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Biotronic System Network Efficiency Investigation

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Introduction

Biotronics (BT) – interface (interaction) between biologic and electronic object(s). These objects can interrelate by sensory measures, and influence one another by influence measures.

Theory of biotronics (BT) – a branch of science which investigates research and control possibilities of processes taking place in the living organisms using electronic measures.

Biotronic system (BTS) – interaction between biologic system (BS) and electronic system (ES). Commonly they both form integrated [1] BTS (IBTS), which can be formed al least of two (Fig. 1,a) or three (Fig. 1,b) control contours (loops).

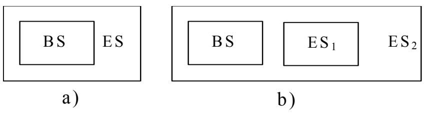


Fig. 1. IBTS, consisting of two (a) and three (b) control contours

Since the ES is generally intended to influence the BS, consequently objectives of the first of them are of the higher level and span objectives of the second. Control electronic objects of IBTS presented in Fig. 1, b is performed in two hierarchical levels. BS and ES interaction devices are controlled in the lower level (ES_1), and interaction tactics with respect to states of BS and ES_1 is controlled in the higher level (ES_2).

Several or even tens of such IBTS are used in practice. They exchange information and techniques of analysis and (or) techniques of control among themselves. Therefore they are connected to IBTS network, which can be autonomous or created by employing already operating networks (or their parts). IBTS network specifics consists of peculiarities of measures implemented in its nodes, which assure rational operation of BS and ES.

IBTS network design

General purpose of IBTS network – to assure efficient interchange between separate systems of it (separate levels of it), additional purpose (in some cases) – partially control operation of these systems. As in case of design of any other system of control, in the case of IBTS network design it is also required to form precisely its objectives, tasks, principles of formation and operation. Hierarchy, openness, dynamism, modularity and other criterions are attributed to IBTS network formation principles.

According to the view of functionality, IBTS network of one hierarchical level (Fig. 2, a) is considerably simpler, open for expansion and guarantees higher autonomy of separate IBTS.

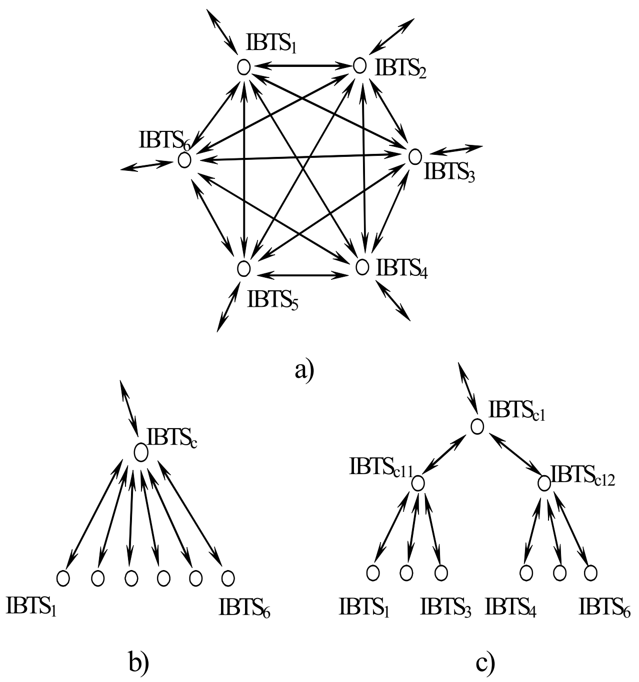


Fig. 2. IBTS networks of one (a), two (b) and three (c) levels

However, if we assess technical efficiency of such network by $IBTS_1$ task fulfillment (finding required information) probability [2], then in case of communication with $IBTS_2$ we receive, that it is expressed as

$$E_1 = Kp_1 \cdot P_1 \cdot P_{1-2} \cdot P_{2-1} Kp_2 P_2; \qquad (1)$$

here Kp_1 and Kp_2 – steady state availability coefficients of the 1st and 2nd IBTS; P_1, P_2, $P_{1\text{-}2}$ and $P_{2\text{-}1}$ – probabilities, that 1st and 2nd systems and interfaces between them (in both directions) will accomplish their tasks. If $IBTS_2$ does not have this information, and this information with equal probability can be located at any one of the rest systems, then average value of efficiency

$$E_{1V} = \prod_{i=1}^{N/2} Kp_i \cdot P_i \cdot P_{1-i} \cdot P_{i-1}; \qquad (2)$$

here N – number of IBTS in the network.

If a central system is created in the network ($IBTS_c$ Fig 2,b),

$$E_1^{(0)} = Kp_1 \cdot P_1 \cdot P_{1-c} \cdot P_{c-1} Kp_c P_c; \qquad (3)$$

here Kp_c and P_c – respective indicators of central IBTS.

When $Kp_1 \approx Kp_c$, $P_1 \approx C_p$, $P_{1\text{-}2} \approx P_{1\text{-}c}$, and $P_{2\text{-}1} \approx P_{c\text{-}1}$, then

$$E_1^{(0)} \rangle\rangle \; E_{1V}\,. \qquad (4)$$

Furthermore, the search for information in environment (I_A) is substantially more expensive in one-level IBTS network. Thus it is obvious, that it is more rational to create IBTS network according to the structure presented in Fig. 2, b. IBTS network the structure of which is presented in Fig. 2, c is more efficient than the former only then, when

$$P_{1\text{-}c} \cdot P_{c\text{-}1} < P_{1\text{-}c11} \cdot P_{c11\text{-}1} \cdot Kp_{c11} \cdot P_{c11} \cdot P_{c11\text{-}c1} \cdot P_{c1\text{-}c11}. \qquad (5)$$

$P_{1\text{-}c}$, $P_{c\text{-}1}$, $P_{1\text{-}c11}$, $P_{c11\text{-}1}$, $P_{c11\text{-}c1}$ and $P_{c1\text{-}c11}$ values are determined by interface throughput, busyness, reliability and other features. These values can be increased by using redundant interfaces (when developing IBTS network structure). Kp_1, Kp_2, ... Kp_{c11} values depend on $IBTS_1$, $IBTS_2$, ... $IBTS_{c11}$ device and process reliability and ability to react quickly.

Since main objective of the network is to assure efficient operation of $IBTS_i$, and tasks of these systems: to control BS and protect them and themselves, then the following several control process types can be distinguished:

- BS operation control;
- BS protection from disasters;
- $IBTS_i$ self-protection;
- other

Mostly BS processes are slow. Therefore quick-reaction ability of interfaces and $IBTS_{c11}$ and $IBTS_{c1}$ has a little limiting influence on $IBTS_i$ efficiency index value. So the network structures presented in Fig. 2, b and Fig. 2, c would be suitable to control these processes.

When protecting BS from disasters, which mostly are unexpected and abrupt, network structures presented in Fig. 2,a or Fig. 2, b would be more suitable.

Third group control process efficiency is inversely proportional to number of IBTS hierarchical levels, and at the same time to the number of interfaces connecting these levels in serial or parallel manner.

Since IBTS network structure has to be selected during its design, then number of hierarchical levels in it can not be variable. Thus IBTS control information has to be positioned at several several levels of hierarchical network. It can be seen from the results of bionics investigations [3], that in order to increase IBTS network efficiency the reliability control of its components (devices and processes) [4] it is most applicable, investigations of which could be expanded to the creation of separate branch of rebilitronics in the future. But at the present time it falls to rely on IBTS persistence [5] increase (usually by measures of logical reliability increase).

Lowest level IBTS structure is presented in Fig. 3.

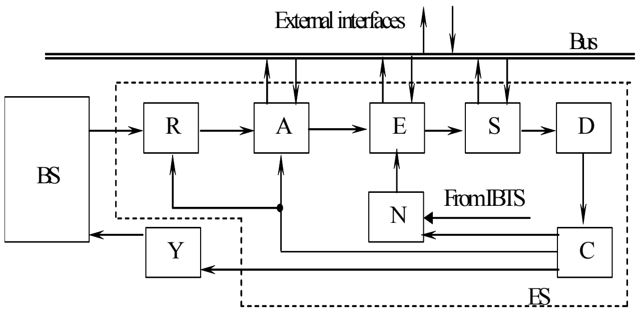


Fig. 3. Lowest level IBTS structure

ES consists of receptive (R), analysis (A), evaluation (E), search (S), decision (D), control (C) measures and normative base (N). This ES controls performance measures (Y). Search measures, with respect to evaluation results, perform the search for additional information and decision-making techniques throughout IBTS network.

In order to increase the persistence of IBTS network, several equivalent centers with corresponding interfaces between then have to be established in it (Fig. 4).

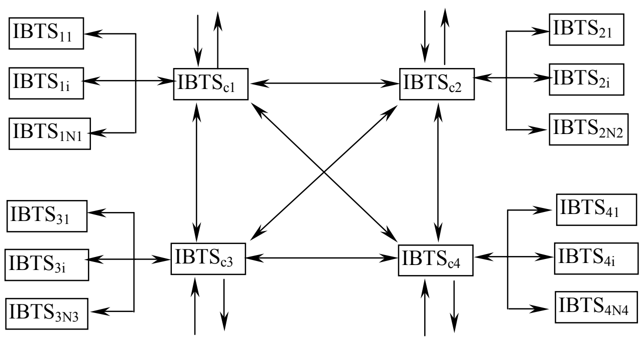


Fig. 4. A scheme of IBTS inter-relations

Every $\{IBTS_{cj}\}$ has connections with environment. That creates opportunities to delegate control to other systems after failure of one $IBTS_{cj}$. These centers (C) can be established in large performance nodes (S), and already existing networks (e.g. Internet) can be used as interfaces (connections) between them. Then typical structure of IBTS network would be similar to one presented in Fig. 5.

In this figure LAN, MAN and WAN – local, remote and global networks. Each LAN can be formed of several IBTS, presented in Fig. 3. Various measures can be used as IBTS interfaces with the network (see Fig. 6).

Each lowest-level IBTS and LAN control system (LANCS) should have in its databases everything required to perform operative BS control, BS protection from disasters and self-protection. Tactical control measures would be stored in LANCS and in centers, and strategic – in centers. Why? Entireties of operative, tactical and strategic measures form huge arrays, the constant protection of which is too difficult and beside the purpose to perform for lowest level IBTS. Additionally, entirety of these measures is constantly being developed. It is too expensive to perform renovation works of these measures by lowest level IBTS on a constant basis. Rarely used arrays when needed can always be found in the second or even higher level.

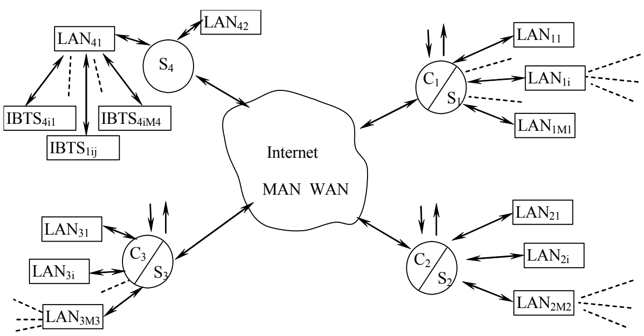


Fig. 5. Interfaces (interconnections) of IBTS networks

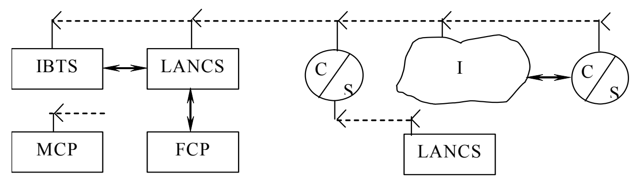


Fig. 6. IBTS interface types (MCP and FCP – mobile and fixed control measures)

Considering the purpose of IBTS, tasks of intermediate (second) level IBTS can be delegated to the centers {$IBTS_c$}. Therefore, the highest reliability and at the same time efficiency requirements are raised for lowest and highest level systems when estimating number and importance of performed functions.

Selection of IBTS network centers

When network centers are identified with large performance (activity) locations (S), and the number of these locations (S_v) is higher than number of centers, a problem of center location selection emerges [6–8].

When selecting center locations it is purposeful to consider the following:

- size and configuration of spanned territory ($\{q_i\}$ and $\{k_i\}$);
- differences in conditions suitable for this type of activities:
  - arrangement of useful areas ($\{\Delta_i\}$);
  - soil fertility $\{d_i\}$;
  - work-force allocation ($\{\check{z}_i\}$);
  - occupation of people suitable for this type of work ($\{u_i\}$);
  - distances between separate locations ($\{p_i\}$);
  - distances between realization locations ($\{r_i\}$);
  - arrangement of large nodes ($\{s_i\}$);
  - distances between large nodes ($\{l_i\}$);
  - etc.
- possible areas of biologic activity ($\{v_i\}$);
- total losses of interfaces between $IBTS_i$ and $IBTS_c$.

Indexes of listed factors are denoted in brackets.

When number of large nodes is increased on account of smaller nodes, primary expenditure per production unit decreases, but problems of work force accumulation and utilization of prospective areas increase.

Number of {$IBTS_{ci}$} at any time t ($D(t)$) is determined using this operator:

$$\min_{D(t)}[(C_{I1}(t)+C_{E1}(t))D(t)+(1-P_1(t))D(t)C_{p1}(t)]; \qquad (6)$$

here $C_{I1}(t)$ and $C_{E1}(t)$ – expenditures on center establishment and exploitation (respectively), falling to one $IBTS_i$ exploitation duration unit in time t; $P_1(t)$ – probability of task accomplishment of one IBTSc task in time t; $C_{p1}(t)$ – losses during one IBTSc exploitation duration unit in time t, when it fails to accomplish its task.

Considering placement of S_v nodes, a coefficient matrix is formed for meaningful variants of center placement {Θ_i}, each row of which is formed of coefficient values attributed to nodes ($1 \div S_v$) of one selected variant. Number of rows corresponds the number of meaningful variants N_v.

$$\begin{array}{c|ccccc|} & S_1 & \ldots & S_i & \ldots & S_V \\ \Theta_1 & K_{11} & \ldots & K_{1i} & \ldots & K_{S_V} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ \Theta_j & K_{j1} & \ldots & K_{ji} & \ldots & K_{jS_V} \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ \Theta_{N_W} & K_{N_W1} & \ldots & K_{N_Wi} & \ldots & K_{N_WS_V} \end{array} \quad \text{or} \quad \begin{array}{c|ccccc|} & K_1 & \ldots & K_i & \ldots & K_{SV} \\ \Theta_1 & 0 & \ldots & 1 & \ldots & 1 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ \Theta_j & 1 & \ldots & 1 & \ldots & 1 \\ \ldots & \ldots & \ldots & \ldots & \ldots & \ldots \\ \Theta_{N_W} & 0 & \ldots & 1 & \ldots & 0 \end{array} . \qquad (7)$$

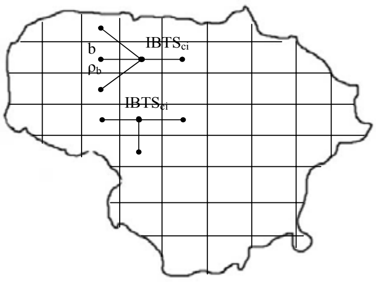
For each variant

$$\sum_{i=1}^{S_v} K_i = D(t). \qquad (8)$$

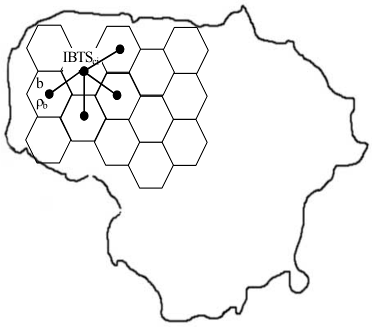
All the territory assigned to the network (Fig. 7) is divided into rectangular of hexagonal form cells $\{L_b\}$ ($1 \le b \le N_L$; N_L – number of cells) and respective significance coefficient value $\rho_b(t)$ is assigned to each of them.

Selected size (number) of cells determines the precision of further decisions. It is possible to optimize N_L.

$$\rho_b(t) = f[\{q_i\},\{k_i\},\{d_i\},\{\Delta_i\},\{\check{z}_i\}, \{u_i\},\{p_i\},\{r_i\},\{s_i\},\{l_i\},\{v_i\},t]. \qquad (9)$$



a)



b)

Fig. 7. Territories are partitioned using squares (a) and hexagons (b)

Expression of $\rho_b(t)$ value is formed after completing investigations of influence of factors indicated in formula (9) on the network efficiency. One of simplest expressions could be such:

$$\rho_b(t) = \sum_{i=1}^{N_q} a_{qi} \cdot q_i(t) + \sum_{i=1}^{N_k} a_{ki} \cdot k_i(t) ...$$

$$... \sum_{i=1}^{N_v} a_{vi} \cdot v_i(t); \qquad (10)$$

here N_q, ..., N_v – numbers of indexes of respective groups; d_{qi}, ..., a_{vi} – significance coefficients of i-indexes of respective groups. Value $\rho_b(t)$ is assigned to the center of the cell. Size of the cell (Ω_b) can vary in the range 0 to 1,0. Then total $IBTS_{ci}$ moment

$$M_{ci}(t) = \sum_{b=1}^{N_{ci}} \Omega_b \cdot \rho_b(t) \cdot h_b; \qquad (11)$$

here N_{ci} – number of cells attributed to the first $IBTS_c$, h_{1b} – distance between the center of the b-cell center and the center of the cell in which $IBTS_{c1}$ (in general case - $IBTS_{ci}$) is located. Number N_{ci} depends on $\{\Theta_j\}$. Cells are related only to these activity nodes (from S_v), whose coefficients (see formula (7)) are equal 1 in the case of that variant.

Moment of overall j-variant IBTS network

$$M_j(t) = \sum_{i=1}^{S_v} K_{ji} \sum_{b=1}^{N_{ci}} \Omega_b \rho_b(t) \cdot h_{ib}; \qquad (12)$$

here N_{ci} – number of cells assigned to i-$IBTS_c$.

Even if

$$\sum_{i=1}^{D(t)} N_{ci} = N_L; \qquad (13)$$

The numbers $\{N_{ci}\}$ should be optimized. For this reason each j-variant of IBTS network $\{\Theta_j\}$ is modified additionally by forming several (Z_j) sub-variants: Θ_{i1}; .. Θ_{jg} .. Θ_{jzj}. From all $\{\Theta_{jg}\}$ the one $\{\Theta_o\}$ is selected, which has the smallest moment ($M_o(t)$).

Technical IBTS network structure

Since operation distances of local communication measures have little of influence on IBTS efficiency (transfer speed – high, channels with high throughput and interferences are insignificant in them), consequently it is possible to use the lines to form $\{S_i\}$ connections with $IBTS_c$ which would end at the large nodes $\{LAN_i\}$ with access equipment as an endpoints (Fig. 8).

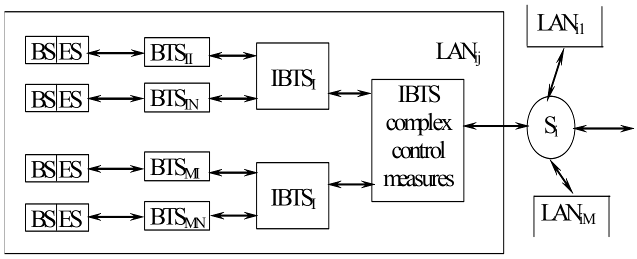


Fig. 8. Territorial part of IBTS network

BS and ES interface structure is presented in Fig. 9.

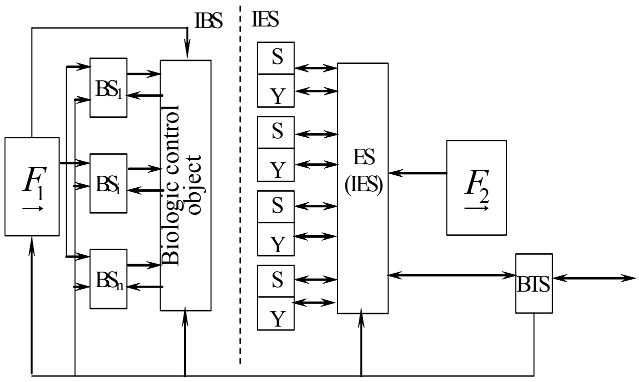


Fig. 9. BS and ES interface

BS and ES operate under sets of influence factors $\underset{\to}{F_1}$ and $\underset{\to}{F_2}$. $\underset{\to}{F_1}$ influences $\{BS_i\}$ or U biologic processes, which determine BCO states and its signaling measures. With the help of sensors (S) and influence measures (Y) IES interact with IBS. Separate control contours with their own receptive and influence means are used to control each process or each group of processes. Information is provided for ES (IES) through BTS interface. BTS performs systemic control of IBS and IES. External control of IBTS and LANCS is performed (see Fig. 6) through MCP and FCP. Technical measures of IBTS network are presented in Fig. 10.

In Fig. 10 DNS – Domain Name System. DNS server in such network is a program, which serves the address domain name system (DNS). This program is installed in constantly operating $IBTS_c$, which is connected to the

Internet. In order to maintain DNS server external visibility from Internet, $IBTS_c$ has to have the real IP address.

ES (IES) and BTS function in partly autonomous mode, by using information received from LAN servers. MCP and FCP measures are used to control it externally. When there is not enough information in LAN servers, a DNS server inquiry is made; these servers are controlled by their own FCP, an they are constantly updated and supplied with new information (through MAN, WAN). All $IBTS_c$ maintain connection over these networks. Practically, their databases can be identical. When one $IBTS_c$ fails, the same services can be provided by another system (from $\{IBTS_{ci}\}$).

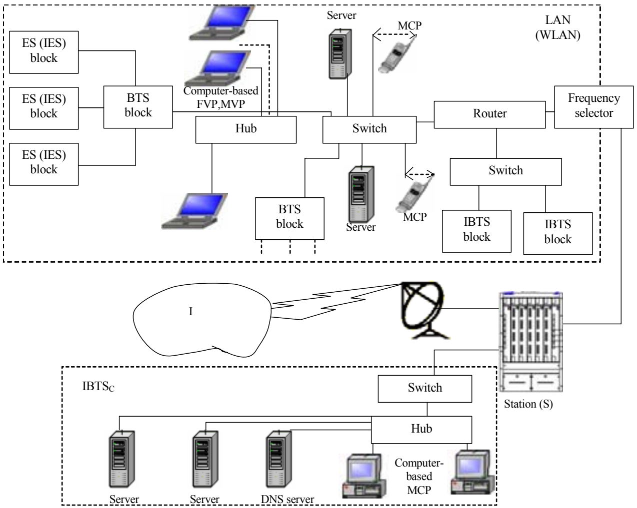


Fig. 10. Connection of IBTS network components (measures) (WLAN – wireless LAN)

Scheme of IBTS network presented in Fig. 10 is not the only possible variant. It can be modified, and new components can be added to it. It is only a structure, demonstrating component interconnections and operation principles.

Efficiency of IBTS network

Structure of IBTS network presented in Fig. 10 is selected for further investigations. Each component in it is characterized by task accomplishment probability [2] (P_{S1}, ..., P_{SM}, P_{BT},...P_D) (Fig. 11) and connections between endpoints of these component series are foreseen. There can be other connection combinations also.

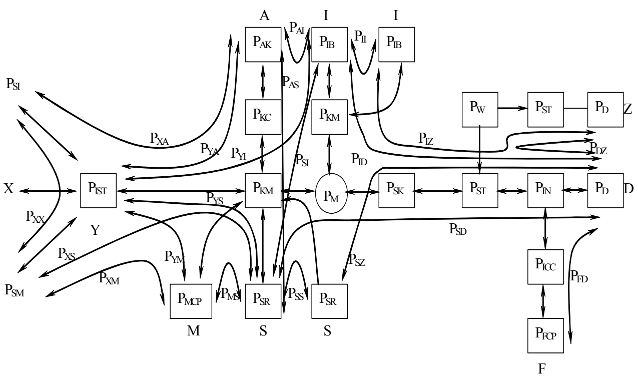


Fig. 11. Scheme of possible component interconnections

Task accomplishment probability matrix (P) is formed.

$$P=\begin{vmatrix} P_{XX} & P_{XY} & P_{XM} & P_{XS} & P_{XA} & 0 & 0 & 0 & 0 \\ P_{YX} & 0 & P_{YM} & P_{YS} & P_{YA} & P_{YI} & 0 & 0 & 0 \\ P_{MX} & P_{MY} & 0 & P_{MS} & 0 & 0 & 0 & 0 & 0 \\ P_{SX} & P_{SY} & P_{SM} & P_{SS} & P_{SA} & P_{SI} & P_{SD} & P_{SZ} & 0 \\ P_{AX} & P_{AY} & 0 & P_{AS} & 0 & P_{AI} & 0 & 0 & 0 \\ 0 & P_{IY} & 0 & P_{IS} & P_{IA} & P_{II} & P_{ID} & P_{IZ} & 0 \\ 0 & 0 & 0 & P_{DS} & 0 & P_{DI} & 0 & P_{DZ} & P_{DF} \\ 0 & 0 & 0 & P_{ZS} & 0 & P_{ZI} & P_{ZD} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & P_{FD} & 0 & 0 \end{vmatrix}. \quad (14)$$

Since protection measures are not provided in this scheme (protection structure can be developed separately), and IBTS processes (as it was already indicated) are relatively slow, it can be assumed that most of component interconnections (P_{XX}, …, P_{XA}, …) will not have a high load and their reliability will be sufficient. Thus it can be assumed that

$$P_{XY} \approx P_{YX}; P_{XA} \approx P_{AX}; ....P_{FD} \approx P_{DF}; \quad (15)$$

Then

$$P_{XX} = P_{S1} \cdot P_{BT} \cdot P_{SM} \approx P_S{}^2 \cdot P_{BT}; \quad (16)$$

$$P_{XA} = P_S \cdot P_{BT} \cdot P_{KM} \cdot P_{KC} \cdot P_{AK}; \quad (17)$$

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$$P_{YI} = P_{BT} \cdot P_{KM} \cdot P_M \cdot P_{KM} \cdot P_{IB} = = P_{BT} \cdot P_{KM}{}^2 \cdot P_M; \quad (18)$$

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$$P_{SZ} = P_{SR} \cdot P_{KM} \cdot P_M \cdot P_{SK} \cdot P_{ST} \cdot P_W \cdot P_{ST} \cdot P_D = = P_{SR} \cdot P_{KM} \cdot P_M \cdot P_{SK} \cdot P_{ST}{}^2 \cdot P_W \cdot P_D; \quad (19)$$

here P_W – task accomplishment probability of Internet (see Fig. 5).

Significance coefficient matrix (η) of interconnections is formed.

$$\eta=\begin{vmatrix} \eta_{XX} & \eta_{XY} & \eta_{XM} & \eta_{XS} & \eta_{XA} & 0 & 0 & 0 & 0 \\ \eta_{YX} & 0 & \eta_{YM} & \eta_{YS} & \eta_{YA} & \eta_{YT} & 0 & 0 & 0 \\ \eta_{MX} & \eta_{MY} & 0 & \eta_{MS} & 0 & 0 & 0 & 0 & 0 \\ \eta_{SX} & \eta_{SY} & \eta_{SM} & \eta_{SS} & \eta_{SA} & \eta_{SI} & \eta_{SD} & \eta_{SZ} & 0 \\ \eta_{AX} & \eta_{AY} & 0 & \eta_{AS} & 0 & \eta_{AI} & 0 & 0 & 0 \\ 0 & \eta_{IY} & 0 & \eta_{IS} & \eta_{IA} & \eta_{II} & \eta_{ID} & \eta_{IZ} & 0 \\ 0 & 0 & 0 & \eta_{DS} & 0 & \eta_{DI} & 0 & \eta_{DZ} & \eta_{DZ} \\ 0 & 0 & 0 & \eta_{ZS} & 0 & \eta_{ZI} & \eta_{ZD} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \eta_{FD} & 0 & 0 \end{vmatrix}. \quad (20)$$

Values of significance coefficient values for interconnections are calculated considering what part of all network connections do connections between endpoints comprise, durations of these connections and other factors.

Generalized technical efficiency of overall IBTS network (E) is identified with its average task accomplishment probability at any time t ($P_u(t)$) and is calculated using the following formula:

$$E = P_u(t) = \sum_{\substack{i=1 \\ j=1}}^{\substack{j=m \\ i=m}} P_{ij}(t) \cdot \eta_{ij}; \tag{21}$$

here $P_{ij}(t)$ – accomplishment probability of the task, which has been formed between initial i-location and and j-endpoint, in time t; η_{ij} – significance coefficient of connection between initial i-location and and j-endpoint; m – number of interconnections realized in IBTS network (e.g. XY, … DF, …). It is possible to consider also connection durations [2], amount of transferred information and other factors when calculating E value.

Integrated information, object and licence protection systems can be added to this network.

Conclusions

It can be seen from the presented material, that during creation of BTS network creation of several hierarchical control levels is inevitable..

In order to provide these systems with information on a constant basis it is purposeful to create several central informational systems ($IBTS_c$) in this network.

Method presented in [2] can be applied when evaluating IBTS network efficiency.

With further development of IBTS network expansion possibilities research, it would be advisable to supplement presented complex of systems with various-purpose protection systems.

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A. Valinevičius, P. Balaišis, D. Eidukas, N. Bagdanavičius, E. Keras. Biotronic System Network Efficiency Investigation // Electronics and Electrical Engineering. – Kaunas: Technologija, 2006. – Nr. 3 (67). – P. 13 – 18.

Conceptions of biotronics (BT) and integrated biotronic systems (IBTS) have been presented. It was shown, that IBTS consist of biologic system (BS) and electronic system (ES). It was shown that in order to assess IBTS efficiency it is needed to investigate the interaction between BS and ES. In order to form IBTS interaction IBTS network was formed and several functions of this network were distinguished. Separate network structures were used for each of these functions and network efficiency evaluation methods were offered. Considering the purpose of IBTS the network centers were predicted. Optimization possibilities for the number of these centers and their placement were shown. IBTS network logical structure was formed in order to evaluate its technical efficiency. Efficiency calculation technique for IBTS network of this structure was presented. Ill. 11, bibl. 8 (in English; summaries in English, Russian and Lithuanian).

А. Валинявичюс, П. Балайшис, Д. Эйдукас, Н. Багданавичюс, Э. Кярас. Исследование эффективности сети систем биотроники // Электроника и электротехника. – Каунас: Технология, 2006. – № 3 (67). – С. 13 – 18.

Приведены определения биотроники (БТ) и интегрированных биотронных систем (ИБТС). Показано, что ИБТС составляют биологические системы (БС) и электронные системы (ЭС).Показано, что в целях оценки эффективности ИБТС необходимо моделировать содействие БС и ЭС. Для обеспечения качественного взаимного функционирования ИБТС построена сеть указанных систем, предусмотрены функции компонентов указанной сети. Предложен метод оценки эффективности сети ИБТС. Оговорены основные принципы выбора центральных ИБТС и рассмотрены их функции. Показана возможность и целесообразность оптимизации мест построения указанных центров на заданной территории. Составлена логическая блок-схема сети ИБТС. Приведены формулы для расчета эффективности указанной сети. Ил. 11, библ. 8 (на английском языке; рефераты на английском, русском и литовском яз.).

A. Valinevičius, P. Balaišis, D. Eidukas, N. Bagdanavičius, E. Keras. Biotronikos sistemų tinklo efektyvumo tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2006. – Nr. 3 (67). – P. 13 – 18.

Pateiktos biotronikos (BT) ir integruotų biotroninių sistemų (IBTS) sampratos. Parodyta, kad IBTS sudaro biologinė sistema (BS) ir elektroninė sistema (ES). Parodyta, kad, norint įvertinti IBTS efektyvumą, reikia tirti BS ir ES sąveiką. IBTS sąveikai užtikrinti sudarytas IBTS tinklas ir išskirtos kelios šio tinklo funkcijos. Kiekvienai iš šių funkcijų panaudotos atskiros tinklo struktūros ir pasiūlyti šio tinklo efektyvumo įvertinimo būdai. Atsižvelgiant į IBTS paskirtį, numatyti tinklo centrai. Parodytos šių centrų skaičiaus ir išdėstymo optimizavimo galimybės. IBTS tinklo techniniam efektyvumui įvertinti sudaryta loginė jo struktūra. Pateiktas šios struktūros IBTS tinklo efektyvumo skaičiavimo metodas. Il. 11, bibl. 8 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).