Performance Evaluation for Cost Calculation of Business Processes

Teilprojekt M1/M2:

F. Bause
V. Tatah
M. Völker
LS Informatik IV

Teilprojekt M3:

T. Geißen
A. Meinke

LS Industriebetriebslehre

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F. Bause[+], T. Geißen[#], A. Meinke[#], V. Tatah[+], M. Völker[+]

+ LS Informatik IV, Universität Dortmund, D-44221 Dortmund
{bause,tatah,voelker}@ls4.cs.uni-dortmund.de
LS Industriebetriebslehre, Universität Dortmund, D-44221 Dortmund
{T.Geissen,A.Meinke}@wiso.uni-dortmund.de

Abstract: Performance measures and costs are important figures for the evaluation of business processes (BP). Since the end of the 80ies, cost accounting instruments received considerable interest which fairly apportion indirect costs according to the input involved, e.g. activity based costing (ABC). In practice, such accounting systems are difficult to use, because they require detailed information on the BP dynamics. When modeling and analyzing BP these information are in principle available.

This paper describes an implemented approach supporting the determination of performance measures for activity based costing using a modeling paradigm based on process chains.

1 Introduction

Business processes (BP) are a chain of internal activities as well as activities across companies that result in an output [15]. Managing BP includes methods, instruments, and tools to support their design, enactment, management, and analysis [1]. Recently, BP have changed dramatically. Just-in-time production/delivery, outsourcing, B2B/B2C, virtual factories/companies are familiar terms denoting particular facets of this development. Consequently, an evaluation of BP nowadays cannot be done on static information only, but has to take the dynamics of systems into account. Besides, it is necessary to cost out such BP in order to evaluate them.

Cost accounting instruments support such cost-oriented evaluation of BP. Traditional cost accounting instruments are widely used in most companies. These instruments, however, usually sum up the costs accrued from the business activities without considering to what degree each of the products or services contribute to the total costs. In contrast, process-oriented cost accounting instruments like activity based costing (ABC), which accurately allocate the accrued costs to each business activity and product, are attracting a great deal of attention. But in practice, companies seldom employ ABC because of the lack of available detailed information concerning cost causation.

The aim of the paper is to demonstrate how ABC could get the required data from dynamic simulation models. Performance measures accessed from simulation results, like throughput, lead time, population etc., can be used as bases for ABC calculations. The paper focuses on a comprehensive cost calculation which also takes sophisticated cost-relevant measures into account, and describes how sufficiently detailed measures assist to calculate costs.

Most enterprise resource planning (ERP) tools available today fall short of providing these measures required for the management of BP. Tools with modeling capabilities are used for building different model scenarios of the BP. These scenarios are analyzed in order to select the optimal ones that best represent the objectives of the company. Existing BP software tools, like SAP R/3 CO [19] and the ARIS Process Cost Analyzer [18], provide a basic support for cost analysis, but do not display all cost-relevant measures of BP [16]. E.g., the ARIS-toolset models process flows without considering resources and inventory, thus ignoring relevant elements influencing the dynamics of BP.

In this article we describe the performance evaluation for cost calculation of BP in the *ProC/B*-paradigm. *ProC/B* and its corresponding toolset [2] have been developed in a large interdisciplinary research project, the collaborative research center "Modelling of Large Logistics Networks" [17], in which supply chain and business process management are important research topics. The evaluation of some cost-relevant measures based on standard performance measures has been described in [5]. In this paper also non-standard measures are used to support comprehensive cost calculations. In our approach, all cost calculations are based upon steady-state results obtained by a simulation of the model, assuming that steady-state exists.

The outline of the paper is as follows. The next section deals with a comparison of two cost accounting techniques followed by an introduction of the *ProC/B*-paradigm in Sect. 3. Sect. 4 deals with the evaluation of performance measures and the subsequent cost calculation. An exemplary evaluation of a BP model is presented in Sect. 5 and the conclusions follow in Sect. 6.

2 Traditional Cost Accounting versus Activity Based Costing

This section illustrates the deficits of traditional cost accounting compared to activity based costing by means of an example (cf. Fig. 1). As mentioned, evaluations of business processes are often requested not only with respect to performance measures such as lead time or utilization, but also with respect to costs. Cost calculation is an important condition in order to judge the efficiency of business processes. A considerable amount of indirect costs (costs which cannot be directly related to labor or material) compared to direct costs exist within companies. Examples for indirect costs are labor costs, capital costs, depreciations, and costs for energy. These costs have to be fairly allocated to products, customers, or orders according to the input involved. Traditional cost accounting instruments do often distort product costs, if they are used on products which differ in quantity and size. The main reason is that the traditional cost accounting usually allocates *all* costs according

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to the allocation base 'labor costs' [9]. In Fig. 1, all indirect costs (4424 [€/period]) are allocated via the allocation base labor hours (220 [h/period]). Although the concentration on a single allocation base does not represent cost causation best, it is commonly used in practice. This is due to the fact that available real data are restricted to labor hours alloted pro rata to products and total costs. The latter are externally given in the operational accounting sheet. Considering the example in Fig. 1, the following data are usually available in practice: products A, B, C and D and their quantities, total indirect costs, and the individually caused labor hours.

Original Data

Product	Quantity/Year	Material Costs/Unit	Material Costs/Year	Labor Hours/Unit	Orders/Year	Total Indirect Costs
A	10	6	60	5	1	
B	100	6	600	50	3	
C	10	18	180	15	1	
D	100	18	1,800	150	3	
Quantity Consumed			2,640	220	8	
Total (in €)			**264**	**2,200**	**1,960**	**4,424**

☐ Available in practice
▨ From operational accounting sheet

1. Calculation of Indirect Cost Rates

Traditional Cost Accounting

Characteristics: Unidimensional Allocation Base

Allocation Base	Indirect Costs	Units	Indirect Costs Rate
Labor Hours:	4,424 €	220	**20.11 €**

Activity Based Costing

Caracteristics: Multidimensional Allocation Bases

Allocation Base	Indirect Costs	Units	Indirect Cost Rate
Material Costs:	264 €	2,640	**0.10 €**
Labor Hours:	2,200 €	220	**10.00 €**
Orders:	1,960 €	8	**245.00 €**

2. Calculation of Unit Costs

	Allocated Indirect Costs*	Unit Cost*
A:	100.55 €	**10.05 €**
B:	1,005.50 €	**10.05 €**
C:	301.65 €	**30.16 €**
D:	3,016.50 €	**30.16 €**

	Allocated Material Costs	Allocated Labor Costs	Allocated Order Costs	Σ Allocated Indirect Costs	Unit Cost
A:	6 €	50 €	245 €	301 €	**30.10 €**
B:	60 €	500 €	735 €	1,295 €	**12.95 €**
C:	18 €	150 €	245 €	413 €	**41.30 €**
D:	180 €	1,500 €	735 €	2,415 €	**24.15 €**

* Calculation:
Allocated Indirect Costs = Indirect Cost Rate · Labor Hours per Unit and Product.
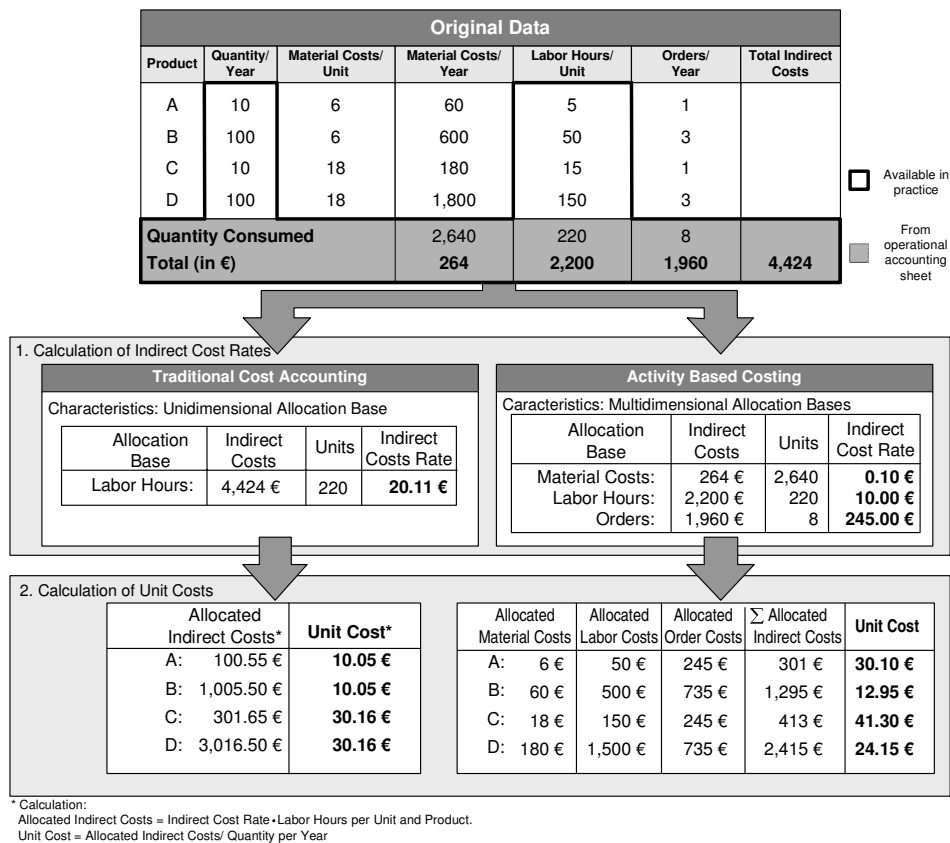Unit Cost = Allocated Indirect Costs/ Quantity per Year

Figure 1: Traditional cost accounting vs activity based costing

In current discussions, ABC attracts more and more attention. It considers the activities which are actually caused by products and orders so that costs can be transparently assigned and traced to a product, a service, or a customer [10]. Thus, an efficient resource allocation is ensured, capacity utilizations are illustrated, calculations are improved, and, consequently, wrong management decisions are avoided. But, ABC requires precise and detailed data on resource consumption, material costs, labor hours, and orders alloted to

the single products. In Fig. 1, all original data are needed for ABC. As in practice such data are not available in the necessary detailedness, they have to be generated in a different way. Simulations, however, provide the data required for ABC.

The limitations of traditional cost accounting compared to ABC are illustrated in Fig. 1. The four products differ in volume and size (A and C are low-volume products, B and C are high-volume ones, A and B are small-sized, C and D are big-sized) which influence material consumption, labor hours, machine utilization, and quantities. Costs are calculated by using the two instruments as follows: Using the traditional cost accounting, the total indirect costs of the considered period (4424 [€/period]) are divided by the allocation base labor hours (220 [h/period]) so that the indirect cost rate (20.11 [€/h]) is given. Afterward the unit costs can be calculated by determining the allocated indirect costs per product and afterward the unit costs. E.g., unit costs of product A are calculated by multiplying the indirect cost rate (20.11 [€/h]) by the labor hours (5 [h/unit]) caused by product A. The resulting allocated indirect costs (100.55 [€/period) are divided by the product units of product A (10 [units/period]) so that each unit of product A costs 10.05 [€/unit]. The unit costs of products B, C, and D are calculated in the same way. The calculation of unit costs by using ABC is much more sophisticated. Multidimensional allocation bases (material costs, labor hours, and number of orders) are used which all cause individual indirect cost rates. This differentiation continues when calculating allocated indirect costs which are the sum of allocated material costs, allocated labor costs, and allocated order costs. Data thus obtained are much more sophisticated which lead to more sophisticated unit costs (30.10 [€/unit]) for product A.

The analysis of the allocated indirect costs with traditional cost accounting brings forth two (wrong) conclusions: First, high-volume products cause the same costs per unit as low-volume ones (10.05 €) and secondly, costs for big-sized products are thrice as much as the costs of small-sized ones (30.16 €). The more detailed allocation of costs according to ABC presents a different result. The multidimensional allocation bases (in the example only material costs, labor hours, and orders), necessary to manufacture certain products, are considered and influence the allocation of indirect costs. E.g., product B causes only thrice as much orders as product A although the quantity per year of B is ten times higher. This can be considered when using ABC in order to fairly allocate costs to products with ABC. It becomes obvious that the allocation of costs to products by ABC is preferable. Thus, an instrument is needed which provides data in the needed quantity and quality. In the following, such an instrument will be introduced.

3 The *ProC/B*-Paradigm

The process chain paradigm is a modeling language especially designed for logistics networks [13, 14]. Originally, it is a description language for the specification of logistics networks and has been successfully applied in consulting projects. Subsequently, part of the process chain paradigm has been formalized resulting in the so-called *ProC/B*-paradigm [2]. *ProC/B* enables the analyst to combine modeling and analysis with respect to performance evaluation as well as cost calculation. *ProC/B*-models have a well-defined seman-

tics [3] and can be precisely specified so that the analysis of performance measures, like throughput and lead time (response time), can be and has been automated.
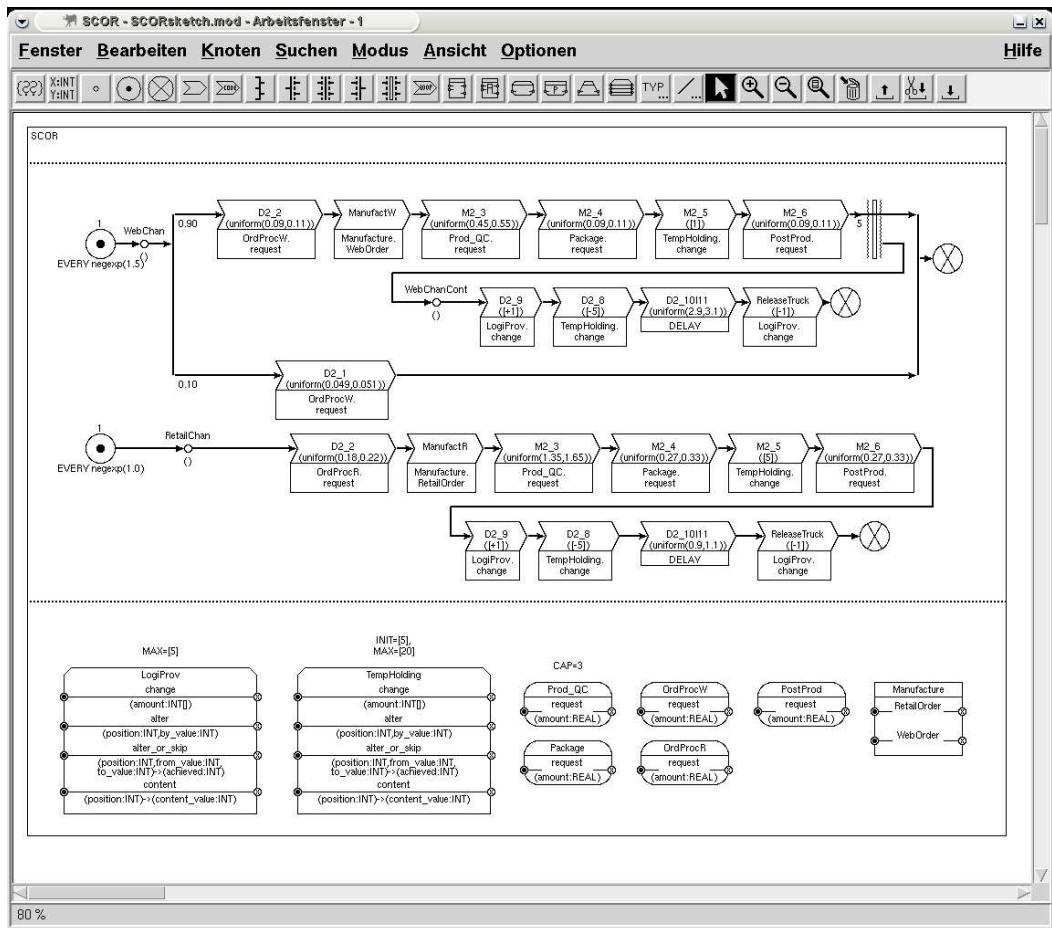

Figure 2: Example of a *ProC/B*-model

The *ProC/B*-paradigm follows a hierarchical concept. *ProC/B*-models are based on functional units (FUs), which can be considered as the departments of a company or even as entire companies. The interior of a FU contains process chain descriptions which are composed of activities, corresponding to provided services. The FU might make use of other internal FUs (Sub-FUs) in order to perform these services. Sub-FUs show the same notation as their "Super-FUs": a set of process chains specifying the activities being performed when calling a service and (internal) FUs whose services can be employed for executing activities. Following this approach, the user can benefit from using just one single set of elements in all layers of the model. Outsourcing is also covered by *ProC/B*. A special construction (External-FU) gives the possibility to use services of non-sub- but neighbored-

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FUs. *ProC/B*-models have an acyclic graph structure with FUs providing services in one direction and using services in the other direction. The leaves are made up of Standard-FUs which model elementary time (Server-FU) or space (Counter-FU) consumption. This hierarchical approach enables the modeler to handle large models.
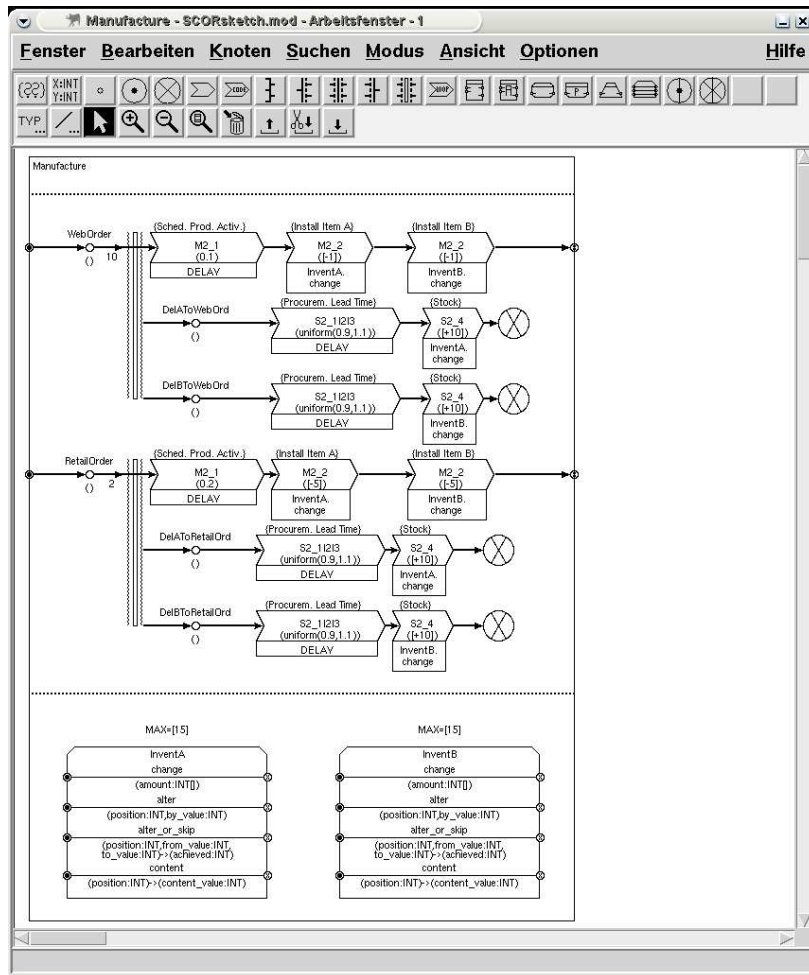

Figure 3: Example of a functional unit

Figs. 2 and 3 depict an example of a *ProC/B*-model. The model consists of three process chains named *WebChan*, *RetailChan,* and *WebChanCont*. Each process chain captures the behavior pattern of a particular type of process. Process chains are specified by a set of process chain elements describing individual activities (like e.g. *D2_2*). The activities are (partially) ordered in time, e.g. by describing them as a sequence. Alternative and concurrent behaviors can be described using OR- and AND-connectors. E.g., process chain

WebChan (cf. Fig. 2) uses an OR-connector to specify that 10% of all processes do only perform action *D2_1*. Processes of a process chain are created by a source (depicted as a circle with a dot). E.g., processes of process chain *WebChan* are created according to an exponential distribution specifying the inter-arrival time of processes. Dependencies between processes of different process chains can be expressed using process chain connectors. In Fig. 2, for example, a single process of the process chain *WebChanCont* is created whenever five processes of process chain *WebChan* have finished activity *M2_6*. In order to perform an activity, a process might use the services provided by a FU. E.g., the FU *Manufacture* provides two services *RetailOrder* and *WebOrder*. The latter is used by processes of process chain *WebChan* for performing activity *ManufactW*. The specification of FU *Manufacture* presented in Fig. 3 is similar to the specification shown in Fig. 2: two process chains describe the services *RetailOrder* and *WebOrder* whose activities are based on two internal FUs, *InventA* and *InventB*.

Given such a precise description of a *ProC/B*-model, it is possible to conduct performance analysis, e.g. by simulating the model. Modeling and analysis of *ProC/B*-models are supported by a corresponding toolset including a graphical user interface, which provides facilities to specify *ProC/B*-models (cf. Figs. 2 and 3).

For more details on the *ProC/B*-paradigm and toolset we refer the reader to [2].

4 Evaluation of *ProC/B*-models

4.1 Performance Measures

One objective of modeling business processes is to evaluate performance measures. Typical results of such an analysis are mean values, variances, and confidence intervals for, e.g., throughputs of processes, contents of inventories, and utilizations of resources. The *ProC/B*-toolset uses transformer modules mapping the *ProC/B*-model specification to the input languages of specific analysis tools. Currently available are mappings to tools for simulation, queueing network analysis (HIT [6, 7]), and a Petri net based analysis (APNN-toolbox [8]). The latter mapping offers the additional possibility to use the Möbius framework [11]. Mostly, complex *ProC/B*-models can only be analyzed via simulation. But there are several situations in which non-simulative techniques are appropriate or can be used to support a simulative investigation, like e.g. in early design phases or when debugging simulation models [4]. Efficient queuing network algorithms provide the modeler with results for standard measures, like throughput and utilization. The simulation environment also supports the determination of these standard measures, and additionally allows for user-specified result values (so-called *REWARDS*) which are recorded in data streams during a simulation experiment using corresponding *UPDATE*-commands (cf. Fig. 5). The definition of these user-defined values can be easily annotated in the *ProC/B*-model, so that elaborate modifications of the simulation program are not necessary.

Time series analysis techniques are applied on the fly to all these individual streams of

data. For all streams, it is possible to estimate the usual characteristics: means, standard deviations, confidence intervals, and histograms. Every data stream may be stratified in detailed, possibly multiple ways based on the structure of the model: activities of some lower-level FU are initiated by activities in some higher-level FU. When analyzing business processes, it is often important to differentiate measurements at lower-level FUs (e.g. service completion times) according to specific, higher-level originators. Considering, e.g., the process chain *WebChan* in Fig. 2, it might be interesting to distinguish between the sojourn times in FU *OrdProcW* for those processes which performed activity *D2_1* and for those which performed activity *D2_2*. The *ProC/B*-toolset is capable of furnishing such detailed measurements, streams, and results for any FU as well as for any of its provided services [2]. These special analysis capabilities enable cost calculation based on performance results. Additionally, user-specified REWARDS make sophisticated measurements possible, like determining overtimes.

4.2 Cost calculation on the basis of performance measures

Given performance results, it is possible to use ABC for fairly allocating indirect costs to products (for details on indirect costs see [10, 12]). Relevant information provided by *ProC/B* are the exact usage of resources (e.g. employees, capacities, and assets) involved in a certain business process or its subprocesses and the allocation of these resources to products or orders pro rata. Furthermore, *ProC/B* provides information about the activities within a business (sub-)process which determine its cost causation (e.g. set-ups, throughput). ABC uses such data for allocating the costs which are caused by a product when it passes a business (sub-)process and uses resources.

Usually, ABC is carried out in two steps. First, the indirect cost rates have to be calculated. They are determined by dividing the indirect costs of a certain business (sub-)process (e.g. total indirect costs for submitting orders in a certain period) by the number which are in total caused in the business (sub-)process (e.g. number of orders in a certain period). This makes the costs transparent for conducting a certain activity (e.g. ordering) once. The second step is the calculation of unit costs. The afore determined indirect cost rate (e.g. costs for one order) is multiplied by the number of activities that are actually caused by a product (e.g. number of orders caused by product x). By this, the allocated indirect costs of a product are given. By dividing them by the product units, the unit costs which are caused in a particular business (sub-)process are given (cf. Fig. 1). The calculated results from ABC can be used for different economic analyzes. It is possible to calculate contribution margins as well as the contributions per product, order, or customer.

ProC/B provides the necessary information for using ABC. However, not every cost relevant information in business can be deduced from simulation results. It is necessary to supplement these with external indirect costs, given in the operational accounting sheet (e.g. employee wages), or known from practical experience. Surely, *ProC/B* could provide the indirect cost rates and unit costs directly, if all indirect costs were integrated into the simulation. But from the economic point of view, it is interesting to have indirect cost rates, allocated indirect costs, and unit costs in single business (sub-)processes. This facil-

itates management decisions, as e.g. expensive business (sub-)processes can be identified. In the following, an example considering ABC with *ProC/B* will be introduced.

5 Example

In this section we present an example concerning the modeling and simulation of a part of a supply chain. Its purpose is to show the suitability of *ProC/B* by illustrating the determination of performance and cost-relevant measures.

Fig. 4 shows a supply chain with several actors: suppliers, logistics service providers, producers, and clients. The clients place monthly orders of products resulting in a load for producers and their machines. The products are manufactured from raw materials which have to be delivered by the suppliers. The modeled part is highlighted in Fig. 4 and includes one producer together with its suppliers and clients.
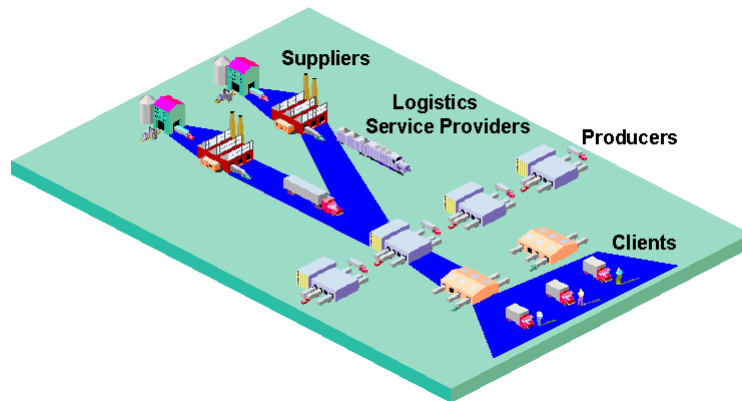
Figure 4: Example of a supply chain

5.1 Performance Measures

The measures needed for a cost calculation include the throughput at machines and their utilization. Additionally, the number of executed product changes, which are caused by manufacturing different products on the same machine, needs to be known. Further measures are the overtime of the workers at the machines (a standard working time is given as a fixed value) and the number of the necessary order transactions. All these values enable the modeler to assign costs to products.

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Figure 5: The *producer*-FU, magnifying some elements relevant for cost calculation

Fig. 5 shows the FU *producer* magnifying some elements relevant for recording the special measures. E.g., the update of the user-de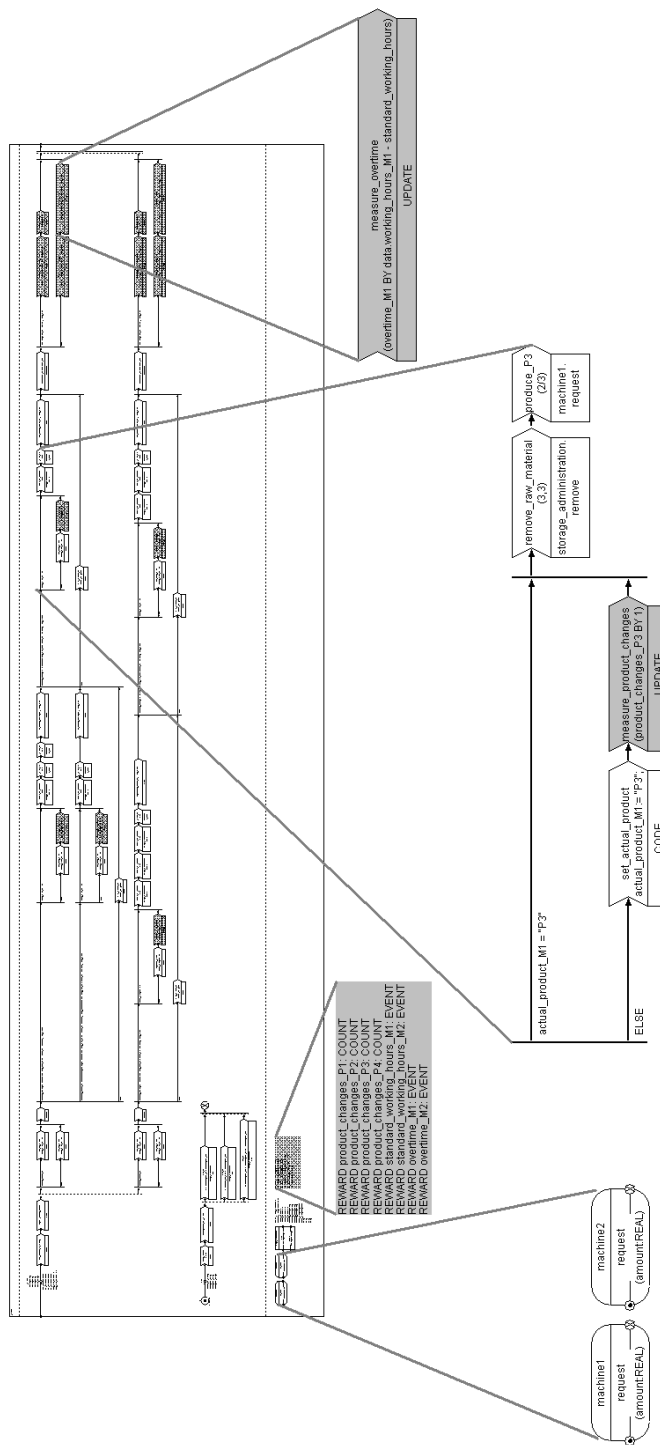fined reward *product_changes_P3* accounts for changes in the production sequence whenever a new sequence starts with product *P3*. This part is followed by picking up raw materials from a storage and using a machine for production. After completing the monthly production, an update of the rewards follows measuring the working hours and the overtime needed in that particular month (shown in the rightmost magnification). Two servers, each modeling a machine, and the definitions of the user-defined rewards are shown in the two leftmost magnifications of Fig. 5. Apart from these user-defined rewards, standard measures are also computed.
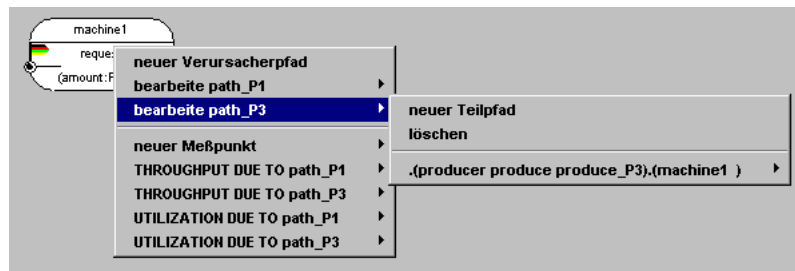

Figure 6: Menu for selecting measures and defining originator paths

Fig. 6 depicts the menu of the server *machine1* with the measures selected for analyzing this server (*THROUGHPUT*, *UTILIZATION*). These measures are recorded due to two originator paths (*path_P1* and *path_P3*) distinguishing products *P1* and *P3*. The definition of *path_P3* (usage of *machine1* originated from activity *produce_P3* of process chain *produce* at FU *producer*) is shown at the bottom of the sub-menu in Fig. 6.

Some results from a simulation of the *ProC/B*-model are illustrated in Fig. 7. The results are alloted pro rata to the participants of the supply chain (*suppliers*, *producer1*) and the products respectively (e.g. *P1* causes overtimes on *machine1* amounting to 9.27 [h/month] whereas *P3* causes 23.11 [h/month]).

5.2 Cost calculation on the basis of performance measures

On the basis of these data, the indirect cost rates can be calculated by using multidimensional allocation bases (e.g. number of set-ups, utilization of machines). Exemplarily, the calculation of the indirect cost rate for *setting-up machine1* is illustrated (further indirect cost rates are given in Fig. 8). All indirect costs (in this case 1,900 €, which is the wage for the person who actually conducts the set-ups) are divided by the total number of set-ups caused by *P1* and *P3* on *machine1*. In Fig. 7, the number of set-ups are given in [set-ups/h] which have to be converted into [set-ups/month]. Considering 230 [h/month], the calculation is as follows:

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ProC/B-results			
Producer1			
Technical Measure	*Mean*	*Stdev*	*Con 90%*

	Technical Measure	Mean	Stdev	Con 90%
P1 on Machine1	THROUGHPUT in [unit/h]	0.714601	10.679616	0.714601 ± 4.42%
	UTILIZATION in [%]	11.9099	32.3905	11.9099 ± 5.02%
	LABOR HOURS in [h/month]	33.78	12.02	33.78 ± 3.03%
	OVERTIME in [h/month]	9.27	10.43	9.27 ± 10.97%
	PRODUCT CHANGE in [set-up/h]	0.399572	16.468991	0.399572 ± 5.10%
	⋮	⋮	⋮	⋮
P3 on Machine1	THROUGHPUT in [unit/h]	0.624159	10.923524	0.624159 ± 4.23%
	UTILIZATION in [%]	41.6101	49.2911	41.6101 ± 4.91%
	LABOR HOURS in [h/month]	84.25	29.49	84.25 ± 3.05%
	OVERTIME in [h/month]	23.11	25.99	23.11 ± 11.22%
	PRODUCT CHANGE in [set-up/h]	0.401920	16.201277	0.401920 ± 5.08%
	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮

Suppliers			
Technical Measure	*Mean*	*Stdev*	*Con 90%*

	Technical Measure	Mean	Stdev	Con 90%
Raw Material	THROUGHPUT R1 in [order/h]	0.010819	31.365298	0.010819 ± 8.11%
	THROUGHPUT R2 in [order/h]	0.004920	82.502022	0.004920 ± 9.53%
	THROUGHPUT R3 in [order/h]	0.003790	143.203839	0.003790 ± 10.37%
	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮

Figure 7: Performance results from the *ProC/B*-model

$$(0.399572 + 0.401920)[set-ups/h] \times 230[h/month] = 184.3432[set-ups/month]$$

$$\frac{1,900[€/month]}{184.3432[set-ups/month]} = 10.3069[€/set-up]$$

Consequently, each set-up costs 10.31 €. Afterward, the set-up costs which are actually caused by the products can be calculated. *P1* causes 91.9016 set-ups per month. By multiplying the set-ups per month by the indirect cost rate (10.31 [€/set-up]), the allocated indirect costs caused by set-ups of *P1* on *machine1* (947.51 [€/month]) are given. Finally, the set-up costs per unit of *P1* (5.76 [€/unit]) are calculated by dividing the allocated indirect set-up costs (947.51 [€/month]) by the number of units of *P1* which are produced per month (164.358 [units/month] = 0.714601 [units/h] x 230 [h/month]). Analog to this, the other indirect costs rates, the allocated indirect costs, and the unit costs can be determined (see Fig. 8). In the example, multiple allocation bases (labor hours, overtimes, set-ups, machine utilization) are used. Of course there are many more which can be used and which are provided by *ProC/B*. Due to complexity reasons, a restricted number of allocation bases is illustrated.

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ProC/B-results

Producer1

Technical Measure	Mean
P1 on Machine1	
THROUGHPUT in [unit/h]	0.714601
UTILIZATION in [%]	11.9099
LABOR HOURS in [h/month]	33.78
OVERTIME in [h/month]	9.27
SET-UPS in [set-up/h]	0.399572
P3 on Machine1	
THROUGHPUT in [unit/h]	0.624159
UTILIZATION in [%]	41.6101
LABOR HOURS in [h/month]	84.25
OVERTIME in [h/month]	23.11
SET-UPS in [set-up/h]	0.401920

ProC/B-results and Indirect Costs for P1 and P3

Product	Quantity in [unit/month]	Labor Hours in [h/month]	Set-ups in [set-up/month]	Overtime in [h/month]	Utilization in [%]
P1	164.358	33.78	91.9016	9.27	11.9099
P3	143.556	84.25	92.4416	23.11	41.6101
Quantity Consumed		118.03	184.3432	32.38	
Total		923.73 €	1,900.00 €	1448.10 €	20,000.00

1. Calculation of Indirect Cost Rates

Traditional Cost Accounting

Allocation Base	Indirect Costs	Units	Indirect Cost Rate
Labor Hours:	24,271.83 €	118.03	**205.64 €**

Activity Based Costing

Allocation Base	Indirect Costs	Units	Indirect Cost Rate
Labor Hours:	923.73 €	118.03	**7.83 €**
Set-ups:	1,900.00 €	184.3432	**10.31 €**
Overtime:	1,448.20 €	32.38	**44.72 €**

2. Calculation of Unit Costs

	Allocated Indirect Costs*	Unit Cost*
P1:	6,946.52 €	**42.26 €**
P3:	17,325.17 €	**120.69 €**

	Allocated Labor Cost	Allocated Set-up	Allocated Overtime	Utilization	Total	Unit Cost
P1:	264.50 €	947.51 €	414.55 €	2,381.98 €	4,008.54 €	24.39 €
P3:	659.68 €	953.07 €	1,033.48 €	8,322.02 €	10,968.25 €	76.40 €

* Calculation:
  Allocated Indirect Costs = Indirect Cost Rate · Labor Hours per Unit and Product.
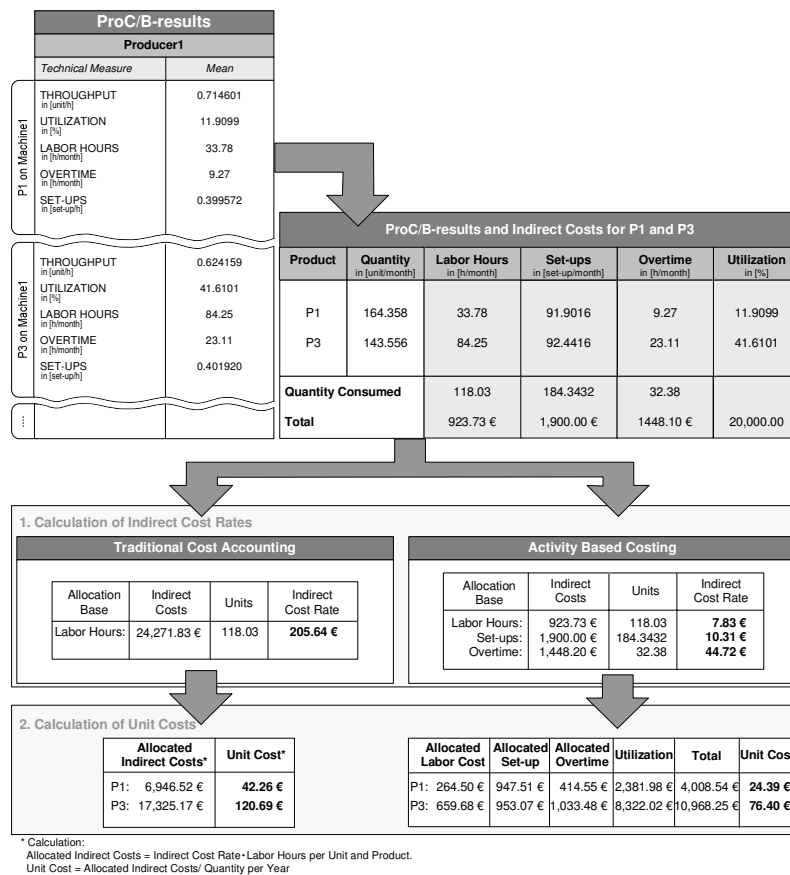 Unit Cost = Allocated Indirect Costs/ Quantity per Year

Figure 8: Elements and procedure of a cost calculation

In order to illustrate the more precise allocation of indirect costs on products compared to the traditional cost accounting, the results of the traditional cost allocation according to the allocation base 'labor hours' are also given in Fig. 8. The comparison of the different instruments reveals some important differences. First of all, both show that product *P3* causes significantly more costs than *P1*. But, the unit costs according to the traditional cost accounting are significantly higher than the unit costs according to ABC. Thus, the (imprecise) results of the traditional cost accounting might lead to wrong conclusions. The reasons for this difference are multifaceted. The most important one is that the traditional cost accounting does not distinguish between used capacity costs and idle time costs. In the example (see Fig. 8), the traditional cost accounting allocates the externally given total indirect machine costs (20,000 €) on the two products according to the labor hours. It is not considered that the *ProC/B*-results reveal a total utilization of *machine1* by *P1* and *P3* of only 53.52%. In fact, the traditional cost accounting does not consider utilization at all. In contrast, ABC allocates the costs which are actually caused by the products. ABC

allocates, e.g., the set-up costs (1,900 [€/month]) by multiplying the set-up cost rate (10.31 [€/set-up] by the individually caused number of set-ups (91.9016 [set-ups/month] for *P1* and 92.4416 [set-ups/month] for *P3* respectively). The traditional cost accounting takes the total costs for set-ups (1,900 [€/month]) and allocates them according to labor hours. Consequences from false values might be that products (or orders) with a positive profit margin ($[price/unit] - [cost/unit] \geq 0$) are judged to be unfavorable. This can happen because of unit costs which are too high compared to the costs the product actually causes. These problems can be avoided by using ABC. As *ProC/B* provides detailed information about utilization, overtime, standard working hours, set-ups, etc., the costs can be allocated according to the actual use of resources by different products. Thus, *ProC/B* allows for allocating costs with the preferable ABC with acceptable effort.

6 Conclusions

In this paper we presented the *ProC/B*-paradigm emphasizing the evaluation of cost-relevant measures. *ProC/B* and the corresponding toolset enable the analyst to determine detailed performance figures such that modern cost accounting systems are applicable. Standard performance measures, like utilization, are calculated proportionately to the originators requesting service. Furthermore, non-standard figures, like overtime, can be obtained with the same level of detail. We have presented an example from a supply chain context demonstrating the evaluation of performance measures for cost calculation.

Current research aims at an integrated cost simulation which allows for considering costs (or other economical measures) during simulation. One advantage of integrating costs into the simulation run is to have cost information permanently available which also facilitates transient analyzes. Furthermore, cost-based decisions can be made during the run so that costs can influence the dynamics of the model.

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