

# THE EPC II THEORY. ACCOUNTING IN ENTERPRISE BUSINESS PROCESS CONTROL SYSTEMS

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**ABSTRACT**

The 1 to 1 relationships of charts of accounts, accounting journals and tables of accounting records with corresponding tables of accounts, business transactions and transactional records in the framework EPC II system have been presented in the paper. These tables are the main information kinds, that is tables in which one can write down all information needed for management and business process control in any enterprise, or they are composed of them. In this way it has been shown that the Theory of Enterprise Process Control is compatible with generally accepted accounting principles. This analysis is an example of demonstrating conformity of the EPC II theory with real management and process control systems. The main information kinds with their key attributes were taken from the complete list of them, which is included in the paper. What is more, the tight relationships between resource flow in business processes and turnover on the accounts of the framework EPC II system have been discussed. Owing to these relationships one can determine the impact of any decision variable on the accounting records in a given enterprise.

**KEYWORDS**

integrated management systems, reference models, relational databases, EPC II theory.

## **The problem of conformity of information structure in accounting and EPC II systems**

The EPC II theory (Enterprise Business Process Control) [1–6] describes the structure and behavior of all systems of management and business process control. On the other hand accounting is the oldest and the most common technique of gathering, processing and presenting information required for making decisions in enterprises. Therefore The EPC II theory should contain a proof of conformity of data structure in accounting systems [7] and in systems of controlling [8], considered as business control based on information derived from accounting system, with the structure of the relational database of the framework EPC II system. In other words, one should demonstrate that between sets of key attributes of

corresponding database tables, taken from accounting systems and EPC II systems, there are 1 to 1 relationships [9].

In order to prove it, the structure of accounting records, conformable with generally accepted accounting principles [7], as well as the complete list of the **main information kinds** and the list of **structural attributes** are presented hereunder [4, 5]. The main information kinds are the tables in which (after adding the proper non-key columns) one can write down all information needed for management and business process control in any enterprise. The structural attributes are key attributes of the main information kinds.

## **Accounts and accounting transactions**

All changes in assets, liabilities, equity, revenue or expenses of a given enterprise are recorded in **accounts** [7]. These changes are variations of values of

resources belonging to the enterprise or to entities of its environment. So changes on accounts result from the resource flow between an enterprise and its environment (reported by financial accounting) and within an enterprise (planned and reported by controlling and managerial accounting [8]). Each account  $c \in C$  has two sides (then it is called T-account). The left side is called **debit** and the right side – **credit**. On the left side one records the changes of the account value, which correspond to resource inflow, and on the right side – the ones corresponding to resource outflow.

The state of every account changes as a result of **accounting transactions**. For each transaction the sum of debits should be equal to the sum of credit. Transactions should be recorded chronologically in the journal or in several journals. In both cases the common number of all consecutive transactions  $ntr \in NTR$  should increase in the whole reporting period. In the EPC II systems all business transactions, not only the accounting ones, are performed in accordance with a definite **transaction procedures**  $f \in FTR$ . Accounting procedures are special cases of transaction procedures,  $f(ntr) \in FCTR \subset FTR$ .

Each accounting procedure corresponds to one **transactional record**  $ntr \in NTR$  and to at least two **transactional accounting records**  $(ntr, c) \in NCTR$ . The **side** of a transactional accounting record is either **debit** or **credit**. The side, as well as the **value** of a transactional accounting record, that is the value of debit  $Db(ntr, c)$ , or credit  $Cr(ntr, c)$ , is a function of the transaction number and the account number.

The accounts are classified in many different ways. In the EPC II theory all accounts divide into the activity ones and the resource ones:  $C = CA \cup CR$ . The resource accounts represent the value of resources in their locations, including supply resources before their acceptance, whereas the activity accounts – the value of work in progress, as well as the value of output products in the course of their acceptance by customers (Figs. 2, 3). **Receivables**, that are recorded immediately after product acceptance by the customers, as well as the **cash**, which is collected from customers and is used to pay suppliers, are counted among resources.

Division of accounts into activity ones and resource ones is important, because it corresponds to the structure of business processes [3]. In the EPC II theory, unlike in the well known standards [10–12], the **business process** is an ordered set of activities and separating them resources [1] (Fig. 2) and each **business transaction** (not only the accounting ones) is assigned to a definite activity [5] (Fig. 3).

Therefore relationships between the structure of the framework EPC II system and structures of real accounting systems may be more direct than in the case of other models of business process management systems [10–17].

For the case of resource accounts there is a balance equation:

$$X = X_0 + Y - U,$$

where  $X_0$  – the value of resources before the transaction,  $X$  – the value after the transaction,  $Y$  – the value of resources received to their locations,  $U$  – the value of resources taken from locations. In other words,  $Y$  – the debit,  $U$  – the credit. If for a given transaction  $U > 0$ , then  $Y = 0$  and if  $Y > 0$ , then  $U = 0$ . Analogously, in the case of activity accounts:

$$X_a = X_{a0} + U_a - Y_a$$

where  $X_a$ ,  $U_a$  and  $Y_a$  are correspondingly the value of work in progress, the value of costs of consuming or using the input resources needed for execution of a given activity and the value of products of this execution. Therefore the accounts corresponding to work in progress are called **cost accounts**. On these accounts, as well as on the accounts of resources in locations belonging to the enterprise, the **balances**, that is results of balancing debits and credits, are recorded on the side of debits.

The resources delivered by suppliers and waiting for acceptance, as well as products in the course of acceptance by customers, do not belong to the enterprise. Therefore in financial accounting the values opposite to the values of these resources are balanced. They are **liabilities** (because they increase when supplies are received by the enterprise)

$$-X_l = -X_{l0} - Y_l + U_l$$

and **revenues** (because they increase when the enterprise products are received by customers)

$$-X_b = -X_{b0} - U_b + Y_b.$$

On the accounts of liabilities and revenues the balances are recorded on the side of credits. Generally, it is presented in the following table [7]:

Table 1  
Major types of T-accounts.

Account	Normal balance and increase	Decrease
Asset (resource)	Debit	Credit
Liability	Credit	Debit
Equity	Credit	Debit
Revenue	Credit	Debit
Expense (cost)	Debit	Credit

The accounts of liabilities and the accounts of resources (assets) considered in the balance of the enterprise (or its site) as a whole are called balance-sheet accounts. The accounts of revenues and the accounts of expenses arising in the enterprise (or in its site), that is those activity accounts which are visible in the enterprise balance sheet, are called income accounts. Other activity accounts and resource accounts may be used in financial accounting as subsidiary accounts, whereas in managerial accounting and in controlling for recording resource flow and work in progress inside of the enterprise.

### The structural attributes

All database tables that appear in EPC II systems are called **information kinds** and their rows – **information elements**. For all of them one can determine primary keys or candidate keys [9], whose attributes belong to the presented below set of 18 **dimensional attributes**. **Derivative structural attributes** are second appearances of dimensional attributes in the keys of the tables, which describe relationships between tables whose key attributes are the same, e.g. in the table indexed by pairs (previous activity, following activity).

Tables in relational databases of information systems correspond to concepts used in these systems. Values of the keys of these tables are identifiers of individual instances of those concepts. Therefore the presented here list of 29 structural attributes may be considered as description of identifiers of instances of all concepts that appear in the EPC II theory.

#### Dimensional attributes

- a item number of activity kinds,  $a \in A$ ,
- r item number of resource kinds,  $r \in R$ ,
- q item number of parameters of activities and resources,  $q \in Q$ ,
- o item number of options (values) of a definite enumerative parameter “q”,  $o \in O$ ,
- f item number of transaction procedures,  $f \in F$ ,
- i item number of information kinds,  $i \in I$ ,
- b item number of attributes of a definite information kind “i”,  $b \in B$ ,
- k item number of generic transitions for a definite activity kind “a”,  $k \in K$ ,
- j item number of data processing phases for a definite time scale (and the item number of functional layers as well),  $j \in J$ ,
- s item number of organizational units,  $s \in S$ ,
- h item number of time scales and organizational levels,  $h \in H$ ,

- v item number of resource locations inside definite organizational systems,  $v \in V$ ,
- c item number of accounts,  $c \in C$ ,
- m item number of information places,  $m \in M$ ,
- e item number of batches or specimens of resources of a definite kind “r”,  $e \in E$ ,
- d item number of information elements of a definite kind “i”,  $d \in D$ ,
- t time,  $t \in T$ , e.g. in notation (year-month-day-hour-minute-second-0.1sec),
- n item number of orders and transactions or any other chronological events of a definite type,  $n \in N$ .

#### Derivative structural attributes

- u item number of superior activity kinds (including process kinds  $p \in P \subset U$ ),  $u \in U \subset A$ ,
- g item number of activity kinds in associations with other activity kinds (including activity groups and activities following other activities),  $g \in G \subset A$ ,
- z item number of groups of resource kinds, including resource categories, resource location kinds and kinds of complex resources, consisting of other resources,  $z \in Z \subset R$ ,
- qx item number identifying parameters of definite options of enumerative parameters, including parameters of options of associative parameters,  $qx \in QX \subset Q$ ,
- l item number of generic transitions coupled with other generic transitions or item number of transitions composed of other transitions,  $l \in L \subset K$ ,
- y item number of data processing phases and functional layers of control units,  $y \in Y \subset J$ ,
- su item number of superior organizational units,  $su \in SU \subset S$ ,
- w item number of organizational units associated with other organizational units, including groups of organizational units,  $w \in W \subset S$ ,
- vg item number of aggregated resource locations,  $vg \in VG \subset V$ ,
- cg item number of aggregated accounts,  $cg \in CG \subset C$ ,
- mg item number of aggregated information places,  $mg \in MG \subset M$ .

Each structural attribute may be counted among one of three general dimensions of the information structure of EPC II systems:

1. information on kinds of processes and resources,
2. information on enterprise organization,
3. labels of executions of definite processes or related events.

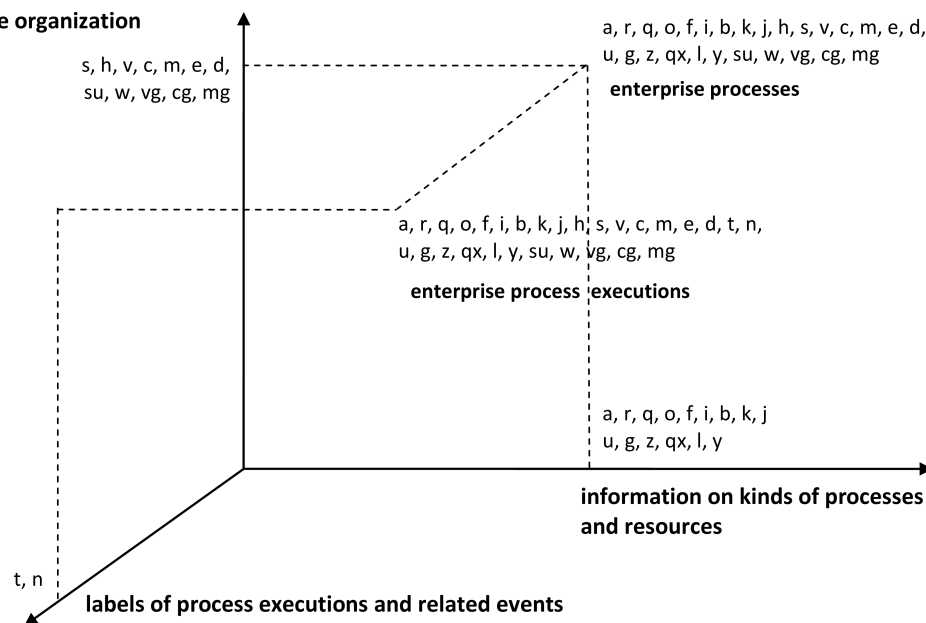


Fig. 1. Dimensions of the structure of Enterprise Process Control systems.

All information kinds which may be used in different enterprises have key attributes belonging to the subset  $\{a, r, q, o, f, i, b, k, j, u, g, z, qx, l, y\}$ . Elements of information on organization of a given enterprise are identified by attributes  $\{h, s, v, c, m, e, d, su, w, vg, cg, mg\}$ , whereas the ones describing processes located in specific organizational systems and activities located in their functional subsystems – by the key attributes belonging to both of these subsets. Executions of definite activities and events related to them are identified by attributes  $\{t, n\}$ .

### The main information kinds

**Administrative information kinds** are tables containing data needed for management and process control. Among them one should distinguish the **main information kinds** that are neither subclasses nor natural joins of other information kinds [4, 5]. The tables derived from definite information kinds by adding new non-key columns to them are also counted among subclasses of these information kinds. The natural joins do not have to be permanently recorded, because they may be reconstructed on the grounds of the main information kinds or their subclasses. Therefore it was possible to say that in the tables of the main information kinds (after adding non-key columns, selected for specific applications) one can write down all information needed for management and business process control in any enterprise.

The main information kinds, analogously to the structural attributes, may be divided into three groups:

1. information on kinds of processes and resources,
2. information on business process control systems,
3. plans, orders and reports on executions of definite activities and related to them transactions or other events.

The second part of the list of the main information kinds is presented below in three tables:

- a) enterprise organization and its business processes,
- b) batches and specimens of resources,
- c) transitions and their relationships with resources, whereas the third part in four tables:
- a) periodic plans and reports,
- b) orders and reports on order executions,
- c) periodic transactions,
- d) business transactions and other events related to orders.

Information on accounts, including transactional account records, may be identified without using account numbers, what was demonstrated in [5], but for the reason of practical importance of generally accepted accounting principles the account number “c” was introduced to the list of structural attributes and the list of the main information kinds was supplemented by

4. accounts and transactional accounting records.

Furthermore, to better show relationships between the structure of account records and the structure of business processes, apart from the number of resource information places  $m \in MR \subset M$  the new

structural attribute  $v \in V$  was introduced as the number of **resource locations** in organizational systems  $(sm, v) \in SV \subset S \times V$ . Because information places are no longer required for describing the process structures, now their numbers are key attributes only for those main information kinds, which are used in database management systems of the EPC II systems and refer

5. to relationships between information elements and data processing procedures, as well as
6. to associations of information elements with database transactions and to the state of an EPC II system [4].

In real information systems there are thousands of tables and these tables are different in different systems. Yet the number of the main information

kinds is finite and relatively small. All presented below parts of their current list encompass in total only 221 items. It causes that selecting the main information kinds or their natural joins, which match the specific tables of real management systems, is relatively easy.

Considerable fragments of the list of the main information kinds have been already published in [4,5]. The complete list, considering discussed here changes and supplements, is presented below. It should be stressed that the list of the main information kinds is not only one of many tables, which appear in EPC II systems. Its importance for the EPC II theory is similar to significance of the standard chart of accounts for accounting or the Mendeleev table for chemistry.

Table 2

kinds of information on kinds of business processes and resources													
ia	name	a	r	q	o	k	j	g	z	qx	l	u	description
1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	A	a											activity kinds and their groups
2	R		r										resource kinds and their categories
3	URA	a	r										activity inputs, i.e. associations of activity kinds with kinds of their input resources
4	YRA	a	r										activity outputs, i.e. associations of activity kinds with kinds of their output resources
5	AU	a										a	associations of activities with their superior activities
6	APA	a						a				p	associations of activities with following activities of the same processes
7	ZR		r						r				associations of resource kinds with their groups
8	AG	a						a					associations of activity kinds with their groups
10	RL		r					a					associations of reusable resources with their roles considered as activity groups
11	RLG		r					a				g	associations of reusable resource roles with their aggregated roles
12	URLA	a	r					a					associations of reusable resources in definite roles with activities of definite kinds
15	Q			q									dictionary of activity and resource parameters
16	QO			q	o								options (feasible set values) of enumerative parameters
17	QQ			q						q			associations of associative parameters with their component parameters
18	QOQ			q	o					q			parameters of options of enumerative parameters
20	AQ	a		q									activity parameters
21	AQO	a		q	o								options of enumerative activity parameters and parametric activity kinds
22	AQQ	a		q						q			associations of associative activity parameters with their component parameters
23	AQOQ	a		q	o					q			parameters of parametric activities
24	APQO	a		q	o							p	associations of activities with their superior parametric processes
25	AQPQO	a		q	o					q		p	associations of activity parameters with their superior parametric processes
27	RQ		r	q									resource parameters
28	RQO		r	q	o								options of enumerative resource parameters and option resource kinds

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1	2	3	4	5	6	7	8	9	10	11	12	13	14
29	RQQ		r	q						q			associations of associative resource parameters with their component parameters
30	RQOQ		r	q	o					q			parameters of parametric resources
31	URQA	a	r	q									parameters of input resources of activities
32	YRQA	a	r	q									parameters of output resources of activities
33	URQOA	a	r	q	o								options of enumerative parameters of input resources of activities and input parametric resources of activities
34	YRQOA	a	r	q	o								options of enumerative parameters of output resources of activities and output parametric resources of activities
35	URAQO	a	r	q	o								resource inputs of parametric activities
36	YRAQO	a	r	q	o								resource outputs of parametric activities
37	URQAQO	a	r	q	o					q			parameters of input resources of parametric activities
38	YRQAQO	a	r	q	o					q			parameters of output resources of parametric activities
40	RLQ		r	q					a				parameters of reusable resources in their definite roles
41	RLQO		r	q	o				a				options of enumerative parameters of reusable resources in their definite roles and parametric reusable resources in their definite roles
42	RLQQ		r	q					a	q			associations of associative parameters of reusable resources in their definite roles with their component parameters
43	RLQOQ		r	q	o				a	q			parameters of parametric resources in their definite roles
44	URLQA	a	r	q					a				parameters of input reusable resources of activities in their definite roles
45	URLQOA	a	r	q	o				a				options of enumerative parameters of reusable resources used by definite activities in their definite roles and parametric reusable resources used by definite activities in their definite roles
46	URLAQO	a	r	q	o				a				reusable resources used by parametric activities in their definite roles
47	URLQAQO	a	r	q	o				a	q			parameters of reusable resources used by parametric activities in their definite roles
50	AK	a					k						generic transitions
51	URAK	a	r				k						resource inputs of generic functional transitions
52	YRAK	a	r				k						resource outputs of generic functional transitions
53	AKU	a					k				k	a	couplings of generic functional transitions with generic control transitions
54	URLAK	a	r				k		a				associations of generic functional transitions with reusable resources in their definite roles
55	AKPA	a					k		a		k	p	horizontal couplings of generic decision transitions with following decision transitions belonging to activities of the same processes
56	AKL	a					k				k		associations of complex generic transitions with their component transitions
60	J						j						data processing phases
61	AJ	a					j						the phases of processing data on definite activities and the layer information on activity kinds
62	RJ		r				j						the layer information on resource kinds
63	URAJ	a	r				j						the layer generic information on resource inputs of activities
64	YRAJ	a	r				j						the layer generic information on resource outputs of activities
65	RLJ		r				j	a					the layer generic information on reusable resources in their definite roles
66	URLAJ	a	r				j	a					the layer generic information on assignment of reusable resources in their definite roles to definite activities

Table 3

kinds of information on organization of an enterprise and on its business processes															
ia	name	a	r	s	h	j	v	g	z	u	su	y	w	vg	description
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
70	H				h										time scales and organizational levels
71	HJ				h	j									data processing phases and functional layers on organizational levels
72	HJU				h	j					s				synchronizing transitions
80	S			s											organizational units and their groups
81	SSU			s							s				associations of organizational units with superior organizational units
82	SV						v				s				resource locations
83	US						v				s				inputs of resource locations to organizational units
84	YS			s			v				s				outputs of resource locations from organizational units
85	RV		r				v				s				located resources
86	RLV		r				v	a			s				located reusable resources in definite roles
87	URS		r	s			v				s				inputs of located resources to organizational units
88	YRS		r	s			v				s				outputs of located resources from organizational units
89	URLS		r	s			v	g			s				feasible assignments of reusable resources in definite roles to organizational units
90	SA	a		s											located activities
91	URSA	a	r	s			v				s				inputs of located resources to located activities
92	YRSA	a	r	s			v				s				outputs of located resources from located activities
93	URLSA	a	r	s			v	g			s				feasible assignments of reusable resources in definite roles to located activities
94	SW			s									s		associations of organizational units with their groups
95	SVVG						v				s		s	v	associations of resource locations with aggregated resource locations
96	SAWG	a		s				a					s		associations of located activities with aggregated located activities
97	RVZVG		r				v		r		s			v	associations of located resources with aggregated located resources
100	SJ			s		j									functional subsystems and their information places, functional and control units
101	SJU			s		j					s	j			couplings of functional subsystems with system control units
102	VJ				h	j	v				s				places of information on resource locations
103	USJ			s		j	v				s				inputs of resource information places to functional subsystems
104	YSJ			s		j	v				s				outputs of resource information places from functional subsystems
105	RVJ		r		h	j	v				s				clusters of information on located resources
106	RLVJ		r		h	j	v	a			s				clusters of information on located reusable resources in definite roles
107	URSJ		r	s		j	v				s				inputs of located resources to functional subsystems
108	YRSJ		r	s		j	v				s				outputs of located resources from functional subsystems
109	URLSJ		r	s		j	v	a			s				feasible assignments of reusable resources in definite roles to functional subsystems
110	SJA	a		s		j									functional activities and their information clusters, activity functional and control units
111	URSJA	a	r	s		j	v				s				inputs of located resources to functional activities
112	YRSJA	a	r	s		j	v				s				outputs of located resources from functional activities

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
113	URLSJA	a	r	s		j	v	a			s				feasible assignments of reusable resources in definite roles to functional activities
114	SJAA	a		s		j		a							associations of functional activities with information on work in progress
115	SJAU	a		s		j				a	s	j			couplings of functional activities with activity control units
116	SJP				h	j				p	s	3			functional business processes
117	SJAPA	a		s		j		a		p	s	3	s		the order relationships of functional activities in definite business processes

Table 4

kinds of information on resource batches and specimens														
ia	name	a	r	s	h	j	v	e	g	su	description			
120	ER		r					e			batches and specimens of resources			
121	ERL		r					e	a		roles of specimens of reusable resources			
122	ERV		r				v	e		s	batches and specimens of located resources			
123	UERS		r	s			v	e		s	inputs of batches or specimens of located resources to organizational units			
124	YERS		r	s			v	e		s	outputs of batches or specimens of located resources from organizational units			
125	UERSA	a	r	s			v	e		s	inputs of batches or specimens of located resources to located activities			
126	YERSA	a	r	s			v	e		s	outputs of batches or specimens of located resources from located activities			
127	ERLV		r				v	e	a	s	roles of specimens of located reusable resources			
128	UERLS		r	s			v	e	a	s	feasible assignments of batches or specimens of reusable resources in definite roles to organizational units			
129	UERLSA	a	r	s			v	e	a	s	feasible assignments of batches or specimens of reusable resources in definite roles to located activities			
130	ERVJ		r		h	j	v	e		s	the layer information on batches and specimens of located resources			
131	UERSJ		r	s		j	v	e		s	inputs of batches or specimens of located resources to functional subsystems			
132	YERSJ		r	s		j	v	e		s	outputs of batches or specimens of located resources from functional subsystems			
133	UERSJA	a	r	s		j	v	e		s	inputs of batches or specimens of located resources to functional activities			
134	YERSJA	a	r	s		j	v	e		s	outputs of batches or specimens of located resources from functional activities			
135	ERLVJ		r		h	j	v	e	a	s	the layer information on specimens of located reusable resources in definite roles			
136	UERLSJ		r	s		j	v	e	a	s	feasible assignments of batches or specimens of reusable resources in definite roles to functional subsystems			
137	UERLSJA	a	r	s		j	v	e	a	s	feasible assignments of batches or specimens of reusable resources in definite roles to functional activities			

Table 5

kinds of information on transitions in business process control systems														
ia	name	a	r	k	s	j	v	e	g	l	u	su	y	description
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
140	TR	a		k	s	j								transitions
141	UTF	g		k	s	j	v					s		inputs to functional system transitions from places of information on located resources
142	YTF	g		k	s	j	v					s		outputs from functional system transitions to places of information on located resources
143	URTF	a	r	k	s	j	v					s		inputs to functional transitions from clusters of information on located resources
144	YRTF	a	r	k	s	j	v					s		outputs from functional transitions to clusters of information on located resources



1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
145	URLTF	a	r	k	s	j	v		a			s		associations of functional transitions with clusters of information on reusable resources in definite roles
146	TFG	a		k	s	j				k				associations of composite transitions with their component transitions
147	TFF	a		k	s	j			a	k	p	s		couplings between functional transitions in a definite data processing phase
148	TFU	a		k	s	j				k	a	s	j	couplings between functional and control transitions
150	SATF	a		k	s	j			a					associations of functional transitions with clusters of information on functional activities
151	UERTF	a	r	k	s	j	v	e				s		inputs to functional transitions from clusters of information on batches or specimens of located resources
152	YERTF	a	r	k	s	j	v	e				s		outputs from functional transitions to clusters of information on batches or specimens of located resources
153	UERLTF	a	r	k	s	j	v	e	a			s		associations of functional transitions with clusters of information on specimens of reusable resources in definite roles

Table 6

kinds of information on periodic plans and reports												
ia	name	a	r	s	h	j	v	e	t	g	su	description
1	2	3	4	5	6	7	8	9	10	11	12	13
160	HT				h				t			sampling periods (including planning periods) of definite time scales
161	SJT			s		j			t			periodic plans and reports on burden of functional subsystems
162	VJT				h	j	v		t		s	periodic plans and reports on resource locations
163	USJT			s		j	v		t		s	periodic plans of picking or burdening organizational groups of resources from definite resource locations by functional subsystems and headers of their specifications
164	YSJT			s		j	v		t		s	periodic plans of producing or returning organizational groups of resources to definite resource locations by functional subsystems and headers of their specifications
165	RVJT		r		h	j	v		t		s	periodic plans and reports on located resources
166	RLVJT		r		h	j	v		t	a	s	periodic plans and reports on burdening reusable located resources in definite roles
167	URSJT		r	s		j	v		t		s	periodic plans of picking or burdening located resources by functional subsystems
168	YRSJT		r	s		j	v		t		s	periodic plans of producing or returning located resources by functional subsystems
169	URLSJT		r	s		j	v		t	a	s	periodic plans of burdening reusable located resources in definite roles by functional subsystems
170	ERVJT		r		h	j	v	e	t		s	periodic plans and reports on batches or specimens of located resources
171	UERSJT		r	s		j	v	e	t		s	periodic plans of picking or burdening batches or specimens of located resources by functional subsystems
172	YERSJT		r	s		j	v	e	t		s	periodic plans of producing or returning batches or specimens of located resources by functional subsystems
173	ERLVJT		r		h	j	v	e	t	a	s	periodic plans and reports on burdening specimens of reusable located resources in definite roles
174	UERLSJT		r	s		j	v	e	t	a	s	periodic plans and reports on burdening specimens of reusable located resources in definite roles by functional subsystems
180	SJAT	a		s		j			t			periodic plans and reports on functional activity executions
181	URSJAT	a	r	s		j	v		t		s	periodic plans of picking or burdening located resources by functional activities
182	YRSJAT	a	r	s		j	v		t		s	periodic plans of producing or returning located resources by functional activities
183	UERSJAT	a	r	s		j	v	e	t		s	periodic plans of picking or burdening batches or specimens of located resources by functional activities

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1	2	3	4	5	6	7	8	9	10	11	12	13
184	YERSJAT	a	r	s		j	v	e	t		s	periodic plans of producing or returning batches or specimens of located resources by functional activities
185	URLSJAT	a	r	s		j	v		t	a	s	periodic plans of burdening specimens of reusable located resources in definite roles by functional subsystems
186	UERLSJAT	a	r	s		j	v	e	t	a	s	periodic plans of burdening specimens of reusable located resources in definite roles by functional activities

Table 7

kinds of information on orders and reports of executing activities and on related resource flows												
ia	name	a	r	s	j	v	e	n	g	su	description	
1	2	3	4	5	6	7	8	9	10	11	12	
190	SJN			s	j			n			orders of burdening functional subsystems	
191	USJN			s	j	v		n		s	orders of picking or burdening organizational groups of resources from definite resource locations by functional subsystems and headers of their specifications	
192	YSJN			s	j	v		n		s	orders of producing or returning organizational groups of resources to definite resource locations by functional subsystems and headers of their specifications	
193	URSJN		r	s	j	v		n		s	orders of picking or burdening located resources by functional subsystems	
194	YRSJN		r	s	j	v		n		s	orders of producing or returning located resources by functional subsystems	
195	UERSJN		r	s	j	v	e	n		s	orders of picking or burdening batches or specimens of located resources by functional subsystems	
196	YERSJN		r	s	j	v	e	n		s	orders of producing or returning batches or specimens of located resources by functional subsystems	
197	URLSJN		r	s	j	v		n	a	s	orders of burdening reusable located resources in definite roles by functional subsystems	
198	UERLSJN		r	s	j	v	e	n	a	s	orders and reports on burdening specimens of reusable located resources in definite roles by functional subsystems	
200	SJAN	a		s	j			n			orders of functional activity executions	
201	URSJAN	a	r	s	j	v		n		s	orders of picking or burdening located resources by functional activities	
202	YRSJAN	a	r	s	j	v		n		s	orders of producing or returning located resources by functional activities	
203	UERSJAN	a	r	s	j	v	e	n		s	orders of picking or burdening batches or specimens of located resources by functional activities	
204	YERSJAN	a	r	s	j	v	e	n		s	orders of producing or returning batches or specimens of located resources by functional activities	
205	URLSJAN	a	r	s	j	v		n	a	s	orders of burdening specimens of reusable located resources in definite roles by functional subsystems	
206	UERLSJAN	a	r	s	j	v	e	n	a	s	orders of burdening specimens of reusable located resources in definite roles by functional activities	

Table 8

kinds of information on periodic business transactions												
ia	name	a	r	k	s	j	v	e	t	g	su	description
1	2	3	4	5	6	7	8	9	10	11	12	13
210	TRT	a		k	s	j			t			periodic transactions, including database transactions identified by sampling times
211	UTFT	a		k	s	j	v		t		s	inputs from places of information on located resources to periodic functional transactions
212	YTFT	a		k	s	j	v		t		s	outputs to places of information on located resources from periodic functional transactions
213	URTFT	a	r	k	s	j	v		t		s	periodic functional transactions of picking or burdening located resources
214	YRTFT	a	r	k	s	j	v		t		s	periodic functional transactions of producing or returning located resources

1	2	3	4	5	6	7	8	9	10	11	12	13
215	UERTFT	a	r	k	s	j	v	e	t		s	periodic functional transactions of picking or burdening batches or specimens of located resources
216	YERTFT	a	r	k	s	j	v	e	t		s	periodic functional transactions of producing or returning batches or specimens of located resources
217	URLTFT	a	r	k	s	j	v		t	a	s	periodic functional transactions of burdening reusable located resources in definite roles
218	UERLTFT	a	r	k	s	j	v	e	t	a	s	periodic functional transactions of burdening specimens of reusable located resources in definite roles
219	SATFT	a		k	s	j			t	a		periodic functional transactions of initiating or terminating activity work in progress

Table 9

kinds of information on business transactions and on other events related to orders												
ia	name	a	r	k	s	j	v	e	n	g	su	description
220	TRN	a		k	s	j			n			business transactions and other events related to orders
221	UTFN	a		k	s	j	v		n		s	inputs to business transactions from places of information on located resources
222	YTFN	a		k	s	j	v		n		s	outputs from business transactions to places of information on located resources
223	URTFN	a	r	k	s	j	v		n		s	business transactions of picking or burdening located resources
224	YRTFN	a	r	k	s	j	v		n		s	business transactions of producing or returning located resources
225	UERTFN	a	r	k	s	j	v	e	n		s	business transactions of picking or burdening batches or specimens of located resources
226	YERTFN	a	r	k	s	j	v	e	n		s	business transactions of producing or returning batches or specimens of located resources
227	URLTFN	a	r	k	s	j	v		n	a	s	business transactions of burdening reusable located resources in definite roles
228	UERLTFN	a	r	k	s	j	v	e	n	a	s	business transactions of burdening specimens of reusable located resources in definite roles
229	SATFN	a		k	s	j			n	a		business transactions of initiating or terminating activity work in progress

Table 10

kinds of information on accounts and on accounting transactional records												
ia	name	a	k	s	h	j	c	t	n	cg		description
230	C											accounts
231	CT				h			t				periodic plans and reports on changes of account balances
232	CTF	a	k	s		j						associations of functional transitions with accounts
233	CTFN	a	k	s		j			n			transactional accounting records
234	CTFT	a	k	s		j		t				periodic transactional accounting records
235	CCG									c		associations of accounts with aggregated accounts

Table 11

kinds of information on relationships between information elements and data processing procedures														
ia	name	a	r	f	i	b	k	s	j	m	e	d	mg	description
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
240	F			f										transaction procedures
241	I				i									Information kinds (including administrative information kinds)
242	BI				i	b								attributes of information kinds
243	INIF			f	i									inputs of administrative information kinds to transaction procedures
244	OUIF			f	i									outputs of administrative information kinds from transaction procedures

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1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
245	INBIF			f	i	b								inputs of attributes of administrative information kinds to transaction procedures
246	OUBIF			f	i	b								outputs of attributes of administrative information kinds from transaction procedures
247	DI				i							d		information elements
248	BDI				i	b						d		attributes of information elements (and their current state)
250	DIER		r		i						e	d		employee authorizations to access to information elements
251	DIFER		r	f	i						e	d		employee authorizations to procedures of access to information elements
252	BDIER		r		i	b					e	d		employee authorizations to access to attributes of information elements
253	BDIFER		r	f	i	b					e	d		employee authorizations to procedures of access to attributes of information elements
255	IAK	a			i		k							associations of generic transitions with information kinds
256	BIAK	a			i	b	k							associations of generic transitions with attributes of information kinds
260	M									m				information places
261	MMG									m			m	associations of information places with aggregated information places
262	IM				i					m				located information clusters
265	MTR	a					k	s	j	m				adjacencies of information places to transitions
266	IMTR	a			i		k	s	j	m				associations of transitions with located information clusters
267	DITR	a			i		k	s	j			d		associations of transitions with information elements
268	BDITR	a			i	b	k	s	j			d		associations of transitions with attributes of information elements

Table 12

kinds of information on the EPC II system state and on associations of database transactions with information elements														
ia	name	a	i	b	k	s	h	j	m	d	t	n	description	
270	MTRN	a			k	s		j	m			n	associations of business transactions and other events with information places	
271	IMTRN	a	i		k	s		j	m			n	associations of business transactions and other events with located information clusters	
272	DITRN	a	i		k	s		j		d		n	associations of business transactions and other events with information elements	
273	MTRT	a			k	s		j	m		t		associations of database transactions with information places	
274	IMTRT	a	i		k	s		j	m		t		associations of database transactions with located information clusters	
275	DITRT	a	i		k	s		j		d	t		associations of database transactions with information elements	
276	REPT		i			s	h				t		lists of transactions, orders, plans and reports for definite planning periods	
277	STATET		i	b			h			d	t		state of attributes of information elements after all transactions at beginning times of planning periods	
278	STATEF		i	b			h	j		d	t		state of attributes of information elements after all transactions belonging to definite data processing phases at beginning times of planning periods	
279	STATETR	a	i	b	k	s		j		d	t		state of attributes of information elements after specific database transactions (at beginning times of planning periods)	

## Functional business processes

Transactional accounting records  $(ntr, c) \in NC-TR \subset NTR \times C$  are identified by associations of accounting transactions “ntr” with accounts “c”. These associations are related to the structure of business processes. In order to show it one should extend the above mentioned definition of generic business processes. The **functional business process** is an ordered set of functional activities and separating them clusters of information on located resources [5] (Fig. 2).

The **functional activity**  $(s, j, a) \in SJA$  is a **generic activity**  $a \in A$ , assigned to the **functional subsystem**  $(s, j) \in SJ$ , that is to the **organizational unit**  $s \in S$ , monitored in the **functional layer**  $j \in JF$  [19] and controlled with the sampling period (planning period) of the **time scale**  $h(s, j) \in H$ , which is proper for this subsystem. The **located resource**  $(sm, v, r) \in RV$  is a **generic resource**  $r \in R$  in the **resource location**  $(sm, v) \in SV$  (e.g. in a warehouse) within a definite **organizational system**  $sm \in S$ . The located resources between functional activities from the functional layer  $j \in JF$  of the **organizational level**  $h \in H$  are represented by **clusters of information on located resources**  $(sm, v, r, h, j) \in RVJ$  belonging to the **information layer**  $(h, j) \in HJ \subset H \times JF$ , where  $h \in H$  is a number of the time scale and corresponding organizational level, whereas  $j \in JF$  is a number of the functional layer which is directly below the given information layer.

For a given time scale  $h > 1$  five functional layers may exist [1]. These are layers of transactions designed for:

- $j = 4$  scheduling orders for executive subsystems (which are also organizational systems of a lower level),
- $j = 3$  coordination of working subsystems in organizational systems,
- $j = 2$  assignment of working activities to organizational subsystems,
- $j = 1$  reengineering (internal structure changes) for organizational systems of lower level,
- $j = 0$  initiating and closing administrative orders that substituting transactions whose execution time may not be neglected.

Inputs and outputs of located resources to and from functional activities are identified by corresponding associations of functional activities with clusters of information on located resources  $(s, j, a, sm, v, r) \in URSJA$ ,  $(s, j, a, sm, v, r) \in YRSJA$ . Associations of functional activities  $(s, j, a)$  with clusters of information on work in progress are identified by the fours  $(s, j, a, g) \in SJAA$ , because they may con-

cern different functional activities  $(s, j, g)$  assigned to the same functional subsystem  $(s, j)$ .

## Accounting transactions in EPC II systems

Each **business transaction**  $(s, j, a, k, n) \in TRN$ , including all accounting transactions, is an execution of a **transition**  $(s, j, a, k) \in TR$  [5], which is one of transaction procedures  $f(s, j, a, k) \in FTR$  that are related to a given functional activity [1]. Moreover this transaction is assigned to a definite **order**  $(s, j, a, no) \in SJAN$ , which is an order of executing a given functional activity  $(s, j, a) \in SJA$ . In other words, the order number is function of the transaction identifier  $no = no(s, j, a, k, n)$ . It should be stressed that in EPC II systems there are no transactions which are not related to definite orders and there are no orders which are not related to definite functional activities. E.g. the acceptance order completion is related not only to the acceptance transaction, which causes that receivables arise, but also to the payment transaction (Fig. 3), although the payment time may be considerably later than the acceptance time. The notion of transition is analogous to the concept of transitions from Colored Petri Nets (CPN) [20].

In EPC II systems all transitions and all transactions divide into decision ones and information ones. The transactions are executed correspondingly at times of start and finish of executions of definite activities, but in the case of continuous activities – at beginning and end times of planning periods, which belong to the time periods of their executions. In the figure 3 decision and information transactions are represented by names of subsets of corresponding functional transitions TFD and TFI, where  $TFD \cup TFI = TF \subset TR$  [2].

Division of the transition set into subsets of decision and information transitions and into subsets of transitions belonging to the functional layers,  $j \in JF = \{0 \dots 4\}$ , causes that at the beginning of every planning period  $(h, t) \in HT \subset H \times T$ , there are 10 **data processing phases**,  $j \in J = \{0 \dots 9\}$ . The order of data processing phases at a given instant of discrete time is in accordance with their numbering. Transitions from information phases  $j \in JI = \{0 \dots 4\}$  act first, whereas transitions from decision phases  $j \in JD = \{5 \dots 9\}$  act later. Detailed information is processed before aggregated information, whereas detailed decisions – after more general decisions. So between sets of functional layers  $JF$ , information phases  $JI$  and decision phases  $JD$  there are 1 to 1 relationships resulting from function dependencies:

$$\begin{aligned}
 jf &= j, & \text{for } j \in JI &= \{0 \dots 4\}, \\
 jf &= 9 - j, & \text{for } j \in JD &= \{5, \dots 9\}.
 \end{aligned}$$

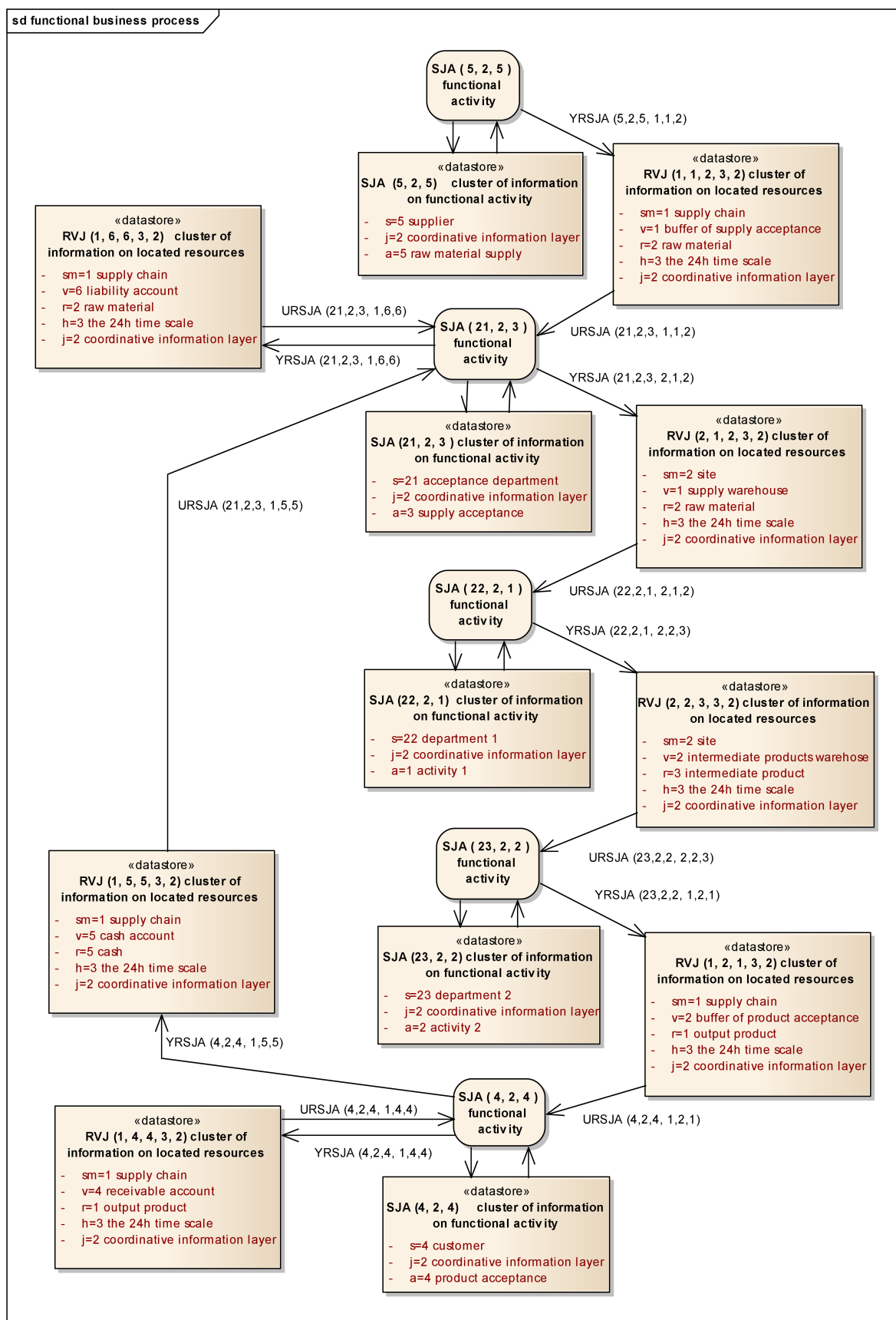


Fig. 2. Functional business process with its financial resources.

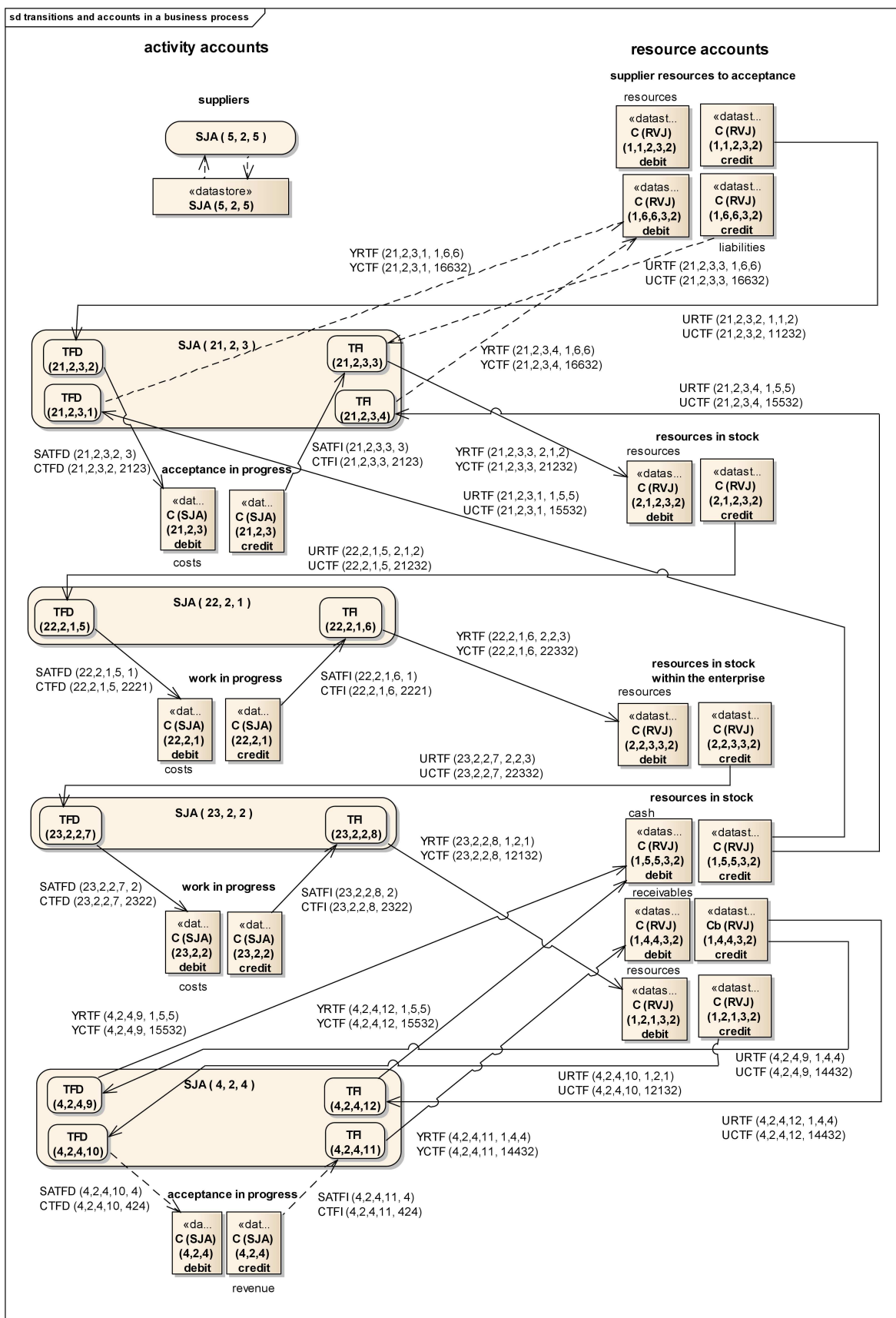


Fig. 3. Accounting transitions as operations of resource flow between accounts.

On the other hand  $JF \subset J$ , so the list of data processing phases is a main information kind, whereas the list of functional layers is its subclass.

There is 1 to 1 relationship between the accounting journal NTR and analogous list of accounting transactions  $TRCN \subset TRN$  in an EPC II system. It means one can add the non-key column "ntr" to the table TRCN and the non-key columns (s, j, a, k, n) to the table NTR in such a way that the values of "ntr" are different in all rows of the table TRCN and the values of (s, j, a, k, n) – in all rows of the table NTR.

From the viewpoint of database systems the column "ntr" is the primary key of the table NTR and the set of columns (s, j, a, k, n) – its candidate key [9], whereas for the table TRCN the columns (s, j, a, k, n) are the primary key and the column "ntr" – the candidate key. Obviously, the non-key columns "ntr" in the table TRCN and (s, j, a, k, n) in the table NTR are tabular records of function dependencies  $ntr(s, j, a, k, n)$  and  $s(ntr), j(ntr), a(ntr), k(ntr), n(ntr)$ . It was shown in the table of transactions for sample orders of the sample business process (Figs. 2, 3).

Table 13

SJAN – orders of functional activity executions				
s	j	a	n	description
21	2	3	2	the work order 2 of the raw material acceptance
22	2	1	3	the work order 3 of the activity 1 in the department 1
23	2	2	3	the work order 3 of the activity 2 in the department 2
4	2	4	1	the work order 1 of the output product acceptance by the customer

Table 14

TR – transitions						
s	j	a	k	description	f	h
21	2	3	1	the transition of advance payment before the working activity of the raw material acceptance	101	3
21	2	3	2	the start transition of the working activity of the raw material acceptance	102	3
21	2	3	3	the end transition of the working activity of the raw material acceptance	103	3
21	2	3	4	the transition of payment after the working activity of the raw material acceptance	104	3
22	2	1	5	the start transition of the working activity 1 in the department 1	105	3
22	2	1	6	the end transition of the working activity 1 in the department 1	106	3
23	2	2	7	the start transition of the working activity 2 in the department 2	107	3
23	2	2	8	the end transition of the working activity 2 in the department 2	108	3
4	2	4	9	the transition of advance payment before the working activity of the output product acceptance by the customer	109	3
4	2	4	10	the start transition of the working activity of the output product acceptance by the customer	110	3
4	2	4	11	the end transition of the working activity of the output product acceptance by the customer	111	3
4	2	4	12	the transition of payment after the working activity of the output product acceptance by the customer	112	3

Table 15

TRN – business transitions							
s	j	a	k	n	description	ntr	no
21	2	3	1	21	the advance payment before the working activity of the raw material acceptance	821	2
21	2	3	2	21	the start of the work order of the raw material acceptance	822	2
21	2	3	3	21	the end of the work order of the raw material acceptance	823	2
21	2	3	4	21	the first installment of payment after the work activity of the raw material acceptance	824	2
21	2	3	4	22	the second installment of payment after the work activity of the raw material acceptance	825	2
21	2	3	4	23	the final payment after the working activity of the raw material acceptance	826	2
22	2	1	5	31	the start of the working activity 1 in the department 1	831	3
22	2	1	6	31	the end of the working activity 1 in the department 1	832	3
23	2	2	7	31	the start of the working activity 2 in the department 2	841	3
23	2	2	8	31	the end of the working activity 2 in the department 2	842	3
4	2	4	9	11	the advance payment before the working activity of the output product acceptance by the customer	851	1
4	2	4	10	11	the start of the working activity of the output product acceptance by the customer	852	1
4	2	4	11	11	the end of the working activity of the output product acceptance by the customer	853	1
4	2	4	12	11	the payment after the working activity of the output product acceptance by the customer	854	1



## Accounting records in EPC II systems

Each **resource account**  $c \in CR$  corresponds to a definite place of information  $(sm, v, h, j) \in VJ$  or cluster of information  $(sm, v, r, h, j) \in RVJ$  on located resources. Each **activity account**  $c \in CA$  corresponds to a definite **place of information on the functional subsystem**  $(s, j) \in SJ$  or a **cluster of information on the functional activity**  $(s, j, a) \in SJA$ , which belongs to place  $(s, j) \in SJ$ . Activity information places and resource information places correspond to the synthetic accounts [5]. For the sample functional process (Fig. 2) clusters of information on functional activities and on located resources correspond to the following accounts:

Table 16

CR – resource accounts	
c	description
11232	the account of the raw material before acceptance in the coordination layer of the site level
12132	the account of the output product before acceptance by the customer in the coordination layer of the site level
14432	the account of the enterprise receivables in the coordination layer of the site level
15532	the account of the enterprise cash in the coordination layer of the site level
16632	the account of the enterprise liabilities in the coordination layer of the site level
21232	the account of the raw material after acceptance in the coordination layer of the site level
22332	the account of the intermediate product in stock in the coordination layer of the site level

Table 17

CA – activity accounts	
c	description
424	the account of revenue related to the working activity of the output product acceptance by the customer
2123	the account of the costs related to the working activity of the raw material acceptance
2221	the account of the costs related to the working activity 1 in the department 1
2322	the account of the costs related to the working activity 2 in the department 2

Each accounting transaction

$$(s, j, a, k, n) \in TFCN \subset TF \times N \\ \subset S \times J \times A \times K \times N$$

corresponds to two or more transactional accounting records

$$(s, j, a, k, n, c) \in CTFN \subset TFCN \times C \subset$$

$$\subset TF \times N \times C \subset S \times J \times A \times K \times N \times C.$$

The resource flow resulting from the transaction may be graphically presented in the form of arcs running from the credit sides of certain accounts to the debit sides of other accounts. The credits on these accounts decrease, whereas the debits increase. However, if the balance of a given account represents the values of revenues resulting from the sales or the values of liabilities resulting from the purchase (which in the figure 3 is marked with dotted lines), then its credits increase and its debits decrease.

The table of accounting records  $(s, j, a, k, n, c) \in CTFN$  may be divided into four subclasses:

$$CTFN = CTFDN \cup CTFIN \cup UCTFN \cup YCTFN,$$

where

CTFDN – debits of transactions on activity accounts,

$$CTFDN \subset TFD \times N \times CA$$

CTFIN – credits of transactions on activity accounts,

$$CTFIN \subset TFI \times N \times CA$$

YCTFN – debits of transactions on resource accounts,

$$YCTFN \subset TF \times N \times CR$$

UCTFN – credits of transactions on resource accounts,

$$UCTFN \subset TF \times N \times CR.$$

In the example (fig.3) the values of debits and credits are represented by symbols Y, U, Ya, Ua, Yl, Ul, Yb, Ub of the balance components that are discussed in the first part of the paper. Receivables and cash are distinguished among other resources by the symbols Yr, Ur, Yc, Uc.

Revenues and receivables, as well as their exchange for cash, arise in transactions which are copies of customer transactions. Liabilities and their payments with cash, as well as costs and resources (except for receivables and payments for sold products) arise in the enterprise transactions.

Transactions which are represented in the example by transitions  $(22,2,1,5)$ ,  $(22,2,1,6)$ ,  $(23,2,2,7)$  are useful for managerial accounting, more precisely – for calculating costs in internal cost centers and to calculating value of resources stored inside of the enterprise. Transactions represented by transitions  $(22,2,1,5)$ ,  $(23,2,2,7)$  may be also useful for financial accounting, because certain costs of executing activities inside of sites, e.g. the costs of using human resources, should be remembered for periodic settlements with employees.

Table 18

CTFDN – debits on activity accounts								
s	j	a	k	c	n	description	Db	ntr
21	2	3	2	2123	21	increase in the cost of the raw material acceptance and in the related value of work in progress	Ua	822
22	2	1	5	2221	31	increase in the cost of the activity 1 in the department 1 and increase in the related value of work in progress	Ua	831
23	2	2	7	2322	31	increase in the cost of the activity 2 in the department 2 and increase in the related value of work in progress	Ua	841
4	2	4	10	424	11	increase in the value of products in the course of acceptance by the customer	Ub	852

Table 19

CTFIN – credits on activity accounts								
s	j	a	k	c	n	description	Cr	ntr
21	2	3	3	2123	21	decrease in the value of the raw material in the course of acceptance	Ya	823
22	2	1	6	2221	31	decrease in the value of work In progress of the activity 1 in the department 1	Ya	832
23	2	2	8	2322	31	decrease in the value of work In progress of the activity 2 in the department 2	Ya	842
4	2	4	11	424	11	decrease in the value of products in the course of acceptance by the customer and increase in the revenue of the enterprise	Yb	853

Table 20

YCTFN – debits on resource accounts								
s	j	a	k	c	n	description	Db	ntr
21	2	3	1	16632	21	decrease in liabilities as a result of the advance payment before the raw material acceptance	Yl	821
21	2	3	3	21232	21	increase in the value of the raw material after acceptance	Y	823
21	2	3	4	16632	21	decrease in liabilities after the first installment of payment for the accepted raw material	Yl	824
21	2	3	4	16632	22	decrease in the value of liabilities after the second installment of payment for the accepted raw material	Yl	825
21	2	3	4	16632	23	decrease in liabilities after the final payment for the accepted raw material	Yl	826
22	2	1	6	22332	31	increase in the value of the intermediate product in stock after the activity 1 in the department 1	Y	832
23	2	2	8	12132	31	increase in the value of the output product after the activity 2 in the department 2	Y	842
4	2	4	9	15532	11	increase in the value of the enterprise cash as a result of the advance payment before the output product acceptance by the customer	Yc	851
4	2	4	11	14432	11	increase in receivables as a result of the product acceptance by the customer	Yr	853
4	2	4	12	15532	11	increase in the value of the enterprise cash as a result of the payment after the output product acceptance by the customer	Yc	854

Table 21

UCTFN – credits on resource accounts								
s	j	a	k	c	n	description	Cr	ntr
1	2	3	4	5	6	7	8	9
21	2	3	1	15532	21	decrease in the value of cash as a result of the advance payment before the raw material acceptance	Uc	821
21	2	3	2	11232	21	decrease in the value of the raw material waiting for acceptance	U	822
21	2	3	3	16632	21	increase in liabilities as a result of the raw material acceptance	Ul	823
21	2	3	4	15532	21	decrease in the value of cash after the first installment of payment for the accepted raw material	Uc	824
21	2	3	4	15532	22	decrease in the value of cash after the second installment of payment for the accepted raw material	Uc	825
21	2	3	4	15532	23	decrease in the value of cash after the final payment for the accepted raw material	Uc	826

1	2	3	4	5	6	7	8	9
22	2	1	5	21232	31	decrease in the value of the raw material in stock after withdrawal to the activity 1 in the department 1	U	831
23	2	2	7	22332	31	decrease in the value of the intermediate product after withdrawal to the activity 2 in the department 2	U	841
4	2	4	9	14432	11	decrease in receivables as a result of the advance payment for the output product by the customer	Ur	851
4	2	4	10	12132	11	decrease in the value of the output product as a result of withdrawal to the acceptance by the customer	U	852
4	2	4	12	14432	11	decrease in receivables as a result of the final payment for the output product by the customer	Ur	854

Analogously to the above discussed relationship between tables NTR and TRCN there is 1 to 1 relationship between the tables NCTR and CTFN, which are tables of transactional accounting records in contemporary accounting systems and in the framework EPC II system. It means one can add the non-key column “ntr” to the tables CTFDN, CTFIN, UCTFN, YCTFN which make up the table CTFN, and the non-key columns (s, j, a, k, n) to the table NCTR in such a way that the values of (ntr, c) are different in all rows of the table CTFN and the values of (s, j, a, k, n, c) – in all rows of the table NCTR. The columns (ntr, c) are the primary key of the table NCTR and the columns (s, j, a, k, n, c) – its candidate key, whereas for the table CTFN the columns (s, j, a, k, n, c) are the primary key and the column (ntr, c) – the candidate key. The columns (ntr, c) in the table CTFN and (s, j, a, k, n, c) in the table NCTR are tabular records of function dependencies  $ntr(s, j, a, k, n, c)$ ,  $c(s, j, a, k, n, c)$  and  $s(ntr, c)$ ,  $j(ntr, c)$ ,  $a(ntr, c)$ ,  $k(ntr, c)$ ,  $n(ntr, c)$ ,  $c(ntr, c)$ , where  $c(s, j, a, k, n, c) = c$ ,  $c(ntr, c) = c$ .

### The structure of the chart of accounts in EPC II systems

The account number,  $c \in C$ , was introduced to the list of dimensional attributes for its practical importance. Formally it was not necessary, because it is function dependent on other structural attributes. The function dependencies may be demonstrated after division of the list of accounts  $C = CA \cup CR$  into subclasses (subsets of the set of all rows), to which one can create such candidate keys that are primary keys of other information kinds of the framework EPC II system. Each of these subclasses one can present as a result of mapping a definite information kind; e.g.  $C(SJ)$  is the set of numbers of synthetic accounts corresponding to places of information on functional subsystems  $(s, j) \in SJ \subset S \times J$ .

The activity accounts  
 $c \in CA = C(SJ) \cup C(SJA) \cup C(SJQO) \cup C(SJAQO)$   
 have 1 to 1 relationships with

- places of information on functional subsystems  
 $(s, j) \in SJ \subset S \times J \subset S \times J$
- clusters of information on functional activities  
 $(s, j, a) \in SJA \subset S \times J \times A \subset S \times J \times A$
- clusters of information on functional parametric subsystems  
 $(s, j, q, o) \in SJQO \subset S \times J \times Q \times O$
- clusters of information on functional parametric activities  
 $(s, j, a, q, o) \in SJAQO \subset S \times J \times A \times Q \times O$ ,

The analogous 1 to 1 relationships appear between the resource accounts and corresponding clusters of information on located resources

$$c \in CR = C(VJ) \cup C(RVJ) \cup C(RLVJ) \cup C(ERVJ) \cup C(ERLVJ) \cup C(VJQO) \cup C(RVJQO) \cup C(RLVJQO) \cup C(ERVJQO) \cup C(ERLVJQO).$$

The tables SJ, SJA, VJ, RVJ, RLVJ, ERVJ, ERLVJ are the main information kinds, whose key attributes may be read from the above presented list. Other mentioned here tables of information clusters refer to parametric (option) functional subsystems, parametric functional activities, parametric resource locations and parametric located resources [4]. They are not the main information kinds but one can easily generate them as natural join of other information kinds. E. g. SJQO is a natural join of SJ and AQO, where the key column “a” of the table AQO correspond to the non-key column g(s) of the table SJ, whereas ERVJQO is a natural join of ERVJ and RQO with the common key column “r”.

For the business process presented in the Figs. 2 and 3 the sample subclasses of the account list

$$CSJA = C(SJA) \subset CA \subset C,$$

$$CRVJ = C(RVJ) \subset CR \subset C,$$

are as follows:

Table 22

CSJA – accounts of activity information clusters				
c	description	s	j	a
2123	the cost account of the raw material acceptance in the coordination layer of the site	21	2	3
2221	the cost account of the activity 1 in the department 1 in the coordination layer of the site	22	2	1
2322	the cost account of the activity 2 in the department 2 in the coordination layer of the site	23	2	2
424	the revenue account of the product acceptance by the customer in the coordination layer of the site level	4	2	4

Table 23

CRVJ – accounts of resource information clusters						
c	description	sm	v	r	h	j
11232	the resource account of the raw material before acceptance in the coordination layer of the site level	1	1	2	3	2
16632	the liabilities account related to the raw material before acceptance in the coordination layer of the site level	1	6	6	3	2
21232	the resource account of the raw material after acceptance in the coordination layer of the site	2	1	2	3	2
22332	the resource account of the intermediate product in the coordination layer of the site	2	2	3	3	2
12132	the resource account of the output product before acceptance by the customer in the coordination layer of the site level	1	2	1	3	2
14432	the receivables account related to the output product before acceptance by the customer in the coordination layer of the site level	1	4	4	3	2
15532	the enterprise cash account in the coordination layer of the site level	1	5	5	3	2

The basic rules of classification of analytic accounts result from the tree structure of information clusters in activity and resource information places [4]. However, they are not all classification criteria, which may be used for dividing analytic accounts into more detailed analytic accounts. Therefore it is important that any classification criterion may be presented as an enumerative parameter of functional activities or clusters of information on located resources. Options of such a parameters identify corresponding parametric activities or resources and consequently they define definite branches in the classification tree of the chart of accounts. What is more, this tree structure may be a multilevel one, because for parametric activities and for parametric resources one can also define options of their enumerative parameters [4].

The table CTFN, like the list of accounts C, may be divided into subclasses, for which one can select candidate keys which are primary key of other information kinds. It is convenient to define these subclasses for debits and credits of activity and resource accounts separately:

$$\begin{aligned} \text{CTFDN} &= \text{CTFN}(\text{STFDN}) \cup \text{CTFN}(\text{SATFDN}) \cup \\ &\quad \text{CTFN}(\text{SQOTFDN}) \cup \text{CTFN}(\text{SAQOTFDN}) \\ \text{STFDN} &\subset \text{TRN}, \text{SATFDN} \subset \text{SATFN}, \end{aligned}$$

$$\begin{aligned} \text{CTFIN} &= \text{CTFN}(\text{STFIN}) \cup \text{CTFN}(\text{SATFIN}) \cup \\ &\quad \text{CTFN}(\text{SQOTFIN}) \cup \text{CTFN}(\text{SAQOTFIN}) \\ \text{STFIN} &\subset \text{TRN}, \text{SATFIN} \subset \text{SATFN}, \end{aligned}$$

$$\begin{aligned} \text{YCTFN} &= \text{CTFN}(\text{YTFN}) \cup \text{CTFN}(\text{YRTFN}) \cup \\ &\quad \text{CTFN}(\text{YERTFN}) \cup \text{CTFN}(\text{YVQOTFN}) \cup \\ &\quad \text{CTFN}(\text{YRQOTFN}) \cup \text{CTFN}(\text{YERQOTFN}), \end{aligned}$$

$$\begin{aligned} \text{UCTFN} &= \text{CTFN}(\text{UTFN}) \cup \text{CTFN}(\text{URTFN}) \cup \\ &\quad \text{CTFN}(\text{UERTFN}) \cup \text{CTFN}(\text{URLTFN}) \cup \\ &\quad \text{CTFN}(\text{UERLTFN}) \cup \text{CTFN}(\text{UVQOTFN}) \cup \\ &\quad \text{CTFN}(\text{URQOTFN}) \cup \text{CTFN}(\text{UERQOTFN}) \cup \\ &\quad \text{CTFN}(\text{URLQOTFN}) \cup \text{CTFN}(\text{UERLQOTFN}). \end{aligned}$$

All above mentioned tables, whose primary keys are candidate keys of subclasses of the table of transactional accounting records CTFN, are known as the main information kinds of the framework EPC II system, or they may be automatically generated as natural join of the main information kinds.

## Conclusions and final comments

It is shown in the paper there are 1 to 1 relationships between the chart of accounts, the transaction journal and the tables of accounting records conformable with generally accepted accounting principles and corresponding tables of accounts, business transactions and transactional records in the framework EPC II system. This analysis is an example of verification of conformity of the EPC II theory with the structures of real management information systems.

What is more, it is demonstrated there are tight relationships between resource flow in business

processes and turnover on the accounts of the framework EPC II. Some of those relationships refer to financial accounting and all of them may be used in managerial accounting and controlling. They may facilitate technical interpretation of decision and reports of controlling. Furthermore they enable looking into details of the enterprise state. Owing to them one can show how any decision variable influences accounting records in a given enterprise and consequently – economic criteria of the enterprise performance.

Assignment of resource flow transactions and transactional accounting records to definite time scales and organizational levels, as well as to definite functional or information layers, enables recording on accounts all deviations of resource flows from their planned values. Moreover it enables analysis of differences between general and detailed plans of resource flows. Cumulative deviations of detailed plans from general plans may be calculated analogously to backlogs in following plans from higher layers by detailed plans and schedules from lower layers in the follow-up production control systems [21, 22].

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