

# Informational-Analytical Decision Support Of Strategic Acceptance Process At The Enterprise

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**Abstract:** In this paper decision support system for development of the commercial enterprise is considered. An algorithm for the construction of enterprise development trajectories is offered on the basis of the chosen strategy. System software development is carried out using Java; the database support is provided by MySQL. The software architecture is described using UML notation. Dataflow model is developed in BPWIN, and the conceptual data model is developed in ERWIN.

## 1 Introduction

Each enterprise that establishes its own strategic plans for development, is obliged to take into account features and prospects of the market development on the considered period. On each period the enterprise defines a segment of the market on which it will function, its strategy of marketing and price policy. It also investigates strengths and weaknesses of the enterprise and competitors. In this paper we will consider one of the strategic planning problems – a problem of the construction of the *development trajectory* for the commercial enterprise. The development trajectory represents the quantity of the monetary resources allocated on each interval of time, providing necessary capacities for the planned throughputs [Tr98]. This paper is devoted to the problem of creating a decision support system (DSS) intended to aid the construction of this trajectory.

## 2 Problem statement

In this paper, we consider the problem of the development of the commercial enterprise. This problem consists in the definition of resources necessary for achieving a target on each time interval.

Let us consider some enterprise engaged in manufacturing and selling the production of several kinds. Depending on the chosen strategy of the enterprise, it is necessary to construct its development trajectory. The initially available information is the enterprise condition and the market condition. The developed strategy includes the throughput and

the sales amount necessary to be achieved on the scheduled period; production capacities supported by money resources correspond to this strategy. In this paper we suggest to use system optimization approach [Gl80], [VG91] for a trajectory construction.

The initial information is based on the results of analysis of the internal and external environment of the enterprise. In this work we investigate only the internal enterprise environment – i.e. the enterprise, competitors and consumers.

The market research allows constructing the *directive area* which we consider from the point of view of competitors and consumers. The results of analysis of the industrial enterprise activity allow constructing the *enterprise area* defined by constraints on existing enterprise resources.

To solve the stated problem, the enterprise management considers two development strategies [GS95]:

- Strategy of an appearance to the market (i.e. presence in the market);
- Strategy of segment expansion of the market (the greatest possible capture of the market).

Two development trajectories correspond to these two strategies. The first trajectory is characterized by the minimum expenses connected to the minimal increase of a production potentiality that will enable to provide the market appearance. The second trajectory assumes the maximum increase in a production potentiality which will allow releasing a volume of production for the maximal capture of the market.

A market research is preliminary carried out by marketing departments of the enterprise. As a result, a condition of competitors and a condition of consumers in the market are defined. These investigations are not considered in this paper.

Let us introduce the following notions:

$i$  - kind of released production,  $i \in \overline{1, n}$  ;  $n$ - quantity of production kinds;

$j$  – kind of resource,  $j \in \overline{1, m}$  ;  $m$ - quantity of resource kinds;

$t$ - the period of carrying out the calculations;  $t \in \overline{1, T}$  ;

$x_i^t$ ,  $i \in \overline{1, n}$  - throughput of the product  $i$  at the moment of time  $t$ ;

$\Delta x_i^t$  - increase of throughput of the product  $i$  at the moment of time  $t$ ;

$$x_i^{t+1} = x_i^t + \Delta x_i^t \quad i \in \overline{1, n} ;$$

$a_{ji}^t$  - quantity of  $j$  resources necessary for the enterprise to produce  $i$  products at the moment of time  $t$ ;

$b_{ji}^t$ - quantity of  $j$  resources necessary for the competitors to produce  $i$  products at the moment of time  $t$ ;

$r_j^t, j \in \overline{1, m}$  - volumes of the enterprise resources at the moment of time  $t$ ;

$F^t$  - enterprise profit at the moment of time  $t$ ;

$C_i^t$  - unit price of the product  $i$  at the moment of time  $t$ ;

$Z_i^t$  - total expenses for manufacturing of the unit of product  $i$  at the moment of time  $t$ .

$P_i^t$  - unit price of the product  $i$  made by competitors at the moment of time  $t$ ;

$S_i^t$  - total expenses for production of the unit of product  $i$  made by competitors at the moment of time  $t$ ;

$q_j, j \in \overline{1, m}$  - quantity of the resources that are at competitors disposal.

$G^t$  - the profit of competitors calculated at the moment of time  $t$ ;

$W^t$  - utility function of production purchase by consumers at the moment of time  $t$ ;

$h^t$  - budget restrictions of consumers at the moment of time  $t$ ;

$L_j^t$  - expenses for purchase of the equipment  $j$  during time  $t$ ;

$P_j^{ot}, j \in \overline{1, m}$  - unit cost of the resource  $j$  (in this paper it is an equipment) at the moment of time  $t$ ;

$N_j$  - unit productivity of the resource  $j$ ;

$u_{ji}^t$  - number of units of the equipment  $j$  necessary for production of  $i$  product units at the moment of time  $t$ ;

$$u_{ji}^t = \frac{x_i^t}{N_j} = \frac{x_i^{t-1} + \Delta x_i^{t-1}}{N_j}, \quad i \in \overline{1, n}, \quad j \in \overline{1, m};$$

$V = \{v_j^t \mid j \in \overline{1, J}\}$  - means allocated for completion of the resource  $j$ , in this paper – for the purchase of equipment.

In general, the development problem can be presented as three models describing the functioning of the enterprise and the market.

1) Model of the commercial enterprise on each examined period  $t$ :

$$F^t = \left( \sum_{i \in \overline{1, n}} C_i^t x_i^t - \sum_{i \in \overline{1, n}} Z_i^t x_i^t \right) \rightarrow \max \quad (1)$$

with resource constraints

$$a_{ji}^t \cdot x_i^t \leq r_j^t \quad i \in \overline{1, n} \quad j \in \overline{1, m}, \quad (2)$$

$$x_i^t \geq 0, \quad i \in \overline{1, n}, \quad (3)$$

2) Competitors model on examined period  $t$ :

$$G^t = \left( \sum_{i \in \overline{1, n}} P_i^t x_i^t - \sum_{i \in \overline{1, n}} S_i^t x_i^t \right) \rightarrow \max \quad (4)$$

with resource constraints:

$$b_{ji}^t \cdot x_i^t \leq q_j^t \quad i \in \overline{1, n} \quad j \in \overline{1, m} \quad (5)$$

$$x_i^t \geq 0, \quad i \in \overline{1, n}, \quad (6)$$

3) The consumers model in the market on the examined period  $t$  which is represented with the maximization of utility function. The consumer behavior model should take into account consumer preferences and budget restrictions.

### 3 Development trajectory construction algorithm

As this problem is considered in dynamics this algorithm will be examined for each time interval.

**Stage 1.** The enterprise defines the minimal development trajectory. This strategy corresponds to a new market entry. In this case the enterprise's purpose is the minimal increase of capacities necessary for supporting its throughput. The issues of leaving the «old markets» are not considered, only the increase of the enterprises production potentialities.

The enterprise carries out marketing researches, analyzes the market and defines the area of market functioning. Two areas ( $D_0, D_0^d$ ) is constructed.  $D_0$  - area of enterprise functioning,  $D_0^d$  - area of market functioning, determined by crossing of competitors and consumers functioning area (Fig. 1). In the given figure the example for two goods which are made by the enterprise is represented ( $x_1$  and  $x_2$ ).

Let us assume in this case that the enterprise defines its purpose as the minimal increase of capacities necessary for the market entry. At the transition from the point  $B$  to the point  $M$  the enterprise defines new throughputs  $x_{i \min}^t \quad i \in \overline{1, n}$ .

The enterprise solves a problem (1)-(3) to obtain the throughputs  $x_{i \min}^t$ . Then to obtain the capacities necessary to maintain the throughputs  $x_{i \min}^t \quad i \in \overline{1, n}$  the problem (7) - (9) is solved:

$$L_j^t = \sum_{i=1}^n P_j^{ot} \cdot u_{ji} \xrightarrow{u \geq 0} \min \quad (7)$$

with constraints

$$N_j \cdot u_{ji}^t \geq x_{i \min}^t \quad (8)$$

$$P_j^t \cdot u_{ji}^t \leq V_i \quad (9)$$

As a result of the solution of the given problem  $u_{ji \min}^t$ ,  $i \in \overline{1, n}$  is determined. It represents the minimal resources that are necessary for releasing  $x_{i \min}^t$ ,  $i \in \overline{1, n}$ .

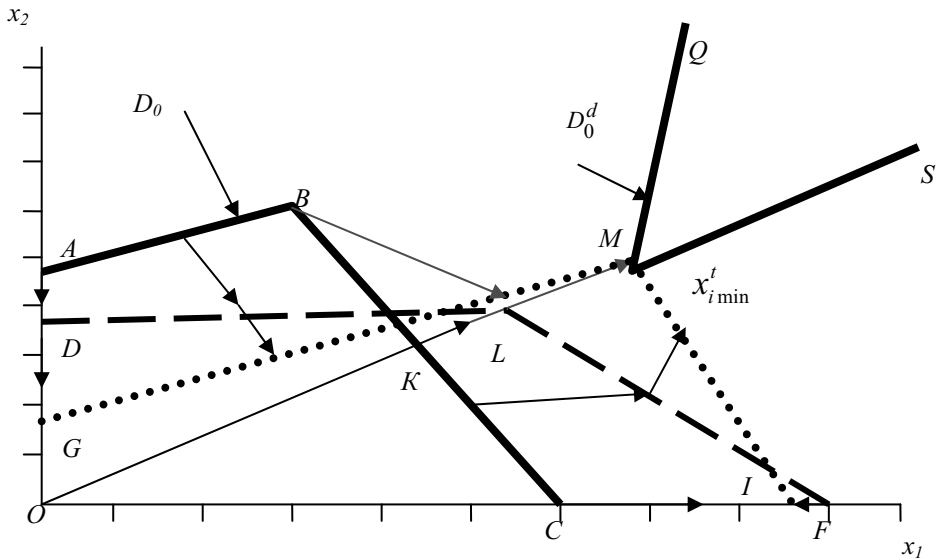


Fig. 1 – Construction of the enterprise area and the market area

On the next time interval the area of market functioning can move in two directions:

- 1)  $D_0 \cap D_0^d \neq \emptyset$  - in this case the enterprise does not increase the throughputs, and it works without changing any of the development strategies.
- 2)  $D_0 \cap D_0^d = \emptyset$  - in this case it is necessary to execute a stage 1 and finally to

determine  $u_{j \min}^t = \sum_{i=1}^n u_{ji \min}^t$ . This iterative process is carried out on all time intervals.

Finally, the increase of resources on each time interval is calculated:

$$\Delta u_{ji \min}^t = u_{ji \min}^t - (u_{ji \min}^{t-1} - u_{ji \min}^{t-1} \cdot Am), \quad i \in \overline{1, n} \quad (10)$$

where  $Am$  is an amortization factor.

$$V_{\max}^t = \sum_{j=1}^n u_{j\max}^t \cdot P_j^{ot}, \quad u_{j\max}^t = \sum_{i=1}^n u_{ji\max}^t$$

So, the minimal development trajectory of the commercial enterprise is constructed.

**Stage 2.** On this stage, the definition of a development trajectory on the basis of the market segment's expansion strategy is carried out. The enterprise determines maximum throughputs necessary for the market entry and determines the corresponding capacities increase. The enterprise solves a throughput definition problem (1- 3). Finally the enterprise defines a new functioning area (Fig. 2).

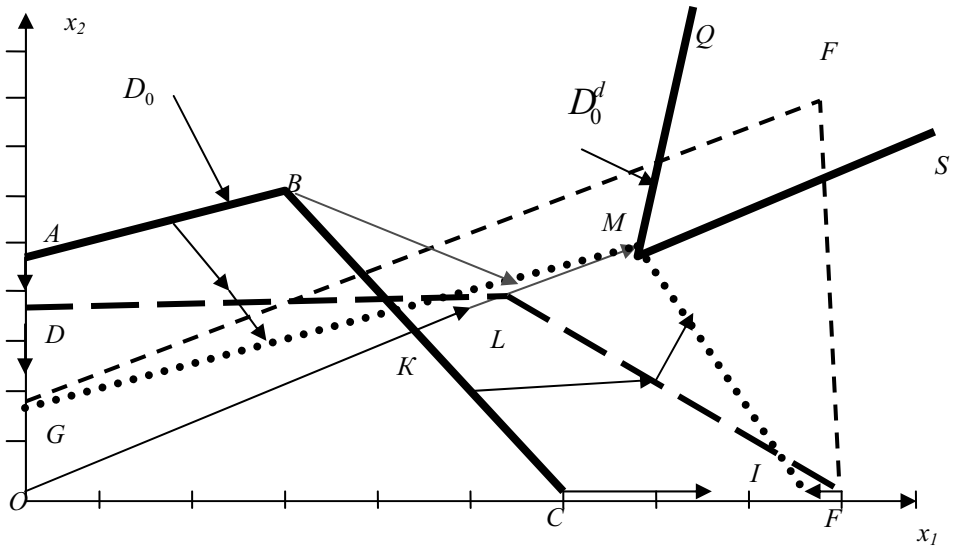


Fig. 2 – Formation of the new area of constraints

In the present state of affairs the enterprise sets its purpose as the maximum increase of capacities necessary for capturing the greatest possible market share. At the transition from point  $B$  to point  $F$  the enterprise determines the new throughputs  $x_{i\max}^t, i \in \overline{1, n}$  (for a new area of functioning). After the definition of throughputs  $x_{i\max}^t, i \in \overline{1, n}$ , the enterprise defines the capacities necessary to maintain the throughputs  $x_{i\max}^t, i \in \overline{1, n}$ . To do this, the problem (11) - (13) is solved:

$$L_j^t = \sum_{i=1}^n P_j^{ot} \cdot u_{ji\max} \xrightarrow{u \geq 0} \min \quad (11)$$

with constraints

$$N_j \cdot u_{ji}^t \geq x_{i \max}^t \quad (12)$$

$$P_j^t \cdot u_{ji}^t \leq V_i \quad (13)$$

As a result, the minimal resources  $u_{ji \max}^t$  necessary to maintain the throughputs  $x_{i \max}^t$ ,  $i \in \overline{1, n}$  are defined.

On the next time interval the functioning market area can move in two directions:

1)  $D_0 \text{ I } D_0^d \neq \emptyset$  - in this case the enterprise does not change the activity and the strategy remains constant during the considered period.

2)  $D_0 \text{ I } D_0^d = \emptyset$  - in this case it is necessary to define  $u_{j \max}^t = \sum_{i=1}^n u_{ji \max}^t$ . This iterative process is carried out on all time intervals.

Finally the increase of resources on each time interval is found

$$\Delta u_{ji \max}^t = u_{ji \max}^t - (u_{ji \max}^{t-1} - u_{ji \max}^{t-1} \cdot Am), \quad i \in \overline{1, n} \quad (14)$$

As a result, the trajectory of the maximal development of the commercial enterprise is constructed. After that, the decision former finds the minimal and maximal expenses for the equipment for all time intervals.

$$V_{\max}^t = \sum_{j=1}^n u_{j \max}^t \cdot P_j^{ot},$$

$$u_{j \max}^t = \sum_{i=1}^n u_{ji \max}^t.$$

**Stage 3.** Two-criteria optimization problem (15 - 18) is solved:

$$F_1^t = \sum_{j=1}^m u_j^t \cdot N_j \rightarrow \max, \quad (15)$$

$$F_2^t = \sum_{j=1}^m u_j^t \cdot P_j^{ot} \rightarrow \min, \quad (16)$$

with constraints

$$x_{i \min}^t \leq u_{ji}^t \cdot N_j \leq x_{i \max}^t \quad i \in \overline{1, n}, \quad (17)$$

$$\sum_{j=1}^n u_j^t \cdot P_j^{ot} \leq V, \quad (18)$$

where  $u_j^t = \sum_{i=1}^n u_{ji}^t$ .

Solving a problem (15) - (18) on each time interval the decision former receives a set of effective decisions for the given commercial enterprise.

Having generated a strategy of the enterprise, the administration can choose one of the development trajectory variants.

#### 4 Information support for the strategic decision making

During the research of a subject domain of problem decisions for resource distribution, the conceptual model of the system and its data flow model have been developed (see Fig. 3 and Fig. 4).

The conceptual model for development trajectory construction represents the full logic description of data formation processes for the construction of the functioning area of the enterprise, the market area including the area of competitors functioning and consumers functioning. For the description of document circulation and the processing of the information the data flow diagram has been constructed. It represents a network of interconnected activities: definition of competitors in the market, definition of market condition, definition of resources, definition of demand in the market, etc.

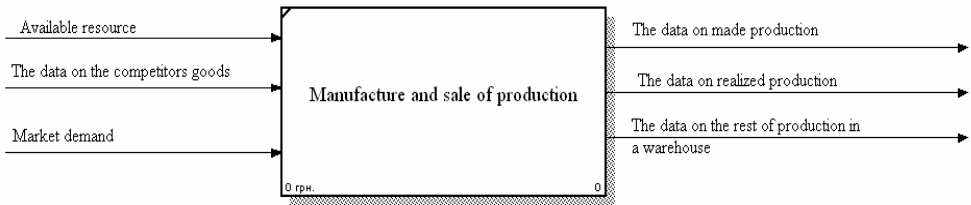


Fig. 3 – Conceptual model of the system

The database structure has been developed with ERWIN 4.0. The database has been implemented with MySQL. This model evidently and clearly reflects all necessary information. The database structure is presented on Fig. 5.

The table "Product" is used for storage of the information on kinds of the made goods. The table "Unit\_of\_measurement" is used for storage of the information on units of measurements. The table "Producers" is used for storage of the information on manufacturers of the goods. The table "Period" is used for the storage of information on



the calculations periods. The table "Market\_Analysis" is used for the storage of information on predictions of demand in the market. The table "Consumers" is used for storage of information on consumers. The table "Production" is used for the storage of information on production at the enterprise. The table "Selling" is used for the storage of information on sale of the goods. The table "Consumer" is used for the storage of information on consumers in the market. The table "Equipment" is used for the storage of information on the equipment, its productivity and the monetary restrictions for it. The table "Result" is used for the storage of information on calculation results necessary for supposing strategic decisions [CDG01].

Figure 6 shows a DSS as a part of the "RESOURCE" integrated software solution.

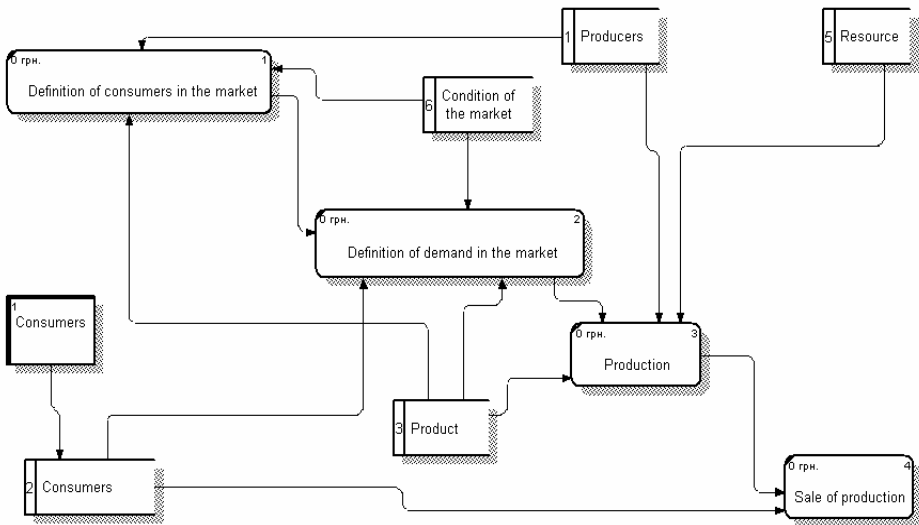


Fig. 4 –Data flow diagram

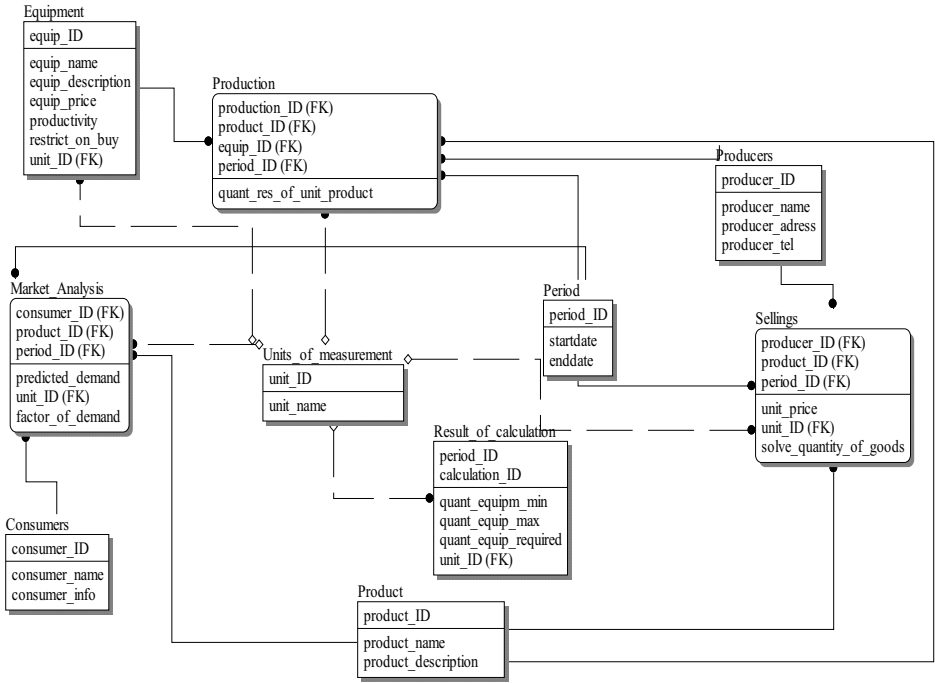


Fig. 5 – Conceptual data model

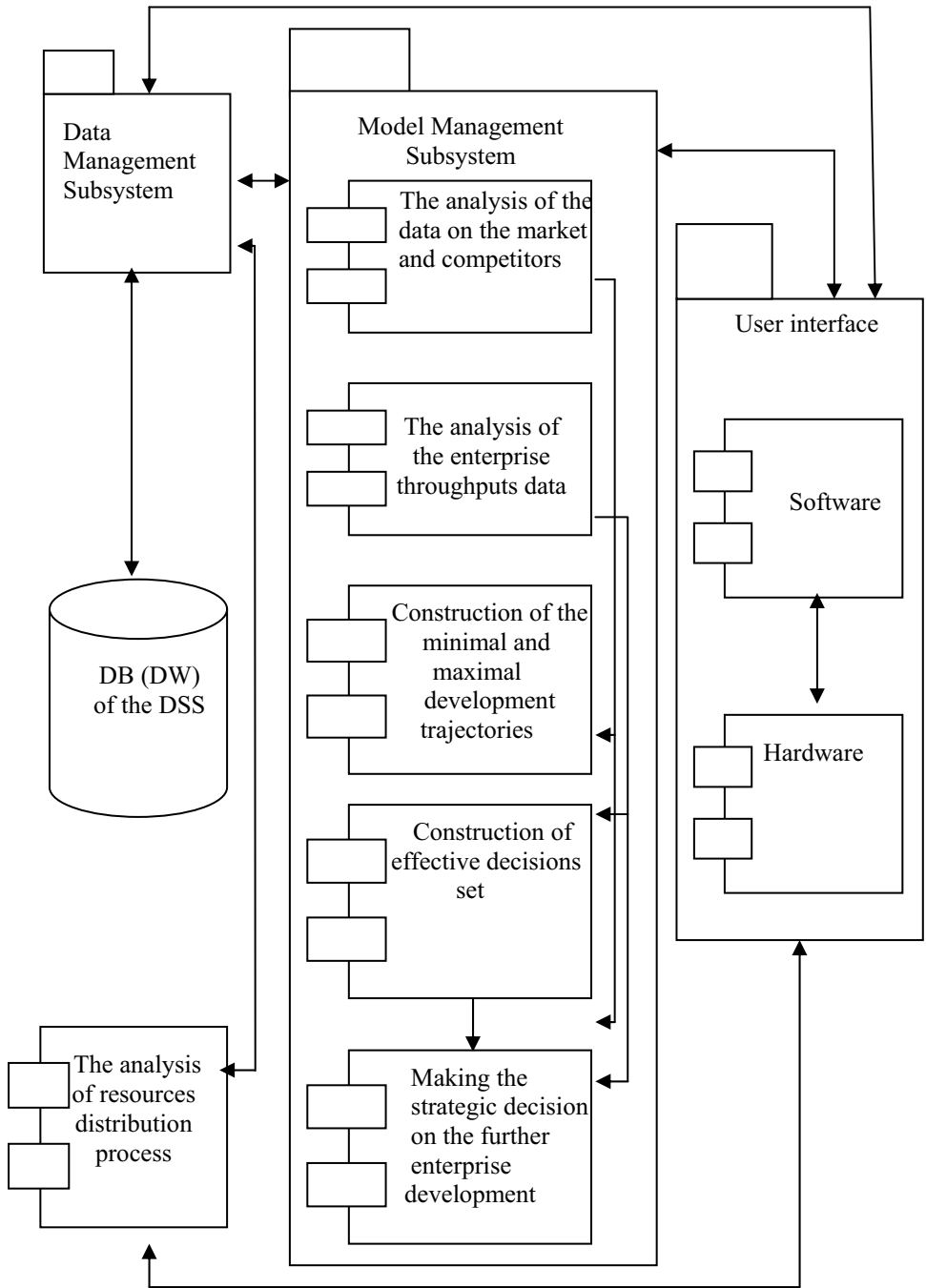


Fig.6 - Enterprise resource management DSS

The following modules of the software solution are considered the most important ones:

- “UserAccess” module is a main module providing user access to the basic modules and forms of the developed software product. It allows viewing and actualization of the necessary information.
- “Database” module is responsible for the database access;
- “Mathematics” module describes mathematical decision algorithms for the specific problem;
- “Result” module is used for formatting reports containing the calculation results; the report data is subsequently inserted in the corresponding database table.

## 5 Conclusion

Developed DSS allows the department of enterprise planning to analyze the information on competitors and consumers in the market, to define the minimal and maximal bandwidths of the enterprise and to operate its industrial resources, thus solving a problem of financial resources distribution in intervals of planning. After preliminary trajectories have been developed, the DSS allows choosing strategies for enterprise development and analyzing consequences of the decisions made.

In that way the presented DSS allows more effective planning in enterprises. In order to speed up data processing and to reduce the acceptance time for the strategic decisions, it is rational to distribute the selected labor, financial and material resources.

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