterprise's information system can be represented by the following rule:

WHEN *<occurrence of event in enterprise's cognitive domain (**K**) is identified>*
  IF <there is NM concerning it exists>
  THEN <configure relevant performative semiotic situation>
    INVOLVING <actors>
    AFFECTING <thing(s)>
  ELSE <configure relevant communicative semiotic situation>
    INVOLVING <actors>
    CONCERNING <thing(s)>

One of the important consequences of the autopoietic approach to an enterprise and its information system is that the later is viewed as an "**interwoven**" system with enterprise system rather than viewing it as a "**subsystem**".

4. Case Study

4.1. Background

Grand Prix Automobile Insurance Company (GPAIC) is a small company that sells automobile insurance policies to licensed drivers in the Province of Quebec. The company headquarters are located in Montreal. The company employs about 150 people, most of which are insurance agents located at several different offices throughout the province. GPAIC was established in 1991, and has grown to about 50,000 policyholders today. Last years net profit was $875,000.

Mission
GPAIC is committed to provide value-added and high quality services to its customer, a level of financial security and performance which fully meet their needs, while at all times maintaining its financial strength.

Goals
- Customer focus professional people.
- Excellence in customer service through technology.
- Financial strength.

Objectives
- **Customer**: Maximize the value to GPAIC's customers by providing superior quality services.
- **Growth**: Grow revenue and assets on profitable basis. Increase GPAIC's number of customers.
- **People**: Cultivate an environment with GPAIC's values, develops and retains high-quality people.

Structure
GPAIC does business in three primary locations; the Montreal headquarters, the Quebec city office, and the Sherbrooke office. The Montreal headquarters consist of Policy Department, the Claim Department, Information Services Department and insurance agents. The Quebec city office consists of the Legal Department and insurance agents. The Sherbrooke office consists of the Personnel Department, the Payroll Department and insurance agents.

GPAIC 's Activities
For the purpose of this example only one of its major activities will be discussed, namely, claim handling activity.

Claim mission
GPAIC is committed to amaze its customers with its claim settlement process, while reaching a fair and rapid settlement.

Claim Goal
Immediate initiation of claim settlement with minimal hand-offs and at fair cost.

Claim Procedures
Upon the reception of a claim, it is recorded and stored. Next, the matching policy is found and a determination is made as to whether the claim is covered by the provision (coverage) of the policy. If the claim is not covered, the claim is rejected, the claim status modified, and the policyholder notified of the claim rejection. If the claim is covered, the claim is checked for a minimum of two accompanying estimates. If the estimates are missing, a pending status is recorded for the claim and the policyholder

is notified to obtain the necessary estimates. If the estimates are included, the claim type is determined. If the claim involves a collision with another vehicle, a police accident report request is sent to the police department, and the status of the claim is modified. When the accident report is received, it is determined whether the policyholder was at fault (or charged) for the accident. If the policyholder was not charged or the accident did not involve a collision, a claim payment is generated and sent to the policyholder, and the claim is updated. If the policyholder was charged, a claim payment is still made as described above, but also; the policy is updated to reflect an increased rate for the next invoice.

4.2. GPAIC Conceptual Models

GPAIC cognitive domains

The GPAIC's internal cognitive domain includes things such as Mission statement, Goals/Objectives, Organizational structure, Functions, Policy application, Policy, Claim, Invoice, and Accident.

The GPAIC's external cognitive domain includes things such as Customer, Deriving record, Vehicle, Vehicle registration record, Police, Accident, Medical report, Expert witness evaluation report, Weather bureau report, and Repair shop report.

GPAIC Actors Set

Internal actors set includes, for example, GPAIC Management (**MG**), Policy Department (**PD**), Claim Department (**CD**), Information Services Department (**IS**), Legal Department (**LD**), Insurance Agent and Claim database.

External actors set includes, for example, Motor Vehicle Registration Agency (**MV**), Police Departments (**PL**), Automobile Repair Shops (**RS**), Emergency Clinics (**EC**), Weather Bureau (**WB**), Expert witness (**EW**)

Situations

Examples of the conceptual (analysis) situations that are needed to handle collision claims are listed in Table (1). A modified version of activity diagram (Situation Dependency Diagram) is used to depict the situations' dynamic (Figure (4)).

TABLE (1): Conceptual situations for collision's claim handling

	Name	Description ♣, ♥	Type ♦
[1]	Recording & Storing Claim	<(NM(Claim), Data Content), Record& Store, {CD, IS, X}, A new claim record>	SP
[2]	Determining Claim Coverage	<{(NM(Claim), Coverage amount?), (NM(Policy), Coverage)},Determine, {CD, PD, X}, Reject/Accept Decision>	SC
[3]	Checking the Estimates	<(NM(Claim), Accompanied estimates?), Check, {CD, X}, Processing/Pending Decision>	SC
[4]	Obtaining Accident Description	<(NM(Accident), Data Content?), Obtain, {CD, PL, EC, WB}, Request for the relevant reports>	SC
[5]	Determining Driver's Responsibility	<{(NM(Accident), Data Content), (NM(Driver), Responsibility?)}, Determine, {CD, LD}, Decision on driver's responsibility>	SC
[6]	Updating Claim's Status	<(NM(Claim), Data Content), Update, {CD, IS, X}, Updated claim's data content>	SP
[7]	Notifying the Customer	<(NM(Claim), Data Content), Send, {CD, Policyholder}, Notification to the customer>	(S/P)P
[8]	Generating the Claim Payment	<(NM(Claim), Data Content), Generate, {CD, MG}, Payment check>	(S/P)P
[9]	Updating Policy's Data Content	<{(NM(Policy), Data Content), (NM(Claim), DataContent)}, Update, {CD, PD, IS, X}, Updated policy data content}>	SP

♦ SC = Semiotic Communicative, SP = Semiotic Performative, (S/P)P = (Semiotic/Physical) Performative.

♣ ? means that there is no established NM or it is unknown

♥ X stands for any supporting artifact (e.g., claim database)

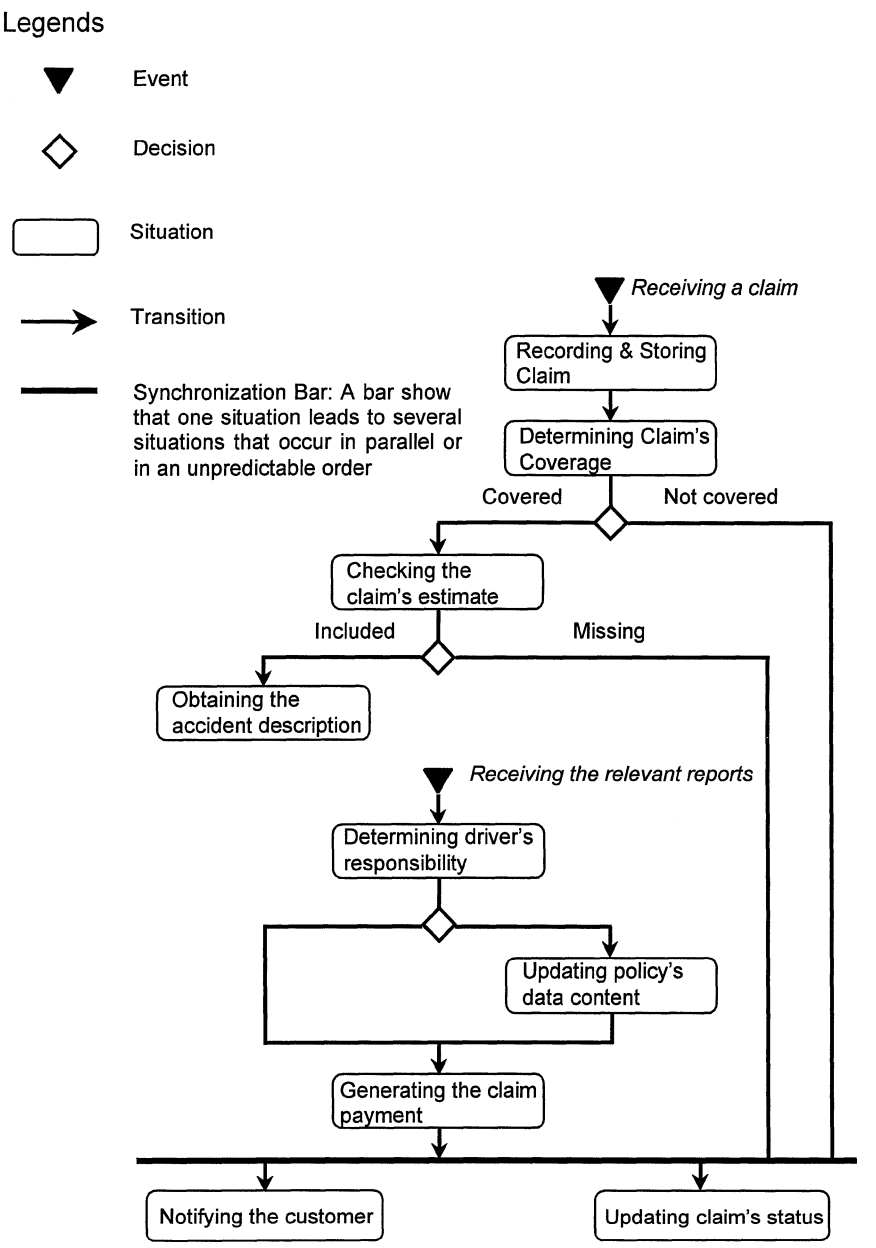

Figure (4): Situation Dependency Diagrams for collision claim handling

5. CONCLUSIONS

The model of enterprise information system that is discussed in the previous section has many implications on the conceptual and practical levels. On the conceptual level, there are five implications. **First** it represents explicitly the "**virtuality**" [12, 19] of information system as it conceptually separates between requests (demands or environmental perturbations), i.e., WHEN part, and their satisfiers (semiotic situations), i.e., IF...THEN...ELSE part. Thus it provides a perspective view to the EIS rather than the conventional descriptive one. **Second**, it emphasizes on the parallelism between the physical reality, i.e., enterprise's physical situation space, and the virtual reality, i.e., enterprise's semiotic situational space. Such explicit display of correspondence helps in narrowing the gap between software design and work design [4] by promoting the notion of "action-enabled-by-information" and by viewing the information system "**interwoven**" system with enterprise system rather than viewing it as a subsystem. **Third**, it introduces the concept of structural plasticity of information system by subordinating its structure to the function required and allowing the information system structure to be seen as an emergent order that is dynamic and constantly changing. **Fourth**, it presents a starting point for communication-based approach to information system conceptualization. Moreover, it shows the role of that communication in system self-organization, through construction and re-construction of the enterprise's negotiated reality. It also provides a conceptual construct, i.e., semiotic communicative situation, for establishing communication infrastructure. **Finally**, it calls for revisiting our existing information system development methods to accommodate the salient feature of autopoietic systems, namely, the simultaneous **organizational closure** of the enterprise negotiated reality and **structural openess** that is manifested in its situation space [1].

On the practical level, the conceptual (analysis) situations, which represent system's requirements, can be mapped into design situations. This mapping process can be accomplished through activities such as: deciding the proper representation of data/information content of the things in the enterprise's cognitive domains, describing the detailed steps of the associated action, and classifying the involved actors with respect to their role in completing the action (executor, governor, provider, requester) and with respect to their type (human, artifact). Once the mapping is completed, each design situation can serve as reusable and/or novel context for component-based application. Moreover, the design situation dependency diagrams can serve as architecture for Web-Based information system. In such architecture each design situation can be implemented as a thick

hyperdocument where its nodes can contain the logic and data that support the situation's action beside reference to other hyperdocuments (situations).

In conclusion the proposed metamodel views information system's architecture as an emergent and self-organizing structure that is constructed and re-constructed in accordance to the environmental perturbations and by the interactivity of its components, not as a priory constructed one. It also provides interdisciplinary and unifying approach to "information system phenomena". For instance, one of its core concepts, the concept of "negotiated meaning" and its actualization, are related to different disciplines such as management (e.g., organizational memory), artificial intelligence (e.g., ontology), and cognitive sciences (e.g., cognitive map). Moreover, communications, in its various forms (human-human, computer-computer, and human-computer), is treated as an organic component of the proposed model.

However, a number of topics deserve further research effort is needed to fully operationalize the proposed approach. One of these research topics is to construct and test a system development methodology based on an "inverted perspective", which views an enterprise from within, i.e., one which guarantees the simultaneous **organizational closure** of the enterprise negotiated reality and **structural openess** of its information system as realized in its situation space.

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Appendix A

A.1: Claim's Negotiated Meaning

NM(Claim)

Description of data/information content

Definition

A request by customer to pay expenses covered by a policy for a vehicle, policyholder, property, and/or other person.

Data Content

Claim Amount, Claim Date, Claim Description, Claim Number, Claim Payment Amount, Claim Payment Date, Claim Payment Explanation, Claim Rejection Reason, Claim Status (accepted, rejected, pended), Claim Type (collision, theft, windstorm, vandalism), Coverage Amount, Coverage Code, Coverage Description, Estimate Amount, Estimate Company Name, Estimate Description, Driver responsibility (responsible, not responsible).

Business Rules

- Involved parties contact should be made within twenty-four hours of the receipt of the claim by the Claim Department
- Any claim must include, at least, two estimates
- Any claim payment in excess of $10,000 must have GPAIC CEO' authority
- Any claim checks of $2,000 or more must have two signatures of authorized personnel

Context

Policy, Policyholder, Relevant accident reports

Description of Communication Schema

Actors involved in NM(Claim) construction and maintenance (*Type, Role(s), Location(s)*)

- GPAIC Management (human, governor/ decision maker, Montreal)
- Policy Department (human, information provider, Montreal)
- Claim Department (human, governor/ decision maker/requester, Montreal)
- Information Services Department (human/artifact, information services provider, Montreal)
- Legal Department (human, information provider, Quebec City)
- Police Departments (human, information provider, different locations)
- Automobile Repair Shops (human, information provider, different locations)
- Emergency Clinics (human, information provider, different locations)
- Weather Bureau (human, information provider, different locations)
- Expert Witnesses (human, information provider, different locations)

Types of Communication

- Local synchronous (e.g., face-to-face)
- Local asynchronous (e.g., retrieving data from a database)
- Distributed asynchronous (e.g., email)

Accepted Level of Consensus

To be determined in accordance to GPAIC' mission, goals, and objectives (organizational closure's constraint)

Invoking Condition(s)

- Deciding the data/information content elements.
- Updating data /information content.
- Creating a claim record.
- Formulating/modifying business rules

A.2

Situation's Name
Obtaining accident description
Invoking Condition(s)/Event(s)
Processing decision is made
Type
Semiotic communicative
Thing(s) Involved
Accident
Action
Send a request for information to the relevant bodies
Actors involved in the situation (Type, Role, Location)
- Claim Department (human, ***requester***, Montreal)
- Police Departments (human, information provider, different locations)
- Automobile Repair Shops (human, information provider, different locations)
- Emergency Clinics (human, information provider, different locations)
- Weather Bureau (human, information provider, different locations)
- Expert Witnesses (human, information provider, different locations)

Types of Communication
- Local synchronous (e.g., face-to-face)
- Local asynchronous (e.g., retrieving data from a database)
- Distributed asynchronous (e.g., email)

Outcome(s)
Several copies of the information request are sent to the relevant actors.
Related Situations
Pre: Checking claim's estimates
Post: Determining driver's responsibility

A.3

Situation's Name
Updating policy's data content
Invoking Condition(s)/Event(s)
Decision on the driver's responsibility is made
Type
Semiotic performative
Thing(s) Involved
Policy, Claim
Action
Update policy's data content
Actors involved in the situation (*Type, Role, Location*)
- Policy Department (human, information provider, Montreal)
- Claim Department (human, information provider, Montreal)
- Information Services Department (human/artifact, executer, Montreal)

Outcome(s)
Updated policy's data content
Related Situations
Pre: Determining driver's responsibility
Post: Generating the claim payment