ECONOMIC INTERESTS HARMONIZATION MODEL DURING CLIENTS AND TRANSPORT SYSTEM INTERACTION

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This article is devoted to the decision making process modeling during cargo transporting planning and clearing a requisition. Author's methodology is based on the game theory, correlogram forming and client's classification expert system.

This article observes decision making process modeling during cargo transporting planning and clearing requisitions which takes into account interests of several participants of logistic interaction to the utmost. However, the following detailed elaboration of clearing a requisition in the referred article is not presented.

The objective determines the following goal setting:

1. Client classification problem applied to one's cargo system (cargo point) servicing
2. Developing the methodology of decision making on clearing a requisition in condition of variant environment
3. Interest harmonization of logistic interaction participants
4. System of charging modification in accordance with the achieved compound.

Segmentation problem of clients who ship cargo from a certain set of cargo points is referred to classification and pattern recognition tasks.

It is necessary to mention that the proposed expert system performs rather single instance (dispatch) recognition than certain client recognition, because one client can perform dispatches of different type.

Every single case represents a set of attributes and can be evaluated as a vector of n-dimensional space. Classification attributes' values are stated as components of this vector.

Every single case is characterized by the following parameters: speed, urgency, dispatch regularity, dispatch amount, client paying capacity, type of rolling-stock used, cargo type, cargo cost, dispatch frequency, operating mode, leasehold or in-house roller-stock, leasehold or in-house cargo points, legal restrictions, transition costs.

The referred parameters are not uniform and differ both by units and method of formalization possibility.

Amongst these parameters the formalizable ones can be assigned. Their values can be defined numerically and normalized without applying weighting coefficients. Conditionally formalizable parameters can be evaluated by number series normalized using weight assigning or based upon empirical data processing. Values of non-formalizable parameters can be assigned in a qualitative sense only.

The above-mentioned parameters can be divided by the degree of attribute intensity into accurate and non-accurate. Accurate parameters are: cargo cost, transition cost, dispatch amount. Non-accurate ones have some binary limitations (speed, urgency, etc.).

Non-accurate parameters can be expressed as linguistic variables relating to conditionally formalizable ones.

To develop an optimal plan of interaction with a certain client it is necessary to define one's request type in a certain moment of time.

According to this task, expert system contains a number of rules defining a subset every single case belongs to. Considering features of railway system functioning several types of single cases can be assigned: "Wholesale", "Rapid", "Accurate", "VIP", "Special", "Minor", "Indifferent", "One-off".

Every type differs by certain values of the 14 parameters mentioned above.

In the suggested expert system "diagnosis" decision is made by consecutive comparison of attributes with the sets of the characterized type of relations.

Decision making on type identification is performed in three steps. The first two are obligatory and the the third is used in case of doubt about the previously made decision.

On the first step there is a comparison of single instance with the group of both formaliz-

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able and non-formalazible accurate parameters. On this stage classification system works from a modified algorithm derived from Shannon - Fano encryption algorithm .

The classifier is presented in table.

case refers to, some analytic coefficient estimation is provided.

Client segmentation on the basis of modified Shannon-Fano code allows to solve cargo point usage optimization problem.

Shannon code construction

<table>
<tr><td rowspan="8">In-house roller-stock</td><td rowspan="5">yes</td><td rowspan="5">In-house cargo point</td><td rowspan="3">yes</td><td rowspan="3">speed</td><td>high</td><td colspan="3">rapid</td></tr>
<tr><td rowspan="2">cargo</td><td rowspan="2">Dispatch amount</td><td>other</td><td>special.</td></tr>
<tr><td>high</td><td>wholesale</td></tr>
<tr><td rowspan="2">no</td><td rowspan="2">regularity</td><td>yes</td><td colspan="3">accurate</td></tr>
<tr><td>other</td><td colspan="3">vip</td></tr>
<tr><td rowspan="3">no</td><td rowspan="3">regularity</td><td rowspan="2">other</td><td rowspan="2">Dispatch amount</td><td>low</td><td colspan="3">minor</td></tr>
<tr><td>other</td><td colspan="3">indifferent</td></tr>
<tr><td>no</td><td colspan="5">One-off</td></tr>
</table>

So, classified table construction allowing to define the type each case belongs to is based on applying the following parameters: speed, dispatch regularity, dispatch amount, leasehold or in-house roller-stock, leasehold or in-house cargo points.

On the first step in-house roller-stock availability is estimated, its attribute takes on "yes" or "no " value. The second step defines the availability of leasehold or in-house roller-stock.

In case of positive answer to the question of cargo point availability cargo delivery speed is analyzed ("cargo" or "high" values). High speed selection clearly determines "Rapid" client type. Other answer presupposes examination on dispatch amount attribute. This parameter is non-accurate and takes on "low", "wagon load", "group", "route" values and can be characterized as "high" ("group", "route") and "other".

"High" value selection clearly determines "wholesale" case type, otherwise "Special".

If client does not possess leasehold or in-house cargo points then it should be examined on dispatch regularity reduced into 2 classes: "regular" and "other". "Regular" value implies dispatch scheduling variance no more than *n* percent. Deviation scope depends on lines and station functioning features and leads to "Accurate" type, otherwise leads to "VIP".

The classifier performs similarly when in-house roller-stock is absent.

On the next stage all the non-accurate values of analyzing single case comparison is provided. To achieve objectivity priority and weighting system should be identical for all the mentioned types of relations.

In case when the first two stages can't define which of the eight types of relations this

Every cargo point as a system is characterized by its manufacturing method which defines the equipment used, the preferable type of rolling-stock and cargo point functioning mode. These factors pose the problem of dividing cargo points into several groups. Group point assigning can be performed in different ways.

Every group is characterized by expenses and its function ratio depending on effort and time variation. Expenses function depends on freight flow character and has some optimum.

Then every client type is characterized by some income function which is costly for a client and so the client will try to minimize it. In respect to cargo system client function is the income function.

When loading resources is a demand then optimal cargo point and client functions coincidence in space and time is the market balance model. However, cargo points are some kind of certain client demand.

So, there is a conflict of contradiction of interests defining a plan of zero-sum two-person game with nature.

At the same time nature can be presented, for example, as value of prospective damage of dispatch canceling and opportunity of cargo point usage losing damage ratio.

The solution to every game gives some probability of strategy selection both by certain client and the most probable transport system response.

The resulting system has typical time from several hours up to several days (on the outer base information update is slow, typically for motor transport systems). It has some similarities with stock market processes.

As a result, all the deals of free loading re-servicing can be divided into the following parameters: risk amount is absolute value in terms of money; transport constituent increasing (logistic in general case); environment changing speed (if the client's reaction is higher than free cargo points changing); influence dynamic comparable; much slower than the observed one.

For every client type defined a corresponding set of the referred parameters can be assigned which estimates available tariff range width.

Using daily targeting cargo system task data and having client base with a cargo point pool attributes the strategy of target parameters' achievement can be chosen by several features:

1. Logistic centre income maximization
2. Logistic centre expenses minimization
3. Logistic centre effectiveness maximization

The discovered dualism allows to shift cargo optimal load problem from processing level (and cost pricing principal) to tariff constructing system sphere and market principle correspondingly. Therefore, client type segmentation above is some kind of market segmentation.

It is necessary to mention that this problem is related not only to cargo point area but can be applied to cargo and stock terminal and square renting client loading.

The suggested loading resources distribution system (as a model) initially becomes out-of-plan, constructed on accidental time distributed demand and supply. As a result, cargo point pool behaves as a self-regulated management system that achieves average (macro system) constants by transient process resulting. Hence, combined train traffic schedule considering necessity disappears. Such system requires sufficient maintenance (monitor of fault numbers, possible unused roller-stock, etc.).

In modern functioning conditions not all solutions are applicable and stick to game theory cargo system functioning analysis.

In the referred games random turns are prevailing and that in turn is determined by some accidental distributed function but not the player. This function is assigned by client characteristic and cargo point ratio. The game examined is a game with incomplete information, hence inevitably wrong decision making possibility appears.

Nature strategy is a full totality of external conditions in which decisions are made. Nature condition space is assigned as:

$$\Theta = \{\vartheta_1, \vartheta_2, \ldots, \vartheta_n\}.$$

Considering railway transport functioning features a priori probability distribution can be defined $\xi(\vartheta)$ on nature condition space .

This a priori probability distribution we'll call combined railway strategy. Certain matrix type of risks and losses or loss function is defined by cargo point and client parameters ratio. So, probability distribution of strategy selection depends on both cargo point features and eight types of clients referred above.

Thus, let the client choose between dispatch area changing (A value) and date changing (according to the algorithm of clearing a requisition) (B value). Wins and losses values are the certain function of client type and game type, i.e.

Then game matrix is defined as:

	A_1	A_2	A_j	...	A_n
B_1	a_{11}	a_{12}	a_{1j}		a_{1n}
B_2	a_{21}	a_{22}	a_{2j}		a_{2n}
B_i	a_{i1}	a_{i2}	a_{ij}		a_{in}
...				...	
B_m	a_{m1}	a_{m2}	a_{mj}		a_{mn}

Here (a_{ij}) is payment element matrix, which can be arranged by two main methods:

1. Considering absolute client losses/profits (this is more laborious method)
2. Considering comparative advantages of A-series strategies over B-series ones (it is more suitable for this problem).

Let's estimate game solution probability in pure strategies (it happens when all the client and his dispatch parameters are obvious and there are conflicts of banal profit maximization and expenses minimization).

During conditionally random distribution the average of distribution is the average profit value.

A combined strategy, in which this game is solved, is a changeable and flexible client tactics mathematical model. The client cannot evaluate that kind of situation because cargo system based upon client segmentation offers several values of probability distribution.

Let us choose some combined on time strategy $S_A = S_A(p_1, p_2, ..., p_m)$ and some combined on dispatch area strategy $S_B = S_B(q_1, q_2, ..., q_n)$, every type pure strategies probabilities are given in brackets.

Then, all the incoming strategy values together form a full group of events $\sum p = \sum q = 1$.

For every game matrix (defined by cargo point type or cargo system in general case) and probability distribution (defined by client type) some pair of strategies which arrange optimal game solution can be defined: $S*_A = S*_A\ (p_1, p_2, ..., p_m)$ and $S*_B = S*_B\ (q_1, q_2, ..., q_n)$.

Game solution is defined by methods of linear programming.

Let's define the first strategy (optimal) of cargo point changing. This strategy should provide winning effect for a client no less than v, in any variants of B strategies, and effect equaled v, when one of the variants on time shifting strategy is offered.

Let the railroad offer some pure strategy B_j while choosing some unidentified optimal strategy $S*_A$. Then average area shifting realization effect (A behavior) is:

$$a_j = p_1 a_{1j} + p_2 a_{2j} + ... + p_m a_{mj}.$$

According to the main theorem of game theory, effect average of distribution cannot be less than game cost v. Then for every probable A strategy (area shifting variant) it can be assigned:

$$\begin{cases} p_1 a_{11} + p_2 a_{21} + ... + p_m a_{m1} \geq v; \\ p_1 a_{12} + p_2 a_{22} + ... + p_m a_{m2} \geq v; \\ .... \\ p_1 a_{1n} + p_2 a_{2n} + ... + p_m a_{mn} \geq v. \end{cases}$$

If client using A strategy maximizes one's own profit, then it results in linear programming task of defining non-negative variables $x_i = \frac{p_i}{v}$ leading linear function to its minimum:

$$L(x) = x_1 + x_2 + ... + x_m \rightarrow \min.$$

Similarly, we get a dual problem of linear programming by fixing area shifting strategies and considering optimality of area and dispatch date shifting strategies.

Thus, defining methods of choosing a behavioral strategy is reduced to the solution of a pair of linear programming dual problems. According to game theory, such solution always exists.

Information converting processes described above, clearing requisitions on cargo transportation, single problems of creating entire system of servicing clients on cargo points cannot be isolated from economical components. Namely, optimization of economical component both as a whole transport system and certain area (station, cargo point) is one of the aims of this research.

So, the suggested solutions consider economical orientation of logistics which can be defined as "management research orientation concluding in effective management of material, information and financial resources connected in production and trading sphere".

The suggested algorithms of clearing a requisition are analyzed from the point of view of economical logistics orientation.

As transport complex (and cargo process in particular) is a sphere of opposed interest intersection, a complex economical model of interest harmonization is offered. This model developing is the following:

1. Research of the main technical, operational and economical indexes
2. Research of each transition case parameters represented by consignor of goods
3. Comparison of consignor of goods and transport company interests.
4. Coordinated decision making (several decisions) allowing to achieve target area with some degree of accuracy.

Thus, it is clear that it is a question of settled approach.

Every transport company including railway or its organization department is a complex production and economic system which develops in time and chosen environment.

The state of such transport company can be presented as some set of attributes. The simplest model of these attributes presentation is a vector conditionally defined as

$$Y = \{\mathrm{Org}; \mathrm{Prod}; \mathrm{Econ}\}.$$

Here are the following vector parameters presented in general case: "Organizational" - information about organization functioning objective, market position, prospective, authority relations, etc.; "Production" - attributes directly managing organization functioning: potential and real capacity, performance, machinery type used, etc.; "Economic" - functioning cost price, expenses (several types), income, profit, functioning profitability etc.

Every group of attributes should be considered in the following correlation field constructing. Certain estimation of expenses that appears in transport organization functioning is defined by engineering process features. Consignor of goods request forming is influenced by systematic factors operating during all the logistic chain: from raw material purchasing to product consumption.

Using analogous vector method shows that every consignor of goods can be defined by vector

Vector components that characterize consignor of goods slightly differ from the correspondent transport organization characteristics. So, during engineering process analysis it is important to consider logistic system type, production demand features and client position on the organization life cycle curve.

Let's consider the organization as belonging to pulling or pushing logistic system in detail. It influences all the transport relations.

In transport index module there are composite store expenses parts, immediate transportation expenses, cargo unit supplying character and cargo type. It also allows to estimate the expression of optimal dispatch amount for each client considering environment features such as seasonality, etc.

Let's pay attention to the 14 indices referred above that formulate client requirements to transport process.

Economic indices can be extended by introducing a part of transport and logistic components in the resulting production cost. Combined presentation of client and transport organization vectors is the way of transport process harmonization. Unified approach development, considering individual client interests and features allows to apply new tariff system construction methods and reduces expense pricing influence.

The result of such system is railway optimal strategy evaluation (or transport organization) by client interests satisfaction and forming new service priorities and achieving given profitability in the defined time period.

Let some field (a set of accordance) be organized (X, Y) as a result of consignor of goods and transport organization information array processing, where X - general client features vector, Y - general transport organization features and demands vector.

To optimize the system functioning in general it is necessary to discover contradiction zones of transport system and client interaction. Contradictions are defined on basis upon correlation force index of single field components (X, Y).

The main method allowing correlation between vector component values defining is correlation-regression analysis.

Contradiction zone evaluation is performed after cross factoring correlation matrix constructing $R = \begin{vmatrix} r_{x_1y_1} & r_{x_1y_2} & \cdot & r_{x_1y_p} \\ r_{x_2y_1} & r_{x_2y_2} & \cdot & r_{x_2y_p} \\ \cdot & \cdot & \cdot & \cdot \\ r_{x_py_1} & r_{x_py_2} & \cdot & r_{x_ny_m} \end{vmatrix}$.

Upon the construction of given matrix the following problem zone types are defined as:

1. User groups with a negative correlation effect (feedback, as a classic contra dictionary index) - criterion a.

2. User groups with a low correlation effect absolute value are potentially unexplored relation zone demanding additional studying - criterion .

Pay matrix variants forming for every of eight case types (client types) is defined by two factors:

1. General logistic expenses structure of every instance

Considering logistic expenses structure, transporter can not fully examine client production but main features of every business functioning consideration (especially in cases of client type “Wholesale”, “Special”, “Rapid”, etc.) Hence, it is possible to develop several typical schemes of general logistic process proceeding. It is achieved by applying following structures: logistic chains of operations; operation structure on time; cost evaluation of every logistic operation.

2. Value of transport expenses index calculated in every cargo dispatch case.

This index directly depends on the geographical location of the market (invariable) and logistic expenses of production resulting in price ratio. It is appropriate to consider both transport expenses and expenses on possible production storage in distribution network here.

Resulting element values of pay matrix is influenced by client and transporter target position. The correlation of aims of both process participants depend on request case “diagnosis”.

Some of eight entered case types can evince close correlation behavior, so the number of pay matrix types can be less than the number of types.

Pay matrix forming process is shown on figure.

b

action events, which have some differences and similarities. Every single event z can be viewed as a vector in attribute space and correlogram data is in attributes’ capacity. In that case sets of vectors can be presented as

$$Z = \begin{pmatrix} z_{11} & z_{12} & \cdot & z_{1n} \\ z_{21} & z_{22} & \cdot & z_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ z_{m1} & z_{m2} & \cdot & z_{mn} \end{pmatrix}.$$

For this segmentation task every string of Z matrix is assigned as an operational unit, which can be presented as client type correlation with a transport organization (in general case there are several organizations). Then, this task becomes multidimensional.

Attributes normalization is not necessary because in *Z* matrix elements capacity there are some data in [-1; 1] limits.

The next stage is metrics introducing and calculation of distance between operational units, i.e. type behavior. This distance can be found by classic Euclid metrics as

$$R = \sqrt{\sum_{i=1}^{n} \left(z_{ik} - z_{il}\right)^2},$$

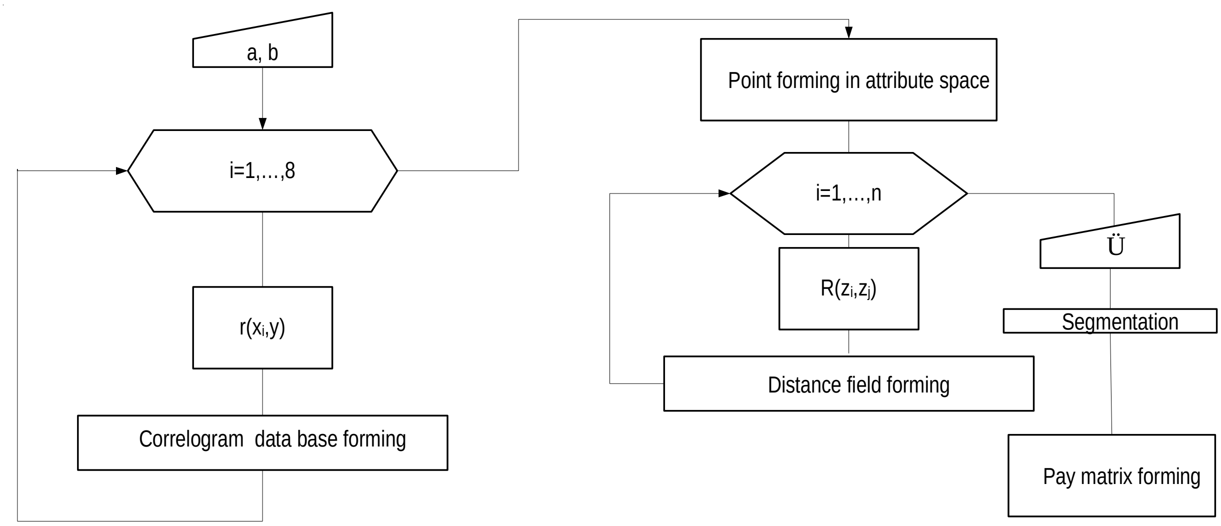

Fig. **Aggregative scheme of pay matrix forming**

So, on the first step feedback value criteria is entered, after that, for every case type, calculation of correlation fields between transport organizations instances and requirements is performed.

Resulted correlation fields are accumulated in data base. By filtering this base on a and criteria a set of vectors is accumulated or inter-

where *R* - is the distance between *k*-th and *l*-th operational units by (1, 2, ..., *l*) attributes, $i \in [1; n]$; z_{ik}, z_{il} - values of *i*-th attribute for *k*-th and *l*-th operational units.

In this case it is not necessary to enter defined similarity (proximity) measure function in special measure’s capacity, because class sorting can be performed by type distance.

Any cluster analysis can be applied to certain margin proximity value (b) entering.

Analyzing this method let's mention that correlogram attributes can differ by meaning. In case of great number of points in *Z* matrix strings the algorithm is complicated by the introduction of several zone spaces or proximity measure calculation.

For every relation type identified this way pay matrix forming process considers fundamental economic, technological and other features. Expenses division principle by components: initial-ending operation expenses, transition (movement) expenses; can be applied to new tariff system developing.

The following tariff system development should be considered for federal railway transport and for general logistic terminal (where another transport infrastructure can be used). In case of railway tariff variant solution, range of discretion in tariff policy construction will be essentially limited. Pay matrix (risk matrix) operation is possible by means of initial-ending operations only. So, inside the tariff infrastructural component it is possible to conditionally point out "cargo point component". The second direction, which is not connected with the railway transport, is the tariff forming on cargo transition and dispatching in major logistic terminals. There are possible modifications here both in initially-ending operations tariffs and general transition tariff (motor transport, for example). Thus, in this article decision making process of request consulting on cargo transition is examined (any transport-logistic terminal in general case). In conditions of changeable environment and interest contradiction the main mathematical apparatus by compromise achieving is the game theory.

The suggested concept makes it possible to approximate market principles of tariff construction in transport-logistic systems.

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