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**Gammack, J., Pigott, D. and Hobbs, V.J. (2002) *Context as history: the cat's cradle network*. In: Burstein, F., Linger, H. (eds), 2002, *Knowledge Management and Context*, Australian Scholarly Publishing, Kew Vic Australia. Pp 122-134.**

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## Context and History: The Cat's Cradle Network

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### Abstract

The issue of context has long troubled the endeavour of modelling and representing knowledge, and today is central to the effective management of digital assets. The deep semantics associated with usage of particular digitised artefacts must be represented to a degree sufficient to avoid intentional or unintentional misrepresentation through the repurposing enabled by digital technologies. Any representational issue of relating context to digital objects involves linking in some form, and the assumptions about how linking occurs determines implementation strategy. We describe four models that may be distinguished in approaching implementations of linked documents: the causal, the associative or attributive, the purposive (usage based) and the communal, and contend that most, if not all, current knowledge modelling schemes can in principle be shown to reduce to a formal equivalence of one or other of these. We argue that the communal model is the candidate most likely to provide satisfactory contextualisation, and that an historically contextualised network of communally grounded linkages provides the most adequate mechanism for modelling knowledge provenance. We propose the concept of the 'cat's cradle network' as a model for such an historicised contextualising network.

### 1. Introduction

The endeavour of modelling and representing knowledge has long been troubled by the issue of context. Context provides *extra* information as to the applicability of information-laden propositions or rules in particular situations. Various attempts to capture this extra information have been attempted in knowledge based, and latterly in knowledge management, systems. Among the several important research issues in knowledge management identified by Alavi and Leidner (2001) is the storing of contextual information along with created knowledge.

Early attempts to capture knowledge in tree structured rule formats foundered, since the required number of rules becomes ever expansive, and is still essentially incomplete (Collins, 1987). Modelling metaknowledge, using 'metarules' is to all intents and purposes futile, since the applicability problem, implied by Wittgenstein's (1953) analysis, notes that rules cannot contain the rules for their own application. Data-set bound sub-symbolic representations suffer from the same problems, and most formalisms that rely on symbolised entities and relationships adopt expedient solutions of deciding granularity and depth of representation on a domain basis. In such cases the issue of context is not treated in its essential quality, but its ultimately conditioning effects on interpretation are merely eroded. This is because the underlying representation is essentially a graph, or a finite and closed network, which shows a particular state, or an historical snapshot, without direct reference to how those relations came to be seen as significant to what they denote. A representation must always be considered as only half of a pair – it is a representation OF something TO someone. Without the interpretive context to use the representation it remains indeterminate. Yet without constraints on the interpretation, it is vacuous at worst or ambiguous at best. What is missing in the represented network

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<sup>1</sup> From January 2002. This work was undertaken when the first author was at Murdoch University.

is the *scripting* context of why the relations are as they are, and the procedural mechanisms to determine the significance of the historical relations in the present situation.

For intentionally produced symbolisations not all interpretations have equal validity: a concept of 'relative truth' applies. This point is well made in Belenky et al (1986 p98), using the example of poetry criticism. 'A (good interpretation) is firmly grounded in the poem itself, while a bad interpretation contains too much of the reader and too little of the poem'. This might suggest a research agenda based around elaborating the representation within its own framework, as Alavi and Leidner (2001) seem to imply with their generic 'how much context to model' research question. Such an approach however, falls into the pragmatist trap of deciding some finite number of metarules on a circumstantial basis, eroding the tacit by expanding the explicit. Not that such a strategy is necessarily ineffective for everyday purposes, but it misses the essential point about context.

The issue of context, along with ownership and provenance, is central to the effective management of digital assets today. This stems from the fundamentally hypertextual and recontextualising web-browser interface increasingly being seen as the principle HCI tool by the vendors of operating systems, applications, and development systems alike. From this, the prospect of infinite skeins of tangled, anonymous and ubiquitous document reuse and repurposing threatens the very concepts of ownership, proprietorship and even authorship by their relentless promiscuity. The management need goes beyond mere access controls and document administration: instead the deep semantics associated with usage of particular digitised artefacts must be represented to a degree sufficient to avoid intentional or unintentional misrepresentation and misuse.

Within the knowledge management literature, appeal has frequently been made to Polanyi's (1966) concept of tacit knowledge, tangibly realised in many systems by having a 'user in the loop'; an open interpreter of symbolised outputs into an active situation. This somewhat defeatist strategy avoids many of the problems of context, but potentially introduces degrees of freedom to the interpretation of modelled knowledge which are incompatible with the learning and intentionality embodied in the symbolised representation.

The issue addressed by this strategy reflects the closed nature of symbolised representations, and their need to be opened through contextual interpretation into active situations. In this paper we take this state of affairs as a necessary starting point, and do not attempt to model context simply by elaboration using the usual conventions of network based conceptual structures. Instead we will argue that a thread (or technically a clew<sup>2</sup>) to the tacit knowledge of communities and individuals can be modelled. This gives a new set of primitives for modelling relevant contextual information, *on its own terms*, which both constrains and guides intended interpretations of propositional knowledge. This becomes relevant if knowledge assets are not to be taken out of context, misused or take part in misleading reformulations through the repurposing of assets enabled by digital technologies. Whilst metaphorically extending a fixed rope to touch the open sky may appear futile, when the other end is grounded in its originating community, it provides a directional and contextual lead into a given closed pattern of declaratives. This lead provides a formal basis for information retrieval procedures, extending the hypermedia/hypertextual solution to the problem in which preserving information in a fixed linear format makes retrieval difficult (Landow, 1992), and which we consider in section 3 below.

## **2. Managing Knowledge Assets**

The continuing requirement for organisations and content providers to trade in digitised assets brings a concomitant need to manage those assets effectively. Data, diagrams, and documents; photographs, artwork, and multimedia content is increasingly being produced, digitised and made available in abundance. Such resources are valuable assets of information intensive organisations, and around them

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<sup>2</sup> This term describes the thread which, in Greek legend, Ariadne gave to Theseus, to find his way back through the labyrinth having slain the Minotaur within.

sophisticated management systems must be developed in order that the efficient management of resources moves that information from the potential to the actual (Trendwatch, 2000). Managing digital assets not only involves internal distribution, accessibilities and efficiencies, but also wider protections involved when derivative works or repurposings result from external distributions or acquisitions. Our research embraces knowledge management not only from the technical side of document management and communication, but from the organisational and community perspective of usage practices. It is through grounding in this context that the technical descriptions obtain their meaningful use.

Producers of, and investors in, recorded digitised content typically have the right to determine the legitimate contexts of use, and the moral indenture associated with reuse or repurposing. Internet technologies enable the reproduction, reformatting, selection and derivative product development from internal repositories of material, but also potentially by third parties in ways which may compromise the integrity of the source material. For effective reuse to occur, relevant contextual information accompanying the creation of digitised artefacts must be recorded. Such information qualifies and constrains the possibilities of misrepresentation and misinterpretation, whilst admitting a variety of legitimate uses. Issues include identifying provenance and legitimate ownership of digitised artefacts, allowed uses under different representational and contextualisation protocols, and the potential for reformatting and repurposing of material in knowledge repositories.

We recognise that media artefacts, and symbolic materials generally, are open to selective and contextual interpretation by others upon publication. This however does not exclude the intentions of the original author, nor the community context within which the work was produced and to which it references. Without appeal to philosophical conceptions of knowledge admitting the transcendental, the universal or the transcultural, the frame of reference for any symbolised artefact must ultimately be embodied in community and cultural norms. This is the level at which laws are mundanely shaped and socially agreed, which is important, since it conditions the status of an artefact and its potential for legitimate use.

All methods of resituating, use, and reuse, work by currently active referencing to the artefact. They amount to the proposition: *This media artefact is being used here, in this way*. We have argued elsewhere (Pigott, Hobbs, & Gammack, in press) that without a system of rigorous control, the repurposing and resituating of media artefacts is fraught with the perils inherent in semantic overloading. For our purposes here, however, we concentrate on the actual mechanism of use, reuse and resituating: the process of denotation that we may generalise as a link. In the abstract, a link is a part of a graph, the interconnective principle between the several nodes that make it up. A semantically rich artefact that is textually poor derives its meaning from situation in a context and so the current-instance meaning of any media artefact will be the composite of the use, the link, and the artefact. Leaving aside questions of suzerainty for the moment, this dynamic meaning of a media artefact can be seen to reside above all in the link.

Thus, the representational issue of relating context to digital objects involves linking in some form, and the assumptions about how linking occurs determines implementation strategy. We have already proposed (Pigott et al., in press) a system invoking referencing that keeps artefacts in context and maintains the tacit dimension of knowledge they embody by representing the norms of community of practice responsible for conceptual construction. Because a community of practice is a social and political entity, a set of rules of comportment or etiquette to manage digital assets is required. In other words, we must identify a protocol for the 'management of etiquette', or a computerised implementation of the management of rules of digital asset use. Such rules exist in the social domain, and are referenced to the community norms. Legally formulated rules (for example) provide for this by not attempting precisely to define terms such as 'reasonable doubt', but instead referencing them to human judges in procedurally described ways. What is considered reasonable however, can and does vary across communities and times.

Particularly since contextualisable organisational knowledge artefacts are typically retained in an intra- or extranet, with linked databases and cross referencing to physical assets, we see such procedural relationship modelling as the essential activity in organisational knowledge management. This must find a way to link represented information with usage norms, which we will argue are in a domain incommensurate to the documents themselves. In the next section we examine the formal issues involved in relational linking more closely, as these underlie many typical systems used in knowledge modelling and management.

### **3. Models for Linking**

Four models may be distinguished in approaching implementations of linked documents. Without making claims that these four are necessarily exhaustive, we identify the causal, the associative or attributive, the purposive (usage based) and the communal. We contend that most, if not all, current knowledge modelling schemes can in principle be shown to reduce to a formal equivalence of one or other of these models, and now outline their essential characteristics with reference to their source philosophical traditions and implied epistemological stances.

#### **3.1 The causal**

Many implementations assume a causal model as a computational basis for Internet technologies: arcs directly relate nodes of content in a forward chaining manner. The Internet is presented as a network of documents, but is in fact not a true network per se. A network has the property of cyclicity, whereas the nature of hypertextually linked documents (certainly as linked via the hypertext transport protocol) is acyclic. In effect the World Wide Web is a DAG (directed acyclic graph) – it is more than a tree, in that it is possible to return to the original document at one remove, but fails to blossom into a proper document network in any real sense. Although the properties of referentiality can be mined by robots, the only indication of context would be the HTTP\_REFERER CGI-variable. When users move to a new document, the context of framing is lost, and users arrive in a new document with only their memory as guide, following opportunistic paths constrained by immediate availability.

This contrasts with Nelson's (1990) conception of hypertextuality, where the mechanism (and thus the process) of hyperlinking was duplex. "We long ago foresaw the problems of one-way links, links that break (no guaranteed long-term publishing), no way to publish comments, no version management, no rights management. All these were built into the Xanadu design" (Nelson, 1998). The problem flagged by Landow earlier also concerned Nelson - information retrieval is made difficult when text is preserved in fixed formats (Landow, 1992, p18).

That Nelson's well-known criticisms of HTTP/HTML as an implementation of hypertext are well-founded is tacitly acknowledged in several of the current reviews of HTML standards by the W3C. Particularly of interest to the matter under consideration are the new XLINK proposals (W3C, 2001a) which enable bi-directional linking, and possibly even multiple points of departure, and the Ruby proposal (W3C, 2001b) for multiple associative glossing texts to accompany HTML documents.

In the absence of any such formalisms to give semantic limitations in usage and distribution of digital assets there is no inherent provenance or context represented in the resource, and, as Nelson indicates, neither version nor rights management is inherent.

#### **3.2 The Attributive/Associative**

This is the second model for linkage we distinguish, epitomised by the ontologies tradition (e.g. Genesereth & Nilsson, 1987; Gruber, 1993). It makes particular claims about the potential for knowledge sharing, and has the benefit of an implied two-way connectivity. The earlier systems of linkage in the ontologies embodied in LISP databases imply hierarchy in a bi-directional manner, and offer the promise of an objectively assessable linkage practice, corresponding to some natural order.

Here an attempt is made to create a structure of atomicity, of logical hierarchy and domains of knowledge – viz conceptual graphs as Schemas, and the ontologically based systems like Cyc (Guha, Lenat, Pittman, Pratt, & Shepherd, 1990). But these all have an Achilles' heel – they are disguised subjective, (or at least shared consensual objective) and tied into an insidious cultural relativism (even if the cultural relativism is that of international scientism). There is also a problem with cultural imperialism of a sort – staking a claim to the creation of an over-arching ontology is a metaphysical claim, much in the mystical tradition. Certainly the exclusion of alternative ontologies is implicit in the adoption of an ontology.

Another tradition of attribution is the Aristotelian tradition of taxonomies, categories and attributes, met with in the practices of the schemas of XML and in the relational database model. Indeed the 'father of the Entity-Relationship Model', Chen (1976), has suggested his model provides a good model for the web, whilst XML stands fair to provide the standard type descriptions for future web markup. (Chen, 1999). By making the existence of a link the descent in a hierarchy of categorisation, it acquires a certain patina of authenticity; nevertheless, these are (again) disguised conventions. To make a link into a proposition about a statement in a domain is still a disguised judgement.

In both of these cases, the act of linkage is a disguised assertion of a postulate about the relation between two items, and has to be assessed in the light of its tacit dimension. When knowledge is being brought to bear in decision-making applications, this provides for 'late binding' between the outputs of computational processes and their interpretation into the world. Relevant critiques of this are outlined in Sowa (2000) where logic is viewed as pure form, and ontologies provide content. Both however are symbolic and pure ERA schemes based on this fail to recognise the inescapably mind-based role in bringing pre-existing knowledge to interpret meanings in the symbols encoded in programs, database tables and propositional forms. Extending the schemes within symbolic frameworks does not overcome the essential problem. Harnad (1990) has characterised this as the symbol grounding problem, in which symbols are not given meaning by reference to more symbols, but by attribution from a mind that uses them. Whether this is ultimately grounded in perceptual categories (as Harnad would have) or in ideal types (as the Platonists prefer) is immaterial to our purpose here. However, it does set a limitation on linkage that is critical to motivate the adoption of our proposed approach.

Mechanisms based on this tradition include RDF, Ontoseek and topic mapping – which we will not summarise here. The critique of early knowledge representation languages (in particular KRL) by Bobrow and Winograd (1979) remains applicable to these efforts, which implicitly assume the nominalist, correspondence philosophies which were rejected in Winograd's later work as ungrounded (Winograd & Flores, 1986). Their language/action perspective embodies a rejection of such formal ontologies as a basis for knowledge, and motivates solutions within our third category.

### **3.3 The Purposive**

Our third model recognises the role of usage and custom in determining linkages. Usage (as precedent) makes for binding in law, torts, and medical case studies/epidemiology. Usage history becomes context, which enforces future usage. The new use of a symbol or metaphor can eventually eclipse a 'real' metaphor. For example the symbols for saints and their holy places (palm, shell, hat, gourd, tau cross etc) became representative in turn of firstly the pilgrimages, then the pilgrims, and finally of a certain type of piety. Usage also has the power to change the traditional ontological status of concepts. In the Reaganomics era the high street banks shifted emphasis to encourage more private customers to take on greater debts. The concept of consumer *debt* was perceived negatively, and the term consumer *credit* gradually replaced it in the public mind. Yet the terms are linguistic opposites whilst the underlying concept is the same. Eulenberg (1995) describes examples of what he calls 'auto-antonymy' showing words that refer to opposing concepts in different contexts.

The information retrieval problem addressed by hypermedia solutions is described by Landow (1992, p18) thus: "First, no one arrangement of information proves convenient for all who need that

information. Second, although both linear and hierarchical arrangements provide information in some sort of order, that order does not always match the needs of individual users of that information." This removes determination of the structuring of content nodes away from a correspondence realism to user centric linkages.

Purposive linkage recognises that concepts and categories are constructed, in contexts, for intentional purposes, and those will tend to determine and constrain the range of applicable meanings. The psychological literature on memory has long ago moved beyond a simple metaphor of an indexed store, navigated perhaps using tree like ontologies, to an understanding of memory emphasising constructive processing in contexts. Concepts are constructed partly from established semantic usages, but also information on recent uses and frequency of use moderates a simple lookup process. This allows a dynamism based in human semantics to be introduced around static descriptions. In an extensive paper, Barsalou et al (1993) critique standard assumptions about concepts and meaning, particularly that: propositional expressions represent concepts; that concepts are decontextualised and universal in scope; and that the meanings of words are concepts. They argue *inter alia* instead that concepts are models for types of individuals in world models; that concepts are contextualised and local in scope to situations; and that word meanings use concepts but are not concepts. In his earlier, experimental, work on the structure of human memory Barsalou (1982) showed how concepts are contextually constructed rather than invariant, and the direct effects of context on category exemplars. Similarly, Gluck and Corter (1985) have shown how categorisations rely on extrinsic factors, including purposive usage.

Implementations recognising this allow tracking of use to provide contextual information on the usage of digitised information that may subsequently suggest patterns or exemplars, which become reified as distinct segments. An example is the feature at some online stores where users get (say) book purchasing patterns of other individuals mapped against theirs, and preferences are inferred based on an implicit categorisation. It is hard, however, to reverse engineer a cultural context from usage – it is only clear when that context has been created that it came from repeated usage. It is also vulnerable to noise, spurious associations and makes assumptions applicable only in localised worlds. The systematic of the Dublin Core Metadata standard (DCMI, 2001) promises to make contextualisation of electronic resources standardised through the imposition of standardised bibliographic practices. But through use, the system may become fractured and lead to incompatibility, with major players making information ghettos with a set of mutually incomprehensible patois. And since usage patterns necessarily imply nothing invariant about customary meanings or ontological status, knowledge systems reliant solely on such patterns are temporally limited.

### **3.4 The Communal**

The final model for linkage we identify as the communal. In this model we see the other categories of linkages as being contextualised by community norms, and the grounding of the metadata types as being in the 'mind' of that community. The framing context for this is the myths and stories with which that community identifies itself, and excludes other identifications, giving a consensual, but not a necessary, coherence to its formal artefacts. As the community constructs and evolves its own concepts, the rights associated with those become inherited from the deep values shared by the community, or its general culture. The very fact of different cultures' existence with their cohesive, self-consistent but arbitrary beliefs and laws, at once demonstrates the relativism of their knowledge forms, their provenance and appeal. In addition, not every member of a culture is a determined stereotype, and regardless of dominant conventions, a range of deeper epistemological types underlies all mature cultures (Maruyama, 1980). For organisations for which quality of information, distinctive processes and the creation and management of knowledge assets is exclusive and proprietary the analogy with culture holds. A community of practice will embody the tacit knowledge of that culture's norms, and reference the understanding of that community to interpreting and shaping the metadata of its particular artefacts. Systematic use of metadata from a strategic perspective requires the community to adopt a consistent practice of metadata use or coding, and a separate, orthogonal code prescribing the limited set of terms used in metadata. A third self-referential form of metadata

use derives from hierarchies of these two: from the systematics of codes and codings that allow inter-community (and hence inter-cultural) co-operations between metadata sets required of (say) international library organisations or cultural organisations. It is no surprise to see that such organisations have been a powerful force in influencing current metadata practices.

### **3.5 From Link to Network**

As nodes representing concepts and the links between them coalesce into systems of linked nodes, (and as these systems merge into greater systems still), we encounter the interesting boundary condition which is the intersection of a new portion of an alien knowledge structure with an established one. The network effects that emerge from many such encounters are not haphazard but depend for their character on the nature of the underlying linkage set. Just as it is imperative that the nature of linkage be established before the enframing of new material within a knowledge network can be considered, so the circumstances of the arising of new nodes and links each colours the prior knowledge, and limits the possible meanings of the new material. And so it is that the awareness of the circumstances of the emergence colours the consideration of the existing and the new material.

This is necessary by the very nature of knowledge networks as they arise; not only are they weighted DAGs, they are weighted DAGs with a pedigree. Any static representation of a knowledge network will therefore miss this point in its representation: knowledge networks, even prepackaged, cannot be created *ex nihilo*, but must be built up step-by-step.

A best-practice modelling tool for knowledge networks must therefore take into account not only the current disposition of nodes and links, but also what has gone before and what is yet to come.

## **4. Context and history**

We draw on Barsalou's formulation of the operation of human memory: established, recent and frequent uses, along with contextual factors shape concept constructions and instances of use. Historical usage instances in organisational memory is likewise a strong determinant of the construction or interpretation of represented symbols. Some of this can be identified by time series analysis of database or other recorded instances, but here we wish to propose a new type of network. Our suggested network has the properties of the standard associative network forms, but also embodies a procedural history of its use, grounded in its intentional production within a community narrative.

### **4.1 The Cat's Cradle Network**

Our model for the analysis of purposively constrained information networks is the 'cat's cradle', the canonical string figure. String figures are designs formed from a loop of string, and woven with hand movements into particular identified shapes, such as 'Jacob's ladder' or 'Fish Spear'. They are found across numerous cultures and ages, and play a formalised role in illustrating stories told in a ritualised, as well as a wider social discourse (ISFA, 2001). Starting from the simplest configuration of a loop or cycle, particular operations form distinctive shapes, which are partially determined by the preceding usage context, and which consequent on the history of moves made will achieve an intended design. These figures are intentional productions, which can be described as a series of network snapshots, but deriving from a procedure that outlines a scripting history. The primitives leading to the production of the apparent associations are embodied in these describable procedures, and referenced, in the case of figures used to illustrate myths or other stories, to community understandings.

For our purposes, it is important to understand that it is quite impossible to come to any step in the construction of a cat's cradle without having first gone through all of the prior stages. One cannot simply make a cat's cradle *ex nihilo*, or take short cuts. Networks of linked semantic nodes are similar in that they each possess a history separate from the mere geometry of topology as presented in a network diagram. The process of adding newer nodes, of different agencies and episodes of agency, all

create a situation where the truth-value embodied in a network of knowledge-context is only apparent when three separate phases are recognised and represented:

1. The past and its complete record both of becoming and intention to become, and what each step meant on its own and in process
2. The present and its being and its self-description
3. The expected and actual future states

This recognition is challenging, but it is fair to say that the difference between a purposive network and its reduction into a set of lines and small circles purporting to represent it is precisely in the 'bits left out'. Until a network simple is contextualised into a cat's cradle network with history, intent and description it is inadequate to the job of modelling context.

#### **4.2 Formal Properties of a Cat's Cradle Network**

Extending a simple network involves retaining all of the properties of the network formalism including implicit hierarchical structure, direction, weighting and biasing disposition. What is required, however, is a mechanism to handle change, sequences of state transitions and temporal proximity as is required for modelling context. In modelling we are interested in both representing and measuring these changes. A starting point for the creation of such a model is the Pathfinder network (Schvaneveldt, 1990), which is a dynamic, weighted network used in eliciting and representing human knowledge. It subsumes both other network formalisms and hierarchical clustering schemes such as are used in knowledge modelling, and is therefore an equivalent basis to any particular ontology or causal graph.

We aim to augment the Pathfinder network to enable its disposition through time. We draw on Schvaneveldt's insight when he states "dynamic instantiations of schemata are realised by a procedure in which particular nodes are activated continuously (and activation spreads) until a stable pattern of activation is attained" (Schvaneveldt, 1990 p136).

This points towards extensions of Pathfinder formalism to express the historicisation of network states and implement a cat's cradle network. To accomplish this we need to add specific procedures to enable us to portray and model sequences of state change that permit an explanation of any aspect of the current network configuration. We define a cat's cradle network as an 8-tuple where the first seven are the defined Pathfinder properties (Schvaneveldt, 1990) and the eighth is a vector representing its position within a lattice of federated Pathfinder networks. The bounds of the federation are determined by procedural semantics; a mechanism already implicit in Schvaneveldt's discussions. A corollary of this is that formally any Pathfinder network is a cat's cradle network where the eighth tuple is a singleton, just as it can be shown (Durso & Coggins, 1990) that all other networks are Pathfinder networks where one or more tuples has a singleton or null as value.

With the cat's cradle network, we can model certain phenomena that are incapable of explanation by other modelling formalisms. To choose one instance, a catastrophe event within an (organisational) knowledge network (eg storming out of a meeting, or a departure from a team or organisational unit) would be represented as either stasis or a lacuna. With the representational potential of a cat's cradle network, we can both show and measure the increasing tensility of a stationary node under increasing stress, until the point of disruption. This alone leads to several interesting new possibilities in the modelling of knowledge organisation lifelines, not the least of which is the potential for prediction of such catastrophe events, by modelling the localisation of edge tensor change around an isotropic node. In effect, this is a modelling of contingency, without the assumption of eventuality.

#### **5. Conclusion**

We began by considering context as the extra information brought to declarative representations to make them actively useful. There is more to context than a linear expansion of a knowledge structure, and the way in which symbolised knowledge is brought into being involves an essential otherness of

quality. The research question sharpens towards defining how context can be modelled, handled or interfaced given this other nature, rather than deciding how much more 'to include'. The old distinction between declarative and procedural forms of knowledge applies here, although there is more to context than simply procedural knowledge, which can be declaratively specified. If, as we suggest, context is essentially external to, and other than, the stored representations it may find temporally applicable, there is a further requirement. Some way must be found of relating the present to past learning that preserves and represents intentional conceptual coherence, but does not lose the essential nature of context by freezing it in an elaborated declarative structure. Our metaphor of the thread, specifically clew, connotes a formalism interfaceable with a declarative network, yet with specific properties that retain the integrity of its configuration. This gives a semantic grounding for the stored representations, relevant to establishing provenance and basis for particular presenting configurations, and with implications for managing knowledge assets vulnerable to misuse through unconstrained repurposing. (This is discussed further in Pigott et al. (in press) with a practical implementation demonstrating this approach for multimedia repositories.)

Given our position that the technological formulations of knowledge generally reduce to graph or network forms of identified entities and relationships, we were then motivated to examine the nature of linking in these more closely. We suggested that implementation strategies (for knowledge management) are determined by the philosophy of linking which is brought to bear, and briefly considered indicative classes of work under our identified categories of model.

Moving beyond approaches based on realist philosophies with fixed ontologies as context, the Wittgensteinian notions of use and purpose in determining meaning begin to suggest more temporal and user-centric determinations of context. These comport with psychological understandings of memory function, and implicate histories of use as partial, but not inevitable, determinants of meaning. Organisational histories and experience are not simply mandates for reenacting traditions, to be clung to or overthrown, but provide valuable sources of learning, if their connection to their source is communicable. Without mechanisms for reflecting context, this value is reduced, and misrepresentation likely. As socially held information, an organisational culture provides a backdrop to constrain individual repurposings of organisational artefacts. Part of this is the usage of those artefacts in the stories the organisation tells about itself, its myth of identity, grounded in the provenance of its culture. By retaining a coherent history of artefact purposing, and grounding it in the evolving usage context of communities of practice, the cat's cradle network provides a model to guide this aspect of knowledge management implementation for organisations.

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