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SIMULATION OF LOGISTICS PROCESSES (SIMPROCESS)

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ABSTRACT. The ability to identify and control business processes that cut across functions and organizations has become a new imperative, especially in logistics. Process approach in management forces implementation of appropriate tools. The most sophisticated of available tools is a computerized simulation. The main goal of this paper is to present the issue of building a model that reflects the real business process, as well as simulating the behavior of that model in order to draw conclusions about effectiveness and efficiency of a real business process.

Key words: business process, computerized simulation, logistics process model, simulation model, SIMPROCESS software.

INTRODUCTION

Many organizations nowadays are perceived as systems of business processes. This point of view has been replacing traditional perception of function-based companies. According to the process approach, each enterprise consists of horizontally grouped resources that have own suppliers, customers and add value while transforming inputs into outputs. Functional model assumes vertical structure of resources and sharp distinctions among various functional areas, which often leads to conflicts, inefficiencies and deterioration of competitive position.

From the logistics point of view horizontal management is a very innovative and effective approach, enabling smooth flow of materials and information, within and among companies forming supply chains. In other words process management facilitates eradicating most of the potential disruptions of material/ information flows that take place at functional or organizational boundaries.

Process approach has been popularized mainly thanks to the following management concepts:

- lean management - seeks for perfection by eliminating waste in organization; one of the main principles, on the course of achieving perfection, is identifying and optimizing the value stream - a set of processes that create value for final customer [Harrison, van Hoek 2002],
- business process reengineering - assumes essential redesign of business processes (the way business activities are done and coordinated) to achieve significant improvements in costs, quality, and lead time [Hammer, Quinn 1999],
- benchmarking - comparison of selected processes between partners (e.g. cooperating companies) in order to ascertain the best practices of carrying out tasks, activities and eventually improve process parameters.

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Implementing process model within company entails radical changes in management systems. Functional organization structures have to be replaced by process or matrix configurations, process managers and teams are appointed. Eventually they have to be equipped with new tools for designing, monitoring and measuring processes. One of the most powerful means of analyzing and (re)designing processes is a dynamic/computerized simulation. It allows to trace process behaviour by means of computer system in a very compressed time, without any risk of implementing inappropriate processes or disrupting existing ones.

PROCESS DEFINITION AND TYPOLOGY

Business process is a logical set of activities assembled to accomplish business goal(s). Process takes input from a supplier adds value to it and eventually transfers it to a customer [Harrington, Tumay, 2000].

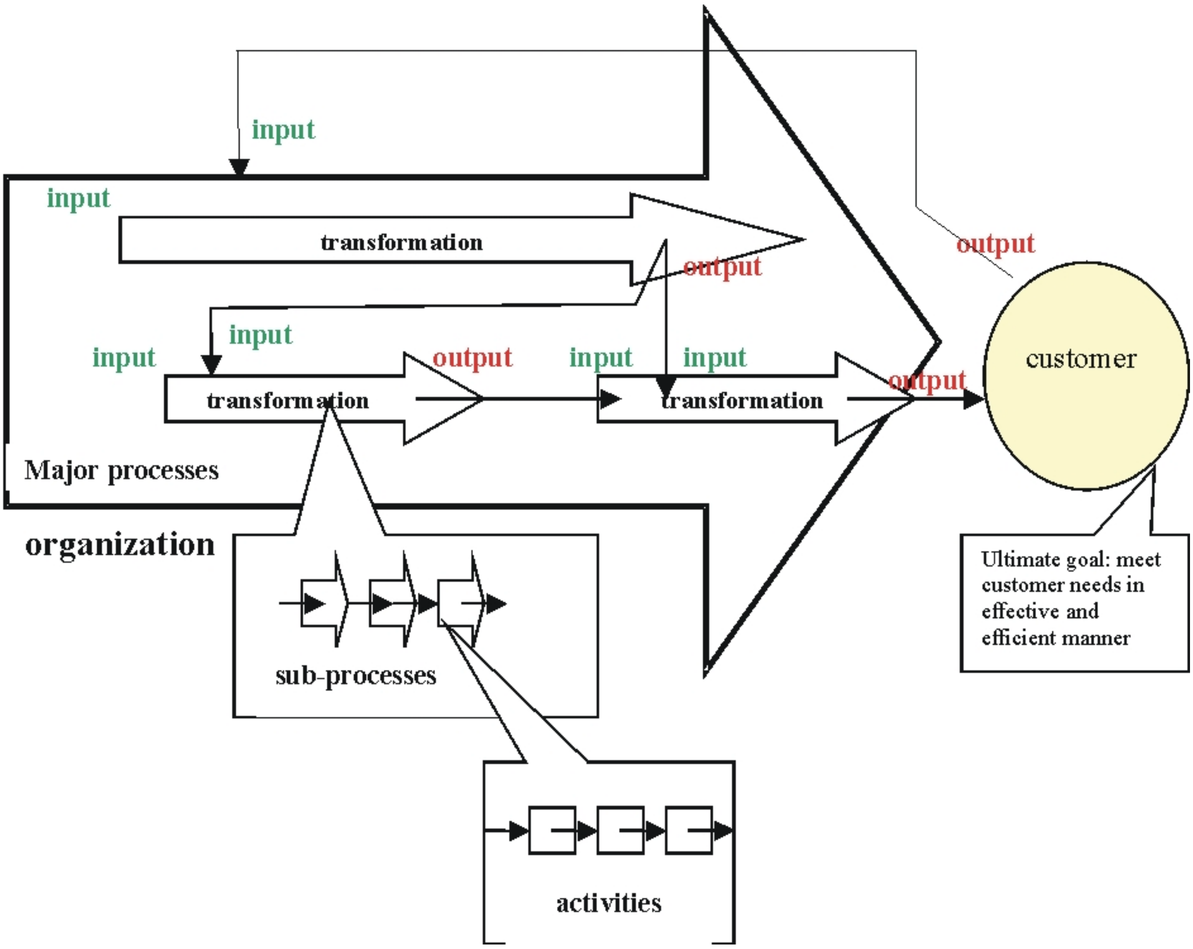


Fig. 1. Business processes in organization
Rys. 1. Procesy biznesowe w organizacji

According to figure 1 each business process has one or more inputs that may originate form other internal processes or external source (supplier or customer process). By analogy certain process serves one or more customers, internal or external. What is more, business processes are connected by entities that flow within and beyond organization, hence the processes act as customers and suppliers against each other. Eventually, business processes have a hierarchical structure. This means that company could be perceived as a single global process consisting of few major processes that could be further broken down into sub-processes, activities and eventually tasks. The number of levels in the hierarchy depends upon size and complexity of organization(s).

A comprehensive, sector-neutral model of process-oriented organization (process classification framework) has been developed by APQC International Benchmarking Clearinghouse, in close cooperation with Artur Andersen. As the authors state, the concept should be regarded as a benchmarking tool, enabling users to compare and accordingly improve business processes across industries. The model distinguishes seven operational as well as seven management and support processes that are broken down into two hierarchical levels table1 [APQS 2004].

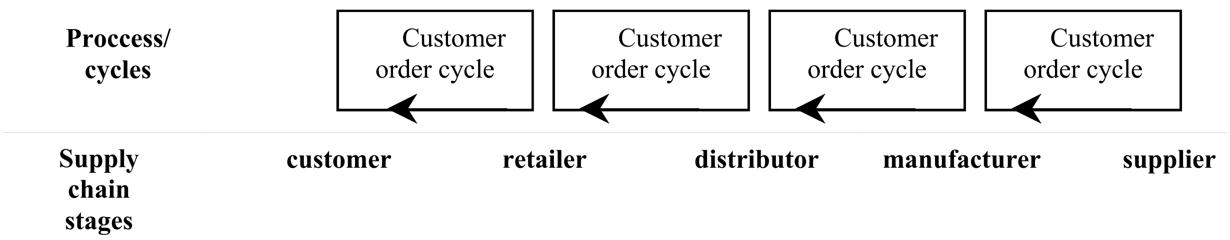
Table 1. Process classification framework
Tabela 1. Ramowa klasyfikacja procesów

Operating processes	Management and support processes
1. Understand markets and customers	8. Develop and manage human resources
2. Develop vision and strategy	9. Manage information
3. Design products and services	10. Manage financial and physical resources
4. Market and sell	11. Execute environmental management program
5. Produce and deliver for manufacturing organizations	12. Manage external relationships
6. Produce and deliver for service organizations	13. Manage improvement and change
7. Invoice and service customers	14. Acquire, construct and manage property

Source: APQS, Artur Andersen, Process Classification Framework,
http://www.apqc.org/portal/apqc/ksn/PCF.pdf?paf_gear_id=contentgearhome&paf_dm=full&pageselect=contentitem&docid=108113
APQS, Process Classification Framework
http://www.apqc.org/portal/apqc/ksn/PCF_Complete_May_5_2004.pdf?paf_gear_id=contentgearhome&paf_dm=full&pageselect=contentitem&docid=115313

The structure of the presented above process classification framework can be perceived, in a sense, as a derivative of the Porter's value chain, since both models divide processes/functions into two groups: value creating and supporting. The former contributes directly to producing and moving goods to final customers, while the latter enables efficient and effective realization of the value creating processes. From logistics angle, improvement and coordination of operating processes is essential, as they directly contribute to material flow. Albeit information as well as external relationships management seem to be also crucial elements of logistics and especially supply chain management.

Next to general approaches, there have been also developed supply chain dedicated models. Chopra and Meindl recognize supply chain as a sequence of processes that take place within and between different organizations (supply chain stages) to fill customer need for product. The processes are perceived as series of cycles, performed at the interface between two successive stages of supply chain (figure 2) [Chopra, Meindl 2001].



Source: Chopra, Meindl, 2001, Supply Chain Management. Strategy, Planning and Operation, Prentice-Hall, New Jersey.

Fig. 2. Supply chain process cycles
Rys. 2. Cykle/procesy w łańcuchu dostaw

Presumably the most recognized and popular model of logistics processes is Supply Chain Operations model (SCOR) developed by Supply Chain Council. SCOR is based on concepts of business process reengineering, benchmarking and process measurement. It distinguishes five main supply chain processes [Swain 2005]:

1. Plan - collecting business data, balancing requirements with resources, issuing plans.
2. Source - sourcing stocked, make to order or engineered to order products.
3. Make - controlling production processes.
4. Deliver - all steps from processing orders to selecting carriers.
5. Return - controlling reverse flows of defective and excess products.

Above processes are broken down into sub-processes (process categories), elements, tasks and finally activities. The model also provides definitions, inputs, outputs, and metrics along with best practices for each process element.

Lambert defines eight key processes that make up the core of supply chain management. All the processes spread over cooperating organization and what is more, they cut across functional areas of each supply chain member. The supply chain processes are as follows [Lambert, Cooper, Pagh 1998]:

- customer relationship management,
- customer service management,
- demand management,
- order fulfillment,
- manufacturing flow management,
- supplier relationship management,
- product development and commercialization
- returns management.

Lambert brakes down the processes into strategic and operational sub-processes and further into activities that reside into functional areas. The model also describes interrelations between all elements [Croxton, Garcia-Dastugue, Lambert, Rogers 2001].

The important feature of the presented above approach is its comprehensiveness. The model goes beyond logistics and describes also marketing along with research and development processes. Nonetheless, interfaces between logistics, marketing and R&D elements are included.

PROCESS DESIGN AND ANALYSIS TOOLS

Implementation of process approach necessitates implementation of process design and analysis tools. There are various approaches and techniques for designing and improving processes. Some of them are utilized commonly across various management concepts, however they differ in level of complexity. Universal tools are described in turn.

The most common technique of analyzing process is flowcharting. In general **flowcharts** portray design and the logic of a certain process. They brake down the analyzed process into activities/events and indicate their interrelationships. These tools differ according to the level of sophistication. The simplest type of flowchart is **block diagram**. It provides quick and uncomplicated view of the process by the means of rectangles (blocks) and arrows. The former represents activities, while the latter indicates relations between activities or the workflow direction. **ANSI standard flowchart** presents each unique activity/ event by different symbol. **Functional** flowchart provides additional information on process flow between areas (functions, posts) in organization, while **graphical flowchart** portrays process flow among various locations (e.g. among nodes of supply chain) [Harrington, Tumay 2000].

Process performance analysis is another tool providing valuable data about the process performance. It boils down to collecting performance data at the activities or tasks level, including processing time, idle time costs, resources usage, quantity processed per time period, etc. Based on these data, statistics of the whole process are derived. Advanced performance analysis should also include variations of the main statistics, which is necessary in making realistic predictions of the behavior of activities and processes, as well as in searching for existing opportunities of process improvement. [Petrovich]

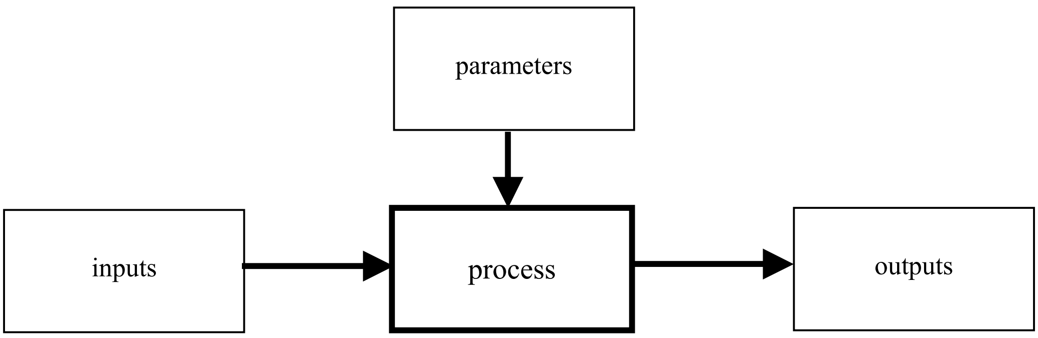
Process flow animation has became available mainly due to rapid development of information technology. Equipped with sophisticated software the analyst is able to track the flow of transactions (entities) throughout the process, accordingly he can indicate bottlenecks, queues, idle resources etc.

Computerized process simulation software packages integrate mentioned above techniques. First they picture the process by means of flowchart. Second, they are equipped with animation facilities that allow to observe the process behavior during simulation stage. Third, computer simulation models describe the process using a set of statistics. It is important to notice that instead of average/ static parameters, probability distribution are harnessed in order to mimic randomness of the model. Dynamic process simulations can be brought to bear during various stages of business management cycle: design phase (to choose the best alternative), operational phase (to enable existing process improvement), scaling down phase (to carry out ex-post evaluation). Therefore computerized process simulation should be regarded as a first comprehensive approach that helps to predict, compare and accordingly optimize the performance of the processes, without the costs and risks of disrupting existing operations [APQS 2004].

From logistics point of view dynamic simulation of processes could provide valuable information on number of orders realized, lead times, logistics resource utilization, inventories levels, etc. Hence on base of such a simulation analyst is able to draw conclusions on logistics customer service as well as logistics costs.

SIMULATION MODEL DEVELOPMENT

Building a model presents the most difficult part of simulating business process. The structure of the model consists of four main elements (figure 3). Inputs are entities that arrive through the process, usually goods, orders and other information. Parameters describe behavior of the process. Both inputs and parameters usually take the form of statistical distributions. Process is a logical representation of analyzed process, including sub-processes, activities along with their interrelations. Eventually, outputs represent main measures (statistical reports) of the process that are captured during simulation.



Source: Petrovich M. V., Performance analysis for process improvement, http://www.mvpprograms.com/docs/PPAtext.pdf

Fig. 3. Structure of a simulation model
Rys. 3. Struktura modelu symulacyjnego

Procedure of designing model includes the following steps [APQS 2004, Petrovich]:

1. **Identification of the simulation object -** there are two approaches in identifying process(es) to be simulated: top-down approach, in which major process is decomposed into elements, e.g. processes, sub-processes and activities; bottom-up approach that starts with defining all activities and grouping them into sub-processes, etc. While making the decision on the process that is to be simulated, the analyst has to choose between complexity and level of details. Simulating whole supply chain excludes high level of exactitude. On the other hand, simulating single purchasing process enables detailed presentation.
2. **Flowcharting the process** - chosen process is to be "represented" to the computer; the analyst using drag and drop technique deploys all the process elements on the screen (the number of hierarchy levels depends on model precision) and links them with connectors, i.e. marks out the way entities go through the process.
3. **Gathering process data and putting them into the model** - data describing entities arrivals and process behavior are to be collected and programmed into the model as inputs and parameters respectively; accordingly real process observation or collection of historical data is necessary at this stage.
4. **Validating the model** - comes down to comparison of the computerized model and the real system behavior; there are two main strategies to validate the model - run the simulation and compare its outputs with historical data of the real process, or ask an expert in the process if the simulated result are reasonable.

The next step after designing the model is simulation of the process, analysis of output data, and eventually decision regarding choice of process alternative, improvement, etc.

SIMULATION BY MEANS OF SIMPROCESS ® SOFTWARE

The range and variety of simulation software packages continues to grow. According to research conducted in 2005 there are at least 48 discrete-event systems simulation and related products [Swain 2005]. Although in many cases offered software are sector oriented, some vendors dedicate their systems to logistics processes (table 2).

Presented below SIMPROCESS® exemplifies universal simulation tool that could be utilized across different sectors, as well as various business processes. The software is also applicable in logistics systems and processes. It could be utilized in mapping and simulating whole supply chains or particular logistics processes.

SIMPROCESS® is a hierarchical process simulation tool that combines process mapping and discrete-events simulation along with activity based costing (ABC). The model is developed here in top-down manner, starting with main processes, through sub-processes and activities at the bottom of the structure. The main building blocks of the model are [Simprocess User's Manual]:

1. Process blocks - represent processes and sub-processes.
2. Activities - basic elements of the process - 19 standard activities are built in the software.
3. Entities - represent goods, information or people that flow thorough the model.
4. Connectors - link processes, sub-processes and activities; determine the way entities flow through the process.
5. Resources - agents required to perform activities (assets and people).
6. Attributes and expressions - tools for customizing model.

The important feature of SIMPROCESS® is model customization option. In order to be able to picture specific behaviour of the process it is possible to use so called logical or mathematical expressions that permits modification of standard model. The mentioned characteristic is really important in simulating logistics processes, especially inventory models.

Table 2. Logistics oriented simulation software
Tabela 2. Programy symulacyjne procesów logistycznych

Software	Vendor	Typical applications of the software	Primary markets for which the software is applied
Arena	Rockwell Automation	Facility design/configuration, scheduling, effective passenger and baggage-handling processes, patient management, routing/dispatching strategy	Airports, health care, logistics, supply chain, manufacturing, military, business process
AutoMod	BrooksSoftware	Decision support tool for the statistical and graphical analysis of material handling, manufacturing, and logistical applications using true to scale 3D graphics. Templates for Conveyor, Path based movers, Bridge Cranes, AS/RS, Power & Free and Kinematics	Warehousing and distribution, automotive, semiconductor, manufacturing, transporta-tion, logistics, airports/baggage/cargo/ security, mail and parcel handling, steel and aluminum, controls testing and emulation
Extend Suite	Imagine That, Inc.	Model continuous, discrete event or discrete rate processes; 3D modeling and analytical distribution fitting	Large scale and rate-based systems, manufacturing, logistics, packaging lines, transportation and more
Flexsim	Flexsim Software Products, Inc.	Manufacturing, logistics, material handling, container shipping, warehousing, distribution, mining, supply chain	Manufacturing, logistics, material handling, container shipping, warehousing, distribution, mining, supply chain
Lean-Modeler	Visual8	Value stream mapping; inventory-level, lead-time, capacity, bottleneck and proof-of-concept analysis.	Manufacturing, supply chain, logistics, lean manufacturing consulting, Six Sigma training
ProModel Optimization Suite	ProModel Corporation	Lean, SixSigma, capacity planning, cost analysis, process modeling, cycle time reduction, throughput optimization and more	Manufacturing and logistics, pharma-ceutical, defense
ShowFlow 2	Webb Systems Limited	Process improvement; investment feasibility; what-if; cycle time, work in process and waiting time reductions; layout improvement	Manufacturing, logistics, retail, distribu-tion, financial services, teaching
SIMUL8 Professional	SIMUL8 Corporation	Work flow management, throughput analysis, de-bottlenecking, new product/process development, capacity analysis, continuous improvement	Business process, call centers, manufacturing, supply chain, logistics, healthcare, financial, pharmaceutical and others
SLIM	MJC" Limited	Strategic logistics network modeling and optimization	Logistics operations (retail, petroleum, freight, express, foods, construction, government, manufacturing and others)
Supply Chain Builder	Simulation Dynamics, Inc.	Address inventory problems and transportation or resource issues; library describes inventories, items, resources, operations, BOMs, and actions.	Manufacturing, service organizations, transport management and other corporations seeking ongoing, online process management tools

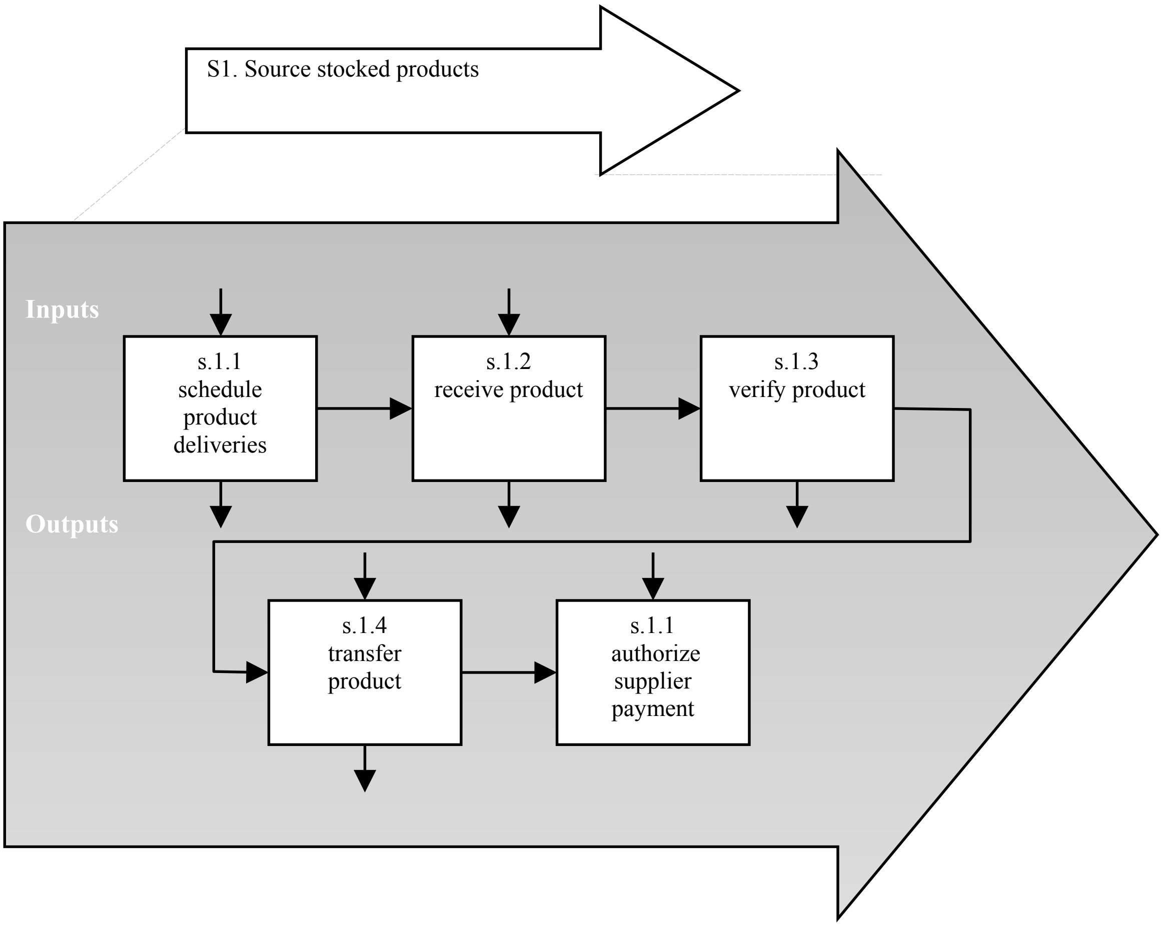
Source: J. Swain, 'Gaming' Reality, Biennial survey of discrete-event simulation software tools, http://www.lionhrtpub.com/orms/surveys/Simulation/Simulation.html

Process that is simulated here by means of SIMPROCESS® application is taken directly from SCOR model v7. It is one of 22 sub-processes (process categories) called source-stocked product. The sub-process consists of five consecutive elements. Its flowchart is pictured at figure 4.

The further assumption (inputs) of the simulated model are as follows:

- two groups of materials (two entities) that flow through the process have different usage pattern. Group A are fast rotating goods, with purchase orders arriving every 70 minutes on average. While group B consists of slow moving goods, with purchase orders put at 15 hours intervals,

- two possible scenarios of process realization are simulated. First, decentralized purchasing alternative, within which different purchasing clerks serve each material group. Second, centralized alternative, where purchasing specialists serve any material, depending on its availability,
- centralized process employs 10 clerks, 8 of them process fast rotating materials orders, while 2 are devoted to service slow moving goods orders. Decentralized process provide work for 9 specialists. In each case cost of single employee amounts 6 000 zł a month.



Source: Supply Chain Council, Supply-Chain Operation Reference-model, http://www.supply-chain.org/site/scor7booklet.jsp

Fig. 3. Structure of a simulation model
Rys. 3. Struktura modelu symulacyjnego

Thus the first step of model design is completed - possible process alternatives are identified.

Two other steps, i.e. flow-charting and putting statistical data to describe model behaviour are realized simultaneously. At the very beginning of programming entities as well as resources are defined (figure 5, 6). Next processes flowcharts and main inputs statistics (table 3) are programmed.

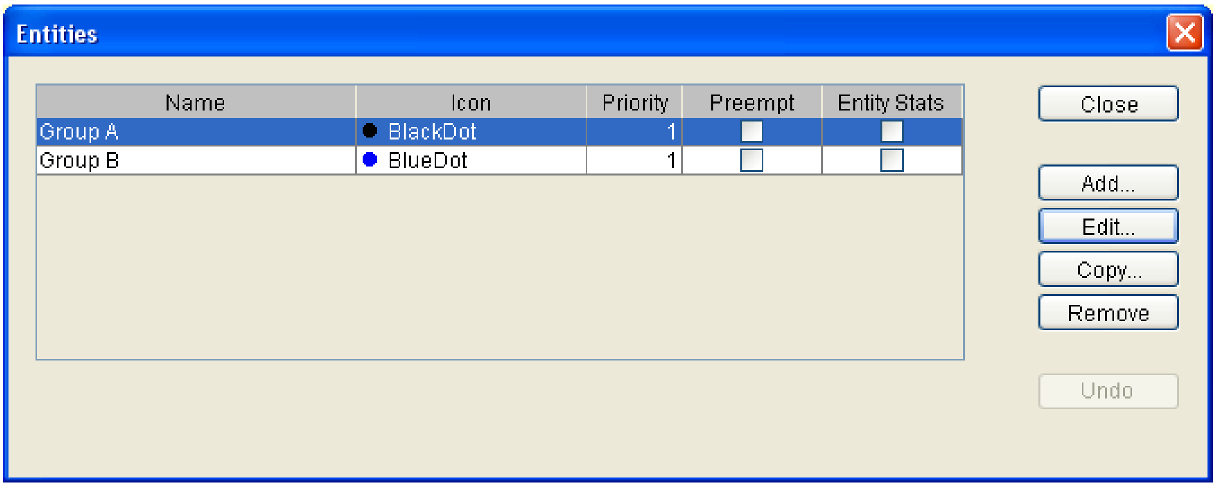


Fig. 5. Entities defined
Rys. 5. Definiowanie przepływów

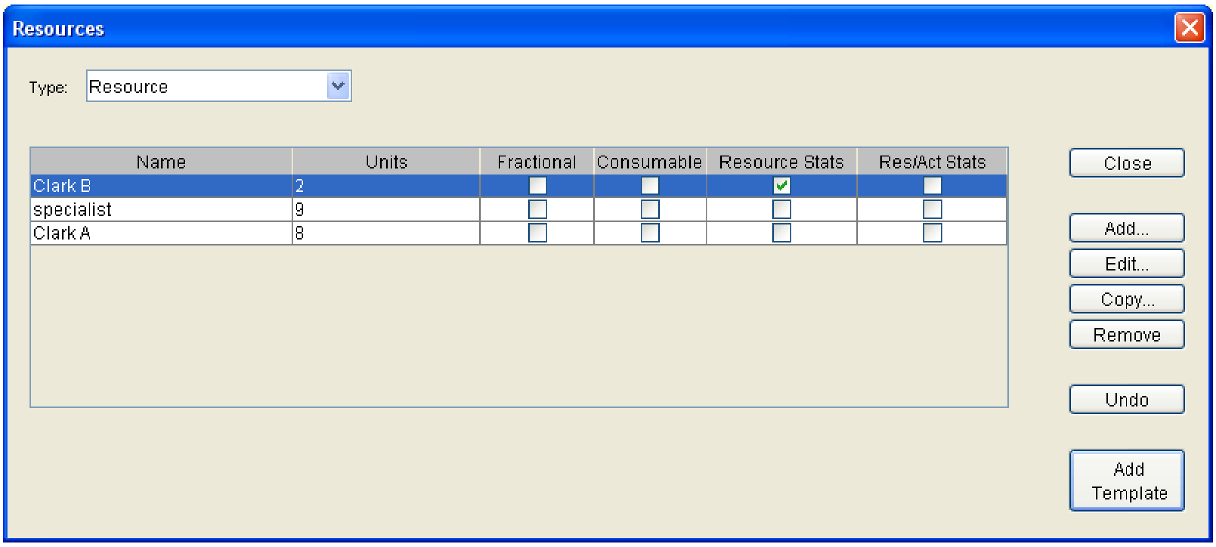


Fig. 6. Resources Defined
Rys. 6. Definiowanie zasobów

Figures below present model structure (flowchart), which consists of three levels. Top level is common for both alternatives. First icon (activity) stands for material order generation. Second icon symbolizes stock to order (purchasing) process that is simulated. The last icon denoting processed orders is necessary for collecting output statistics. Second and third levels of the process structure vary with alternatives.

In decentralized alternative order (entity) goes to A or B sub-process pending on its group assignment. Appropriate flow of the orders is facilitated by branch activity (level 2). Next, at the bottom level, individual clerk is assigned to the order and realizes five consecutive, time-consuming activities. After that clerk becomes idle, which means that he can process next order (level 3). Processed orders, that come out of sub-processes are merged and leave the decentralized process (level 2).

In the centralized alternative, incoming order, regardless of its type, is assigned to any idle specialist. Nonetheless, time needed for processing order still depends upon its type (level 2). Therefore, order with assigned specialist is branched and goes through A or B sub-processes that differ in time durations (level 3). Having realized all activities specialist is set free, which follows entities merger (level 2).

Table 3. Statistical model inputs
Tabela 3. Statystyki wejściowe modelu

Group A		Probability distribution	Average/ mode	Maximum value	Minimum value	Standard deviation	Time
Order generation frequency		Normal	70	n/a	n/a	5	Minutes
Activities duration	Scheduling	Triangular	2	3	1,5	n/a	Hours
	Receiving	Triangular	1	2	0,5	n/a	Hours
	Verifying	Triangular	5	6	3	n/a	Hours
	Transferring	Triangular	1	1,2	0,5	n/a	Hours
	Authorizing	Triangular	1	1,2	0,5	n/a	Hours
Group B		Probability distribution	Average/ mode	Maximum value	Minimum value	Standard deviation	Time
Order generation frequency		Exponential	15	n/a	n/a	n/a	Hours
Activities duration	Scheduling	Triangular	3	4	2	n/a	
	Receiving	Triangular	1	2	0,5	n/a	
	Verifying	Triangular	5	6	3	n/a	
	Transferring	Triangular	1,5	3	1	n/a	
	Authorizing	Triangular	1	2	0,5	n/a	

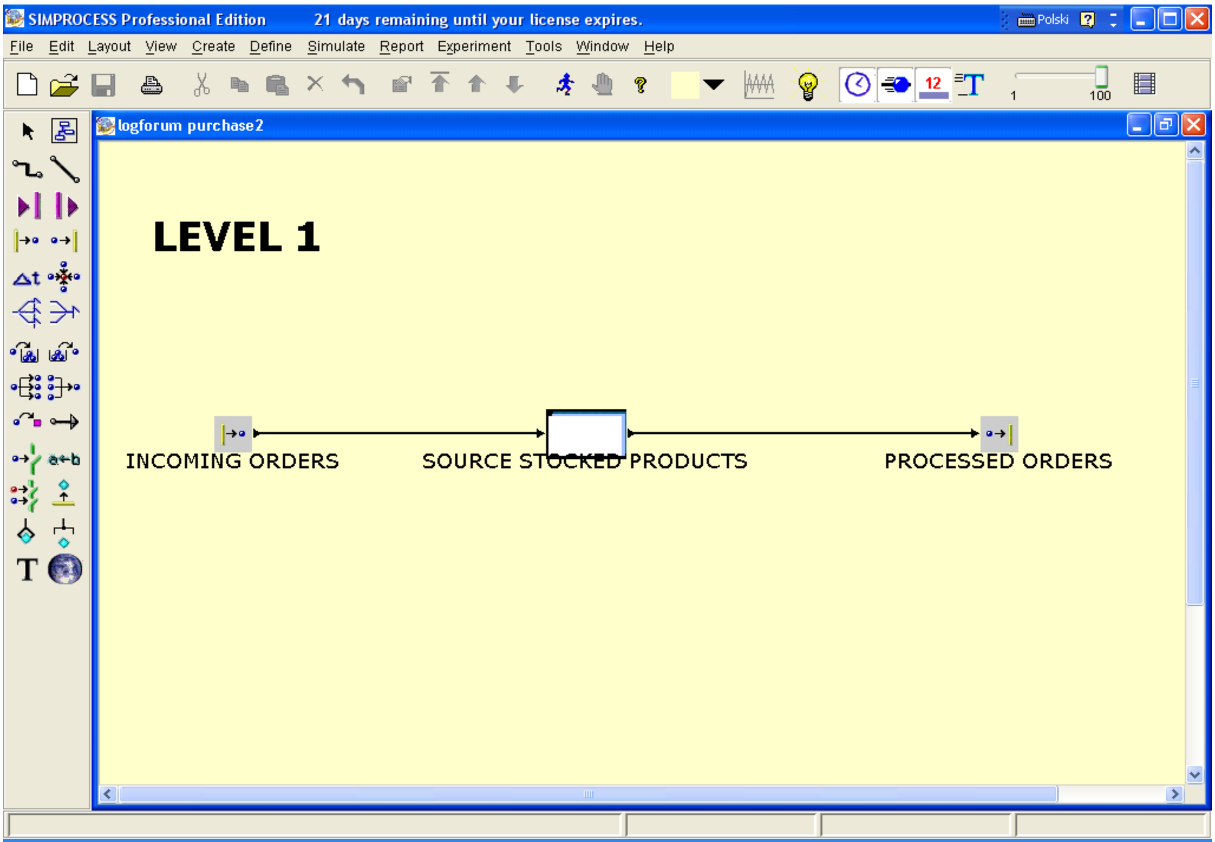


Fig. 7. Purchasing process - level 1
Rys. 7. Proces zaopatrzenia - poziom 1

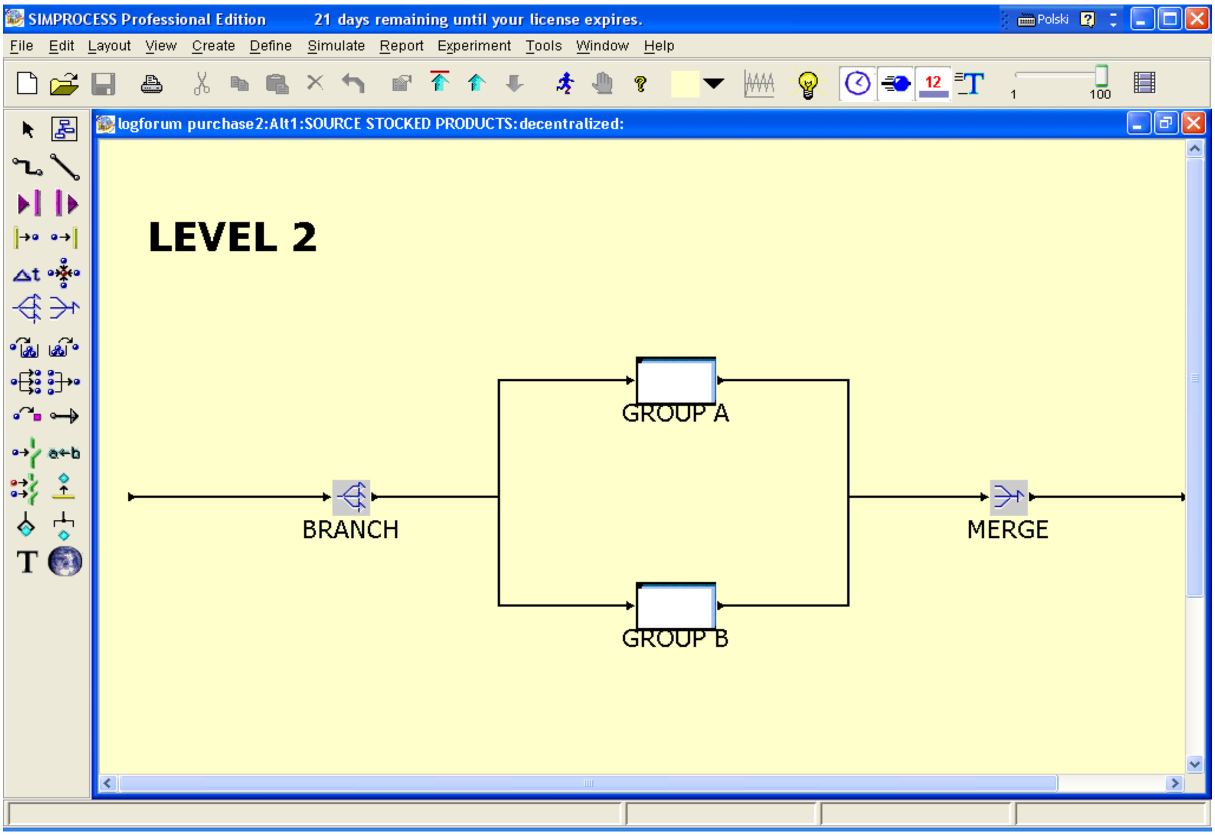


Fig. 8. Decentralized process alternative - level 2
Rys. 8. Proces zdecentralizowany - poziom 2

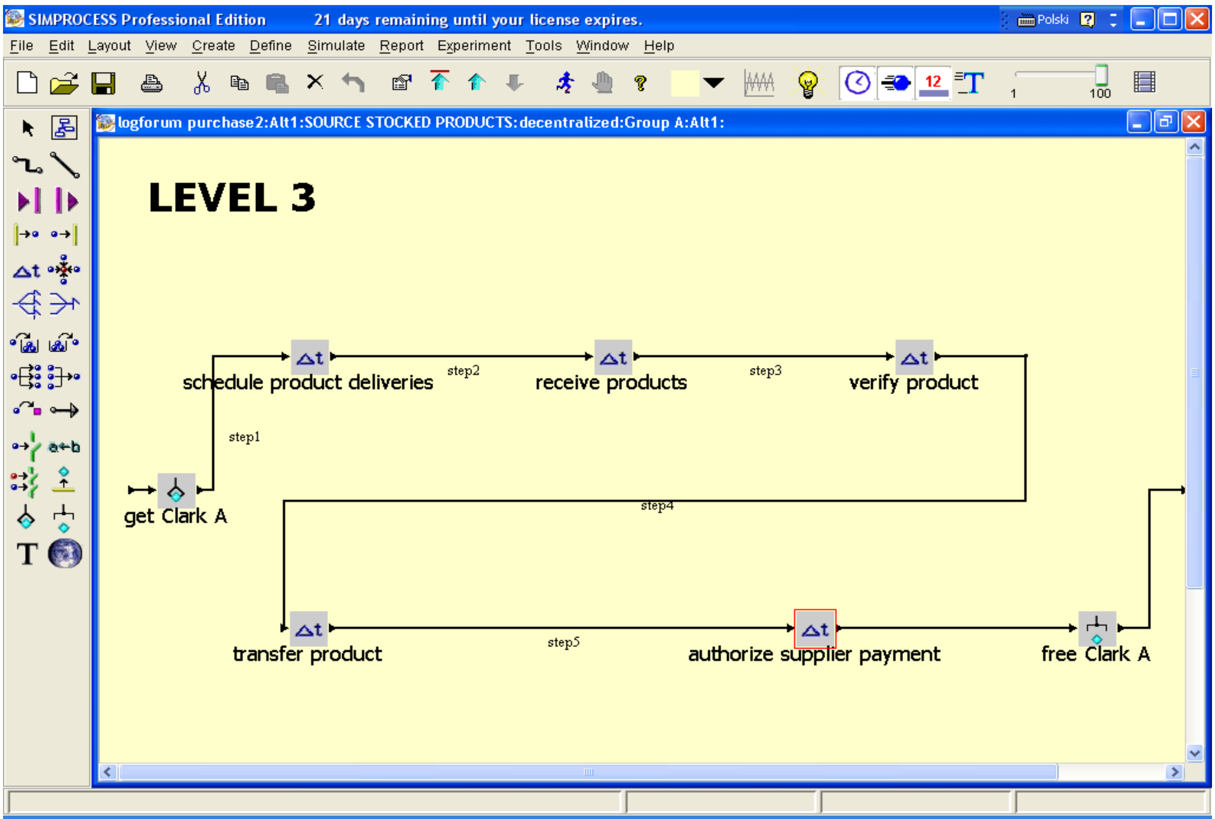


Fig. 9. Decentralized process alternative, group A sub-process - level 3
Rys. 9. Proces zdecentralizowany, sub-process grupa A - poziom 3

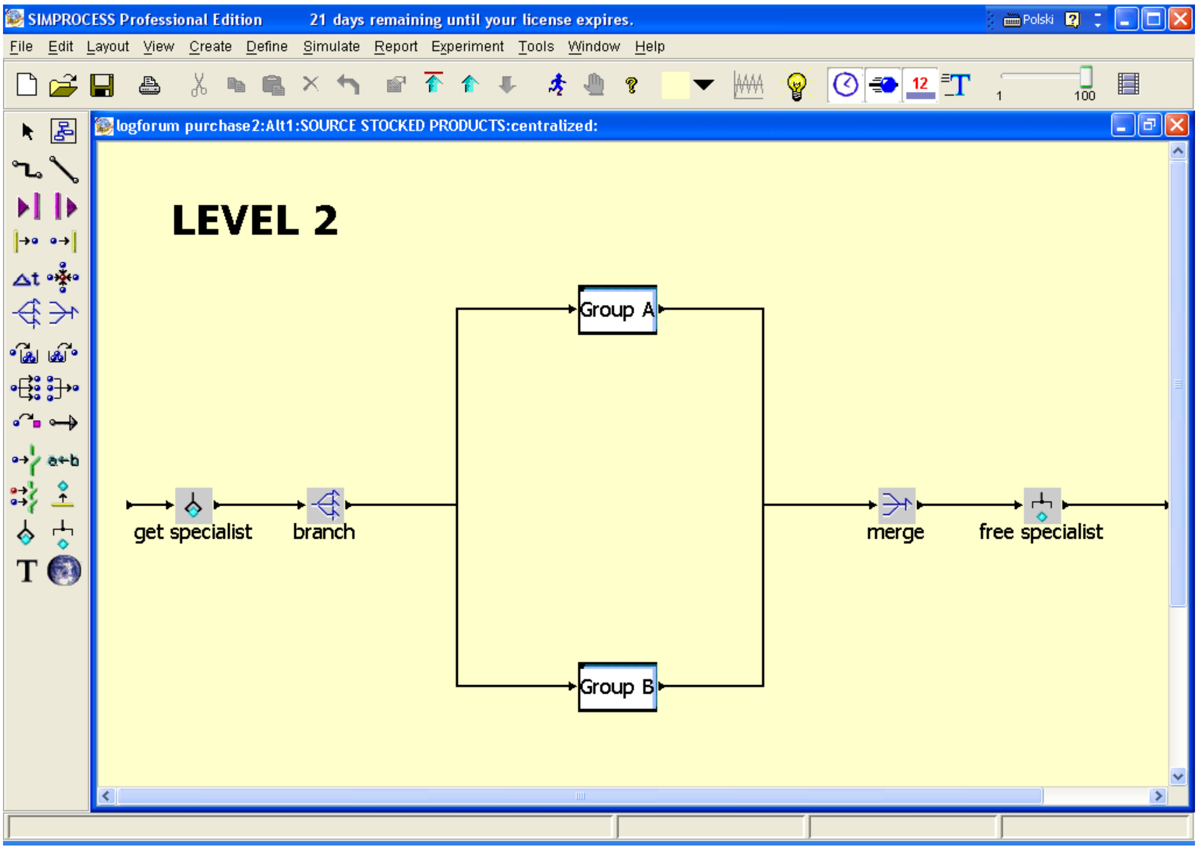


Fig. 10. Centralized process alternative - level 2
Rys. 10. Proces zcentralizowany - poziom 2

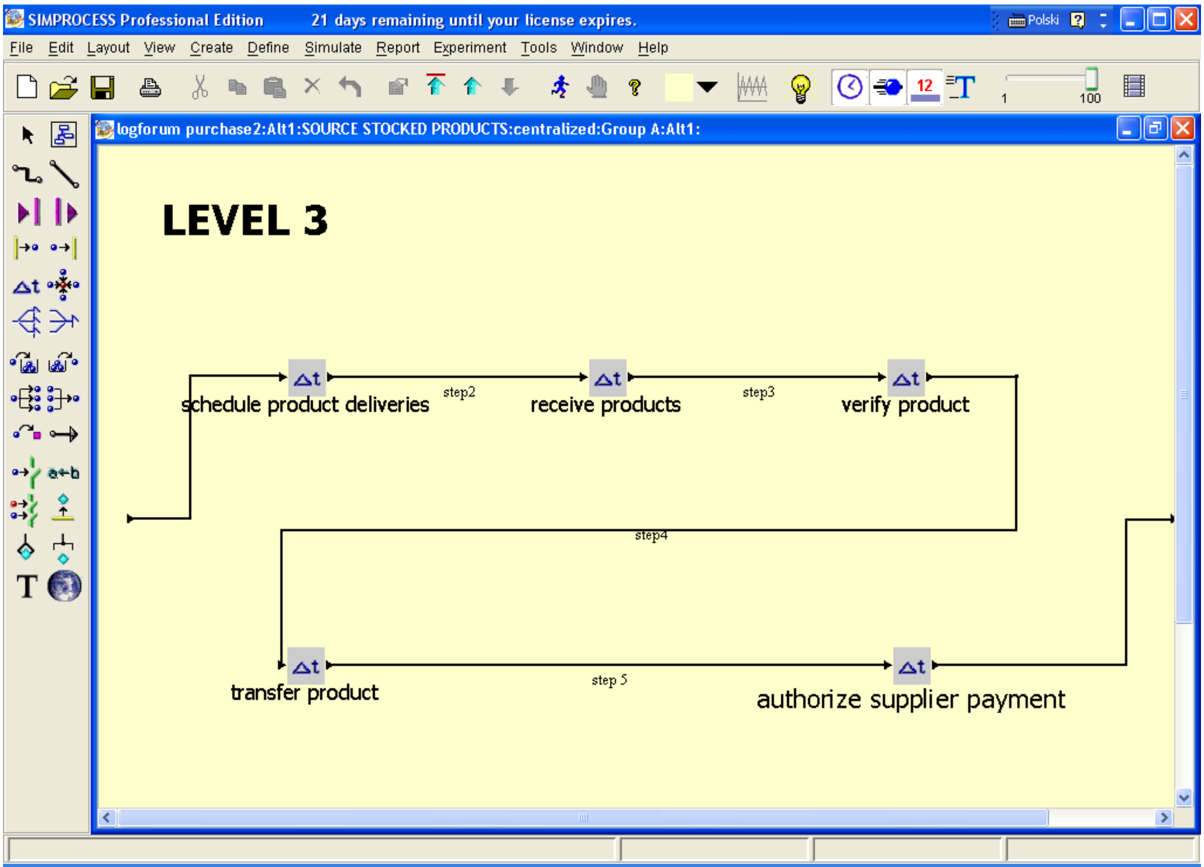


Fig. 11. Centralized process alternative, group A sub-process - level 3
Rys. 11. Proces zcentralizowany, grupa A - poziom 3

Validation of the model is skipped here. Therefore the next step is to set and run simulation. Two process alternatives are simulated during one year long period. Each alternative is run for three replications, which is important when the model contains randomness (parameters are set as statistical distributions). This averages the results and gives the more accurate view on model behavior. The main output statistics are presented in turn.

Table 4. Number of entities (orders) generated and processed
Tabela 4. Liczba przepływów (zamówień) wygenerowanych i zrealizowanych

Process alternative	Entity name	Number generated	Number processed	Customer service
decentralized	Group A	7515	7152	95,2%
	Group B	593	592	99,8%
centralized	Group A	7507	7484	99,7%
	Group B	544	542	99,5%

Assuming that customer service metric for purchasing process is defined as the relationship between number of orders generated and processed, the centralized alternative guarantees better results i.e. facilitates considerably higher performance in case of group A orders, at cost of slight deterioration of service for group B orders, compared to the decentralized alternative.

Table 5. Order cycle time (hours)
Tabela 5. Czas realizacji zamówienia (godziny)

Process alternative	Entity name	In system	Processed	Wait for resource
decentralized	Group A	218,9	9,7	209
	Group B	13,1	11,8	1,3
centralized	Group A	30,7	9,7	21
	Group B	33,7	11,8	22

Above table shows time necessary to process A and B orders within two alternatives. There is a clear distinction in case of group A. Due to insufficient number of clerks in the decentralized alternative, group A orders remain in system for 219 hours, 209 of which they queue up for resources. While in the centralized process alternative wait time is shorten to 21 hours. In case of group B orders, slightly better results are obtained in decentralized alternative.

Table 6. Resource utilization
Tabela 6. Stopień wykorzystania zasobów

Process alternative	Resource name	Busy	Idle
decentralized	Clerk A	99,95%	0,05%
	Clerk B	39,98%	60,0%
centralized	Specialist	99,53%	0,47%

It is clear that centralized alternative guarantees higher level of resource utilization accordingly superior productivity. In the decentralized process clerks B remain idle 60% of time, that is why cycle time of group B orders (presented in table 5) is lower compared to the centralized alternative.

Table 7. Resource cost
Tabela 7. Koszty zasobów

Process alternative	Capacity	Absorbed	%
decentralized	730 000	642 079,0328	88,0%
centralized	657 000	653 921,0923	99,5%

Resource cost are derivative of resource utilization. That is the higher utilization the smaller gap between cost of providing certain capacity level and cost really absorbed in the process. Although real costs of processing orders in both alternatives are almost the same, costs of providing capacity in the decentralized process are clearly higher that in case of centralized process.

To sum up, the centralized alternative seams to be more effective and efficient. It guarantees higher service level of the process, shorter cycle time for A group orders, and higher utilization rate of resources. Only in case of B group orders cycle time the decentralized process gives better performance, however at costs of really low resource utilization. Obviously, process designer could simulate other alternatives that would provide event better results, for instance develop mixed process with universal specialists and one additional clerk devoted for B group orders only.

Presented above example is rather simple. Simulated process is basic, and not all output statistics are presented in this paper. Software packages like SIMPROCESS ® facilitate programming and analyzing more complex, highly customized models with both material and information flows. Also available output statistics deliver more valuable data including costs of performing each activity. Nonetheless author intends to show, in the straight manner, that simulation is a valuable instrument for logistics process analysis. Managers who need to make decision upon credible information about processes that are realized in ever changing, accordingly random environment should utilize it. Simulation shows clearly relations between cost effectiveness and logistics service level, being valuable tool while designing, improving or just evaluating processes performance in both lean and agile logistics systems.

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SYMULACJA PROCESÓW LOGISTYCZNYCH

STRESZCZENIE. Identyfikacja i sterowanie procesami biznesowymi, które przecinają funkcje i organizacje staje się koniecznością, szczególnie w przekrojowej ze swojej natury logistyce. Podejście procesowe do zarządzania rodzi konieczność posługiwania się właściwymi narzędziami. Jednym z najbardziej zaawansowanych instrumentów jest symulacja komputerowa. Głównym celem artykułu jest prezentacja procedury budowy komputerowego modelu procesu biznesowego oraz jego symulacja, której wyniki stanowią informacje niezbędne do podejmowania decyzji dotyczących projektowania i usprawniania procesów.

Słowa kluczowe: proces biznesowy, symulacja komputerowa, model procesów logistycznych, model symulacyjny, oprogramowanie SIMPROCESS.

LOGISTIKPROZESSE-SIMULATION

ZUSAMMENFASSUNG. Identifizierung und Steuerung von Geschäftsprozessen, welche die Funktionen und Organisationen überschneiden wird insbesondere in der Logistik zur Notwendigkeit. Für das prozessorientiertes Denken an das Management sind richtige Toolls erforderlich.
Eines von den meist innovativen Tools ist die Computersimulation. Das Hauptziel des Beitrags ist die Präsentation der Vorgehenswese zum Aufbau eines EDV-gestützten Modells des Geschäftsprozesses und dessen Simulation, dessen Ergebnisse Informationen zum Entscheidungstreffen Projektierung und Verbesserung von Prozessen liefern.

Codewörter: Geschäftsprozess, Computersimulation, Logistikprozesse-Modell, Simulationsmodell, SIMPROCCESS Software.

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