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Seaport cluster labour cost reduction – a modelling approach

Edvard Tijan[1], Saša Aksentijević[2], Bojan Hlača[3]

[1]University of Rijeka, Faculty of Maritime Studies Rijeka, Studentska 2, 51000 Rijeka, Croatia
[2]Aksentijevic Forensics and Consulting Ltd., Gornji Sroki 125a, 51216 Viškovo, Croatia
[3]University of Rijeka, Faculty of Maritime Studies Rijeka, Studentska 2, 51000 Rijeka, Croatia

ABSTRACT

The subject of this research are administrative processes related to a ship's arrival to seaports, typically attributed to elevated levels of cost of labour required to complete the related administrative tasks. In the previous phases of the research, an average expected cost of the administrative labour cost in traditional seaport clusters in Croatia was identified and quantified on an hourly basis. This research continues in its aim by using the results of the previous research as a starting point, and proposes a reengineered simulation model of the administrative process. The main hypothesis is that the usage of such a new model will result in a measurable decrease of the required labour cost. The main hypothesis is confirmed by simulations and calculations of the labour cost reduction.

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1. Introduction

Seaport cluster activities (in many seaport cluster scenarios, including those in Croatia) are usually distributed to multiple locations. Heterogeneous placement and geographical division, beside the diversity of the stakeholders, present a problem in communication within a traditionally operated seaport cluster. Seaport activities are managed by concession owners that use separate and non-aligned activity management systems, further exacerbating communication and information exchange difficulties. From the organizational standpoint, seaport clusters are complex because they handle various types of cargo, seaport facilities have different geographical position, and commercial activities are performed by various concession owners, while state governed bodies are performing administrative and management activities (overseen by ministries in charge of certain activities).

Typically, the process of creating seaport cluster services consists of several steps. The ship gives a notice of her arrival into the port and all administrative processes related to the port arrival are performed and activities related to cargo handling are prepared. Cargo is unloaded by using different transport and unloading systems. Cargo is transported to other destinations or warehouses and storages according to the cargo type and the applicable logistics chain logic. In case that other cargo has to be loaded on board the ship, internal means of transport are used to load the cargo on board the ship which will carry the cargo to its final destination. Finally, the ship is leaving the port. In short, various stakeholders within the seaport cluster provide their service, and the customer's requirements are met.

The document flow in international seaport clusters which use traditional business processes is very similar. This is especially true for Croatian seaport clusters that are governed by the same national set of laws and applicable regulations. However, if the two largest seaport clusters are compared, some differences can be noticed, which are mainly caused by local organizational practices and customary port practices. During the field research in the Port of Ploče and the Port of Rijeka, it was noticed that, in traditionally organized seaport clusters (those that are not organized around common Port Community Systems), a number of overlapping processes, documents and redundant steps exists. In this research, the focus is not on the information flow of the business process modelling, but on operative methods (control flow) that could be applied to reduce labour cost associated with administrative processes of the ships' arrival into the port.

In this research, a main hypothesis is identified during the very inception:

– Modelling and simulation methods can be used in traditionally run ports to optimize processes in order to decrease associated labour costs.

The supporting hypotheses of the research are:

– The analysis of the existing administrative processes in seaport clusters can be used to remove unnecessary redundancies, and,

– The usage of the business process modelling simulations and UML is an appropriate tool for the analysis of administrative processes in traditionally operated seaport clusters.

Reengineering of these processes in seaport clusters is vital for further optimizations and creation of robust Port Community Systems that ensure the interoperability between different stakeholders which operate within seaport clusters. Optimal effects of such implementation cannot be expected unless all processes are optimized and redundancies removed. Therefore, it is vital to perform such optimization before the Port Community Systems is envisaged and consequentially introduced.

In this research, the main and supporting hypotheses will be proven. Based on the previous research (Tijan et al., 2014), by using quantitative indicators, the results of simulations and calculations will prove that a reengineered model of administrative processes related to ships' arrival into the port will yield savings in related labour costs. This research heavily relies on the previous research that used modelling and simulations in order to determine the exact cost of labour incurred for administrative processes of ships' arrival into the port. These costs serve as a starting point for this research. With the development of seaport clusters and changes in the process, it can be expected that the model will have to be reconstructed and simulations will have to be cyclically repeated. This is in line with other researches on simulations. (Afrić, 1999, p. 108)

2. Basic assumptions of port clusters' administrative process reengineering

Thorough analysis of the theoretical foundation of the operations of seaport clusters, geographic concentrations of internally connected companies, specialized suppliers, service providers and associated institutions (Toh, et al., 2010), shows that the flow of information between port cluster stakeholders within traditional port clusters can be described as:

– Operatively demanding – information is primarily transmitted by using paper forms (using mail, fax or courier service), partially by e-mail and, very rarely, by using computer networks. Voice communication (direct or by phone) is an important communication pathway, and very often the only tool available to resolve issues and facilitate processes. Data stored in document media is not structured (Tijan, 2012, p. 129), not well suited for database storage and cannot be easily searched and reused. This greatly increases the required administrative labour load because the same data have to be entered repetitively at different instances managing the process. To resolve this issue, it is necessary to perform the reengineering of administrative and management processes in seaport clusters as a primary step in the creation of the Port Community System architecture.

– Complex, because it includes diverse administrative and business activities performed by various stakeholders in seaport clusters, with different and conflicting business goals. Some of the stakeholders are even competitors on the transport and logistics market.

Therefore, it is possible to identify the following weaknesses in the existing administrative procedures of document processing and exchange of information between stakeholders in seaport clusters:

1. No unique adopted standards for data input and exchange exist within traditional seaport clusters, causing difficulties during data processing.
2. There is a high probability of errors or interruptions in the information flow (data input errors, missing data, lost documents).
3. Late delivery of documents causes delays in data processing.
4. Same data entered several times by different stakeholders in seaport clusters.
5. High cost of data creation, distribution and processing.
6. Inadequate and unconsolidated information contained in documents, especially those related to ships' arrivals and departures (ship's data, estimated time of arrival, cargo information, etc.).
7. Increased forgery risk, because document control is based on stamp checks.
8. Number of circulating documents is too large because they are manually produced in multiple copies and distributed between seaport cluster stakeholders.

The goal of the new model for the reduction of labour cost of administrative tasks of the ships' arrival to ports is to reengineer administrative tasks and business processes and to remove all redundancies, delays and unnecessary steps, processes and documents that are clearly present in the analysed traditional seaport clusters in Croatia, but equally applicable to other seaport clusters that do not fully utilize integrated Port Community Systems. It is expected that the new model will be a solid base for further research and translation of the document flow from material form to dematerialized form in Port Community Systems. Should this step be omitted, and all redundancies would remain, implementation of Port Community Systems would not yield optimal results.

Furthermore, the implementation of a new model will serve as a basis for the simulation of labour costs related to administrative tasks under new circumstances. The comparison of the calculated labour cost of the standard model and the new optimized model should prove the main and supporting hypotheses.

3. Process reengineering

Process reengineering (or reshaping) is a complex procedure that implies cooperation of all stakeholders, but in the case of seaport clusters, it also implies a possible change of laws, regulations and customary practices. The purpose of reengineering is the acceleration of the administrative procedure and ensuring the information accuracy. It is possible to identify two main groups of actions that can lead to the achievement of this goal:

– Data (information) contained in documents can be omitted.

– Entire documents can be removed from the process, if they are redundant or obsolete.

The end result of the reengineering process should be the elimination of time required to check and to approve the applicable documents. Furthermore, the premise is that the port authorities (Harbour Master, border police, sanitary inspectors, and customs) will check the forms and certificates immediately and approve them. This should further eliminate the time required to process the documents, thus reducing the labour cost.

In order to proceed with the creation of a new and improved model, it is necessary to identify all documents and certificates related to the ship's arrival and departure. For the sake of simplicity and comparability, the same nomenclature will be adopted as in the previous research. Therefore, the document designation is adopted as shown in Table 1.

Furthermore, a common approach also needs to be adopted in regard to certificates related to the ship's arrival and departure. There are six identified certificates that are codified (from C1 to C6) and listed in Table 2.

Simulation was performed by using Flexsim simulation software in version 5.1.2. (by FlexSim Software Products Inc., Utah, USA). The tool was used to build, model, simulate and visualize identified business processes, and to create a viable model that can be used to test the main hypothesis. This particular software was used because it

Table 1 Documents related to the ship's arrival and departure (Tijan, 2012, p. 81)

#	Document title	#	Document title
1	Notice of Arrival	22	Minutes from Coordinating-operative Meeting
2	IMDG Reporting Form (DCRForm)	23	Vessel Announcements on the Day:
3	Ballast Water Reporting Form	24	Dangerous Cargo Plan
4	Notification of Ship-generated Waste	25	Ship Sanitation Control Exemption Certificate/Ship Sanitation Control Certificate
5	ISPS CODE Arrival Notification	26	Sanitary Free Pratique
6	Dangerous Goods Manifest	27	Permit for Ship Departure (Customs Clearance to Harbour Master)
7	Notice of Arrival for Mandatory Expanded Inspection	28	IMO Crew List (IMO FAL Form 5)
8	Special Cargo Stowage Plan	29	IMO Passenger List (IMO FAL Form 6)
9	Maritime Declaration of Health	30	Preliminary Stability Calculation (INBOUND)
10	Declaration of Dangerous or Polluting Goods (DECL.o.t.-1/3)	31	Preliminary Stability Calculation (OUTBOUND)
11	Vessel Arrival Notification (PP/M-31a Form)	32	NIL List (Arms, Ammunition,...)
12	Permission for a Vessel to Have Communications with the Shore (UT-VI-222)	33	Narcotics List
13	Vessel Departure Notification (PP/M -31b Form)	34	Crew's Effects Declaration (IMO FAL Form 4)
14	Permit of Vessel's Departure (UT-VI-223)	35	Ship's Stores Declaration (IMO FAL Form 3)
15	List of Forms when Notifying Arrival/Departure of a Vessel from HMO	36	List of Ports of Call
16	Berthing, Unberthing and Shifting of Vessels Report	37	Request for Berthing outside the Customs Area
17	International Dangerous Cargo Manifest	38	Request for Berthing outside the Maritime Frontier Crossing
18	Ship/Shore Safety Check List – Tankers	39	Agent's Declaration of Covering Costs of Stay, Deportation or Repatriation
19	Safety Check List for Handling Dangerous Goods other than Tankers	40	Customs Manifest (Outgoing)
20	Ship/Shore Safety Check list for Loading or Unloading Dry Bulk Cargo Carriers	41	Cargo Manifest
21	List of Vessels Berthed in Port Basins	42	Outgoing Customs Declaration

Table 2 Certificates Related to the Ship's Arrival and Departure

#	Certificate Title	#	Certificate Title
C1	Bunker Convention Insurance	C4	Oil Pollution Insurance – (Civil Liability – CLC)
C2	International Ship Security Certificate (ISSC Certificate)	C5	Wreck Removal Insurance – (Civil Liability – CLC)
C3	Anti-Fouling System Statement of Compliance (AFC)	C6	Document of Compliance for the Carriage of Dangerous Goods

has a proven track in the area of research, including the analysis of the systems and document flow requirements. (Galović, et al., 2011) Simulation was performed in the form of discrete events simulation used to describe the system in details as a sequence of different activities and processes, mimicking real situation by using objects subjected to waiting queues and comparing them to available resources; in this case, the employed personnel were performing actual tasks.

The elements of the model represent individual reengineered sub processes within the actions of filling, delivering and checking forms and certificates during the ship's arrival announcement. The processing time has been programmed for each of the corresponding elements, and it is equal to the time determined by using interview and estimation methods, as described in Table 3. The simulation model required multiple source and output points and endpoints (sinks) because each document or a set of documents mandatorily has to be created in at least one element and end up in at least one element of the end result model. The described simulation process is in fact a time-bound execution of the system state in a given time frame (Smiljanić, 1995).

Figure 1 shows the flow of the new, reengineered process of filling, delivering and checking the forms and certificates during ship's arrival announcement, after redundancies, bottlenecks and delays have been filtered out from the processes in the previous research, distilling the process only to those elements actually required to complete the process successfully.

Sub processes in Figure 1 designated with "I" are processes related to filling the required electronic (Web)

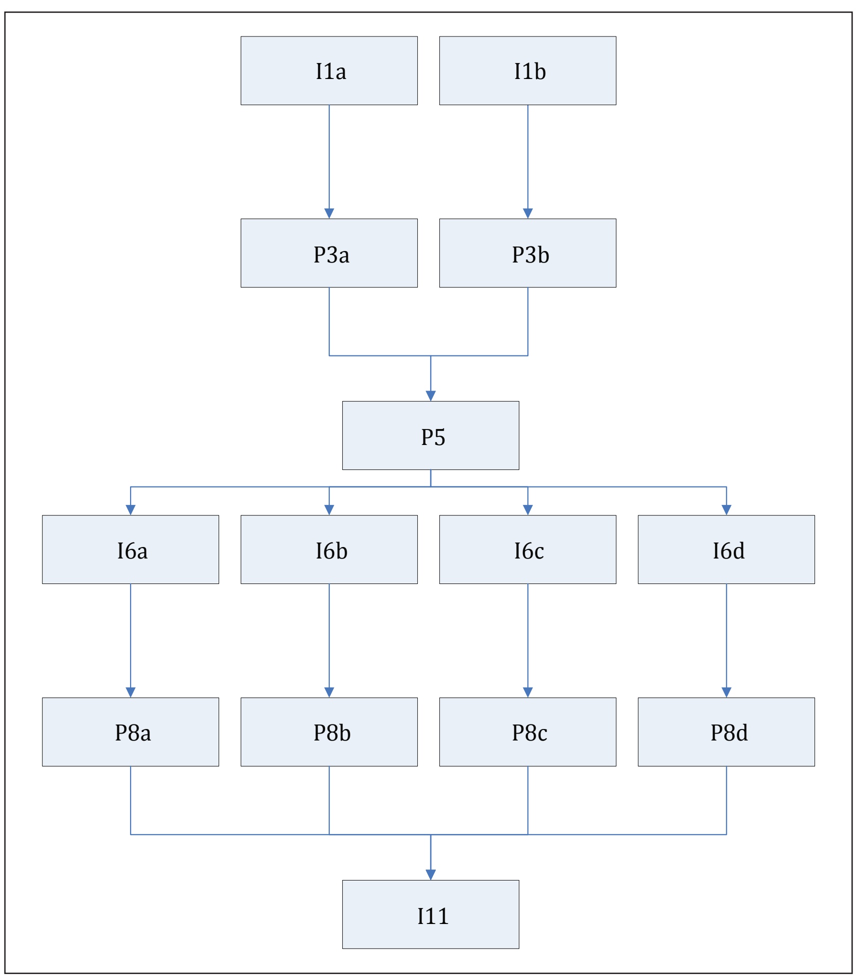

Figure 1 Process paths for the documentation related to the ship's arrival

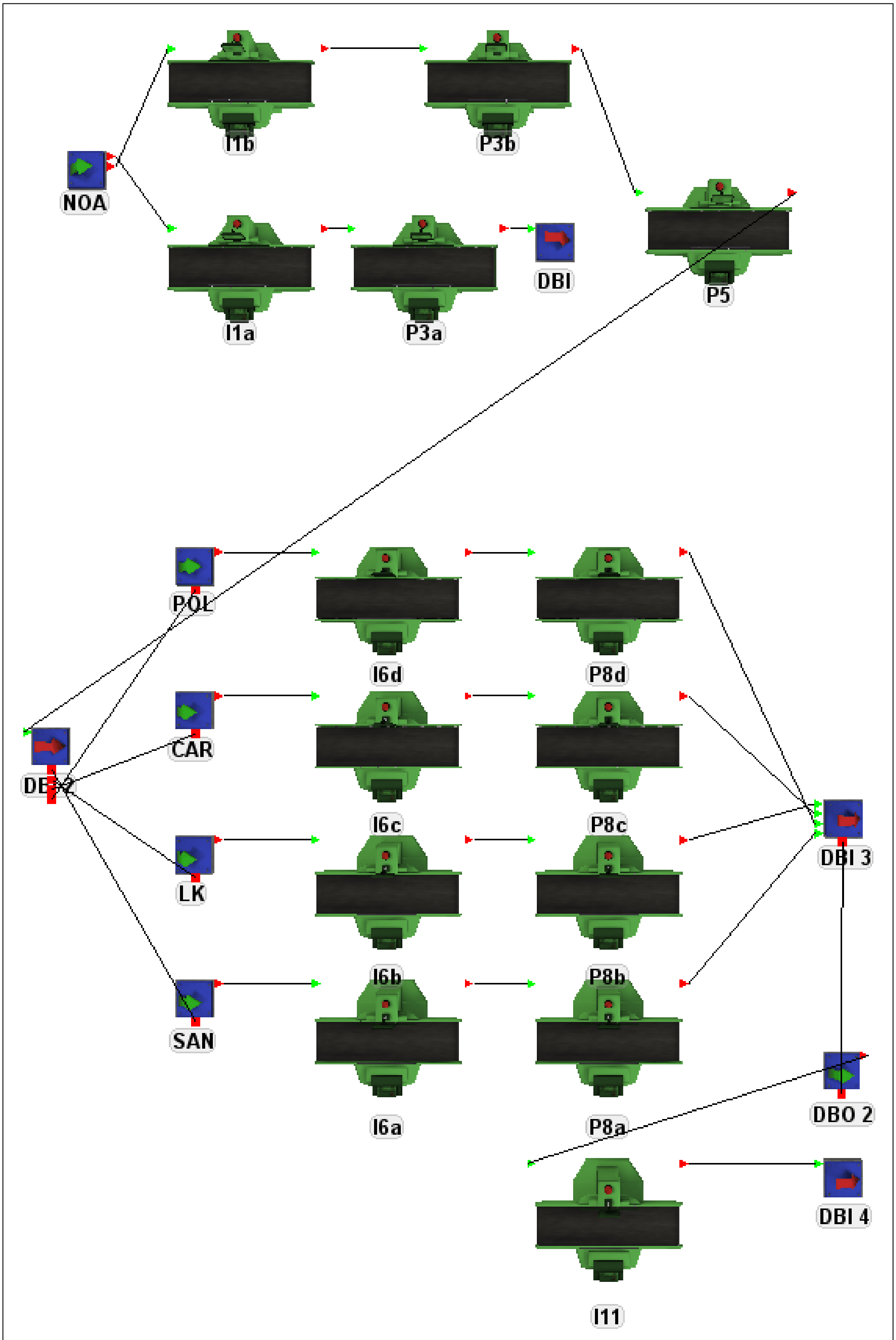

Figure 2 Reengineered simulation model of the ship's arrival announcement documentation processing in optimized seaport clusters

forms and attaching certificates by the ship's agent or captain. Those sub processes designated with "P" are processes (events) related to checks and approvals of electronically processed messages by the involved stakeholders.

Based on these premises and data, a simulation model of process reengineering has been created that entails delivery and checks or electronic forms and certificates during the ship's port arrival announcement. For easier understanding, designations in the model correspond to those used in Figure 1. Compared to the initial model (Tijan et al., 2014), those processes that include document and form delivery are abolished, following the model's assumption that forms and documents are not delivered physically but in the electronic form. The following abolished sub processes are identified:

1. D2a – Delivery of forms, certificates and ISPS CODE Arrival Notification to the Harbour Master,
2. D2b – Delivery of forms and certificates to the Dangerous Goods Inspector of the Port Authority,
3. D4 – Delivery of the acknowledged Declaration of Dangerous or Polluting Goods to the Harbour Master's Office,
4. D7 – Delivery of forms to the Sanitary Inspection, Harbour Master's Office, Customs and Maritime Border Police (on-board delivery),
5. D9 – Delivery of the approved Sanitary Free Pratique Document to the Harbour Master's Office, and
6. D12 – Delivery of the Permission for the Vessel to Have Communication with the Shore from the Harbour Master's office to the ship's agent.

Furthermore, sub process P10 (check #26 – Sanitary Free Pratique) is eliminated, but the time required to check Sanitary Free Pratique is added to the time required to complete sub process I11 (issue #12 – Permission for the Vessel to Have Communication with the Shore).

Source NOA is the beginning of the process of filling electronic forms (Web forms) to announce the ship's arrival to port (I1a) and check them by the Harbour Master (P3a), and the Dangerous Cargo Inspection (P3b). Sink DB1 is the archival of electronic messages for of the Ship's Announcement of Arrival, done by the Port Authority.

After Dangerous Goods Inspection, the inspector confirms the electronic Declaration of Dangerous or Polluting Goods in the system, the Harbour Master's office is informed about the outcome and it confirms (or rejects – not anticipated in this model) the announcement of the ship's arrival to the ship's agent. This information should also be visible to other port authorities (Customs and Border Police), by electronic means.

Source POL is the beginning of the process of filling electronic Web forms by the ship's agent, sent to the Border Police (I6d). Source CAR is the beginning of the process of filling Web forms by the ship's agent, but sent to the customs (I6c). Source LK is the beginning of processing the electronic Web forms by the ship's agent sent to the Harbour Master's office (I6b), while source SAN is the beginning of the same process initiated by the ship's agent, but forms are sent to the Sanitary Inspection (I6a). Such process reengineering does not anticipate the physical delivery of the forms on board the vessel for inspection by the involved stakeholders. Rather, they are verified by using the business information system application.

Processor P8d represents a process of electronic form (message) checking by the Border Police. Processor P8c represents a process of checking electronic forms by the Harbour Master's office, while processor P8a performs checks of electronic messages of the Sanitary Inspection and issuing the electronic message of the Sanitary Free Pratique.

Sink DBI3 is the end of all the described processes of electronic form (message) checks and it triggers source DBO2: the beginning of the creation of the electronic message "Permission for the Vessel to Have Communication with the Shore". This permission is not issued aboard the vessel as in the traditional ship arrival administrative process. It is instead created as an electronic message by the Harbour Master's office. After this permission is created, it is published to all stakeholders involved in the process (ship's agent, captain, Port Authority, Customs and Border Police). Finally, the whole process ends in the sink DBI4.

4. Results of the reengineered processes simulation model

According to the presented and explained logic, a simulation model has been created by using the software package FlexSim. One hundred (100) simulations have run consecutively and the run time has been measured for each occurrence. The shortest run time has been 186.02 minutes while the longest one has been 294.32 minutes with an average run time being 235.85 minutes. All simulation results are shown in Table 3.

The end results of the executed simulation experiments are also graphically shown in Figure 3.

To complete the comparison of the labour cost required for the completion of administrative processes required for the ship's arrival into the port in traditional and reengineered models, the same assumptions will be made as in the original study (Tijan et al., 2014). This means that the average net monthly salary paid in December 2013 in sea transport activities (NKD H-500) of 6,650.00 HRK (Anon., 2014), will be included into the total cost for the employer, with contributions and taxes amounting to 11,427.36 HRK. Based on a 23-day working month, this also means that an average labour cost of this process is 62.11 HRK (8.15 EUR; 1 EUR = 7.62 HRK).

On average, the time required to complete the reengineered administrative process is 235.85 minutes or 3.93 hours. The itemized labour cost for this activity is 244.14 HRK (32.04 EUR). Considering that the quantified labour cost required to execute these processes in a traditional way is 474.05 HRK per ship (Tijan et al., 2014), it

Table 3 Test results of the simulation of the administrative task reengineered processes related to the ship's arrival into the port

Experiment number	Elapsed time	Experiment number	Elapsed time
1	237,49	51	261,33
2	234,02	52	212,87
3	233,55	53	241,84
4	274,17	54	271,58
5	186,23	55	206,05
6	261,88	56	272,56
7	216,13	57	282,62
8	222,70	58	226,78
9	223,90	59	267,28
10	184,63	60	294,32
11	212,90	61	234,91
12	224,43	62	274,43
13	250,41	63	262,82
14	288,37	64	217,06
15	226,88	65	227,64
16	209,70	66	219,62
17	246,69	67	231,08
18	251,75	68	233,13
19	233,83	69	258,50
20	206,10	70	248,59
21	229,65	71	281,12
22	235,22	72	229,07
23	229,44	73	243,11
24	244,87	74	224,43
25	248,27	75	247,17
26	231,30	76	201,72
27	253,28	77	243,09
28	226,20	78	241,87
29	284,33	79	209,53
30	243,46	80	264,73
31	186,11	81	210,02
32	231,23	82	215,38
33	225,13	83	229,76
34	190,83	84	238,29
35	287,73	85	232,73
36	270,61	86	238,27
37	223,36	87	234,00
38	241,70	88	218,80
39	264,29	89	211,19
40	251,50	90	271,45
41	215,88	91	211,92
42	207,15	92	230,18
43	242,78	93	250,29
44	203,81	94	207,95
45	247,28	95	239,42
46	225,60	96	274,62
47	227,50	97	214,70
48	246,87	98	186,02
49	232,38	99	220,55
50	232,38	100	212,29

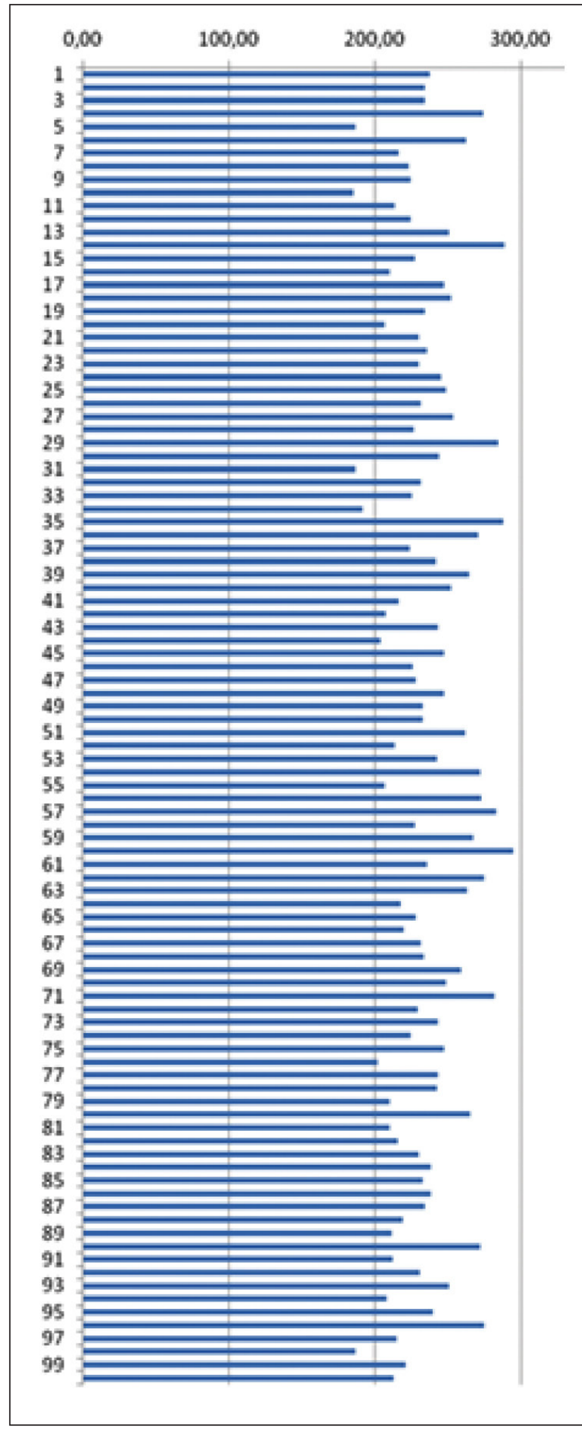

Figure 3 Graphical results of simulation experiments of the reengineered administrative process of the ship's arrival into the port

is possible to come to the conclusion that the result of the new, reengineered model in terms of labour cost reduction is 48.5 %. For example, in the port of Rijeka, based on the number of 500 vessels per year, the savings of up to 26,050 HRK could be achieved just by the ICT enablement of the administrative process of the vessel arrival. If the administrative process of the vessel arrival is reengineered, as stated in this paper, the savings could amount to 108,880 HRK (Tijan et al., 2012).

The achieved results have proved the main hypothesis: the usage of simulation is beneficial for the optimization and reengineering of seaport cluster processes and can be used to decrease labour cost.

5. Conclusion

The previous analysis of the labour cost related to the traditional document processing related to the arrival of ships into the port has shown that this particular activity requires a significant time to be completed, resulting in the duplication of documents, processes, unnecessary steps and redundancies and additional decrease in the labour cost. Furthermore, this lowers the efficiency of work because it ties up resources that could be potentially utilized for other tasks. In this research, the comparison basis has been the previously performed analysis of the labour cost required for the processing of a single ship's arrival into the port, with the established labour cost of 474.05 HRK per ship.

Using this model as a starting point, a new model has been created by using the Flexsim software package. An appropriate methodology has been applied and identified bottlenecks, redundancies, duplications of processes and documentation have been removed (either by a complete abolition or merging them with other appropriate processes). During this step, gaps, delays and overlapping in the document delivery have been identified and then removed.

By using the Flexsim application, an algorithm has been set up with defined elements (sources, sinks, processors and process paths) and numerous simulations have been run. The simple average has shown an average time necessary to process documents related to the ship's arrival into Croatian ports. On average, simulations have shown that the reengineered administrative process takes 235.85 minutes. Reduction in the required time (reengineered processes compared to traditional processes that use paper documents and rudimentary information technologies) is therefore identified to be 48.5 % when the proposed model is practically implemented. Considering that the time required to process administrative tasks is directly proportional to the labour cost of the involved personnel, it is possible to conclude that total savings incurred by the reengineering of the processes related to administrative tasks of ships' arrival into ports on a national level in the Republic of Croatia, under the model's assumptions, could justify the implementation of the Port Community Systems in larger Croatian seaports.

The possibility of a future research lies in the application of the explained process in analysing and reengineering other processes (mainly commercial processes, not administrative ones) related to the introduction of integral business information systems best suited for seaport clusters – Port Community Systems.

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