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A Change Architecture for Enterprises: A Semiotic Model

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Abstract

Architectures for capturing the relationships between and within organisations and their sociotechnical systems represent a progression from a more or less high-level abstraction of the enterprise, through intermediate less-abstract layers, to an implementable design of the automated part of the system. These architectures which are critical to successful enterprise integration do provide a means for modelling enterprise concerns such as business policies, management policies, and user roles, and attempt through various transformations to reflect such entities and business rules in the developed system. Thus the architectures provide a useful, if static, transformation from a high-level abstraction of the enterprise to the engineering entities and processes of the developed system. However, the utilisation of such systems, in turn, effect and change the organisations of which they become a part, frequently in ways that cannot be anticipated beforehand. Architectures thus require, as an integral part of their design, the capability of representing how change at the level of the operational system effects and changes the high level abstraction that represents the enterprise. Conversely, changes at the enterprise level affect the operating system at the local level, again in ways that cannot be anticipated. Hence, a two level model is proposed that consists of a global level and a local level in which the global level is equivalent to the Enterprise. Such a two level model has analogies to biological systems and communication systems where feedback between the global and local levels and between the local and global is critical. The challenge of addressing this two way model of change to the modelling of enterprises and their systems is exemplified through telecommunications software. Two models are compared: the Open Distributed Processing model and a semiotic model of communications. In the ODP example the emphasis is on process at each level without feedback between the levels The semiotic approach to telecommunications software has demonstrated the need and has the potential to model the two way process between the model of the enterprise and the systems that support and change that model.

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1 OVERVIEW

Enterprise integration cannot be effective without models of Enterprises and architectures that incorporate change. The discussion of architectures and models of enterprises that incorporate change as an integral part of their design is illustrated from the domain of telecommunications and the newly emerging TINA distributed Architecture (Nilsson, Dupuy and Chapman, 1995). In this rapidly changing distributed environment, not only is the hardware changing, but in the open market, different vendors offer different services that have the potential to rapidly change the equilibrium of the system. Because such systems are no longer homogenous and centralised, one cannot assume that the direction of change is always mandated from the a point of a centralised control. A model of change is introduced that incorporates both local and global change and has foundations in both biological systems and systems that support communication . That model consists of a global level and a local level with feedback possible between the two levels, and in which the global level is equivalent to the Enterprise.

Taking the application of personal mobility services, two architectures are examined: the Open Distributed Processing (ODP) model (ISO/IEC, 1993) and the language based semiotic model (Halliday, 1978). In the ODP model the Enterprise viewpoint is equivalent to the global level and the remaining viewpoints to the local level. In the semiotic model, the contextual modelling of the Enterprise is equivalent to the global level and lower strata to the local level.

While both models have their strengths and weaknesses, the change model is more easily accommodated in the semiotic model because the connections between the global and local levels are modelled as a feedback loop whereas in the ODP model the links do not permit such feedback. Some hypotheses are made about the of topography of the changes expected in such systems.

2 DOMAIN

The examples chosen to illustrate the discussion are from the domain of telecommunications services. Telecommunications services are fielded in a rapidly changing distributed environment. The emerging TINA architecture has been designed to provide a distributed layered architecture that enables the service provider to develop self-contained modules that can be 'plugged into' the distributed network. The architectural model at its most abstract level describes the Enterprise (refer §4.1). In the telecommunications domain, the principles for describing the Enterprise and carrying that through into computational objects are generic and pertinent for Enterprise integration.

The distributed telecommunications environment has the following characteristics (Linington, 1995):

- (i) autonomy
- (ii) federated naming
- (iii) locally encapsulated states
- (iv) weak consistency

(v) concurrent execution
(vi) fault tolerance
(vii) remote information
(viii) migration
(ix) incremental change
(x) heterogeneity

Architectures that are responsive to the requirements of such distributed environments themselves need to be flexible and able to accommodate change.

3 A MODEL OF CHANGE

It is pertinent here to draw a parallel between such distributed heterogenous environments and the natural environments of biological systems. The application of the paradigm of biological processes to computational processes is already yielding results in a range of applications including learning as well as the simulation of natural processes (Langton, 1992). The natural environment of biological systems shows significant similarities to the distributed environment of telecommunications services in that it is:

(a) parallel
(b) distributed
(c) aggregative
(d) variant

The natural environment is also characterised by

(e) non-linear interaction
(f) non-equilibrium

As the work into feature interaction in the telecommunications environment has shown (Bouma and Velthuijsen, 1994), interaction between telecommunications services is also non-linear. Equilibrium is never absolute, but in common with biological systems (Langton, 1992) may consist of relatively 'long' periods of stasis "punctuated" irregularly by brief periods of rapid evolutionary change.

Change in biological systems occurs as a result of interacting components at the local level which affect and are affected periodically by change at the global level. The model is presented in figure 1.

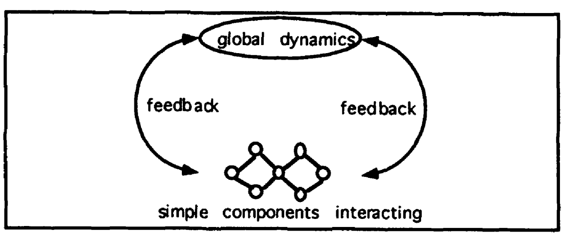

Figure 1 Change in Biological Systems.

The significant features of the model are that interaction takes place at two levels: the global dynamics and the level of interacting components which has been identified as the local dynamics. A feedback loop, or 'dialectic' links the two levels as represented by the arrows. Of interest is the nature of that exchange. A change at the level of the local dynamics does not necessarily feed back directly into a change in the stasis at the level of the global dynamics. When stasis is established at the global level it will persist for some period of time, essentially governing the context at the lower level, until some build up of events at the local level overthrows the global order (Langton, 1992). As will be argued, this model of change has similarities to the balance between the global situational context and the local situational context of the semiotic model of communication (refer §5).

4 ENTERPRISE MODELS AND ARCHITECTURES

The Telecommunications Information Networking Architecture (TINA) is an emerging definition of an open architecture for telecommunications services in the broadband, multi-media and information super-highway era (Nilsson, Dupuy and Chapman, 1995). One example of the services to be fielded through TINA is that of personal mobility services. Personal mobility services, as exemplified in Universal Personal Telecommunications (UPT) (CCITT, 1991), provide the user with selected telecommunication services irrespective of geographical location. The user is no longer indirectly identified by use of a particular terminal, for example, a specific phone number, but by a personal identifier - a network-transparent personal number called the UPT number. Further critiquing of the service has identified not only geographic mobility as important for UPT, but also mobility in time and media (Cross and O'Brien, 1992a).

Two models of personal mobility services will be examined. The first model applies the five ODP viewpoints to relate the abstraction of the Enterprise to the Computational and Engineering viewpoints (McLaughlin and Donnelly, 1995; Strick and Meinköhn, 1995). The Enterprise viewpoint (refer §4.1) of the ODP model is equivalent to the global level in the biological model of change. The second example uses a semiotic model of telecommunications services that is based on the premise that the functional role of a communication event depends on the situational context. It is the situational context that is equivalent to the global level in the biological model of change. The level of the communication event represents the fielded service. The situational context subsumes the concerns of the Enterprise in which the event occurs (Cross and O'Brien, 1994).

4.1 ODP Model - PRISM Project

Five ODP viewpoints have been delineated for specifying and designing distributed management systems:

1. Enterprise
2. Information
3. Computation
4. Engineering
5. Technology

In this discussion, the concern is primarily with the Enterprise viewpoint which is concerned with business policies, management policies and user roles with respect to the systems and the environment with which they interact. It is here that one attempts to describe, if not the global dynamics, at least the dynamics of a number of interacting organisations (Nilsson et al, 1995).

Choices and constraints made from the Enterprise viewpoint, influence the Information viewpoint. From the Information viewpoint the architecture provides a framework for describing what services do, how they are managed, and how terminal and user mobility is achieved.

From the Computational viewpoint, the service architecture describes how a distributed service should be structured in order to provide a service. The software components that serve as a foundation for all services are:

(i) user agents
(ii) terminal agents
(iii) service session
(iv) subscription manager
(v) communication service manager

The five ODP viewpoints represent different abstractions of the same situation, and therefore enable a separation of concerns. The majority of work has gone into the computational and engineering viewpoints, although the PRISM project (Pan-European Reference Configuration for Integrated Broadband Communications IBC Services Management) have attempted to unite the five viewpoints in the creation of new specifications for future broadband systems (McLaughlin and Donnelly, 1995).

The way in which the viewpoints are related and therefore interact is critical to the understanding and subsequent modelling of interacting distributed systems. As the focus here is on the interaction between the global dynamics and local interactions, one needs to examine models that attempt to incorporate all of the viewpoints, especially those that represent the more abstract and global constraints, viz. the Enterprise viewpoint.

The PRISM methodology uses a three stage architecture, consisting of a Service management reference Configuration (SMRC) Framework, an Abstract Architecture, and a Concrete Architecture. In the SMRC framework there are non-directional links between all of the viewpoints, the Enterprise, Information, Computational and Engineering viewpoints. The Enterprise viewpoint, for example, is linked to all three of the other viewpoints, namely, Information, Computational and Engineering, and similarly for the three other viewpoints. The Technical viewpoint is linked only to the Engineering viewpoint.

The policies and constraints of the interacting organisations represented in the Enterprise viewpoint are "reflected" in the Engineering viewpoint: "the organisational constraints have to be reflected in the distribution of the information and functionality in the reference configuration presented in the engineering viewpoint" (ibid. p.18).

The authors of the PRISM model recognise the "conceptual gap" between the Enterprise viewpoint modelling and the computational modelling (Wittman, Magedanz and Eckardt, 1995). The gap is perceived as a mismatch between the functional modelling of the Enterprise Viewpoint and the object oriented modelling of the Computational Viewpoint. Thus the conceptual gap exists because the Enterprise model does not use the ODP Enterprise language, but attempts to model the behaviour or usage of the system which does not readily match the object modelling of the Computational viewpoint. The solution presented by the authors is that the management functions of the Enterprise viewpoint can be modelled as an ODP activity which is itself composed of actions. The relationship is described as "a natural correspondence between a Management Function (MF) that changes something in the system and an ODP activity which is composed of actions i.e. something that happens in the system" (Wittman, Magedanz and Eckardt, 1995, p.83). The interaction is captured in figure 2 (after Wittman, Magedanz and Eckardt, 1995, p.83).

The type of relation between the Viewpoints is described as one of 'correspondence': "the triggering of a MF corresponds with an operation invocation of an activity's head action". However, certain inferences may be drawn. Firstly, that the modelling is based on the functional aspects of the system, put simply, what happens. Secondly, that the direction of the relation is from the Enterprise to the Computational Viewpoint. One should also note that the Information

Model that specifies the information objects used in the Management Service provides input to the Computational model.

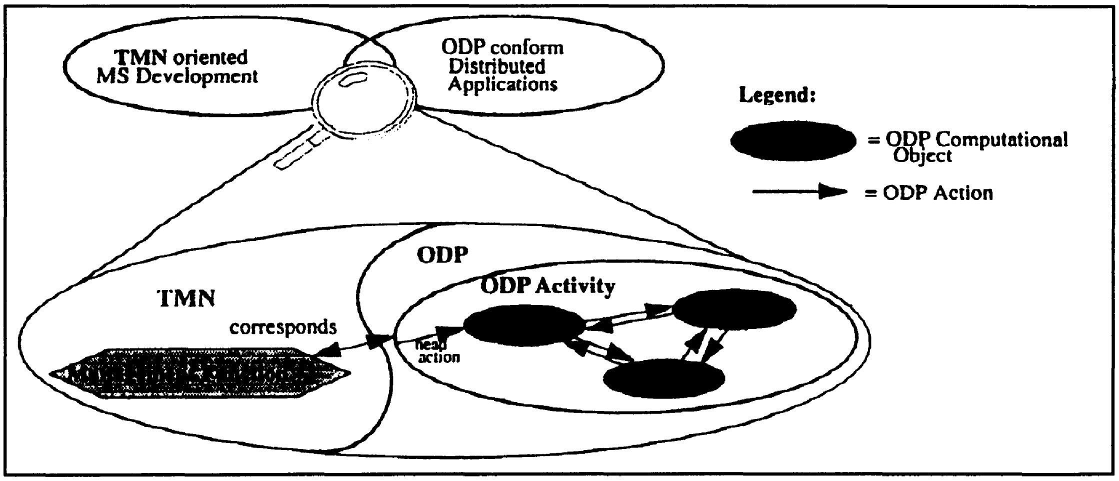

Figure 2 TMN Management Functions and ODP Activities.

In the current state of the PRISM model, there is, understandably, no general algorithm that constructs the links between the models but there is a design process that is dependent on the skill of the designer. There are three steps to the design process:

1. Functionally decompose the Management Service i.e. identify appropriate Management Service Components (MSCs) and Management Functions (MFs).

2. Identify possible entities involved in the realisation of a MSC/MF (MSC/MF is a 'Management Process'). Identify possible information flows by means of an Event Trace Diagram.

3. Identify candidate Computational Objects COs engaged in each MF/management activity that is part of the identified Management Process and draw an Activity Flow Diagram.

4. Give a detailed Computational Specification using an appropriate specification template.

There is no provision for events that occur in the Computational Model to trigger corresponding actions in the Management Functions of the Enterprise Model.

The design methodology of PRISM is exemplified through the User Profile Management Service of Personal Communication Support System (PCSS).

Step 1, the functional decomposition yields two Management Service Components each with a number of management functions as shown in table 1.

Step 2 gives an event trace diagram that enables the identification of the computational objects associated with each Management Function. The user authentication part of the event trace is given in figure 3 (after Wittman, Magedanz and Eckardt, 1995, p.86).

Table 1 Enterprise Specification: Management Service Components

	MS: User Profile Management
MSC No. 1:	**User Registration**
MF No. 10	Manual Registration
MF No. 11	Automatic Registration
MF No. 12	Scheduled Registration
MSC No. 2:	**Authentication**
MF No. 20	User Authentication
MF No. 21	Provider Authentication

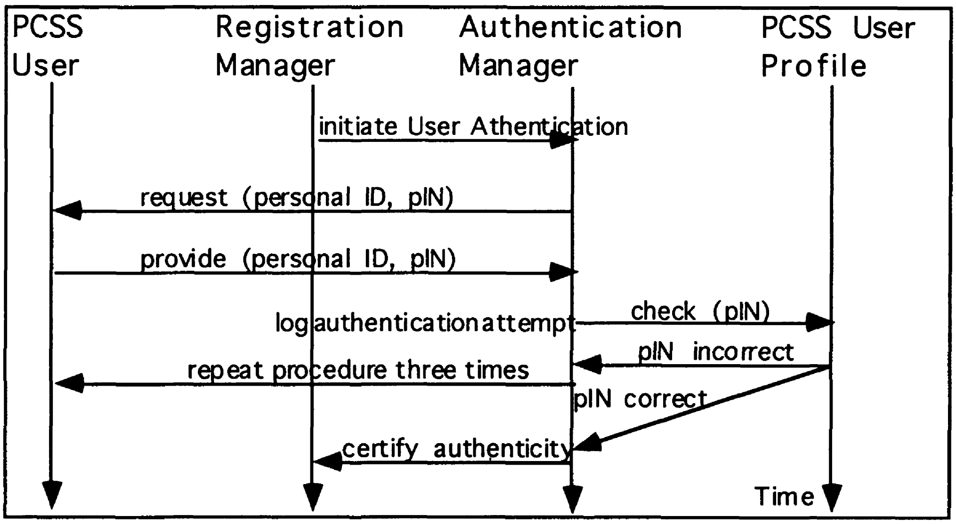

Figure 3 Event Trace of User Authentication.

Step 3 identifies the candidate computational objects engaged in each MF/management activity. Examples of the computational specification of the two MFs, Manual Registration and User Authentication, are given in the following table.

Table 2 Computational Specification - Management Functions

	MS: User Profile Management	**Computational Objects**
MSC No. 1:	**User Registration**	
MF No. 11	Manual Registration	User Agent Registration Manager User Profile Manager
MSC No. 2:	**Authentication**	
MF No. 20	User Authentication	User Agent User Profile Manager Authentication Manager

While all the details of the example have not been replicated Wittman, Magedanz and Eckardt, 1995, pp.84-89), there are sufficient details to illustrate the transformations (Berry and Raymond,

1995) between the Enterprise Model and the Computational Model. Without underestimating the difficulty of developing an adequate model of the Enterprise that is also computationally viable, one of the major problems with the example is the limited model of the Enterprise. The model of the Enterprise is reduced to the functional aspects of a specific application. While this does translate more readily into computational objects, it captures little of the practising credo of an organisation, for example, business policies, that drive the organisation and are reflected in some form in its computational systems. Another problem with the model, is its static nature. There is no provision for change neither from the Enterprise viewpoint nor from the Computational. The links between the viewpoints permit abstraction but not feedback.

4.2 Semiotic Model - Advanced UPT Applications

In the model of advanced UPT applications, which subsume personal mobility, telecommunications services were viewed as the facilitators of the communication process in enterprises (Cross and O'Brien, 1992b). As such, they were most useful when they attempted to accommodate the collaborative interaction that characterises the communicative patterns of an organisation. It was argued that any patterning of services ought to reflect the patterning of communication and the parameters that shape and guide that communication. It was hypothesised that any decomposition into features was serving the more abstract functions of communication. Consequently, architectural designs and strategies aimed at supporting telecommunications services ought to reflect and provide the potential to augment the fundamental characteristics of communication.

Treating communication as a semiotic system, that is, a set of systems of meaning, the context of communication can be organised according to Field, Tenor and Mode, taking the approach of Systemic-Functional theory which has proven a robust theory of language for a wide range of applications (Halliday, 1978; Halliday, 1985).

The model of global context is represented in the following figure.

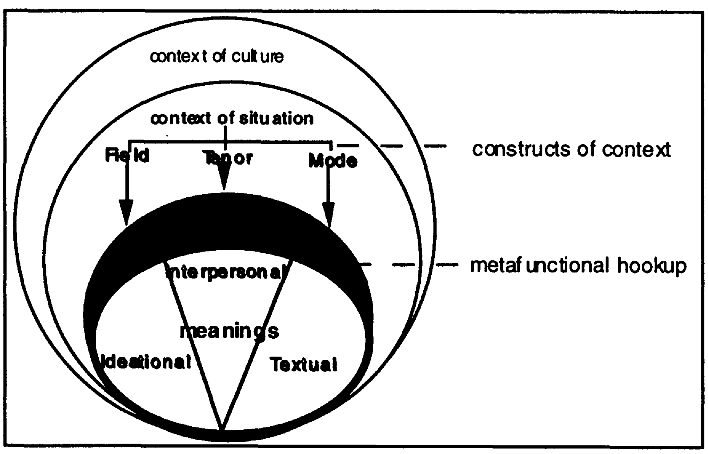

Figure 4 Social Semiotic Context.

The Field of discourse refers to what is happening, to the nature of the social action that is taking place. Field may include the rhetorical mode, what is being achieved by the text in terms of such categories as persuasive, expository, didactic and so on. The Tenor of discourse refers to who is taking part, to the nature of the participants, their statuses and roles. The Mode of discourse refers to what part communication is playing, what it is that participants are expecting communication to do for them in that situation. Mode includes the role of communication, whether it is constitutive of, or is ancillary to, the situation; the medium - whether the process of discourse is shared i.e. spoken or written; and the channel - whether the message is received in graphic or phonic form. With the latter, there is also a choice between visual contact or no visual contact.

Using such an architecture, an advanced UPT service called MORGAN (for organising meetings based in a real or virtual environment) was modelled in which the contextual objects were inherited by the computational objects as the following diagram indicates.

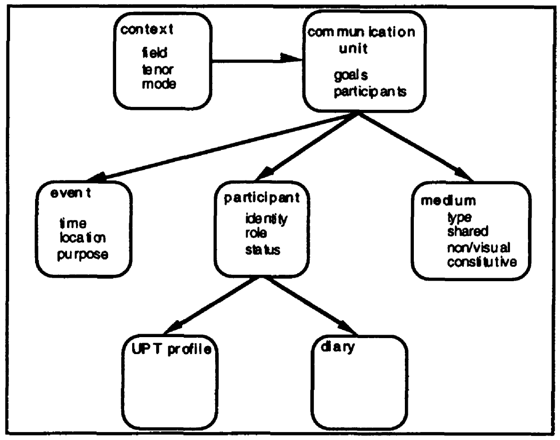

Figure 5 Object-Oriented Model of Communication for Advanced UPT.

It may be noted here that already there is a fundamental contrast with the previous model. The model of the Enterprise is shaped by the ideology in which it is modelled. In the previous model the Enterprise description of the User was in terms of registration and authentication. In the current model, the User is described in terms of his/her availability in space, time and media translating into the computational objects of the profile and diary.

Change in the present example is possible in a limited topdown fashion, as the configuration of the global situational context prefigures the local configuration of the computational system. In terms of the model of change, the local dynamic context was affected by the configuration of the global context, but the latter in turn was static and could not be changed by local dynamic events.

That there would be dialectic changes between global and dynamic context became very evident in the follow on project. In that project, which provided the UPT subscriber with the facility to manage business communication, one of the major tasks was how to manage multiple communication activities and the corresponding situational contexts. Conceptually, each activity, or communication unit (Cross and O'Brien, 1992a) was composed of one or more communication events. Thus the lowest level of granularity was the communication event. The communication units were themselves connected to other communication units to form chains. Chains represent the highest level of granularity, with units being an intermediate level. Again the contextual construct of Field governed the purpose, timing and location of the communication events that constructed a communication unit. Tenor effected the pattern of interaction possible in the communication unit, and Mode determined the possibilities for the method of communication, for example, face-to-face conversations, video conferencing, telephone, fax or email. Global context would generally hold for a communication unit, i.e. a series of communication events, especially for the construct of Field which governs what the communication is about, including its purpose. The Tenor and Mode were not so stable and changed at the local dynamic level of context. The Tenor tended to change as different participants were drawn in and out of the various communication events. The Mode, was also liable to change depending on the availability of participants.

An example of such a communication unit was a communications unit which spanned three separate communication events. The Field remained constant the purpose of which was to organise a visitor from Norway. There were changes in the Tenor for each communication event. There were four participants involved in the communication unit. Participant A was involved in all three communication events, but interacted with three different people, B, C and D respectively in the three communication events.

Tenor is of particular importance to Enterprise modelling as it is a way of describing the social roles with their attendant rights and obligations that people carry in an organisation, and hence the way in which the Enterprise functions as a set of interacting roles. An individual communicates with other role holders in both the same and different organisations. It is through the individual as an incumbent of various roles and his/her interactions, that the microcosm of multiple enterprises working together may be captured (Cross and O'Brien, 1993).

The Mode also changed for each communication event, from a face-to-face conversation, to an email, and finally to a telephone conversation. Without going into explicit details, the changes at the local dynamic level of context changes the potential for behaviour in the corresponding event. For example, each type of media has its own conventions for constructing the textual meanings, and one may reflect on the construction of the opening gambits in face-to-face conversations, emails and telephone conversations, for example.

As with the earlier project, only the global context was modelled explicitly for the communication manager with the local dynamic context informing the functional design of the system but not offering the required feedback (Cross, 1995).

4.3 Strengths and Weaknesses

The strength of the TINA/ODP model is the well defined decomposition of an application via the five viewpoints, particularly, the capability of modelling from an abstraction of the Enterprise. The strength of the semiotic model is the ability to model from the situational context through the theoretically based constructs of Field, Tenor and Mode, to the functionality of a system. In the semiotic model a broader definition of the Enterprise is available that also has a theoretical underpinning (Halliday, 1978).

One way of making the Enterprise viewpoint of the ODP model more rigorous is to organise the decomposition of the services in terms of the three categories of situational context. To take the earlier example of personal mobility, the user authentication process could be analysed and designed as a system in terms of what is happening, the roles of the participants in the authentication process (including software agents) and how the events in the authentication process are realised.

5 GLOBAL AND DYNAMIC CHANGE: A SEMIOTIC MODEL

Both the TINA/ODP and the semiotic model and architecture as they stand only incorporate one way change - from the Enterprise to the fielded service. However, the semiotic model is theoretically capable of accounting for change in which the nature of the communication event itself will alter the situational context, providing a modified environment for the next communication event (O'Donnell, 1990; Ravelli, 1991). An example of how this model of dynamic context might be implemented in an automated system is described by O'Donnell. The result of combining the global and dynamic contexts is given in the following diagram.

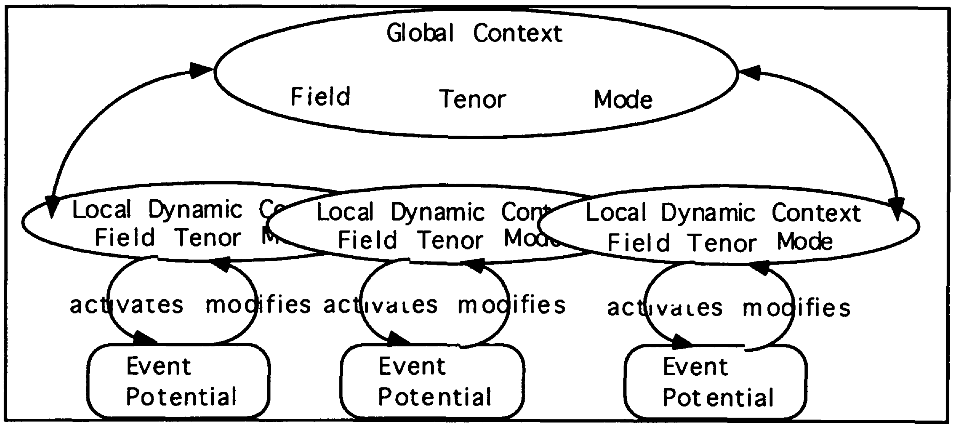

Figure 6 Dialectic between Global and Local Dynamic Context.

In the initial establishment of the event (represented as a potential) the global context initialises the local dynamic context which in turn activates the event. The event in its turn may modify the local dynamic context which then activates a subsequent event. At some critical point the changes made at the level of the local dynamic context will modify the global context and make it possible for a new set of events to commence. In the application of the architecture, the three constructs of Field, Tenor and Mode would each contribute to the modelling.

6 TOPOGRAPHY OF CHANGE

For the explication of the critical point at which the local dynamic overturns the global dynamic, one may return to the modelling of biological systems. In the biological model the links are not necessarily in a lockstep pattern. An interaction or change at the local level does not necessarily change the balance at the global level. It is only periodically that the stasis at the global level is overcome under pressure from activity and change at the local level. Computer simulation of evolutionary processes have indicated three patterns characterising the overthrow of the established order (Lindgren's model (1992) cited by Langton (1992)):

1. punctuated equilibria:
After initial irregular transient action, the system settles down to relatively long periods of stasis "punctuated" irregularly by brief periods of rapid evolutionary change.

2. extinction events:
A diversity of strategies builds up during the long periods of stasis, but often collapses drastically during short, chaotic episodes of rapid evolutionary succession. Extinction events are a natural consequence of the dynamics of the evolutionary process.

3. co-evolution:
A mix of different strategies dominates system during long periods of stasis. For a strategy to do well, it must do well by cooperating with other strategies. Mixes may involve three or more strategies whose collective activity produces a stable interaction pattern that benefits all of the strategies in the mix. Together they constitute more complex, higher-order strategy, which can behave as a group in ways impossible for any individual strategy.

If this is the case then one would expect to see changes at the level of local dynamic context periodically upsetting the balance of the global context.

7 SUMMARY

Enterprise integration relies on adequate models of the Enterprise that capture some of the practising credo of an organisation, and are reflected in some form in its computational systems. In the comparison of the ODP Enterprise model in the PRISM example the model of the Enterprise was reduced to the functional aspects of a specific application. In contrast, the semiotic model of the Enterprise was more broadly based and also had theoretical validity. The ODP model could be made both more rigorous and broader by applying the conceptual constructs of the semiotic model.

Enterprise integration cannot be effective without models of Enterprises and architectures that incorporate change. The exemplar domain of telecommunications is characterised by rapid change. Architectures for such domains require, as an integral part of their design, the capability of representing how change at the level of the operational system effects and changes the high level abstraction that represents the enterprise, as well as the representing how change at the Enterprise level effects change at the local level. A model of change was introduced that incorporates both local and global change with feedback possible between the global level and the local level, where the global level is equivalent to the Enterprise. While neither the ODP model nor the semiotic had incorporated change to any degree, the change model was more easily accommodated in the semiotic model which was able to incorporate both local and global change in its abstraction of situational context. A further hypothesis was made that the topography of change in distributed systems such as telecommunications, was akin to that found in biological systems where changes at the level of local dynamic context periodically upset the stasis of the global context.

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9 BIOGRAPHY

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