THE INTELLIGENT DECISION SUPPORT SYSTEM PROTOTYPE FOR PORT INFORMATIONAL INTEGRATION

Ana X. HALABI-ECHEVERRY[(a)], Sardar M. N. ISLAM[(b)]
Hugo L. NIÑO-VERGARA[(c)], Nelson OBREGON-NEIRA[(d)],

[(a),(c)] Escuela Internacional de Ciencias Económicas y Administrativas, Universidad de La Sabana,
km 7 autopista norte de Bogotá, D.C., Chía (Cundinamarca), Colombia

[(b)] College of Business, Victoria University
City Flinders Campus, Level 13
PO Box 14428, Melbourne, Vic. 8001

[(d)] Instituto Geofísico, Universidad Javeriana,
Carrera 7 no. 42-27 Piso 7, Bogotá, Colombia

[(a, b)] ana.halabi, hugo.nino1@unisabana.edu.co, [(c)] nobregon@javeriana.edu.co [(d)] Sardar.Islam@vu.edu.au

ABSTRACT
This paper demonstrates the different set of values, queries and scenarios offered as a proof of concept of the Intelligent Decision Support System (*i*-DMSS) for port integration. In particular, we consider how an *i*-DMSS can support data and information integration across ports to deliver improved decision-making and outcomes. Each set of options can be saved to feed in the future a knowledge base with the choices made by the users. It constitutes an early prototype as a suitable visual schema for explaining in practical terms the number of scenarios that guide informational integration for ports.

Keywords: Intelligent Decision-making Support Systems, Early Prototype, Port Informational Integration, Port Strategic Decisions.

1. INTRODUCTION

Ports as any other organisation are facing challenging changes in their traditional ways of support decisions and the flexibility increasingly complex in their information systems. It is estimated that current information system must display environment strategies, norms, culture, behaviours and decisions that become increasingly difficult to be monitored, and are continuously affecting business processes and impacting operational strategic goals.

Information and Communication Technologies (ICT) in ports has traditionally focused on necessities at the operational level as a response to port-specific processes (Cetin & Cerit 2010; Mathew et al., 2005; Henesey, 2006). Electronic Data Interchange systems, Vessel Traffic Monitoring and Information systems, and Container Terminal systems are some examples. Vessel traffic monitoring and information systems (VTMIS) have evolved from website-based systems (Forward, 2003). In planning yard distribution and container layouts, ports generally use container terminal systems for managing the movement of cargo through terminals (Almotairi et al., 2011). Current Logistics and Transport Management and Collaboration systems mainly cover requirements of business-to-business (B2B) transactions.

Van Baalen & van Oosterhout (2009) discuss new necessities for IT in ports through information sharing, planning and execution in collaborative ways such as the called port community systems and the inter-organisational systems. By the use of advance ICT in ports, new technological dilemmas arise, such as the need for more intelligent support. The need to introduce intelligent support tools can cope with the complexity of global operations as pointed by Murty et al. (2005). Therefore, as these authors indicate, while current information systems may meet current needs, more intelligence is required to handle the growing complexity within the port domain. For example, information systems in the port domain rarely take advantage of Computational Intelligence technologies such as data-mining, knowledge-based systems and ontologies.

2. AN INTELLIGENT DECISION SUPPORT SYSTEM (*i*-DMSS) FOR PORT INFORMATIONAL INTEGRATION

Artificial Intelligence in its fusion with decision support systems (DSS) supports the prototype design for the (*i*-DMSS) port-to-port solution, that as to the best of the authors' knowledge, it is the first time for a solution of this type be offered. The proof-of-concept of the decision-aid tool, namely, the intelligent decision making support system for port informational integration (*i*-DMSS) was first presented in Halabi-Echeverry (2017). The aim of this paper is to propose the use of computational intelligence technologies to drive knowledge towards port informational integration. The port informational integration concept offered mainly refers to a higher perspective of port cooperation in which development of capabilities on sharing information, planning and execution allows two or more ports to advance and deliver benefits among the partners. The *i*-DMSS for port informational integration provide guidance to experts and decision makers. Cassaigne & Lorimier highlight that an important challenge for tactical/strategic or "non-programmable" decisions (in the words of Herbet Simon) places special emphasis in the DSS's future development. "Strategic decisions are mainly based on knowledge and gut feeling to answer a novel situation, in other words they are characterised by uncertainty and complexity (2006, p.402)". They propose interactions among the parts (human/technology) of an DSS to observe the complexity of the decision supported, i.e., decision maker and the expert knowledge (which sometimes do not reside in the decision maker) and the computational intelligent system.

The *i*-DMSS for port informational integration is meant to be used primarily by multilateral organisations involved in strategic global decision making. Public organisations such as IMO (International Maritime Organization), and private associations like IAPH (International Association of Ports and Harbors) demand a comprehensive integrated independent system to carry out follow-up and control of local developments that could have global influence in terms of economic, environmental, demographic or cultural performance. Major port operators such as HPH (Hutchison Port Holdings), PSA (Port of Singapore Authority); DP (Dubai Port World), APM Terminal (A.P. Moller) may find the *i*-DMSS for port informational integration useful to conduct data analysis based on a variety of aspects apart from the economical approach. The observance of law and regulations by this mega corporations will need a tool to objectively measure the impact of such acquisitions to support political decisions that could be influenced by private interests.

3. FUNCTIONALITIES

The *i*-DMSS for port informational integration promotes functionalities to respond to the next generation of intelligent decision support systems supporting data and information integration across ports to deliver improved decision-making and outcomes for the parties concerned.

The essential functionalities contended in the *i*-DMSS for port informational integration are:

- Integration of heterogeneous repositories,
- Exploitation of multiple learning algorithms,
- Metadata to enable future system automation and user support requirements
- Providing semantic interoperability

3.1 Integrating heterogeneous repositories,

Multiple data hierarchies are outlined as a proof-of-concept in this paper making special emphasis to the literature and the public available resources where they come from. Figure 1 shows various merged data hierarchies and performance indicators included in the *i*-DMSS for port informational integration. As the interrelated nature of these concepts may create complexity of computing, future efforts in this direction must be estimated. The available set of performance indicators is visualised by rectangles in yellow, estimated data-levels by rectangles in blue and measurements by rectangles in skintone. These relationships are not exhausted but an indication of the complexity of the data-driven approach dealt with in the system.

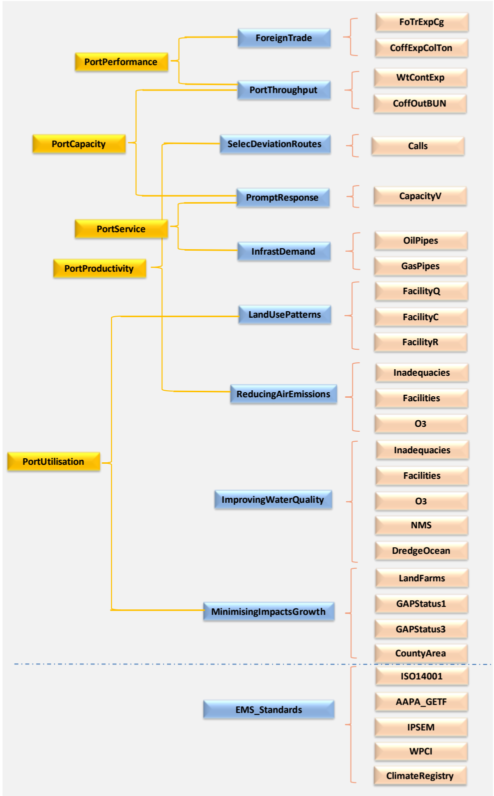

Fig. 1: Hierarchical diagram of concepts, factors and variables contented in the *i*-DMSS for port integration)

3.2 Exploiting multiple learning algorithms

This functionality refers to the general performance of a learner and its prediction capability. The learning space captures the relevant factors and measurement variables simplified during the data mining activity. The performance of learning algorithms is determined by dataset characteristics and algorithms.

Feature Selection (or variable selection) refers to a task that can be formulated as an optimization problem and used with learning algorithms of classification (or clustering). Kacprzyk & Pedrycz (2015) define feature selection in terms of three approaches: filter, wrapper or embedded (p.1216):

The concept of metafeature refers in general to “statistics describing the training dataset of the problem, such as number of training examples, number of attributes, correlation between attributes, class entropy, among others (Prudêncio et al. 2011, p.226)”. Thus, metafeatures define the main properties of a specific dataset using a process known as a learning task, which should be computed in a data-driven way. Castiello & Fanelli (2011) state that Metafeatures must satisfy two basic conditions: “Firstly, they should prove to be useful in determining the relative performance of individual learning algorithms. Secondly, their computation should not be too difficult and burdensome (pp.163-164)”.

An important issue in knowledge discovery regards to finding the finest classifier. Using the automatic system construction wizard in Rapid Miner 5.0®, the metalearning classification is a straightforward process. This wizard also aids evaluating each classifier and finding an optimal parameterisation for the dataset at hand. No single learning algorithm will construct hypothesis of high accuracy on all problems.

The automatic system process of Rapid Miner 5.0® better referred as the PaREn (Pattern Recognition Engineering) system, makes possible to obtain an overview of the performance of a classifier over different datasets. It also includes preprocessing when necessary, i.e., normalisation, discretisation, or missing value replenishment and parameter optimisation setups (Shafait et al., 2010). The success of an automatic pattern recognition is also due to the metafeatures of the datasets for metalearning.

PaREn evaluates the accuracy of the following classifiers on the datasets for cases included in the *i*-DMSS for port integration: 1) the learner supervised rules – OneR, 2) naïve bayes, 3) support vector machines, 4) knearest eighbor, 5) neural networks, and 6) random forest. The evaluation uses a crossvalidation technique along with the root mean squared errors (RMSE) for each classifier. Table 1 shows the corresponding evaluation.

Results of this process suggest Random Forest as the learning algorithm that better performs for the datasets at hand. It has the highest accuracy among the considered classifiers with an acceptable RMSE that brings confidence to the prediction. This special output of Rapid Miner 5.0® is based only on metafeatures.

Table 1: PaREn results for customised datasets on port informational integration and corresponding evaluation

Dataset	# Observ	#Attr+Class	OneR	Naïve Bayes	Support Vector Machines	K-Nearest Neighbors	Neural Networks	Random Forest
Accuracy (Cross-Validation)								
US West coast, the Gulf and Atlantic coasts Dataset (Case 1)	44	27	0.614	0.273	0.636	0.636	0.636	0.682
RMSE			0.083	0.083	0.068	0.056	0.078	0.084
US West coast, the Gulf and Atlantic coasts Dataset (Case 2)	44	26	0.727	0.932	0.932	0.932	0.955	1.000
RMSE			0.083	0.083	0.068	0.056	0.078	0.084
Rjin Schelde Delta Dataset (Case 3)	29	27	0.723	0.862	0.964	0.969	0.964	1.000
RMSE			0.083	0.083	0.068	0.056	0.078	0.084

3.3 Entail metadata to enable future system automation and user support requirements

As said, metadata serves as training and evaluation data for new learning processes (Hilario et al. 2011). This brings an advantage over black box systems giving the user the control and flexibility necessary to combine learning with experience. The metadata is organized in a hierarchy scheme using colours which demonstrate the relationships that may exist between the data elements. Further will be explained that although the *i*-DMSS for port informational integration prototype provides the fixed baseline for those hierarchies, in the future it would be desirable allow the user to interact with the hierarchies using his experience to redefine or confirm the baseline. Figure 2 shows the metadata relationships and Table 2 provides the metadata identification. Each metadata element is provided with a

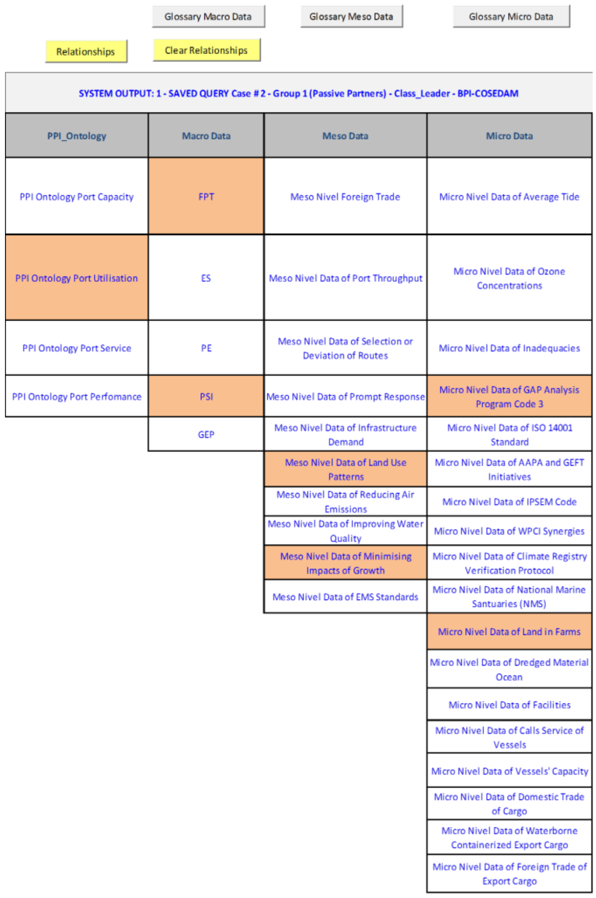

Fig. 2: System Output 2: Flexible Metadata Visualisation

ISBN 978-88-97999-85-0; Affenzeller, Bruzzone, Jiménez, Longo and Piera Eds.

mandatory or optional label which indicates if analyses are subordinate or not to that element. Users can offer other options to interpret the processes embedded in the system. This output available for the user is the flexible metadata produced in the different modelling steps.

Table. 2: Metadata identification

Identifier	Description
dc.title: PortName	*a name given to a port*
dc.title: Latitude	*valid values range between [-90.0,90.0]*
dc.title: Longitude	*valid values range between [-180.0,180.0]*
dc.title: Type	*refers to whether the port is seaport, river or deepwater*
dc.title: Size	*refers to whether the port is large, medium or small*
dc.title: Region	*refers to the maximum level at which data aggregation is useful for analyses*
dc.title: State Jurisdiction	*refers to the general legal competence of countries over their ports*
dc.title: LoCoast	*refers the coastal frontages over which ports are located*
dc.title: Context	*refers to the geographical scope for port integration*
dc.title: Port State Jurisdiction	*refers to the control port area endorsed and accredited in recent years at the international and local level*
dc.title: County	*refers to the narrower legal competence of counties over their ports*
dc.title: Time_Year_Scale_of_Interest	*refers to the time scale of interest (year) to run the queries*
dc.title: Time_Month_Scale_of_Interest	*refers to the time scale of interest (month) to run the queries*
dc.title: Important_events_Outliers	*refers to important events identified through the outliers'' analysis*
dc.title: ClusterStatus	*refers to the cluster status given to a port*
dc.title: EMSstatus	*refers to the EMS status given to a port*
dc.title: Str_Governance	*refers to strategy to integrate information with a port partner where normative and procedural pressures and actions take place*
dc.title: Str_TransportInterconnections	*refers to strategy to integrate information with a port partner belonging inter) organisational network where rational use of coastlines and their demands places special emphasis on.*
dc.title: Str_LogisticsFunctions_Operations	*refers to strategy to integrate information with a port partner where higher purchasing power and consumption levels tend to foster port development.*
dc.title: BPI_Environmental&EcologicalSustainability	*The BPI to promote port integration in cooperative decision-making on environmental and ecological sustainability*
dc.title: BPI_OrganisationNetworking	*The BPI to promote port integration in collaborative decision-making on transport or (inter) organisational networks*
dc.title: BPI_PortLogisticsPerf_Economics	*The BPI to promote port integration through value-added analyses on port performance in terms of economics*
dc.title: tide	*refers to the tide mean current rates (for vessels approaching and mooring)*

3.4 Providing semantic interoperability

The *i*-DMSS for port informational integration uses artificial intelligence to describe interoperability matters in heterogeneous repositories and data (or metadata), and the exchange/use of information such as content, format, semantics (ontologies) and defined standards. Semantic interoperability deals with meaningful and precise exchange and sharing of information. Technologies at this stage include metadata and ontologies.

There are a certain number of standards and technologies needed to achieve an enterprise integration and interoperability. It includes standards and technology for interoperability such as: the eXtended Mark-up Language (XML), Hypertext transfer protocols (HTTP/HTTPS), Web Services and Service-Oriented Architectures (SOAs), and in recent times, Predictive Modelling Mark-up Language (PMML)., XML is a widely used, standardised tagged language proposed and maintained by the World Wide Web Consortium (W3W). It has been proposed to be a universal format for structured content and data on the web but can indeed be used for any computer based exchanged. On then other hand, PMML is recently the most common approach to go towards XML-based formats.

The systems interoperability is a challenge posed for Inter-Organisational Systems (IOS) in ports. New technologies are meant to enable information exchange, planning at a higher level after the exchange of information, real-time chains and seamless communication between stakeholders.

The exchange/use of semantics (ontologies) is a component of the *i*-DMSS for port integration hat draws into conceptualisations on port performance indicators (PPIs) through the efficient use of data hierarchies. Differences between PPIs demand hard work for understanding the aggregation of the information in which they are based on; additionally, they are difficult due to the diverse number of methods for their calculation which is essential for decision-making. A single PPIs interpretation is almost impossible. No one measure will suffice, as the differences between ports and the interrelated nature of the metrics create multiple possible interpretations for single data elements.

For instance: In principle every port could be developed to its maximum capacity, reasoning about the description of port capacity comes to the relationship between vessels' capacity (CapacityV) and waterborne containerized export cargo (WtContExp) that can be measured with significant differences and variations per port. Illustration 1 presents one possible description for this relationship:

Illustration 1: Partial Ontology PPI: Port Capacity

OWL:
Class (PortCapacity partial
DataLevels
restriction (***hasA*** amongst other things some values From CapacityV)
restriction (***hasA*** amongst other things some values From WtContExp)
Paraphrase:
PortCapacity has *amongst other things*, *some* values from vessels' capacity in DWT (CapacityV) and also *some* values from waterborne containerised export cargo (WtContExp)

The ontological description given is provided as a first step to guide future development of a complete semantic model in the *i*-DMSS for port informational integration. Analyses rely on regional and aggregate statistical data to guide the decision maker on daily-basis.

4. PROTOTYPING

An early prototype has served for the purpose of showing some of the explained functionalities:

- **Visual Function: The State's Jurisdiction Choice**

The State's Jurisdiction visual function allows the user to make a choice on one or more territorial boundaries where ports exercise governance and managerial functions, moving from simple to complex outputs for analyses.

- **Visual Function: The Business Process Intelligence Choice**

Once the user has selected the State's Jurisdiction under analysis, options of Business Process Intelligence (BPI) are detected according to the embedded data mining workflows in the system.

- **Visual Function: Selecting Values out of each BPI**

The function on selecting values from each BPI allows the user to further drill down his analyses to a level in which classifications, groupings and/or forecasting are displayed. Although, the information accessed so far is static, i.e., cannot be replaced by the user, it indicates the logical sequence of the BPIs for analyses. It also indicates the targets to be accomplished, for instance, if the user is searching ports with leadership characteristics for competitive purposes or average behaviours to fulfill strategies on Corporate Social Responsibility (CSR).

- **Visual Function: Selecting the period of interest**

The function on selecting the period of interest allows the user to constrain the analyses to a particular period of time.

- **Visual Function: Selecting Possible Maps and or Schemas for Visualisation of Queries**

This function allows the user a simple visual identification of the query fields by pressing the option 'show maps'. In the future it is expected the user interacts with spatial and georeferenced information for each field. Two types of visual schemas are available: fixed maps and fixed forecasting reports.

- **System Ouput 1: Saved Query Report**

Once the user has completed his query, he received a confirmation for all choices. The output report allows the user to verify the selections made. It is possible to use glossaries at the upper part of the report.

- **System Output 2: Flexible Metadata Visualisation**

The second output available for the user is the flexible metadata produced in the different modelling steps. This brings an advantage over black box systems giving the user the control and flexibility necessary to combine learning with experience. The metadata is organised in a hierarchy scheme using colours which demonstrate the relationships that may exist between the data elements. Although the prototype provides the fixed baseline for those hierarchies, in the future it would be desirable allow the user to interact with the hierarchies using his experience to redefine or confirm the baseline.

- **System Output 3: Visualisation of What-IF Scenarios**

Finally, the user is provided with different rules originated from the data mining and analytical workflows. The rules are given names to ease the user's understanding of them.

5. SCENARIO ANALYSIS

Scenarios, demonstrations and examples have been developed to encourage the port authorities and other decision makers to utilise the tool. This subsection seeks to characterise one application case considered for port informational integration and show the effective knowledge in decision-making and the necessary assistance in understanding diverse and complex situations for port informational integration in the US West Coast.

A small concentration of ports, among are: Seattle, Oakland, Tacoma and Portland are showing mainly differences on the vessels' capacity (CapacityV) served by the port. Variables such as waterborne containerised export cargo in twenty-foot equivalent units (WtContExp) can be considered important for grouping 'mega-ports' and therefore, play a less important role for grouping medium-sized ports. The decision-making elements are concerned with the ability to integrate information with a port partner defining new port boundaries for the purpose of sustainability involving ecosystems, normative, systemic and procedural dimensions. The regulatory function of these ports has led port authorities to face high pressures to become accredited and internationally recognised. Moreover, a number of environmental measures produced by agencies and local administrative authorities, are difficult with respect to decision making, and as a result with defining strategies to understand the consequences of cooperation between ports.

Rule 06 in Figure 3 ratify that Portland and Seattle use benchmarks and standards becoming aware of the scope and impacts of their activities. They have done well in reducing air emissions, although there is a warning to Portland probably because of its activities near a water-base river basin. Oakland is in a monitoring stage for its air emissions and water quality conditions. All of them are of medium size belonging to the group of 'passive partners' (rules 11, 13 and 17). Certain rules' names may be duplicated but the outcome of the rule is slighty different.

SYSTEM OUTPUT: 2 - SAVED QUERY Case # 2 - Group 1 (Passive Partners) - Class_Leader - BPI-COSEDAM

PORT PARTNER (What-IF Scenarios)	Activated Rules				
Oakland	R05_Improving Water Quality Monitoring	R08_Reducing Air Emissions Monitoring	R11_Passive Partner_WtContExp	R13_Passive Partner_CapacityV	R17_Passive Partner_CapacityV
Portland	R06_Reducing Air Emissions Toll Free	R013_WholeVerificationWarning	R11_Passive Partner_WtContExp	R13_Passive Partner_CapacityV	R17_Passive Partner_CapacityV
Seattle	R06_Reducing Air Emissions Toll Free	R11_Passive Partner_WtContExp	R13_Passive Partner_CapacityV	R17_Passive Partner_CapacityV	

Fig. 3: System Output 2: Rules Visualisation

Four blocks of information about this case are obtained in Figure 4. The first block shows partners with their coordinates, coastal locations and role in an existing or potential cluster (i.e., an initiative or passive role for port informational integration). The second block shows the common interests for cluster formation. These refer to the identification of a partner port for sustainable development. For the pair of ports Seattle and Portland, a more positive outcome given the established actions (i.e., the reduction of air emissions in the area) indicate those ports can lead mutually advantageous actions in this direction. The third block shows cluster similarities (variables in common among the ports). Ports of Seattle and Portland are characterised by a lower infrastructure capacity and throughput. The cluster differences indicated in the fourth block are featuring the fact that in domestic trade there is a slight imbalance for the ports.

PORT	LATITUDE - N	LONGITUDE - W	LoCoast	ClusterRole
Portland OR	45.56845	-122.73899	Pacific	Passive
Seattle	47.6062095	-122.3320708	Pacific	Passive

PORT	Common interests for cluster formation		
Portland OR	R06: Toll free(keep going) on the reduction of air emissions		
Seattle			

PORT	Cluster Similarities			
			waterborne containerised export cargo	*waterborne containerised export cargo*
Portland OR			R11: less than 706, 500 TEUs	R17: less than 131 million deadweight tons (dwt)
Seattle				

PORT	Cluster Differences			
	vessel calls	*domestic trade of cargo*		
Portland OR	R7: up to 2, 588 calls	R7: greater than 6.9bn U$ dollars		
Seattle	R8: up to 2, 588 calls	R8: greater than 5.5bn U$ dollars		

Fig. 4: System Output 2: Rules Visualisation

6. CONCLUSIONS

The role of this paper is not just to accept the port's technological status-quo, but also to identify what new tools may be required to support strategic decision-making of port managers/authorities. It demonstrates the conceptual i-DMSS through prototyping and adding some explanation of how it would support real port informational integration. At this stage the prototype is offered as a proof of concept.

The *i*-DMSS functionality is tested through a set of values, queries and scenarios that contribute to the identification of design choices under which the prototype for port informational integration may work. Each set of options can be saved to feed in the future a knowledge base with the choices made by the users. This knowledge-driven perspective offers to the community and practitioners the ability to learn from the metadata and metafeatures to build intelligent models for port informational integration that support the prototype design for a port-to-port solution, that to the best of the authors' knowledge, is the first time for a solution of this type to be offered.

This paper reveals inconsistencies in the terminology used in the port domain and suggests an accurate use of terms and links between attributes to allow efficient data mining and consequently decision support process. The aim is twofold: create an illustration of the data-level concept for port integration and describe semantically key data contended in the *i*-DMSS for port informational integration such as: port capacity,

7. FURTHER WORK

We are required to overcome current concerns about the *i*-DMSS for port informational integration update and data management as well as the limitations and complications that may rise adopting an easy-to-use platform available online.

In defining the *i*-DMSS modular development some considerations need to be made. The *i*-DMSS modules will require to provide a guide to describe the decisions and challenges simultaneously to decision makers and developers to incorporate the decision-making side and engineering requirements.

Looking to the future implications of this research, the author estimates a new view of these information systems will offer to the port decision makers an opportunity to integrate their information, and informing stakeholders on relevant issues.

LIST OF REFERENCES

Almotairi, B., Flodén, J., Stefansson, G., & Woxenius, J. (2011). Information flows supporting hinterland transportation by rail: Applications in Sweden. *Research in Transportation Economics*. doi: 10.1016/j.retrec.2011.08.003

Cassaigne, N., & Lorimier, L. (2006). A Challenging Future for i-DMSS. *Intelligent Decision-making Support Systems*, pp. 401-422. Springer London

Castiello, C., & Fanelli, A. (2011). Computational Intelligence for Meta-Learning: A Promising Avenue of Research. In N. Jankowski, W. Duch & K. Grąbczewski (Eds.), *Meta-Learning in Computational Intelligence* (Vol. 358, pp. 157-177): Springer Berlin Heidelberg.

Cetin, C. K., & Cerit, A. G. (2010). Organizational effectiveness at seaports: a systems approach. *Maritime Policy & Management*, 37(3), 195-219.

Forward, K. (2003). Recent Developments in Port Information Technology. In K. Jeffery (Ed.). London, U.K.

Halabi-Echeverry, A. X. (2017). Computational Intelligence for Development of Strategic Decision Making in Port Informational Integration. PhD Thesis. Macquarie University, Australia.

Henesey, L. E. (2006). Multi-Agent Systems for Container Terminal Management. Blekinge Institute of Technology, Sweden.

Hilario, M., Nguyen, P., Do, H., Woznica, A., & Kalousis, A. (2011). Ontology-Based Meta-Mining of Knowledge Discovery Workflows. In N. Jankowski, W. Duch & K. Grąbczewski (Eds.), *Meta-Learning in Computational Intelligence* (Vol. 358, pp. 273-315): Springer Berlin Heidelberg.

Kacprzyk, J., & Pedrycz, W. (2015). Introduction. In J. Kacprzyk & W. Pedrycz (Eds.), Springer *Handbook of Computational Intellig*ence, pp. 1-4. Springer Berlin Heidelberg.

Mathew, R., Leathrum, J. F., Mazumdar, S., Frith, T., & Joines, J. (2005). An Object-Oriented Architecture for the Simulation of Networks of Cargo Terminal Operations. *The Journal of Defense Modelling and Simulation: Applications, Methodology, Technolog*y, 2(2), pp. 101-116. doi: 10.1177/154851290500200205

Murty, K. G., Liu, J. Y., Wan, Y. W., & Linn, R. (2005). A decision support system for operations in a container terminal. *Decision Support Systems*, 39(3), pp. 309-332. doi: 10.1016/j.dss.2003.11.002

Prudêncio, R. C., Souto, M. P., & Ludermir, T. (2011). Selecting Machine Learning Algorithms Using the Ranking Meta-Learning Approach. In N. Jankowski, W. Duch & K. Grąbczewski (Eds.), *Meta-Learning in Computational Intelligence*, 358, pp. 225-243. Springer Berlin Heidelberg.

Shafait, F., Reif, M., Kofle, C., & Breuel, T. (2010). Pattern Recognition Engineering. In proceedings RapidMiner Community Meeting and Conference. Retrieve from http://madm.dfki.de/publication&pubid=4947

van Baalen, P.J. & van Oosterhout, M. (2009). IOS Adoption and Implementation in Global Port Communities. In R.A. Zuidwijk, P.J. van Baalen & J.A.E.E. van Nunen (Eds.), Port Inter-Organizational Information Systems: Capabilities to Service Global Supply Chains (pp. 57-72). Boston - Delft: Now Publishers.

Varga, J., Romero, O., Pedersen, T., Thomsen, C. (2014). Towards Next Generation BI Systems: The Analytical Metadata Challenge. In L. Bellatreche & M. Mohania (Eds.), *Data Ware-housing and Knowledge Discovery*, 8646, pp. 89-101. Springer International Publishing.

AUTHORS BIOGRAPHY

Halabi-Echeverry, Ana. X is the Director of the Master in Operations Management and a Professor in the School of Economics and Administrative Sciences at La Sabana University in Colombia. She is also an Associate Professor of the Decision Sciences and Modelling Program at Victoria University. She completed a PhD in Computing Sciences from Macquarie University in Australia. Her research interests include: Intelligent Systems and Information Science, Sustainable Supply Chains, Governance and Business Ethics. She has published in academic peer-review journals such as Springer Special Editions, Taylor and Francis, Elsevier and IEEE Publications.

Professor **Islam,** Sardar M. N. is Professor of Business, Economics and Finance; and Director, Decision Sciences & Modelling Program, Victoria University, Australia. One of the areas of Professor Islam's specialisations is Applied Managements Science/ applied quantitative modelling. He is currently undertaking research, teaching and doctorate supervision work in Applied Management Science addressing issues in a wide range of disciplines in accounting, economics, finance, business, and law. Many university libraries around the world including all top universities such as Harvard, Cambridge, etc. have many of his books. He has published many articles (total about 200) including a good number of journal articles in international journals.