Decision Support System for Assessing Participants Reliabilities in Shipbuilding

SYLVIA ENCHEVA
Stord/Haugesund University College
Department Haugesund
Bjørnsonsg. 45, 5528 Haugesund
NORWAY

SHARIL TUMIN
University of Bergen
IT-Dept.
P. O. Box 7800, 5020 Bergen
NORWAY

MARYNA Z. SOLESVIK
Stord/Haugesund University College
Department Haugesund
Bjørnsonsg. 45, 5528 Haugesund
NORWAY

Abstract: The world's experience in shipbuilding suggests that new ships can be built to a very high standard in a cost-effective manner, if shipbuilding companies have capacity to undertake new designs and apply modern technologies. In order to facilitate the shipbuilding process we propose use of an automated decision support systems.

Key–Words: many-valued logic, reliability, shipbuilding

1 Introduction

The world's experience in shipbuilding suggests that high standard ships can be built to a very high standard in a cost-effective manner, if shipbuilding companies concentrate on certain foundation key factors.

It is important for the customer that a shipbuilder is capable of developing vessel designs that are tailored to meet the customer's specific requirements. The shipbuilder should be able to modify and adapt a ship during build and/or in service as required. The start-up design is a critical phase has a big influence on the likely success of the program. High-level engineering skills are employed during this phase, and they are foundations set, for the later systems integration and test and evaluation processes.

In order to facilitate of the shipbuilding process we propose use of an automated decision support systems. Most automated decision support systems are based on binary logic, i.e. a responce is either positive or negative. One of their disadvantages is that they do not treat incomplete or inconsistent information. Application of many-valued logic allows the system to handle situations with inconsistent and/or incomplete input. In this paper we present decision making rules an intelligent agent is applying for evaluating a ship designer's reliability.

The rest of the paper is organized as follows. Related work and statements from many-valued logic may be found in Section 2 and Section 3 respectively. The main results of the paper are placed in Section 4. The system architecture is described in Section 5.The paper ends with a conclusion in Section 6.

2 Related Work

Lukasiewicz has devised a three-valued calculus whose third value, $\frac{1}{2}$, is attached to propositions referring to future contingencies [18]. The third truth value can be construed as 'intermediate' or 'neutral' or 'indeterminate' [24], [20], and [21].

The semantic characterization of a four-valued logic for expressing practical deductive processes is presented in [2]. In most information systems the management of databases is not considered to include neither explicit nor hidden inconsistencies. In real life situation information often come from different contradicting sources. Thus different sources can provide inconsistent data while deductive reasoning may result in hidden inconsistencies. The idea in Belnap's approach is to develop a logic that is not that dependable of inconsistencies. The Belnap's logic has four truth values 'T, F, Both, None'. The meaning of these values can be described as follows:

- an atomic sentence is stated to be true only (T),
- an atomic sentence is stated to be false only (F),
- an atomic sentence is stated to be both true and false, for instance, by different sources, or in different points of time (Both), and
- an atomic sentences status is unknown. That is, neither true, nor false (None).

Extensions of Belnap's logic are discussed in [5] and [16].

Another three-valued logic, known as Kleene's logic is developed in [17] and has three truth values, truth, unknown and false, where unknown indicates a state of partial vagueness. These truth values represent the states of a world that does not change.

A brief overview of a six-valued logic, which is a generalized Kleene's logic, has been first presented in [19]. The six-valued logic was described in more detail in [13]. In [11] this logic is further developed by assigning probability estimates to formulas instead of non-classical truth values.

Two kinds of negation, weak and strong negation are discussed in [25]. Weak negation or negation-as-failure refers to cases when it cannot be proved that a sentence is true. Strong negation or constructable falsity is used when the falsity of a sentence is directly established.

Logic in preference modeling is discussed in [3], [15], and [20].

Python applications are known for increasing overall efficiency in the maritime industry [14].

LAMP is a collective name for the tools of Linux, Apache web server, MySQL database application, PHP scripting language, Perl programming language, and Python programming language. They have the advantage of being freely available, easily configured, and robust. They are a subject of constant development and improvement and are well known to be easily deployed, fully configured, and maintained with minimal efforts. The LAMP tools assist developers to do creative work without being bothered by administrative details.

3 Preliminaries

A *concept* is considered by its *extent* and its *intent*: the *extent* consists of all objects belonging to the concept while the *intent* is the collection of all attributes shared by the objects [4].

A *context* is a triple (G, M, I) where G and M are sets and $I \subset G \times M$. The elements of G and M are called *objects* and *attributes* respectively.

For $A \subseteq G$ and $B \subseteq M$, define

$$A' = \{m \in M \mid (\forall g \in A) \ \ gIm\},$$

$$B' = \{g \in G \mid (\forall m \in B) \ \ gIm\}$$

so A' is the set of attributes common to all the objects in A and B' is the set of objects possessing the attributes in B. Then a *concept* of the context (G, M, I) is defined to be a pair (A, B) where $A \subseteq G$, $B \subseteq M$, $A' = B$ and $B' = A$. The *extent* of the concept (A, B) is A while its intent is B. A subset A of G is the extent of some concept if and only if $A'' = A$ in which case the unique concept of the which A is an extent is (A, A'). The corresponding statement applies to those subsets B of M which are the intent of some concept.

The set of all concepts of the context (G, M, I) is denoted by $\mathcal{B}(\mathcal{G}, \mathcal{M}, \mathcal{I})$. $\langle \mathcal{B}(\mathcal{G}, \mathcal{M}, \mathcal{I}); \leq \rangle$ is a complete lattice and it is known as the *concept lattice* of the context (G, M, I).

For concepts (A_1, B_1) and (A_2, B_2) in $\mathcal{B}(\mathcal{G}, \mathcal{M}, \mathcal{I})$ we write $(A_1, B_1) \leq (A_2, B_2)$, and say that (A_1, B_1) is a *subconcept* of (A_2, B_2), or that (A_2, B_2) is a *superconcept* of (A_1, B_1), if $A_1 \subseteq A_2$ which is equivalent to $B_1 \supseteq B_2$ (Lemma 1) [4].

Lemma 1 *[4] Assume that (G, M, I) is a concept and let $A, A_j \subseteq G$ and $B, B_j \subseteq M$, for $j \in J$. Then*
(i) $A \subseteq A''$,
(ii) $A_1 \subseteq A_2 \Longrightarrow A'_1 \supseteq A'_2$
(iii) $A' = A'''$,
(iv) $\left(\bigcup_{j \in J} A_j\right)' = \bigcap_{j \in J} A'_j$,
(i)′ $B \subseteq B''$,
(ii)′ $B_1 \subseteq B_2 \Longrightarrow B'_1 \supseteq B'_2$,
(iii)′ $B' = B'''$,
(iv)′ $\left(\bigcup_{j \in J} B_j\right)' = \bigcap_{j \in J} B'_j$.

The fundamental theorem on concept lattices [6] is

Theorem 2 *Let (G, M, I) be a context. Then $\langle \mathcal{B}(\mathcal{G}, \mathcal{M}, \mathcal{I}); \leq \rangle$ is a complete lattice in which join and meet are given by*

$$\bigvee_{j \in J} (A_j, B_j) = \left(\left(\bigcup_{j \in J} A_j \right)'', \bigcap_{j \in J} B_j \right),$$

$$\bigwedge_{j \in J} (A_j, B_j) = \left(\bigcap_{j \in J} A_j, \left(\bigcup_{j \in J} B_j \right)'' \right).$$

Conversely, if L is a complete lattice then L is isomorphic to $\langle \mathcal{B}(\mathcal{G}, \mathcal{M}, \mathcal{I}); \leq \rangle$ if and only if there are mappings $\gamma : G \to L$ and $\mu : M \to L$ such that $\gamma(G)$ is join-dense in L, $\mu(M)$ is meet-dense in L, and gIm is equivalent to $\gamma(g) \leq \mu(M)$ for each $g \in G$ and $m \in M$. In particular, L is isomorphic to $\langle \mathcal{B}(\mathcal{L}, \mathcal{L}, \leq)\rangle$ for every complete lattice L.

For describing six-valued logic we use notations as in [13]. Thus

- true - it is possible to prove the truth of the formula (but not its falsity)
- false - it is possible to prove the falsity of the formula (but not its truth)

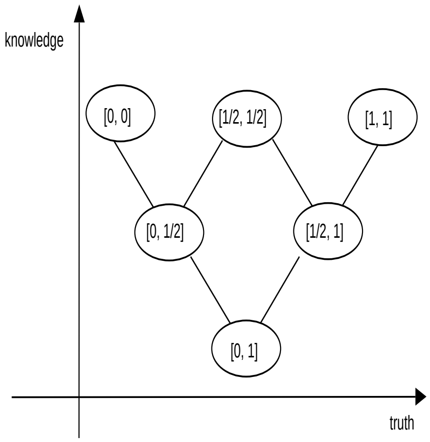

Figure 1: Probability lattice

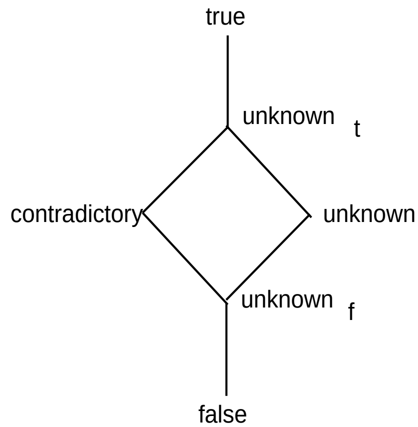

Figure 2: Partial ordering

- unknown - it is not possible to prove the truth or the falsity of the formula (there is not enough information)
- unknown$_t$ - intermediate level of truth between unknown and true
- unknown$_f$ - intermediate level of truth between unknown and false
- contradiction - it is possible to prove both the truth and the falsity of the formula

The six-valued logic distinguishes two types of unknown knowledge values - permanently or eternally unknown value $\top$ and a value $\bot$ representing current lack of knowledge about a state [12]. The epistemic value of formula when it is known that the formula may take on the truth value *t* is denoted by $\bot_t$ and by $\bot_f$ when it is known that the formula may take on the truth value *f*.

Assigning probability estimates to formulas instead of non-classical truth values one obtains the intervals $[0,0], [0,\frac{1}{2}], [\frac{1}{2},\frac{1}{2}], [\frac{1}{2},1], [1,1]$, corresponding to *f*, $\bot_f$, $\top$, $\bot_t$, $\top$, *t* respectively. Relations among them can be seen from the lattice on Fig. 1.

Let P be a non-empty ordered set. If $sup\{x,y\}$ and $inf\{x,y\}$ exist for all $x, y \in P$, then P is called a *lattice* [4].

A lattice [4] showing a partial ordering of the truth values by degree of knowledge is presented in Fig. 2. The knowledge lattice illustrates how the truth value of a formula that has a temporary truth value can be changed as more knowledge becomes available. Suppose a sentence has a truth value $\bot_f$ at one point of time and *f* at another. Its truth value is then determined as *f*, i.e. the system allows belief revision as long as the revision takes place in an incremental knowledge fashion.

4 Companies and Their Strong Sides

Suppose a potential customer wants to order a ship and can choose among different companies. The process of choosing the correct one can be considerably improved if information, like the presented in this section, is available.

For this scenario we consider five companies (objects) denoted $C1, C2, C3, C4, C5$ and their strong sides (attributes) with the following notations:

- $A1$ - Capacity to undertake detailed vessels design
- $A2$ - Scale of demand
- $A3$ - Capability for stability and predictability of demand
- $A4$ - Managing the production and integration of a ship and ship systems
- $A5$ - Effective use of advanced design and production technologies
- $A6$ - Access to intellectual property
- $A7$ - Capability for competitive bidding
- $A8$ - Ability to secure correct contracting environment
- $A9$ - Positive attitude for taking the logic of alternative vessel management forward

The relationships among objects and attributes are shown in Table 1.

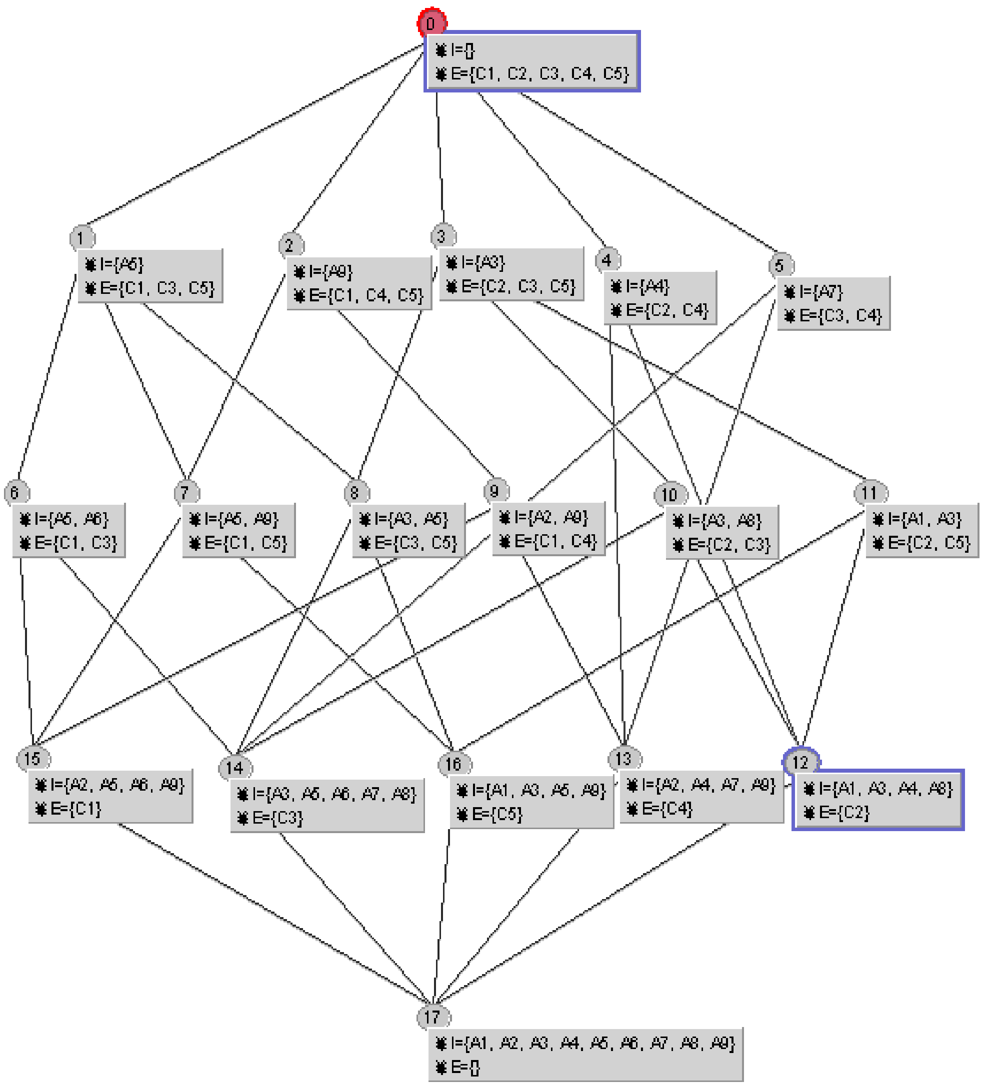

Figure 3: Lattice for companies and their preferences

Table 1: Relationships among objects and attributes

	A1	A2	A3	A4	A5	A6	A7	A8	A9
C1		×			×	×			×
C2	×		×	×				×	
C3			×		×	×	×	×	
C4		×		×			×		×
C5	×		×		×				×

The corresponding lattice is presented on Fig. 3. All concepts are presented by the labels attached to every node of the lattice. The meaning of the used notations is as follows.

- Node number 1 has a label $I = \{A5\}, E = \{C1, C3, C5\}$. It means that only companies $C1, C3, C5$ can provide effective use of advanced design and production technologies.

- Node number 8 has a label $I = \{A3, A5\}, E = \{C3, C5\}$. It means that only companies $C1, C3, C5$ have the capability for stability and predictability of demand, and can provide effective use of advanced design and production technologies.

- Node number 14 has a label $I = \{A3, A5, A6, A7, A8\}, E = \{C3\}$. It means that only companies $C3$ have the capability for stability and predictability of demand, can provide effective use of advanced design and production technologies, have access to intellectual property, have capability for competitive bidding, and ability to secure correct contracting environment.

5 System Architecture

The system implementation uses the so-called LAMP Web application infrastructure and deployment paradigm. It is a combination of free software tools on a Linux operating system of an Apache Web server, a database server and a programming environment using scripting language.

Implementers can choose and mix these tools freely. This in contrast to commercial Web application platforms like for example, WebSphere from IBM [10], JavaServer from Sun [9], and ASP.net from Microsoft [8].

Apache Web server is a robust and extendable Web server. In our implementation, the Web server is extended with a Python interpreter by using 'mod_python' module. A SQLite database engine is a capable relational database engine. It is comparable to MySql and PostgreSQL, but more lightweight and zero administration cost. SQLite does not administer its own user and access control, it uses an operating system file protection mechanism.

The application server provides search and intelligent evaluation services to the Web server. The separation of these two units made it possible to modularly design and implement the system as loosely coupled independent sub-systems.

By providing a client Web interface, the system invites reviewers to submit their reviews of ship designers they have had experience working with. The user authenticator and user profiler modules play an important role in controlling every particular user, client or administrator authenticity. Only valid reviewers can submit reviews. The administrator can approve the results of a search agent before the data is submitted to the database.

The Web server's middleware and the application server's software agents can run in parallel, independently of each other. As such, they can be situated on different servers. The middleware implements the Web user interface side of the system while the software agents implement the evaluation side of decision process. Each of the truth values of a response triggers different rule-based reaction as discussed in Section 3.

6 Conclusion

This paper presents a system facilitating effective a shipbuilding. The decision making process is based on the ability to design, develop, test and integrate modern vessels.

References:

[1] N. J. Belnap, How a computer should think. In *Contemporary Aspects of Philosophy*. Proceedings of the Oxford International Symposia, Oxford, GB, (1975) 30–56

[2] N. J. Belnap, A useful four valued logic, *Modern uses of multiple-valued logic*, J.M. Dunn and G. Epstain (eds), D. Reidel Publishing Co., Dordrecht (1977) 8–37

[3] D. S. Briges and G. B. Mehta, Representations of preference orderings. Springer-Verlag, Berlin, (1995)

[4] B. A. Davey, and H. A. Priestley. Introduction to lattices and order. Cambridge University Press, Cambridge (2005)

[5] J. M. Font, M. Moussavi, Note on a six valued extension of three valued logics, *Journal of Applied Non-Classical Logics*, 3, (1993) 173–187

[6] B, Ganter, G. Stumme, and R. Wille. Formal Concept Analysis - Foundations and Applications. *Lecture Notes in Computer Science*, Springer Verlag, 3626 (2005)

[7] A. Gurfinkel and M. Chechik. Yasm: Model-Checking Software with Belnap Logic. Technical Report 470, University of Toronto, April (2005)

[8] http://msdn2.microsoft.com/en-us/asp.net/default.aspx

[9] http://java.sun.com/products/jsp/

[10] http://www-306.ibm.com/software/websphere/

[11] M. Fitting. Kleene's Logic, Generalized. *Journal of Logic and Computation*, 1(6), (1991) 797–810

[12] O. N. Garcia and M. Moussavi. A Six-Valued Logic for Representing Incomplete Knowledge. Proceedings of ISMVL, (1990) 110–114

[13] J. Garcia-Duque, M. Lopez-Nores, J. Pazos-Arias, A. Fernandez-Vilas, R. Diaz-Redondo, A. Gil-Solla, Y. Blanco-Fernandez, M. Ramos-Cabrer. A Six-valued Logic to Reason about Uncertainty and Inconsistency in Requirements Specifications. *Journal of Logic and Computation*, 16(2), (2006) 227–255

[14] http://www.python.org/about/success/tribon/

[15] J. Kacprzyk, and M. Roubens. Non Conventional Preference Relations in Decision Making. *Lecture Notes in Economics and Mathematical Systems* (LNMES) 301, Springer Verlag, Berlin, (1988)

[16] Y. Kaluzhny, A.Y. Muravitsky. A knowledge representation based on the Belnap's four valued logic, *Journal of Applied Non-Classical Logics*, 3, (1993) 189–203

[17] S. Kleene. Introduction to Metamathematics. D. Van Nostrand Co., Inc., New York, N. Y., (1952)

[18] J. Lukasiewicz. On Three-Valued Logic. Ruch Filozoficzny, 5, (1920), English translation in Borkowski, L. (ed.) 1970. Jan Lukasiewicz: Selected Works. Amsterdam: North Holland, (1920)

[19] M. Moussavi and O. N. Garcia. A Six-Valued Logic and its application to artificial intelligence. Proceedings of the Fift Southeastern Logic Symposium, (1989)

[20] P. Perny and A. Tsoukias. On the continuous extension of a four valued logic for preference modelling. In Proceedings of the IPMU 1998 conference, Paris, 302–309, (1998)

[21] G. Priest. An Introduction to Non-Classical Logic, Cambridge, (2001)

[22] A. N. Prior. A Statement of Temporal Realism. In Copeland, B.J. (ed.) Logic and Reality: Essays on the Legacy of Arthur Prior. Oxford: Clarendon Press, (1996)

[23] C. T. Santos and F. S. Osòrio. Integrating intelligent agents, user models, and automatic content categorization in virtual environment. *Lecture Notes in Computer Science*, 3220, Springer-Verlag, Berlin Heidelberg New York, (2004) 128–139

[24] K. M. Sim. Bilattices and Reasoning in Artificial Intelligence: Concepts and Foundations. *Artificial Intelligence Review*, 15(3), (2001) 219–240

[25] G. Wagner. Vivid Logic: Knowledge Based reasoning with two kinds of negation. *Lecture Notes in Artificial Intelligence*, 764, Springer-Verlag, Berlin Heidelberg New York (1994)