REENGINEERING PORT PROCESSES THROUGH SIMULATION SUPPORT

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ABSTRACT

In the last decades the management of ports has become ever more difficult. The goal of port management is to let ports evolve from logistic distribution centres into transport solution providers. Such evolution can be achieved through Business Process Reengineering (BPR), often jointly to the implementation of Information Technology (IT) solutions. Such approach does not always give the expected results. It is thus very important to use the most suitable tools. In this paper we propose an example of the path followed to study the processes related to four European ports (Taranto, Kavala, Thessaloniki, Igoumenitsa) and show the methodology for the first steps of BPR (as-is process representation and analysis). In our research we studied 10 processes and applied our methodology for their representation and analysis. As an example, focusing on one process, we show how to implement such methodology and how to use a simulation software for the as-is process analysis.

Keywords: Business Process Reengineering, Port, Simulation

1. INTRODUCTION

In the last decades we have assisted to a radical change in the way ports are considered. Indeed, the ports are evolving from logistics distribution centres (the so called third generation) into transport solution providers (namely the fourth generation), thus becoming 'lean' ports (UNCTAD 1999).

The challenge for a lean port is to quickly move cargo and smoothly deliver a service in alignment with the market demand while eliminating all types of waste in the physical and documentary/information processes (Marlow and Paixao 2003). This evolution is based on the concepts of leanness, flexibility, just-in-time and BPR techniques (Marlow and Paixao 2003).

Processes reengineering is a crucial issue to ensure that the port system is efficient. The drivers of port efficiency do not only consist of infrastructure variables, but also of management and/or policy variables. As stated by Clark et al. (2002), the greater the efficiency at the port level, the lower the transport costs, consequently the higher is the ship turnaround. Port efficiency is an important determinant of handling costs too. As a consequence, BPR is necessary for many ports that want to increase their competitiveness.

BPR is offered as an enabler of organizational transformation (Davidson 1993, Venkatraman 1994). Organizations usually adopt a BPR approach when they believe that a radical improvement can be achieved by marrying business processes, organizational structure, and IT change (Stoddard and Jarvenpaa 1995). In the past the use of BPR for organizational transformation in the public sector has largely been neglected. However the trend has changed in the last years and several studies on BPR in Public Administration have been published. For example, in a report entitled "Reengineering through Information Technology" (1993), the US government identified a strategy with several major initiatives to reengineer government services in order to meet the demand for better performance.

While lessons drawn from studies using private-sector organizations might be useful, these findings are not always applicable to public sector organizations since such organizations usually face different sets of issues, problems, and challenges (Swiss 1991).

According to this general approach, many ports have proceeded to reengineer their processes as a consequence of a joint IT introduction. The cases of Asian ports, such as Singapore and Hong Kong, which currently are the most competitive on a global context, are emblematic. The port of Singapore is a very large transhipment hub, serves everyday about 60 container vessels and moves about 45,000 containers (Port of Singapore Annual Report 2006). The key of its success is the rethinking of its processes focused on IT introduction. Such introduction allowed to fasten the information exchange not only inside the port, but also with customers, suppliers, etc. and to fully manage every issue related to administration and planning activities, and all the port operations (Gordon et al. 2005, Lee-Partridge et al. 2000, Tongzon 1995).

BPR does not always give the expected results. It is thus very important to use the most suitable tools. In this paper we propose an example of the path followed to study the processes related to four European ports (Taranto, Kavala, Thessaloniki, Igoumenitsa). The study is part of a larger project, co-financed by the European Regional Development Fund (ERDF) through the INTERREG IIIB ARCHIMED Programme, aimed to promote intermodal transport, increase accessibility and connections with marginal internal areas, and take advantage of the potentialities of TEN-T (Trans-European Transport Network) Egnatia road axis. In particular we expose some results related to the activities focused on the development of an IT platform to support ports and stakeholders in managing administrative and organizational processes and accessing to information. More in detail, we describe in the paper the process analysis that was preparatory to the development of the platform. In particular, we deal with the first phase of BPR, namely the 'diagnose', as defined by Kettinger et al. (1997).

The paper is organized as follows. First we expose the research methodology used, identify the critical processes for each port involved in the research, and provide an overall representation of the port operations. Then we apply the methodology on one process, namely the Management of the Bill of Lading, and simulate such process to analyze the related performance. Finally we give the results of the simulation of all the critical processes (which we did not describe more in detail in the paper due to length's limits) and sum up several conclusions and insights for future research.

2. RESEARCH METHODOLOGY

The BPR literature proposes many methodologies for its implementation although the differences among them are little. To perform our task we followed the approach suggested by the coordination theory (Crowston 1997, Malone and Crowston 1994). Coordination theory perspective suggests identifying the variety of dependencies that arise in a process and the coordination mechanisms being used to manage them.

First of all we performed an extensive study of the literature that permitted us to better understand who are the ports actors and what is the role played by each of them. Moreover we identified the actors for every port involved in the project.

A port community involves many actors that need to exchange and handle many documents. There is a real difficulty in managing different organizations with different ways of thinking (and often languages) while at the same time respecting the international rules and laws.

One of the findings of our research has been that the port environment is composed by different actors so that the processes involved in such network are very often inter-organizational. Ports are complex and multi-part organizations in which institutions and functions often intersect at various levels (Bichou and Gray 2004).

The main protagonists that are typically involved in a port community are:

- Administrative Institutions (namely Port Authority, Harbour Office, Maritime Health Office, Pilots, Towboats, Mooring Personnel);
- Police Institutions (namely Financial Police, Custom House);
- Traders (namely Ship-owners, Shipping-companies, Receivers, Charterer);
- Intermediate (namely Port agents, Forwarding houses, Terminal);
- Financial institution (namely Banks, Chambers of Commerce).

The output of this phase is showed in Figure 1.

To collect data on the processes carried within the ports we conducted direct interviews with different port actors (Shipping Agency mangers, Port Authorities directors and clerks). Two members of the research group went to Greece to interview the actors operating in the Greek ports involved in the project.

From the literature review and the direct interviews, we were able to report a list of the processes carried out within a port.

We also defined a questionnaire to be submitted to the Port Authorities involved in the project in order to identify the critical processes carried out in their own ports. The questionnaire reported a list of the main processes carried out within a port and the main activities carried out within the mentioned processes. When submitted to the interviewed persons, the questionnaire was used as a reference during the interview. Once the critical processes were identified by using the questionnaire, the interview was focused on the collection of data about such processes. The questionnaire was not submitted only to the interviewed persons but was also submitted to the main actors in the ports involved in the project.

By the analysis of the interviews and the responses to the questionnaire submitted to different ports actors, we were able to identify the critical processes for each port involved in the project. The list of the critical processes is reported in Table 1.

After the identification of the critical processes we represented and analyzed them. For the representation we created, for each process:

- the root definition (i.e. the identification of CATWOE, namely Customers, Actors, Transformation, Worldview, Owner, Environment);
- the tree diagram;
- a tabular representation (for each activity we identified inputs, outputs, resources, and duration); and
- the reticular representation.

Table 1: Critical Processes

Port	Critical processes
Taranto	Releasing of the Health Practice
Igoumenitsa	Management of the Documentation for Waste Disposal
	Management of ship failures
	Management of the cargo loading
Kavala	Management of the Bill of Lading
	Bunkering management
	Management of containers in equipped areas
	Management of the International code for the Security of Ports and Ships (ISPS)
Thessaloniki	Integration between port and railway
	Management of works

Then with the support of a specific software (namely Simprocess®) we simulated and analyzed such processes. One of the problems in the process analysis has been the data gathering; indeed not ever the needed data were available or exhaustive. When we found a lack of data for a process, this process was simulated making reasonable hypotheses about the lacking data. Nevertheless we checked with the interviewed people that such data were coherent with the reality.

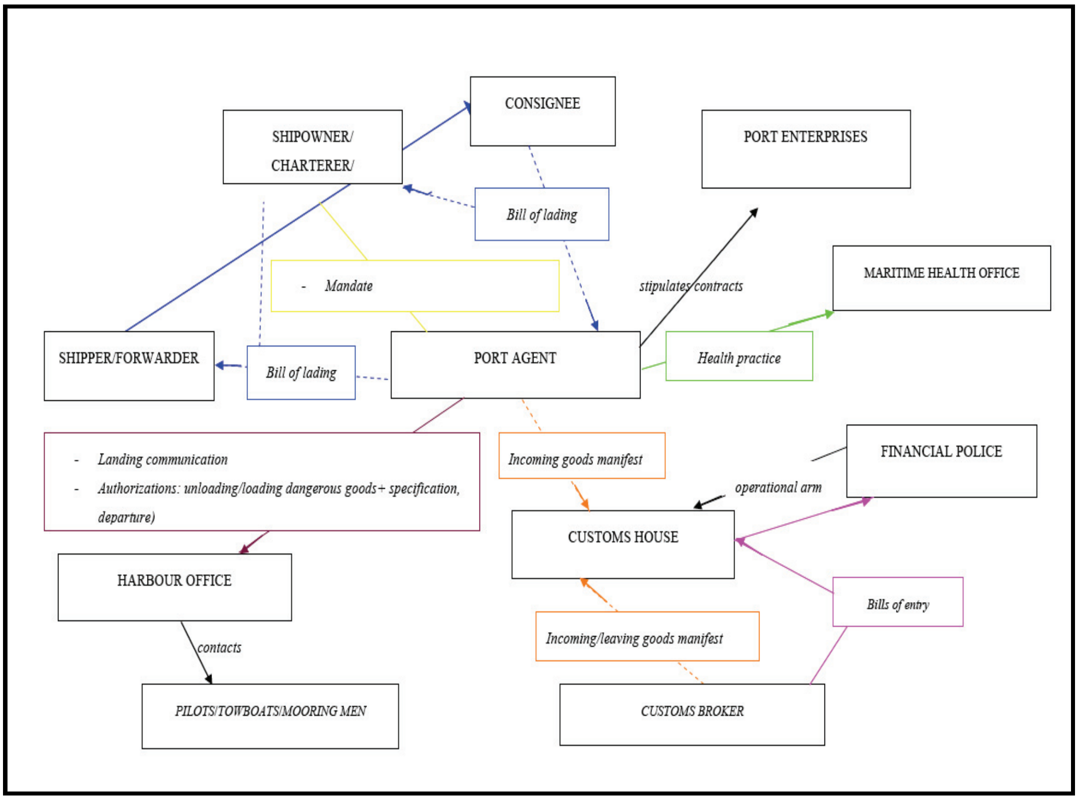

Figure 1: Flows among the Actors Involved in the Port Processes

Next we represent, simulate and analyze only one process as an example, namely the Management of the Bill of Lading. The remainder of the paper is articulated as follows: first we describe the process, then we represent it, and finally we simulate it and analyze the results.

3. PROCESS ANALYSIS AND REPRESENTATION

The 'Management of the Bill of Lading' process starts when the Shipper has to make a cargo shipment and needs the Bill of Lading. The process stops when the Bill of Lading is delivered to the Receiver that forwards it and receives the shipment.

The process customer is the Receiver that, by delivering the received Bill of Lading, qualifies as such and receives the shipment. The process actors are: Shipper, Ship's Master, Port Agent, Receiver, Chamber of Commerce, and Bank. The process transformation is:

Drawing up of the Bill of Lading → Bill of Lading in Receiver's hands

The process worldview is to let the Receiver qualify as such and pick up the cargo arrived at the destination port.

The process environments are the ship delays in arriving at the destination port.

The tree diagram (Figure 2) uses blocks to represent all the activities identified for the process, starting from an initial macro-block, i.e. the process itself, and then dividing it into the macro-activities that constitute the process. The decomposition of the activities is repeated until arriving to the single activities that constitute the process as it was characterized. Each activity represented within the diagram has a code that allows understanding to what macro-block the activity belongs. In the case of a two-way specialization (a situation in which two alternative routes are feasible), e.g. under the 1.2 block, the codes of the two lower level blocks are 1.2.a and 1.2.b.

The tabular representation (Table 2) summarizes each activity, with its code and its characteristics, i.e. description, inputs, outputs, actors, duration, costs, and technical and material resources. In the Duration column we highlighted in red the duration that has been hypothesized for the lack of data. Indeed, not ever it has been possible to gather accurate data from the actors. As stated above we verified with the actors that all the data hypothesized were coherent with reality.

Very useful for the software implementation is the reticular representation (

Figure 3) that graphically describes the activities so the entire path of the process from the initial event to the final event can be identified, along with the interdependencies among the activities. To identify the interdependencies, the inputs and outputs of each activity, as defined in the tabular representation, can be useful.

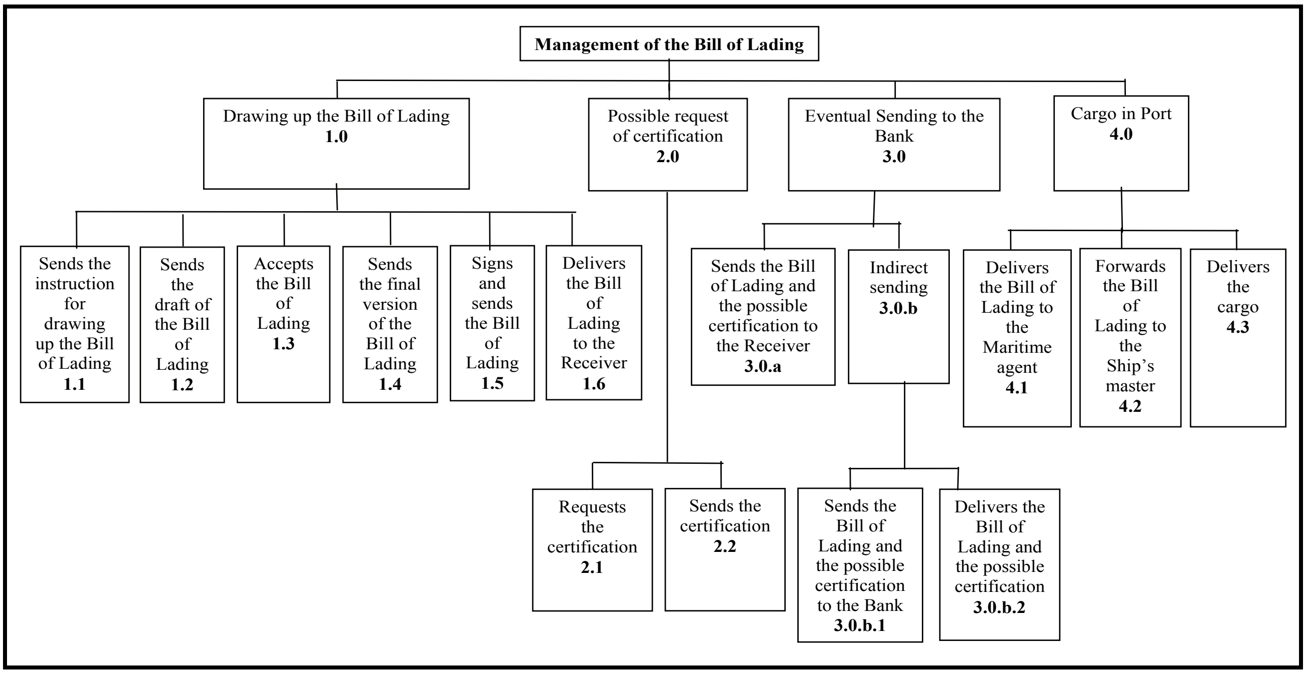

Figure 2: Management of the Bill of Lading (Tree Diagram)

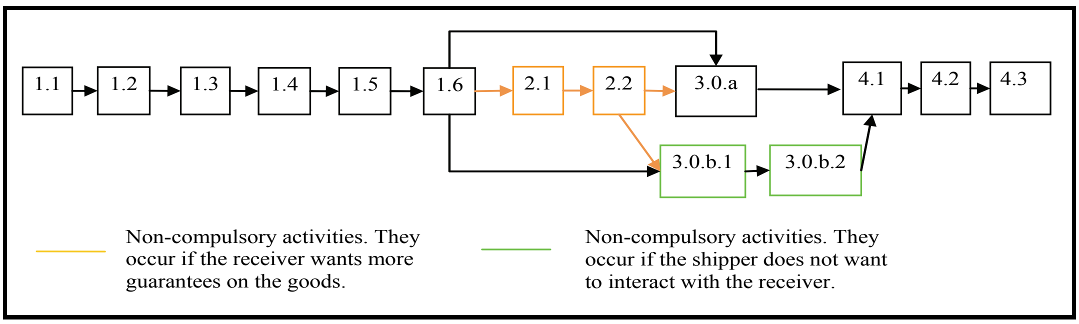

Figure 3: Management of the Bill of Lading (Reticular Representation)

Table 2: Management of the Bill of Lading (Tabular Representation)

Activity ID	*Description*	*Actors*	*Input*	*Output*	*Duration*			*Communication tools*
					Optimistic	*Mean*	*Pessimistic*	
1.1	Forwarding the instruction about drawing up the Bill of Lading	Shipper to Port Agent	Shipping of the goods	Instruction list	15 minutes	30 minutes	12 hours	Fax E-mail
1.2	Forwarding the draft of the Bill of Lading	Port Agent to Shipper	Instruction list	Draft of the Bill of Lading	15 minutes	30 minutes	12 hours	Fax E-mail
1.3	Acceptance of the Bill of Lading	Shipper to Port Agent	Bill of Lading draft	The latest version of the Bill of Lading		Immediate		Fax E-mail
1.4	Forwarding the final version of the Bill of Lading	Port Agent to Master	The latest version of the Bill of Lading	The latest version of the Bill of Lading		10 minutes		Face to face
1.5	Signing and forwarding the Bill of Lading	Master to Port Agent	The latest version of the Bill of Lading	Bill of Lading signed		10 minutes		Face to face
1.6	Delivering the Bill of Lading	Port Agent to Shipper	Bill of Lading signed	Bill of Lading signed		10 minutes		Face to face
2.1	Requesting the certification	Shipper to Chamber of Commerce	Bill of Lading signed	Forwarding of the request		1 hour		
2.2	Forwarding the certification	Chamber of Commerce to Shipper	Forwarding of the request	Certification		30 minutes		
3.0.a	Forwarding the certification and the Bill of Lading	Shipper to Receiver	Bill of Lading signed and certification	Certification and Bill of Lading signed		30 minutes		Courier
3.0.b.1.	Forwarding the possible certification and the Bill of Lading	Shipper to Bank	Bill of Lading signed and certification	Bill of Lading signed and certification		30 minutes		
3.0.b.2.	Delivering the Bill of Lading and the possible certification	Bank to Receiver	Bill of Lading signed and certification	Bill of Lading signed and certification		30 minutes		
4.1	Delivering the Bill of Lading	Receiver to Port of destination Agent	Bill of Lading signed	Bill of Lading signed		2 hour		Face to face
4.2	Forwarding the Bill of Lading	Port of destination Agent to Master	Bill of Lading signed	Bill of Lading signed		Immediate		Face to face
4.3	Delivering cargo	Port of destination Agent to Receiver	Bill of Lading signed	Picking up of goods		Immediate		Face to face

4. PROCESS SIMULATION

Following we simulate the as-is model of the Managing the Bill of Lading. The simulation is the last step of 'diagnose' as defined by Kettinger et al. (1997). Indeed, with such step we can measure, thorough several indicators, the performance of the process. To carry out this task we utilize a specific software, namely Simprocess®. Simprocess® is an object-oriented process modelling and analysis tool that integrates process mapping, object-oriented simulation, and activity-based costing (ABC) into a single tool. Simprocess® allows representation of processes, people, and technology in a dynamic computer model. A model, when simulated, mimics the operations of the business. Because simulation software keeps track of statistics about model elements, performance metrics can be evaluated by analyzing the model output data (as in Figure 9).

In such model, in the first macro-activity, namely 'Drawing up the Bill of Lading', there is a deep information exchange among Shipper, Port Agent, and Ship's Master. All these actors interact to produce the Bill of Lading.

On the basis of the information gathered through the interviews and considering the lacking of some data, we made the following assumptions for the simulation:

- The request of shipping the goods occurs once a day at 09:00 and for ten days, so we analyzed ten process occurrences;
- For all the simulation, the following actors are available: 20 Shippers, 20 Masters, 20 Receivers, 20 Banks, one Port Agent, and one Chamber of Commerce (the choice to insert a number of 20 actors for each role is aimed at not causing queues due to interferences between different process occurrences in the process simulation);
- The probability to request the possible certification is equal to 30%;
- The Shipper takes one hour to request the certification;
- The Chamber of Commerce takes half an hour to send the requested certification;
- The probability that sending the Bill of Lading and the possible certification to the Receiver happens in an indirect way is equal to 40%;
- The activity of sending the Bill of Lading and the possible certification to the Bank takes at least one hour, on average two hours and at most three hours;
- The delivery of the Bill of Lading from the Bank to the Receiver takes at least one hour, on average two hours and at most four hours;
- The delivery of the Bill of Lading to the Port agent takes two hours;
- The forwarding of the Bill of Lading to the Ship's master and the delivery of goods to the Receiver occur only after the ship is arrived at the port, on average after another day since the Bill of Lading is delivered to the Port Agent;
- After forwarding the Bill of Lading to the Ship's Master, it takes one hour before delivering the goods;
- The actors involved are available all the week days in the following hours:
  - Shipper and Chamber of Commerce: from 08:00 to 13:00 and from 15:00 to 20:00;
  - Port agent and Bank: from 08:00 to 13:00 and from 15:00 to 19:00;
  - Master and Receiver: from 08:00 to 20:00;

Some displays of the model created with the software are reported in the next Figures (4-8). Figure 4 shows the overall process, whereas Figures 5-8 show the activities included in the four blocks, namely 'Drawing up the Bill of Lading', 'Possible request of Certification', 'Eventual sending to the Bank' 'Cargo in port'.

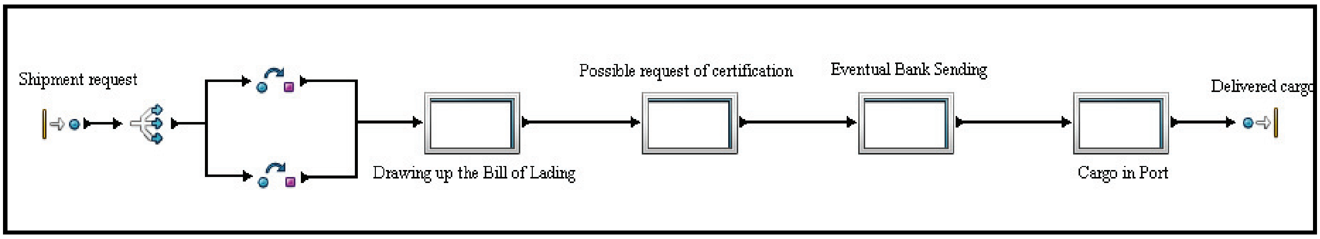

Figure 4: Bill of Lading: As-is Model (General View)

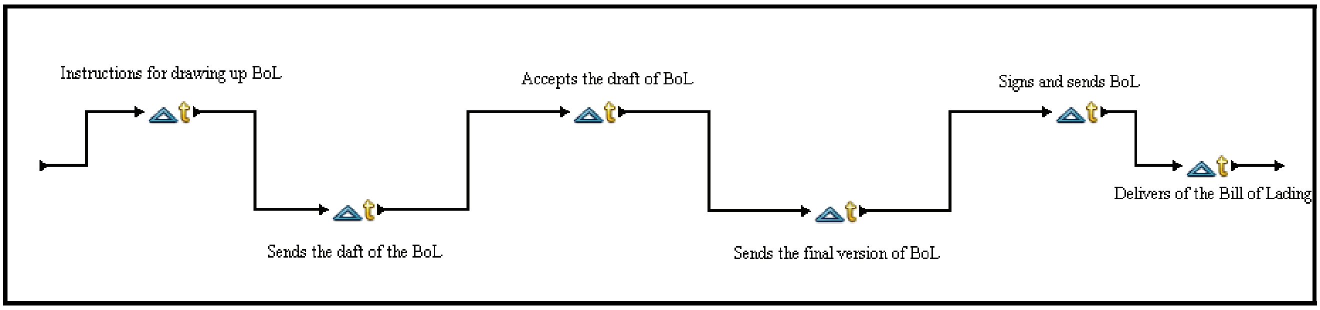

Figure 5: Drawing up the Bill of Lading (Macro-activity 1.0)

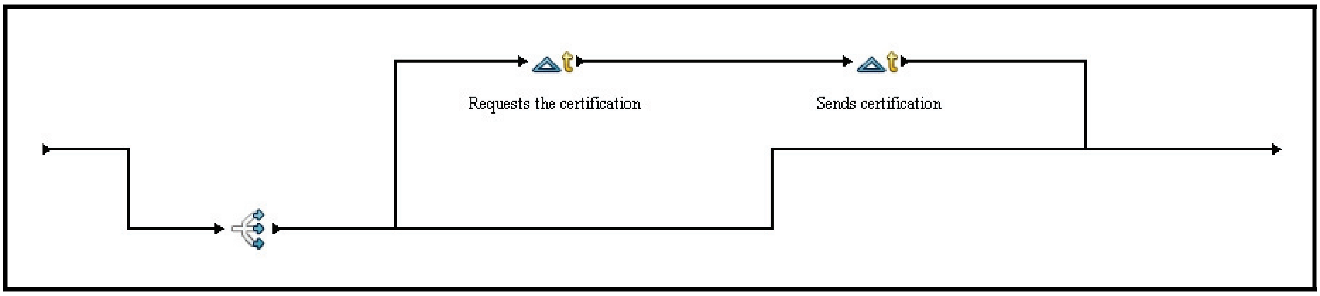

Figure 6: Possible Request of Certification (Macro-activity 2.0)

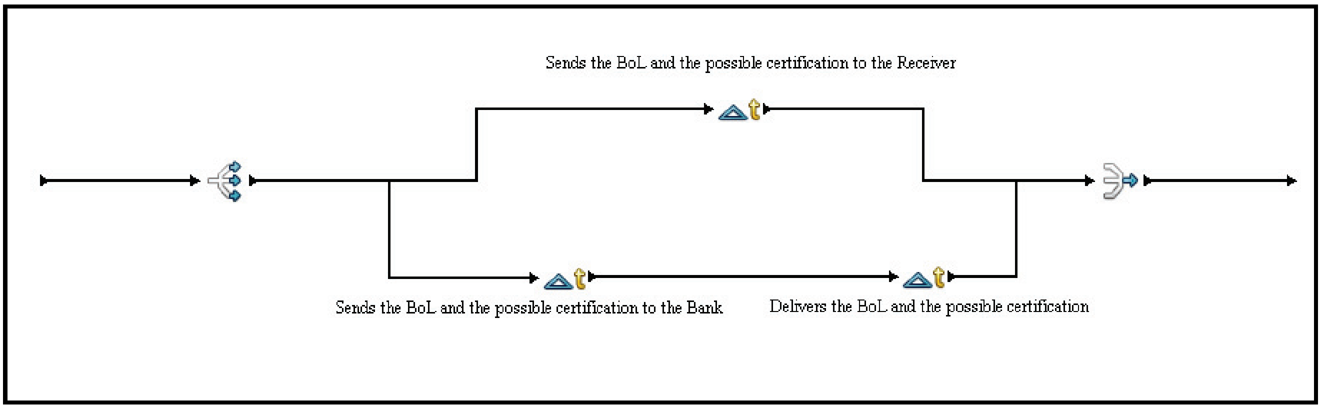

Figure 7: Eventual Sending to the Bank (Macro-activity 3.0)

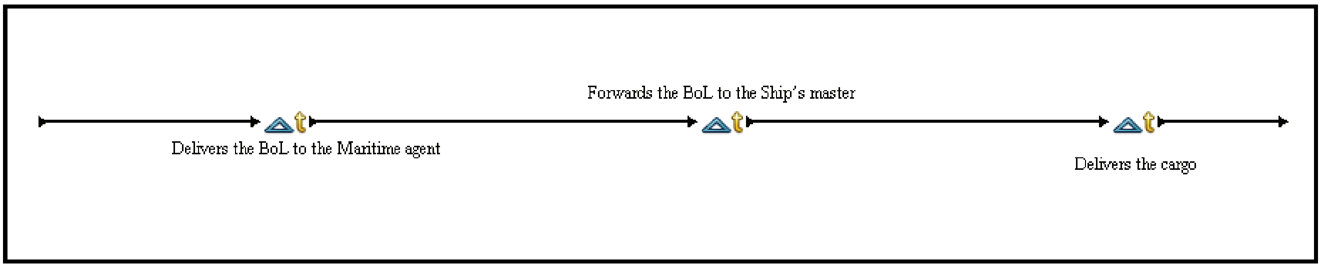

Figure 8: Cargo in Port (Macro-activity 4.0)

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SIMPROCESS Standard Report for Bill of Lading (as-is)

Simulation Run Duration 00:01:31.937
Actual Run Duration     184 days

Entity : Total Count - Observation Based : Replication 1

                    Total      Remaining  Total
Entity Names        Generated  In System  Processed
request + certific         59          0         59
shipment                  184          0        184
simple request            125          2        123

Entity : Count By State - Time Weighted : Replication 1

                    Total In System-----   Processing---------  Wait For Resources--   Traveling----------
Entity Names          Average    Maximum     Average    Maximum    Average    Maximum     Average    Maximum
request + certific      0,926          3       0,191          2      0,241          2       0,494          3
shipment                0,000          1       0,000          0      0,000          0       0,000          1
simple request          1,912          5       0,356          3      0,514          4       1,042          5

Entity : Cycle Time (in Hours) By State - Observation Based : Replication 1

                               Total In System-----   Processing---------  Wait For Resources--    Traveling---------
Entity Names        #Observed     Average    Maximum     Average    Maximum    Average    Maximum      Average    Maximum
request + certific         59      69,288     96,167      14,277     25,745     18,018     38,943       36,994     44,754
shipment                  184       0,000      0,000       0,000      0,000      0,000      0,000       0,000      0,000
simple request            123      68,200     97,302      12,677     23,888     18,363     43,511       37,160     47,608

Resource : Number of Units By State - TimeWeighted : Replication 1

                                                       --------Idle--------  --------Busy--------
Resource Names      Defined Capacity           Capacity    Average    Maximum    Average    Maximum
Bank                20                           20,000     19,337     20,000      0,038      2,000
Chamber of Commerc  1                             1,000      0,410      1,000      0,007      1,000
Master              20                           20,000     19,493     20,000      0,007      2,000
Port  Agent         1                             1,000      0,253      1,000      0,182      1,000
Receiver            20                           20,000     19,417     20,000      0,083      2,000
Shiper              20                           20,000     19,186     20,000      0,231      3,000
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Figure 9: Simulation Report (Partial View)

As emerging from the report generated by the software (Figure 9), during the whole simulation 184 requests of shipping goods were generated (one per day), but only 182 of them were completely processed, i.e. for these process occurrences the goods were shipped by the Port Agent. The remaining two requests did not complete their path because the simulation process was terminated. Moreover, 56 request of shipping with certifications are generated. The path followed by a shipping request to the final event interfered with the paths followed by the other shipping requests. At the most 5 shipping requests and 3 certifications were simultaneously processed. There were waiting times before performing activities because some actors were unavailable at that moment, since they were not working, due to the assumed working hours and the actors involved in performing other activities. The process lasts 68 hours on average for the simple request and 69 hours for the request with certification. 12.5 hours are for performing activities related to simple requests and 14 hours for requests with certification, almost 18 hours are for waiting due to the unavailability of the actors that perform the activities. The actors that work more within the process are the Shipper and the Port Agent. The activities that caused the entities to wait for being processed are:

- the sending of the certification by the Chamber of Commerce;
- the forwarding of the Bill of Lading by the Port Agent to the Master;
- the delivery of goods by the Port Agent;
- the sending of the draft of the Bill of Lading by the Port Agent; and
- the sending of the final version of the Bill of Lading by the Port Agent.

By analyzing the data by macro-activity, we noted that the entities (i.e. the Bills of Lading) spent almost 35.5 hours in 'Cargo in port' (4.0) almost 25.5 hours in 'Drawing up the Bill of Lading' (1.0), almost 0.5 hour in 'Possible request of Certification' (2.0) and almost 2.5 hours in 'Eventual sending to the Bank' (3.0). Considering that for 'Cargo in port', 24 hours are solely dedicated for physical operation (i.e. unloading goods, docking etc.), the real time spent for the administrative process is 11.5 hours on average. Consequently, the real bottleneck of the entire process is the 'Drawing up the Bill of Lading' macro-activity. In this macro-activity there is a heavy and redundant exchange of data that cause a great waste of time.

5. RESULTS OF THE ANALYSIS

Following the same methodologies utilized for the above example (root definition, tree diagram, reticular representation, tabular representation, and software simulation) we have analyzed all the processes indicated in

Table 1. For length's limits we do not show all the tables and figures related to such processes. We limit solely to sum up the results emerged by such study. In this manner we can have a wider comprehension of the port operation and its limits.

For the Management of the Health Practice at the port of Taranto there are no significant criticalities, since the overall duration of the activities aimed at releasing the Health Practice to the Ship's Master is much less than the time that is potentially available to release it. The ship thus has not to wait due to delays, once it is arrived.

As to the Bunkering management at the port of Kavala, there are no significant criticalities. Potential problems should be searched within the activities of communicating dates and hours of the ship arrival between the Port Agent and the Gas-oil company selected for bunkering. As emerging from the information gathered, the Port Agent, after an early communication concerning the ship arrival, does not get in touch with the selected company, although it would be important that the two actors involved in the process remain in contact.

As to the Management of containers in equipped areas at the port of Kavala, there were multiple requests of checking containers that interfered among them. A potential problem could thus be caused by the limited capacity of the container area in that port, which is still under construction. This area, since it does not allow to simultaneously work on a high number of containers, can cause delays in accepting requests.

As to the Management of works at the port of Thessaloniki, there was a work overload for the planning office.

As to the Management of Landing Communication at the port of Thessaloniki, the overall duration of the activities is much less than the waiting times for activities performed in parallel to be completed. This is an evidence of a complex process, which is open to enhancements through BPR techniques.

As to the Integration between Port and Railway at the port of Thessaloniki, there was a considerable difference between the overall time to perform the activities and the time needed to the train to arrive at the port. This confirms what emerged from the face to face interviews, i.e. the need to modernize the railway structure linked to the port of Thessaloniki.

During the literature review and the processes analysis we found that the processes can be divided into two categories: 'documental processes' and 'operational processes'. The former are characterized by heavy document flows (e.g. Releasing the Health Practice, Management of the Documentation for Waste Disposal, Management of the International code for the Security of Ports and Ships, Management of the Bill of Lading); as a consequence, the main criticalities derive from the management of the documental flow. In the latter (e.g. Integration between Port and Railway, Management of works, Management of containers in equipped areas, Management of ship failures, Management of the cargo loading, Bunkering management) there is a predominant operative part. As a consequence, the main criticalities are influenced by the availability of facilities (e.g. docks, terminals), as well as of instruments and tools (e.g. cranes, trucks, ships). Consequently the 'documental processes' can be strongly influenced by BPR because the performance of such processes is mainly based on activity flow improvements, IT solutions, or bottleneck elimination. In the 'operational processes' the improvement of the performance should be obtained not only by BPR but mainly by increasing the resources (human or not) and the facilities. So the BPR effort must be mainly oriented toward the 'documental processes' to have real improvement.

6. CONCLUSIONS

In this paper we first highlighted the need for the ports to adapt their processes to the new global context through the BPR. Then we proposed a methodology based on graphic representation, tabular representation, and software simulation for the first step of BPR (i.e. 'diagnose'). As showed by the literature analysis and empirical evidence, ever more the ports need a rethinking of their processes. Very significant is the case of the port of Singapore. The BPR can be helpful to redesign the general operations of a port. The result of this effort is a radical improvement of the port performance. However the implementation of BPR is not simple, there are many ways of implementing it and many tools available. So it is very important to select the right path to follow.

In this paper we proposed the path followed to deal with BPR. The type of representation used for the process analysis (namely root definition, tree diagram, reticular representation, and tabular representation) was suitable for the next step, i.e. the implementation of the simulation software. Through the simulation support we highlighted the bottlenecks, the main workloads, and the inefficient activity flows.

Nevertheless it has to be noted that the main problem of the BPR implementation was the availability of relevant data. In this paper it is evident how the lack of some data reduces the precision of the analysis.

Finally, with this research we have started to create a repository of the most critical processes within the ports. Such repository could be very useful for all the actors involved in port activity. Indeed, not ever the actors know well who their partners in port processes are. Moreover such repository is useful for research and consulting scope; indeed the possibility to compare the same processes implemented by different ports can allow finding best practices.

Further research could be focused on gathering more available data to redesign the processes and simulate the to-be processes, in order to compare the as-is and to-be process performance, and to enhance the number of processes analyzed.

REFERENCES

Bichou, K., Gray, R., 2004. A logistics and supply chain management approach to port performance measurement. *Maritime Policy & Management*, 31(1), 47-67.

Clark, X., Dollar, D., Micco, A., 2002. *Maritime Transport Costs and Port Efficiency. The World Bank Development Research Group Macroeconomics and Growth Policy Research*, working paper, 2781.

Crowston, K., 1997. A coordination theory approach to organizational process design. *Organization Science*, 8(2), 157-175.

Davidson, W.H., 1993. Beyond re-engineering: the three phases of business transformation. *IBM Systems Journal,* 32 (1), 65-79.

Gordon, J.R.M., Lee, P.M., Lucas, H.C., 2005. A resource-based view of competitive advantage of the Port of Singapore. *Strategic Information System*, 14, 69-86.

Kettinger, W.J., Teng, J.T.C., Guha, S., 1997. Business process change: A study of methodologies, techniques, and tool. *MIS Quarterly*, 21, 55-80.

Lee-Partridge, J.E., Teo, T.S.H., Lim, V.K.G., 2000. Information technology management: The case of the Port of Singapore Authority. *Strategic Information System*, 9, 85-99.

Malone, T.W., Crowston, K., 1994. The interdisciplinary study of coordination. *Computing Surveys*, 26 (1), 87-119.

Marlow, P.B., Paixao, A.C., 2003. Measuring lean ports performance. *International Journal of Transport Management*, 1, 189-202.

Port of Singapore Authority Annual Report, 2006.

Stoddard, D.B., Jarvenpaa, S.L., 1995. Business process redesign: Tactics for managing radical change. *Journal of Management Information Systems*, 12 (1), 81-107

Swiss, J.E., 1991. *Public Management System: Monitoring and Managing Government Performance*. Englewood Cliffs, NJ: Prentice Hall.

UNCTAD, 1999. Technical note: Fourth generation port. *UNCTAD Ports Newsletter* 19, 9-12.

Teo, H., Tan, B., Wei, K., 1997. Organizational transformation using electronic data interchange: The case of TradeNet in Singapore. *Journal of Management Information Systems*, 13 (4), 139-165.

Tongzon, L.L., 1994. Determinants of port performance and efficiency. *Transportation Research A*, 29 (3), 245-252.

The White House, Office of the US Vice-President, 1993. *Reengineering through Information Technology.* Washington, DC.

Venkatraman, N., 1994. IT-enabled business transformation: automation to business scope redefinition. *Sloan Management Review*, 35 (2), 73-87.

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