An integrated system for decision support of the complex case of a port and dry port

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Abstract.
Intermodal logistic systems are complex entities requiring a huge effort to achieve an optimal performance and retain or even increase their share in current competitive business environment. A major key for them is the ability of the involved stakeholders to reach optimal or near optimal solutions. Such systems are characterized by an increased complexity of their operations that require the adoption of computerized approaches. A solution is to design and adopt modern decision support systems (DSSs) that are able of tackling with their complexity and perform in time and "optimal" decision making. In this paper, we present the architecture of such a DSS which is currently developed for the case of the port-dry port complex at Trieste area while a similar methodology is going to be investigated for the case of port of Bari and the case of Port of Igoumenitsa within ARGES project activities.

Keywords. Decision Support System, Logistics, Information and Communication Technologies, Optimization, Analytic Hierarchy Process.

1 Introduction

Till recently, management and decision making was considered more of an art acquired with experience over a long period of time rather than a disciplined process. A successful decision maker was someone that could combine expertise with personal intuition, creativity and judgment to reach decision in a timely manner. Although personal qualifications remain valuable, the increasing complexity of modern business environment and the vast volume of data needed to be taken into account, make the old-time decision maker an almost obsolete figure. At the same time the use of computerized and systematic quantitative methods are becoming a necessity for business to keep up with competition [1].

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Intermodal terminals are no exception. They are complex logistic systems that involve many stakeholders and require a great number of decisions that should be made for different time horizons. Generally, all the decisions involved in a logistic process can be classified as strategic, tactical and operational [2]:

- Strategic decisions have long-lasting effects (usually over many years). They include logistics systems design and the acquisition of costly resources (facility location, capacity sizing, plant layout, fleet sizing etc.). Because data are often incomplete and imprecise, strategic decisions generally use forecasts based on aggregated data or through simulation models [3], [4], or using a combination of modelling and expert knowledge as in the case of the Analytic Hierarchy Process (AHP) approach [5].
- Tactical decisions are made on a medium-term basis (e.g. monthly or quarterly) and include production and distribution planning, as well as resource allocation (storage allocation, order picking strategies, transportation mode selection, consolidation strategy etc.). Simulation models are also quite popular for this decision level [4].
- Operational decisions are made on a daily basis or in real-time and have a narrow scope. Operational decisions, such as the assignment of trucks to containers [6], are customarily based on very detailed data and models.

Here we are going to present a web-based DSS which is developed in order to address different decision levels of the port-dry port complex of Trieste (Figure 1) [7] but its architecture can be adopted for other similar settings.

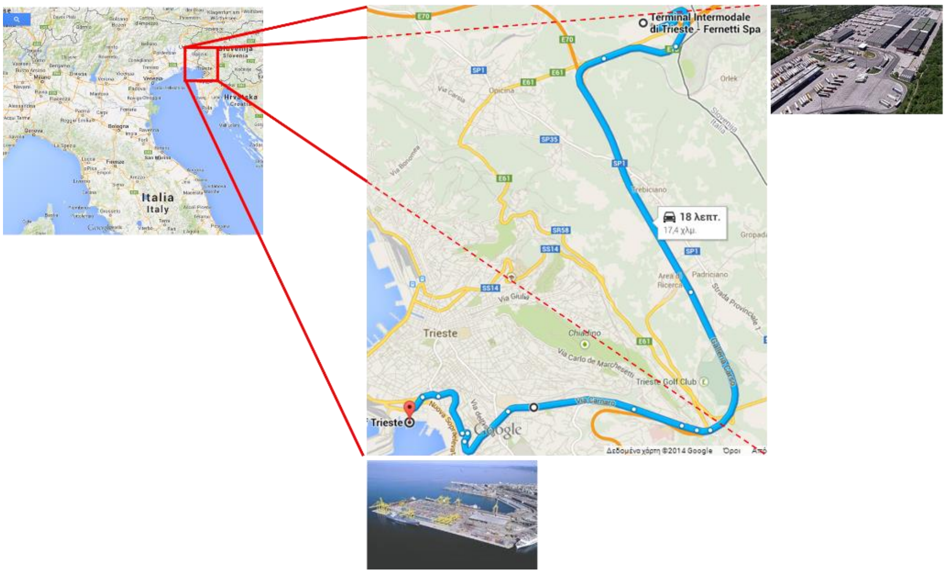

Fig. 1. An overview of the port-dry port complex at Trieste.

It should be noted that for the case of freight transportation through intermodal terminals there are special needs that require high level of performance, which can be accomplished by the implementation of integrated information systems to improve the provided services [8]. Actually, advances in Information and Communication Technology (ICT) can increase the performance of the logistic system [9], [10] as ICT plays a key role towards the development of safe and efficient freight transportation systems [10].

For such systems, new methodologies and tactics have to be proposed and designed specifically for each case customized in most cases to the type of problem that needs to be addressed. They vary from well-defined optimization algorithms to the definition of new long term policies, and from the use of massive volumes of data to methods and models for multicriteria problems involving expert knowledge.

The web-based platform presented in this paper offers to the end user different tools for tackling the different decision levels: a) for the strategic level a module based on a simplification of the AHP is provided, b) for the tactical level a module based on a Discrete Event Systems (DES) simulation model [11] and c) for the operational level a module based on Harmony search that assigns trucks to containers [6]. The rest of the paper presents in brief each one of the aforementioned modules.

2 Method

The web-based approach consists of a set of modules implementing different fundamental technologies for building the DSS. The overall architecture is depicted in Figure 2. The nature of the system confirms that DSS is just an “Umbrella term to describe any computerized system that supports decision making in an organization” [1].

In the following subsections the main technologies involved in each module are described to provide an overview of the system.

2.1 The strategic level module

Strategic Decision Making (SDM) involves fitting the internal capabilities to the external environment by choosing the best alternative [12]. SDM evaluates the different alternatives quantitatively and provides the decision maker with a rational basis for selecting the optimal solution.

In general, a decision making problem consists of the following:

- Studying the problem.
- Organizing multiple criteria.
- Assessing multiple criteria.
- Evaluating alternatives on the basis of the assessed criteria.
- Rank the alternatives.
- Incorporate the judgment of multiple experts.

For the formulation of the multi-criteria decision making problem a simplification of the Analytical Hierarchical Process (AHP) is implemented. The AHP relies on the formulation of a number of pairwise comparison matrices that materialize the developed hierarchy (Figure 3).

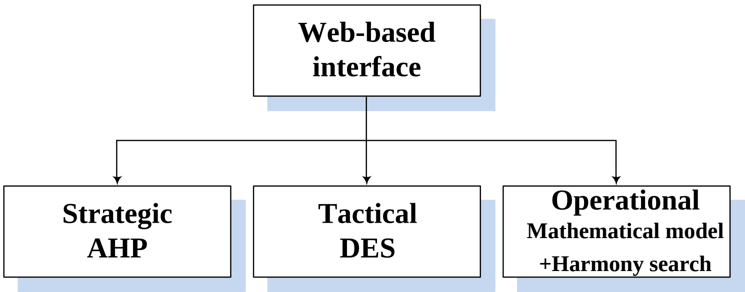

Fig. 2. The overall architecture.

However the end users are asking for a less "complicated" input mechanism. As a result instead of the actual pairwise comparison matrix we formulate the problem by artificially asking the end user to "fix" a criterion (or alternative if we are on the lowest part of the hierarchy) and compare the rest of the criteria against it. The resulting vector after normalization acts as the weighting vector for the criteria (alternatives). The inference engine then relies on the standard AHP framework for reaching a decision.

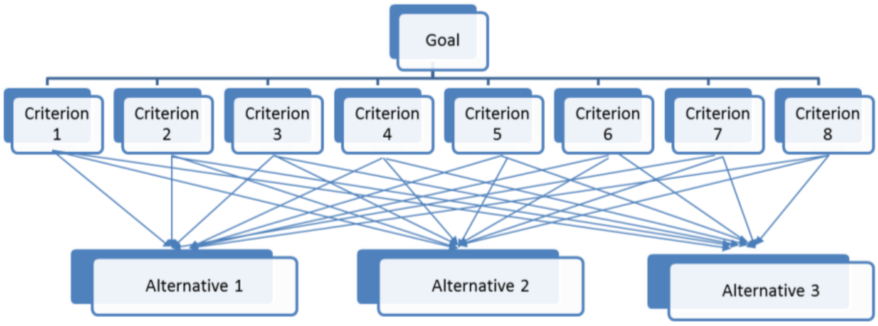

Fig. 3. A hierarchy with three alternative and nine "competing" criteria.

2.2 The tactical level module

In the tactical level there is a complex system embedded in a model-driven DSS that can help a decision maker to plan activities, anticipate the effects of specific resource allocations and assess the consequences of actions and events [13]. "What if analysis" can be performed via a simulation tool that sometimes offer extra confidence to the decision maker than just the simple presentation of numbers in a tabular format.

For the needs of the SAIL project a Discrete Event System (DES) simulation model was developed to simulate the corresponding processes. However, DES are quite time consuming during their execution. They involve stochastic processes that require a great number of simulation executions to reach a certain level of confidence. Therefore a sophisticated and at the same time more practical way is needed to reduce the number of replication devoted between the different competing "what-if" scenarios.

The most common approach during the execution of simulation runs for different scenarios is to allocate them a pre-specified number of replications. However this approach does not take into account either the relative "goodness" of the candidates or the spread of the (simulation) "noise".

On the other hand the Optimal Computing Budget Allocation (OCBA) [14] scheme that does exactly that: it encompasses both the variance and the mean value of the alternative designs (the noisier the simulation output (larger variance), the more replications are allocated. More replications are also given to the design of which mean is closer to that of the best design). It usually operates on a sequential manner allocating a fraction of the total available budget each time till it is exhausted.

The module offers the end user the capability to call through web-services of the DES model, developed in Arena [15] and use the OCBA formulation to split the computational budget avoiding unnecessary replications.

2.3 The operational module

For (near) real time decisions and intermodal Ports, a popular approach uses simplified mathematical models. By this way the decision making process is cast as an optimization problem described by a mathematical expression(s). Many (successful) attempts have been made to tackle the various subproblems encountered at intermodal terminals, especially those which are mainly handling containers [16] are exploiting the mathematical modeling approach. Different assumptions, different optimization criteria as well as the different peculiarities of each case study lead to different formulations and different solution approaches. In other words, there are no "off the shelf" solutions for such logistic problems.

For the specific application the operational decision involves the management of a fleet of trucks that move containers/trailers from main port (Trieste port) to a dry port or the other way around. Actually, it involves the assignment of the trucks to the containers. The process is based on a global optimization algorithm [6] that considers the information gathered through RFID technology for the identification of the location of the various units as well as a database with the requirements for each one of the containers.

The output of the module is a list with the order of the containers that each truck has to serve. Based on the updated information provided by the RFID and the entrance of new requests, the optimization algorithm seeks for a near-optimal solution which is returned to the user, on demand.

3 Conclusions

In this paper we presented the main elements that consist an integrated solution developed for an intermodal complex system. The system incorporates different technologies for the different decision levels since the granularity of the problem does not allow for a unified approach. Within the ARGES project, the proposed solution is envisaged to be investigated for the case of the Port of Igoumenitsa where a dry port is going to be developed in the near future. In addition to this, a similar approach could also be investigated for modeling and optimization the traffic to and from the Port of Bari.

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