

# Lattices and the Collaborative Design in Shipbuilding

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**Abstract.** The paper is devoted to application of formal concept analysis and collaborative design in shipbuilding. Sourcing and shoring strategies of a Norwegian multinational design company is illustrated by a concept lattice.

**Keywords:** multiple location collaborative design applications, virtual organizations, shipbuilding.

## 1 Introduction

The modern globalization trends together with computer, information and communication technologies have great influence on the collaborative nature of a ship design. A few decades ago collaborating partners in the ship design process such as shipyards, shipowners, designers and suppliers were mainly located in one country. Nowadays they operate all over the globe. Collaborative processes inside participant organizations are also becoming much more complicated. On the one hand, the number of subcontractors has increased during the last thirty years. Enterprises tend to concentrate on their core competencies and outsource a number of operations that have been made in-house earlier. This concerns, first of all, shipyards. On the other hand, all collaborative participants in the shipbuilding try to minimize their expenses by offshoring activities, partly or entirely, to other countries. This lead to creation of virtual organizations which became popular among firms of different sizes during the last decade. The establishment of virtual organizations is a response to new business environment conditions. Formation of virtual organizations gives participants benefits of large organizations without disadvantages appropriate to complicated organizations [5]. The nature of the ship design work is favorable to the emergence of virtual enterprises in this area. The technical work is greatly computer-assisted. Information is produced in electronic form (such as, drawings and specifications). This gives a possibility of virtual working. Ship designers benefit from standardization. Standard software is used around the world to make drawing.

It is a very common situation in the modern shipbuilding when the shipowner is, for example, from the Great Britain, a designer is from Norway, the shipyard

is situated in China, and suppliers are from all over the world. Globalization tendencies, tough competition, geographical and cultural remoteness demand high level of inter-enterprise and intra-firm collaboration during the ship design process.

The objective of the paper is to investigate the possibility of application of the formal concept analysis in the area of virtual organizations. The methodology of this paper uses concept lattices as a tool for the formalization and integration of concepts in the shipbuilding process and relationships encoded in different domain-specific concepts, to reveal their association and interaction. Sourcing and shoring strategies of a multinational design company are illustrated by a concept lattice.

The rest of the paper is organized as follows. Related work and statements from formal concept analysis may be found in Section 2. The main results of the paper are placed in Section 3 and Section 4. The paper ends with a conclusion in Section 5.

## 2 Related Work

Formal concept analysis [9], [16] started as an attempt of promoting better communication between lattice theorists and users of lattice theory. Since 1980's formal concept analysis has been growing as a research field with a broad spectrum of applications. Various applications of formal concept analysis are presented in [10]. A technical oriented application field of formal concept analysis is the area of production planning where the concept lattices are used to partition the products into disjoint groups during the optimization of the production cost [16].

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 [7]. The set of all concepts of the context  $(G, M, I)$  is a complete lattice and it is known as the *concept lattice* of the context  $(G, M, I)$ .

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

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

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  $B$ .

The structure of a concept lattice is represented with a Hasse diagram. The Hasse diagram is a special directed graph, where the nodes are the concepts and the edges correspond to the neighborhood relationship among the concepts. The Hasse diagram of a concept lattice is used to describe the concepts hidden in the underlying data system.

## 3 Virtual Organization Concept

Virtual organization concept was first proposed in [8]. Virtual organization can be defined as "one to which different people contribute, from the strategic apex to