MODELING QUALITY OF INFORMATION SYSTEMS

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The module principle is widely used in up to date design of information systems (IS). Host-computer, servers, operative stations, local computing nets, SCADA systems, specialized measuring complexes, local control systems may appear in place of "modules". The modules are assembled of autonomous "components": controllers, operational systems, DBCS applications package, mains-operated adapters, concentrators and etc. Estimation of local quality of separate modules and components in the design process is realized by individual criteria reflecting their information-computing functions and technical peculiarities. However, estimation of integral quality of IS is a non-trivial problem and requires an appropriate simulating device.

Variety of design solutions of IS obtained from the modules (M) to within isomorphism may be represented by means of ortree $D(M,F)$, where M is the set of vertices corresponding to the functional structure of IS, F are the mappings indicating incidence of vertices of ortree [1].

From $D(M,F)$ we can get ortrees of different type completing elements of M, for example, ortree of a hardware $D(T,F_i)$, ortree of the software $D(P,F_p)$, ortree of information ware $D(I,F_i)$. The ortrees of different constituents of M are isomorphic to the isomorphic ortree $D(M,F)$.

This is proved by means of the algorithm for recognition isomorphism of orgraphs [1].

The principle problem of the design choice is reduced to the search on $D(M,F)$ an ortree's route (i.e. configuration) with optimal value of integral criterion connecting the above enumerated indices.

According to the theory of additive utility, the integral criterion, ω may be represented in the form:

$$w = \sum_{i=1}^{k} \lambda_i f_i(v_i) \qquad (i = 1,2,...,k), \tag{1}$$

where λ_i is the weight of the $i-th$ local criteria, $\lambda_i = [0,1]$, $\sum \lambda_i = 1$; $f_i(v_i)$ is a utility function of the $i-th$ local criterion.

Such a convolution method is equivalent to a utility function ranking, since the quantities λ_i show how much integral criterion changes according to change of the $i-th$ local criteria.

Let an element of the module $t_i \in T_i$ contained in configuration be defined by the integral criterion $\omega_i \in W_i$, where W_i is a set of integral criteria that correspond to the subset of elements $T_i \subseteq T$. To each ortree $D(T,F_t)$, $D(P,F_p)$, $D(I,F_i)$ we can associate an ortree of integral criterion $D(W,Q)$ and to each configuration on the ortree $D(W,Q)$ we can associate the total value of the integral criteria $X_T = \sum_{i=1}^{k} \omega_i$, where $\omega_1 \in W_1, \omega_2 \in W_2, ..., \omega_k \in W_k$.

For determining the set of effective on x_T configurations and determining the components of modulus of these configurations, we use the notion of generalized graph [2].

A generalized graph (GG) $G(X,F)$ is an ordinary Berj graph [3] with a set of vertices and mappings F taking to each vertex $x \in X$ the set X (may be empty), i.e.

$$F = \left\{ x_j \mid x_j \in X \wedge \vec{g}(x_i, x_j) \right\}, \tag{2}$$

where $\vec{g}(x_i x_j)$ is an arch directed from the vertex $x_i \in X$ to the vertex $x_j \in X$.

Definition 1. Call the subset of integral criteria

$$W_0 = \left\{ \omega_0^0 \right\}$$
$$W_1 = \left\{ \omega_0^1, \omega_1^1, \ldots, \omega_{n_1-1}^1 \right\};$$
$$W_2 = \left\{ \omega_0^2, \omega_1^2, \ldots, \omega_{n_2-1}^2 \right\};$$
....
$$W_k = \left\{ \omega_0^k, \omega_1^k, \ldots, \omega_{n_k-1}^k \right\};$$

a basic set of GG.

The amount of the elements of basic sets corresponds to amount of the elements of the subset $T_i \subseteq T$ of the ortree $D(T, F_T)$ and equals

$|W_0| = 1; |W_1| = n_1, |W_2| = n_2; \ldots; |W_k| = n_k$, respectively.

Definition 2. (GG) $G(X,F)$ is said to be an oriented graph and the following statements are valid for it:

a) $X = \bigcup_{i=1}^{k} X_i$ and $X = \bigcup_{i=1}^{k} X_i$ $X_i \bigcap X_{i-1} = \varnothing$, i.e. the subsets of different levels vertices have no common vertices;

b) $\exists! x_0 \in X \left[F_{x_0} = X_1 \wedge X_1 = W_1 \wedge F_0^{-1} = \varnothing \right]$ i.e. there is a unique vertex $x_0 \in X_0$ for which (b) is true and the vertex $x_0 \in X_0$ is a root of the graph $G(X,F)$;

c) $\forall x_T \in X_{i=1} \left[F_{x_T} \subseteq X_i \rightarrow F_{x_T} = \left\{ x_T + \omega_0^i, x_T + \omega_1^i, x_T + \omega_2^i, \ldots, x_T + \omega_{n_i-1}^i \right\} \right]$, i.e. exactly $|W_i|$ archs start from the vertex $x_T \in X_{i-1}$;

d) $\forall x_T \in X_k \left[F_{x_T} = \varnothing \right]$ vertices $x_T \in X_k$ of the level k are terminal, the subsets X_k are the subsets of terminal vertices.

By means of GG $G(X,F)$, to each type of module components we can associate its own (GG) $G_0(W_T, F_T)$; $G_p(W_p, F_p)$; $G_1(W_I F_I)$ and etc.

The generalized estimation of modulus quality may be carried out on the basis of the spatial model of GG and represented in the following form:

$$G_M(X,F) = \bigcup_{i=1}^{m} G_i, \tag{3}$$

where G_i is a GG of i -type constituents of the module M .

A spatial module of GG to within isomorphism is represented by means of its own module-graph.

Definition 3. A module-graph of the spatial GG is a graph $G_{x_p}(X', F')$ satisfying the following propositions:

a) $X' = X_0' \bigcup X_1'$ where $X_0' \bigcap X_1' = \varnothing$,

$X_0' = \{x_p\}$ $X_1 = \{x_p + \omega^0, x_p + \omega_1 + \omega_1; ...; x_p + \omega_{n-1}\}$;

b) $\exists! x_p \in X_0' \lfloor F_{x_p} = x_1' \wedge (F')^{-1}_{x_p} = \varnothing \rfloor$, i.e. the vertex $x_p \in X_0$ is a root of the graph $G_{x_p}(X', F')$;

c) $\forall x_T \in X_1' \lfloor F_{x_T}' = \varnothing \rfloor$.

It follows from definition of the module-graph $G_{x_p}(X', F')$ that $G_{x_p}(X', F') \subseteq G_M(X, F)$.

The notion of oriented graph in the theory of graphs doesn't impose restrictions on the generator of graphs (archs and vertices) in the general case, i.e. the archs may have arbitrary geometric length and direction not violating the incidence and connectedness properties [3, p.49].

In this connection, not violating Definition 3, in the graph $G_{x_p}(X', F')$ one can:

1) combine the root $x_p \in X_0$ with the point of origin of coordinates of n -dimensional space;
2) give to each arch $\vec{g}(x_p, x_i)$, where $x_i \in X_1$ appropriate direction and sizes of unit vectors $\vec{l}_0, \vec{l}_1, ..., \vec{l}_{n-1}$ of n -dimensional space.

While fulfilling these conditions, we get a spatial representation of the module-graph $G_{x_p}(X', F')$ that coincides to within isomorphism with the basis of n -dimensional space and origin of coordinates $x_p \in X_0'$ and also with a set of unit vectors $\vec{l}_0, \vec{l}_1, ..., \vec{l}_{m-1}$.

Statement 1. The generalized n -GG graph $G_M(X, F)$ for estimating quality of M may be represented by means of its own module-graph in the space, i.e.

$$G_M(X, F) = \bigcup_{x_p} G_x(X', F'), \; x_p \in X_0 \bigcup X_1 \bigcup ... \bigcup X_{K-1}. \qquad (4)$$

Definition 4. The graph obtained by combining module-graphs by means of expression (4) is said to be a spatial representation of the generalized n -GG in the basis $<\omega_0, \omega_1, ..., \omega_{n-1}>$ or spatial generalized n -GG in the basis $<\omega_0, \omega_1, ..., \omega_{n-1}>$. Denote it by $G_{M_n}(X, F)$.

Statement 2. The spatial graph $G_{M_n}(X, F)$ is isomorphic to the n - GG generalized graph $G_M(X, F)$ in the basis $<\omega_0, \omega_1, ..., \omega_{n-1}>$.

The suggested model determines sufficiently universal and convenient method for modeling quality of IS.

The important advantage of the method is that it enables to get both integral estimation of quality of IS and differential estimation quality in the section of different properties and also in the section of separate susbsystems and modules.

References

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