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Knowledge Representation in Experiential Learning

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Abstract

In organisations peopled by expert individuals with specific experiential knowledge bases, the knowledge they have which is of relevance to the organisation may be lost when they leave it. Some of this knowledge may be tacit and not explicitly requested, expressed or recognised. This paper presents an exploration of potential mechanisms of expert experiential knowledge identification, capture and representation with a view to automated reasoning, sharing and handover within organisations.

We propose a PERT diagram based form of knowledge representation for intelligent planning support in domains oriented to experiential learning (capture). In addition we outline a graphical abstract argumentation framework to aid the reasoned utilisation of experiential learning in the formulation of future plans

Graphical Representation for Systems Support

Studies in cognition [1, 2] have investigated the role of external visual representations in different domains in supporting reasoning, problem solving, and communication. In [3] Dogan and Nersessian remark that in many studies of well-defined problems, diagrammatic representations illustrate either causal or temporal relationships between parts of entities and phenomena that the diagram represents.

In [4] Engelhardt suggests regarding the building blocks of all graphics as falling into three main categories: a) the graphic objects that are shown (e.g., a dot, a pictogram, an arrow), b) the meaningful graphic spaces into which these objects are arranged (e.g., a geographic coordinate system, a timeline), and c) the graphic properties of these objects (e.g., their colours, their sizes).

Graphics can be regarded as expressions in visual languages. Engelhardt proposes that specifying such a visual language means a) specifying the syntactic categories of its graphic objects, plus b) specifying the graphic space in which these graphic objects are positioned, plus c) specifying the visual coding rules that determine the graphic properties of these graphic objects.

Knowledge Representation for Planning with Capture of Experiential Learning

Research in knowledge representation for intelligent support has focused on syntactical reasoning over semantic reasoning.

In domains which tend towards abstract and/or philosophical and/or theoretical scientific contexts and representation, syntactical reasoning is adaptively appropriate. However in the more pragmatic and immediate domains of say planning military operations, with the aim of summarising and comparing plans in order to capture and identify experiential learning, semantic reasoning modalities would appear more useful in helping users to navigate more effectively through large solution spaces to identify plans and tactics that are well-suited to their needs.

Domain metatheory provides the potential to abstract from the details of plan structures to concise summarizations of key decisions within plans, and to important implemental changes within plans.

In [5] and [6] Myers and Lee describe an approach that employs a suite of techniques to identify patterns or exceptions relative to meta-theoretic structures such as role, task or feature abstraction. Myers approach is limited in that the visual representation is restricted to tabular forms which give little indication of sequential dependency between tasks and a paucity of syntactic analysis/reasoning. Myers approach also neglects the capture/representation of plan modification and experiential learning.

From the AI planning point of view, depending on how it is approached, visualisation can play two main crucial roles in planning: (1) to permit collaboration among participant agents in the case of collaborative planning systems; (2) to allow proper interfacing between the software and human planners. What has hitherto been neglected is the potential for visualisation to potentiate and facilitate experiential learning via capture of plan modification in implementation.

To address this problem, I propose a general framework for visualisation in planning systems that will give support for a more appropriate visualisation mechanism based to some extent on that described by Correia Queiroz in [7], but with specific adaptation and extension to experiential learning and abstract argumentation as an aid to utilising experiential learning in the formulation of further plans.

This framework is divided into four main parts:

1) a knowledge representation aspect

2) an identification and recording mechanism for experiential learning

3) plan retrieval and comparison facility

4) graphical support for reasoning in plan formation (using past plans and experiential learning) in the form of an argumentation framework.

The envisioned knowledge base will consist of the following elements:

Knowledge acquisition – Agents record plans of operations before implementation in the 'planning stage', during and after implementation, together with reasons for any modifications to the initial plan that occurred during plan actualisation. This will require some form of agent/knowledge base interface to facilitate knowledge acquisition.

Knowledge representation – Complex projects require a series of activities, some of which must be performed sequentially and others that can be performed in parallel with other activities. This collection of sequential and parallel tasks can be modelled as a network. The Program Evaluation and Review Technique (PERT) is a network model that allows for randomness in activity completion times.

Formalisation of the Use of PERT Diagrams in Capturing Experiential Learning

The objective is to exploit the underlying digraphic structure of PERT Diagrams to represent plans. This will involve tasks, implemented in sequence and in parallel, being represented by labelled directed edges and corresponding series of events represented as labelled nodes. Modifications to a plan during periods of execution will lead to the creation of a series of corresponding graphs or (according to user preference) extensions to original plan.

These changes will also be represented textually as extensions to corresponding tasks (edge labels) and events (node labels) detailing the nature of and reasons for the individual modifications. These textual additions will be made to both the members of each corresponding PERT Diagram pair (in the case of generation of a temporal series of modified PERT Diagrams) or each corresponding node and edge pair (in the case of an extended original graph).

Vertices represent events:

Vertex Set = { Event r : Event 0 is the Start, Event n is the Finish, n > 0,

r= 1, ..., n }

Directed Edges represent tasks:

Edge Set = {Task t : t= 1, ...,m }

The directional arrows (edges) represent tasks to be completed sequentially over time. Diverging edges indicate possibly concurrent tasks (to be implemented in parallel).

Rectangles represent nodes allowing the following data to be recorded:

1) Desired outcome or event

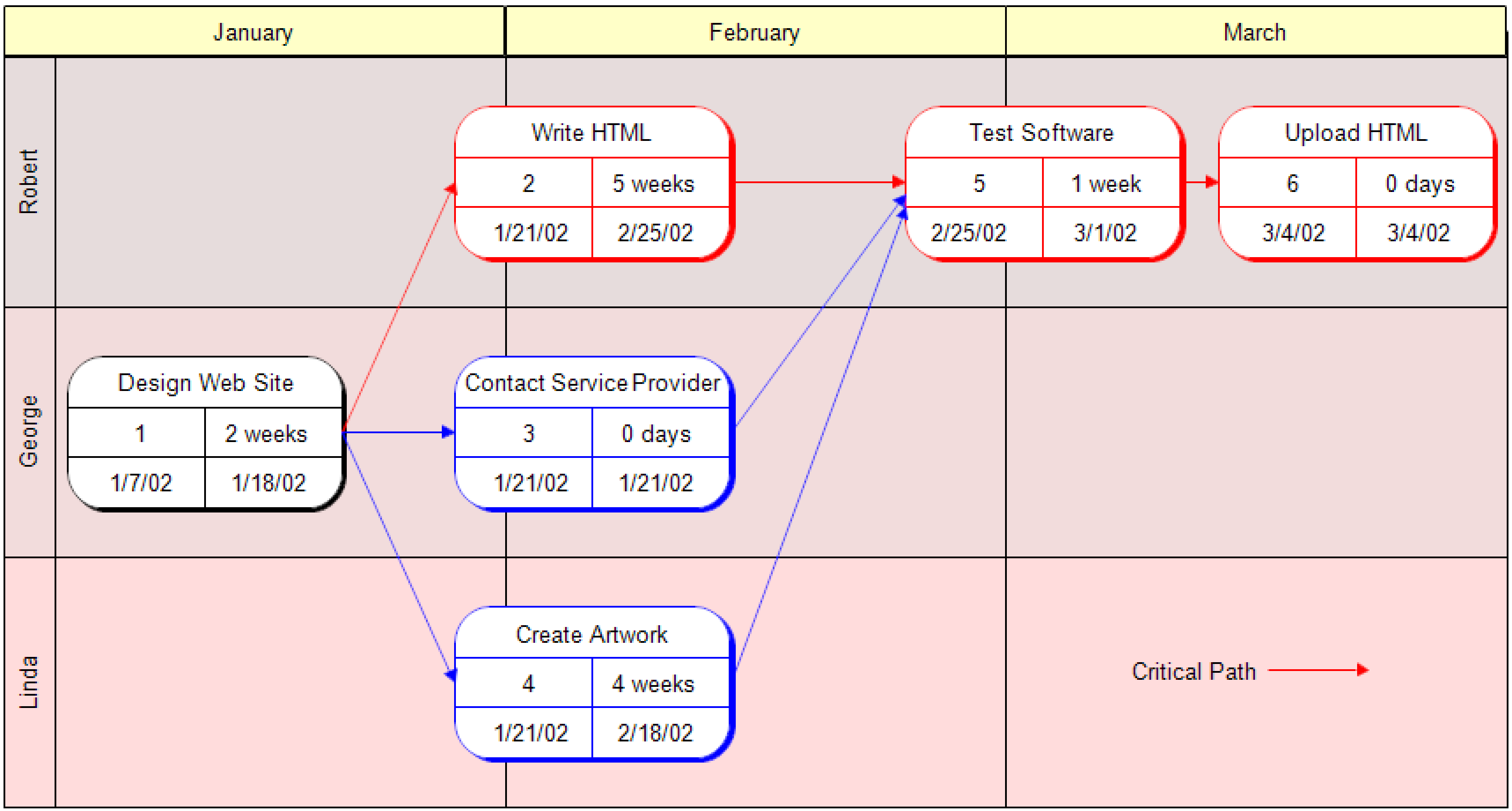
2) Modified outcome or event (plus reasons for modification) or Actual outcome or event (plus reasons for difference from final plan)

A database of past PERT Diagram plan representations will be used as a planning aide:

The database will be searched according to ontological tags describing the characteristic events, roles, resources and other features or attributes of each individual historical plan. The retrieved plans will be ordered according to a relevant similarity metric in ascending order with the most similar to the desired plans tentative (military ontological) characteristics given priority.

When deciding on which metric is most relevant and representative as a measure of the similarity or difference between two plans, we examine how we wish to compare (intended or actualised) events, roles, resources and tasks both at base and attributional level. The following measures tentatively capture this, the second (semantic) metric doing so with use of specific weights to represent the relative contribution of different tasks, roles, resources used and environmental attributes, to divergence from similarity.

PERT/CPM - Web Site Design Process



We suggest the following metrics as a tentative measures of plan structural and plan semantical similarity. In doing so, in the case of structural similarity we consider the underlying graph-theoretic nature of plans, i.e. the plans as being formed of node and edge sets.

Let G(V,E) and G'(V',E') be two graphs with adjacency matrices A and A' respectively corresponding to plans P and P'. Given the structure of the graph (and therefore the corresponding plan) is completely defined by the adjacency matrix, we define the following structural metric on G and G' where n (n') and m (m') are the number of nodes and edges of G (G'):

Let A* be the extension of adjacency matrix A formed by adding rows and columns of zeroes to A until we have a matrix with n* rows and m* columns, where n*= max(n,n') and m*= max(m,m')

Similarly let A'* be the extention of adjacency matrix A' formed by adding rows and columns of zeroes to A' until we have a matrix with n* rows and m* columns

syn(P,P') := d(G*, G'*) = Sum |A*_ij – A'*_ij|

where the sum is over all the indices i: 1<=i<=n*, 1<=j<=m*

We define a semantic metric on P and P' by considering the similarities and differences in the sets of tasks (T,T'), roles (S,S'), resources (R,R') and environmental attributes (E, E') in the individual plans:

sem(P,P') :=

$$w1\,\big|\,|T\backslash T'| + |T'\backslash T| - |T\hat{}T'|\,\big| + w2\,\big|\,|S\backslash S'| + |S'\backslash S| - |S\hat{}S'|\,\big| + w3\,\big|\,|R\backslash R'| + |R'\backslash T| - |R\hat{}R'|\,\big| + w4\,\big|\,|E\backslash E'| + |E'\backslash E| - |E\hat{}E'|\,\big|$$

$T\backslash T'$ is the set of tasks in T but not T', etc

$T\hat{}T'$ is the set of tasks in T and T'.

With similar definitions for S, R, E, etc.

There will also be a graphical argument facility to help determine how best to use the stored plans and associated experiential learning data to inform future plan formation and plan critique, with a view to determining the most adaptive and robust plans for future operations. This will use a Toulmin model [20] based diagram to graphically represent and formulate tests of the applicability of instances of experiential learning to the formation of individual plans and/or test the integrity of given plans in the light of (new) pieces of experiential learning. A more detailed description of the argument theoretic planning aide is given in the next section.

Araucaria

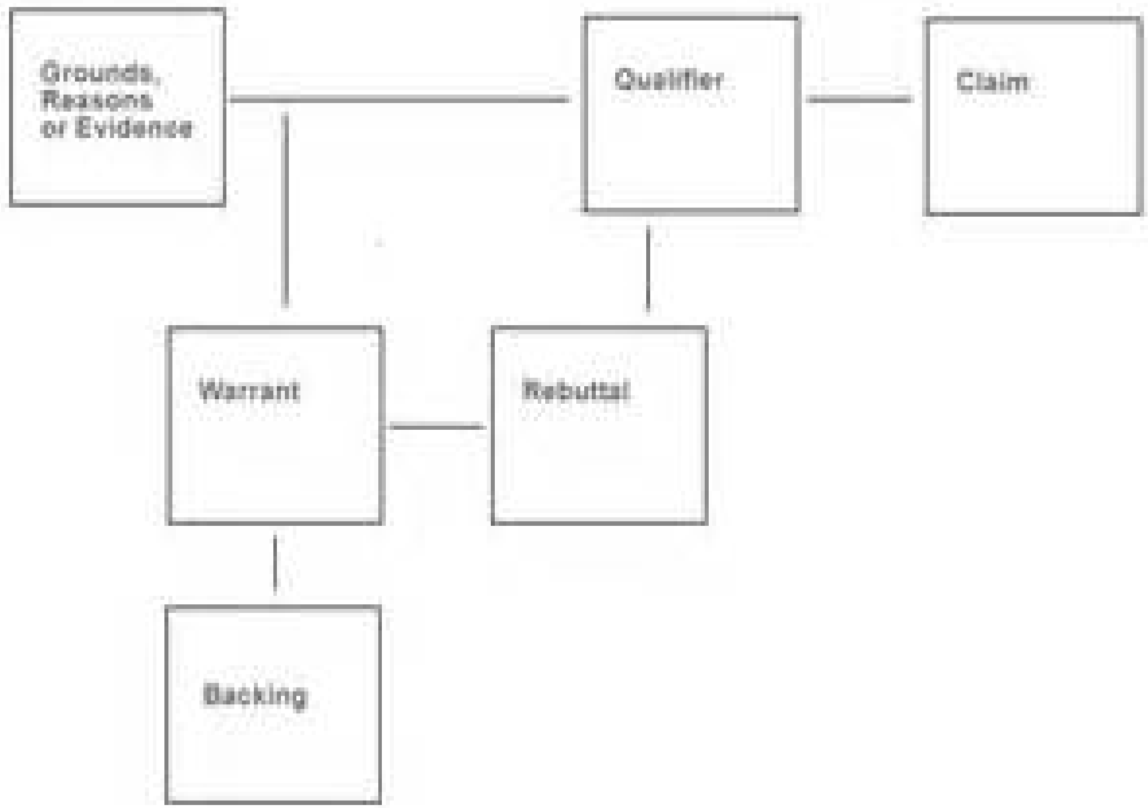
In [8] the Araucaria program for graphical representation of abstract argumentation frameworks, is composed of three main sections:

1) A main window which allows argument diagrams to be constructed from pre-existing text files.

2) An editor for schemes and scheme sets.

3) An interface to an AraucariaDB online repository of marked up arguments.

Toulmin Model



Claim: the position or claim being argued for; the conclusion of the argument.

Grounds: reasons or supporting evidence that bolster the claim.

Warrant: the principle, provision or chain of reasoning that connects the grounds/reason to the claim.

Backing: support, justification, reasons to back up the warrant.

Rebuttal/Reservation: exceptions to the claim; description and rebuttal of counter-examples and counter-arguments.

Qualification: specification of limits to claim, warrant and backing. The degree of conditionality asserted.

The claim will represent the desired objective (mission, operation event) together with the proposed means of actualisation (tasks, roles, resources, etc.)

Instances of experiential learning can be represented as grounds, backing, rebuttal, qualifier as appropriate together with data relating to other (contextual) features of the new plan.

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