Functional Algorithm and Structural Switching of Special Automatic Telephone Information Equipment

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SUMMARY

In this present paper we consider the results of the planning of the special automatic inquiry information equipment (ANIE) for \( q \times 18 \) telephone service of a city automatic telephone exchange (ATZ) on the basis of the methodology (arrived at by the authors) of the logical synthesis of the block structure of the automated information equipment for public use (AIE-OA). Basic requirements of the controlling system are analysed, on which basis the functional algorithm has been put together for the controlling equipment and transmission adaptation equipment, which serve for the connection of the equipment to the ATZ.

The construction has been based on the specially designed equipment for 18-channel tape recordings.

The aim of the work is not only to provide the results of the design of a concrete ANIE, but also the laying down of several methodical basic directions in the design of the AIE-OA with varied application, principally using the methods of communications technology on one of the least elaborated stages of the planning, the block synthesis.

It is proposed that the final objective of the block synthesis of the AIE-OA be the assembling of the block functional diagram directly from the minimum form of the functional algorithm.

In this paper we have included the block functional diagrams of the general structure (Fig. 4) and of the transmission adaptation equipment (UAE) (Fig. 5), and also the basic diagram of the relay variant (perfected by the authors) of the UAE for use with the ATZ of the electromechanical type, for example A-29.

LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AIE-OA</td>
<td>automatic information equipment for public use</td>
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<td>ANIE</td>
<td>automatic inquiry information equipment</td>
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<tr>
<td>ANIE-FD</td>
<td>special automatic 18-channel inquiry information equipment for telephone service</td>
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<td>ATZ</td>
<td>automatic telephone city exchange</td>
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<tr>
<td>BAI</td>
<td>block for storing the information</td>
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<td>BFS</td>
<td>block functional diagram</td>
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<td>BKS</td>
<td>block for co-ordinating the control</td>
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<td>DP</td>
<td>service personnel</td>
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<td>EALB</td>
<td>apparatus for the starting position of the tape</td>
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<td>EVDP</td>
<td>equipment for connecting the DP</td>
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<tr>
<td>EVF (_i)</td>
<td>equipment for connecting the ( i )th KI, where ( i = 1,2,\ldots,K )</td>
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<tr>
<td>FF</td>
<td>functional requirement(s)</td>
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<td>IE</td>
<td>information equipment or facility(facilities)</td>
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<td>IESK(_DP)</td>
<td>individual equipment for controlling the channel of the DP</td>
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<tr>
<td>IESK(_m)</td>
<td>individual equipment for controlling the ( m )th channel of the clients</td>
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<tr>
<td>KI</td>
<td>client, customer</td>
</tr>
<tr>
<td>KSK</td>
<td>switching system of the channel for serving the clients</td>
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<td>LB</td>
<td>logical conditions</td>
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<td>LFA</td>
<td>logical function of the algorithm</td>
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<td>LO</td>
<td>logical operations</td>
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<td>LS</td>
<td>light signal</td>
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<td>LSA</td>
<td>logical diagram of the algorithm</td>
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<td>SS</td>
<td>sound signal</td>
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<td>TSFA</td>
<td>tabulated written functional algorithm</td>
</tr>
<tr>
<td>UAE</td>
<td>transmission adaptation equipment</td>
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</tbody>
</table>

The proposed algorithms guarantee a greater operating reliability and convenience when working with the equipment.

1. INTRODUCTION

In [1] a generalized structural model of automated information equipment for public use (AIE-OA) was proposed. The model is shown in Fig. 1. The model is in reality a unified block diagram of equipment for automation of processes which are connected with serving a great number of people. These persons, called clients or customers [designated henceforth by the letters K], usually possess quite different or not adequate special qualifications. When it is necessary, specially instructed persons, who are designated service personnel [DP], can also participate in this system.

The diversity of the AIE-OA often creates significant difficulties in planning because there is no generalized methodology, especially for the initial stage of the planning, for the block synthesis. The impossibility, as the moment, of referring to a uniform methodology of the block synthesis of the diagrams of the automatic equipment makes it necessary to seek the solutions to this problem within the framework of the individual classes of the automatic equipment. Such a class is the proposed AIE-OA's.

A great proportion of AIE-OA's are constructed with the help of the means and components of telecommunications technology and find practical application in the most varied fields, e.g. for completing lines in business, government authorities, institutes, tourist and health resort establishments, public information offices and for automation of the teaching process or of inquiries of various kinds.
It is proposed that the block synthesis of the AIE-OA should comprise the following three stages:

STAGE A - Determining the basic requirements which in turn consist of the following phases:

A.1 Studying the existing position;
A.2 Studying the existing literature;
A.3 Formulating the basic technical requirements;
A.4 Selecting the structural modification and determining the information flows;
A.5 Formulating the functional requirements in the form of a written functional algorithm.

STAGE B - Construction of the logical diagram of the algorithm (LSA) with the phases:

B.1 Determining the logical function of the algorithm (LFA) for each regime;
B.2 Construction of the whole logical function of the algorithm (LFA);
B.3 Going over from LFA to LSA;
B.4 Minimizing the LSA.

STAGE C - Construction of the block functional diagram (BFS) with the phases:

C.1 Determining the concrete functional blocks on the basis of the structural modification selected;
C.2 Construction of the BFS.

Characteristics features in the block synthesis of the AIE-OA are principally connected with the phases A.4, A.5, B.1, B.2, B.3 and Stage C.

2. THE NATURE OF THE WORK

An example of AIE-OA is the special automatic 18-channel enquiry information equipment for the telephone service (ANIE-FD) planned under the guidance of the authors.

So as to be able to get a certain conception of the planned equipment (ANIE-FD), we can show the following basic technical requirements, determined in phase A.3:

1. The installation must simultaneously serve an unlimited number of clients-subscribers of the ATZ for M types of standard inquiry information which can be obtained with the help of the ordinary telephone set, after selecting the relevant characteristic number;
2. Let the maximum number of subscribers switched into one channel at the same time be S;
3. For storing the inquiry information the recording must be used on the 18-channel tape equipment specially produced for this purpose;
4. The possibility must exist for expanding the number of the various inquiry informations, namely M = q × 18, where q = 1, 2, 3, ...
5. The possibility must exist for the most convenient new recording of the informations; the new recording should be made by a service person (DP).

Phase A.4

It follows from what has been said above that:

\[ K_{\text{MAX}} = S \times M \gg 1; L = 1; M > 1 \text{ and } N = 1, \]

where

\[ K = \text{the number of clients}, \]
\[ L = \text{the number of service persons}, \]
\[ M = \text{the number of connection channels with the clients}, \]
\[ N = \text{the number of connection channels with the service personnel}. \]

Under these conditions the suitable modification of the structural model is selected from the table containing 20 variants in accordance with the algorithm given in [1]. This modification is shown in Fig. 2 and the abbreviations used can be found in the alphabetical list of abbreviations given at the start of this paper.

FIG. 1. GENERALISED STRUCTURAL MODEL OF AIE-OA

FIG. 2. MODIFICATION OF THE BASIC STRUCTURE OF ANIE-FD

We can see that the role of the block EVK, is played here by the telephone set of the \( k^\text{th} \) KL and the role of the block KSK is performed by the ATZ used. It is therefore not necessary to include these blocks in the basic structure of the installation. In this way we obtain the diagram shown in Fig. 3.

FIG. 3. OUTLET BLOCK SCHEMATIC OF ANIE-FD SHOWING THE ACTION OF INFORMATION SIGNALS

We also see that it is provided for that many 18-channel information facilities \( \varphi_y \) (\( y = 1, 2, \ldots \)) of the same type will be used. This gives the possibility of only considering one single information facility. In this way we achieve a significant simplification. Also indicated are the designations of the multitude of the information effects which are changed in the system. It is emphasized that the quantities \( X^a \) and \( Z^a \) of the \( m \)-channels correspond to the capacity of \( X^p \) and \( Z^p \) of the \( p \)-channel of the IE \( \varphi_y \) (\( p = 1, \ldots, 18 \)), whilst for the purpose of avoiding the multiplicity of designations the indices '\( m \)' and '\( p \)' are omitted where possible.
The equipment IESK \( j \) (\( j = 1, \ldots, S \)) has to adapt the work of the ANIE to the particular ATZ. We can therefore call IESK, transmission adaptation equipment (UAE). Because of the specifics of the work of the UAE, this equipment can be planned quite separately. Its work is determined by the type of the actual ATZ used. So, for example, when using an ATZ of the type A-29 (step-by-step system), or similar type, the UAE is characterized by the following input-output actions:

\[
C^p_{m} = \{c_1, \ldots, c_p\};
\]

- \( c_1 \): seizure of the UAE;
- \( c_2 \): preparation for metering a seizure;
- \( c_3 \): end of the seizure;
- \( d_1 \): permission for the seizure;
- \( d_2 \): confirmation of the seizure;
- \( d_3 \): end of the selecting;
- \( d_4 \): metering the seizure;
- \( d_5 \): sound information of the selected service performance of the channel "m";

For the switching in of the channel "p" of the equipment "y", i.e. for the switching in of the selected m-channel of the ANIE-OA:

\[
x^p = x^p = \{x_1, \ldots, x_u\}:
\]

- \( x_1 \): signal for the switching in of the channel "p" of the equipment "y", i.e. for the switching in of the selected m-channel of the ANIE-OA;

For the sound information of the channel "p", which information is transmitted to the ATZ by means of \( d_5 \) without additional processing:

- \( z_1 \): permission for seizure of the channel "p";

The Sender Channel of the DP transmits a number of control signals:

\[
E = \{e_1, \ldots, e_r\},
\]

- \( e_1 \): switching in of the equipment "y";
- \( e_2 \): switching out of "y";
- \( e_3 \): blocking the channel "p";
- \( e_4 \): unblocking the channel "p";
- \( e_5 \): selecting the number of the channel "p";
- \( e_6 \): selecting the number of the equipment "y";
- \( e_7 \): switch on to "record";
- \( e_8 \): switch off from "record";
- \( e_9 \): information for recording on the channel "m".

By means of EVDP this number of effects is converted into a number of electrical signals

\[
A = \{a_1, \ldots, a_u\}
\]

The Receptor Channel of the DP recognizes a number of system conditions \( R = \{r_1, \ldots, r_u\} \), which were produced after the conversion of the number of electrical signals

\[
B = \{b_1, \ldots, b_u\}.
\]

The following signals are provided for:

- \( r_1 \): light signal (LS) "channel free";
- \( r_2 \): LS "channel occupied";
- \( r_3 \): LS "low level of the channel";
- \( r_4 \): sound signal (SS) "low level";
- \( r_5 \): LS "record";
- \( r_6 \): LS "attention";
- \( r_7 \): LS "start";
- \( r_8 \): indication of the level of the recording;
- \( r_9 \): indication of the elapsing time;
- \( r_{10} \): SS for monitoring the recording in channel "p";

- \( r_{11} \): LS "disturbance in the current supply of the IE "y";
- \( r_{12} \): LS "disturbance in the BAI of the IE "y";
- \( r_{13} \): SS "damage!".

The analysis shows that the signals defined by the set \( Y = \{y_1, \ldots, y_p\} \) should not be processed in IESDP. They are sent directly to the BKS with the help of the quantity \( A \). By analogy, the effects \( f_i \) of the set \( F = \{f_1, \ldots, f_r\} \) are, as far as content is concerned, identical to the effects \( b_i \) of the quantity \( B \) for \( i = 1 \) to \( 10 \). The content of the remaining effects is as follows:

- \( f_{11} \): switching in of a chronometer;
- \( f_{12} \): pulse for metering the recording time;
- \( f_{13} \): pulse for zeroing the chronometer.

On the basis of the work performed in phases A.1 and A.2 it was proved that special equipment is necessary for magnetic multi-channel recording. This equipment plays the role of the BAI and operates on two standardized magnetic 9-channel tapes with a width of 1/2", i.e. 12.7 mm. We call "tape A" the tape for the channels 1 to 9 and "tape B" the tape for the channels 10 to 16. In this situation the work of the BAI is characterized by the sets

\[
K = \{x_1, \ldots, x_u\} \quad \text{and} \quad A = \{a_1, \ldots, a_u\},
\]

as follows:

- \( 1 \): switching on the electric motor, common to the 2 tapes (A and B);
- \( 2 \): switching on the movement of tape A;
- \( 3 \): switching on the movement of tape B;
- \( 4 \): switching on the equipment for controlling the start of tape A;
- \( 5 \): the same for tape B;
- \( 6 \): selecting the desired track for the recording;
- \( 7 \): sound information for the recording on channel "p";
- \( 8 \): play-back of the information from channel "p";
- \( 9 \): tape A is in the starting position;
- \( 10 \): tape B is in starting position;
- \( 11 \): metering pulses from tape A;
- \( 12 \): metering pulses from tape B;
- \( 13 \): signal "disturbance in BAI".

Phase A.5

Before the functional requirements (FF) are formulated in the form of a written functional algorithm, it is necessary to determine the work regimes of the AIE-OA. After that a written description is compiled for each regime. For the sake of simplicity, ease of reading and standardization this description appears in the form of a table, as shown below.

<table>
<thead>
<tr>
<th>FF No.</th>
<th>Index of the LB</th>
<th>Written Description Of The Function</th>
<th>Content of the LB</th>
<th>Content of the LO</th>
<th>Index of the LO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
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123-3
Each functional requirement (FF) is numbered with the index "m" (n = 1, 2, ...), and is described in writing in columns 3 and 4. The description itself starts with a series of logical conditions (LB), which are specific for the particular FF. The description of each LB starts with the word "if..." and the connection between the LB's is expressed with the logical conjunction (AND, OR, etc.).

The description of the LB's is shown in Column 3. Column 4 contains the description of the logical operations (LO) provided for in the given FF. These operations should be carried out straight after each other or simultaneously, i.e. without knowing the LB's. It is appropriate to start the description of each LB with the words "we should...". After ending the whole description for a given regime the LB's and the LO's are designated with the associated indices P1 and A and columns 2 and 5.

It is proposed that this writing up in tables be called tabulated written functional algorithm (TSFA). In the case of more complicated equipment the compiling of the TSFA is carried out in steps as the description becomes more and more detailed.

In planning the ANIE-FD the following basic regimes are accepted:

Regime I - normal working regime;
Regime II - recording on channel "m";
Regime III - regime of damage.

Because of a lack of space the actual TSFA's are not used here for ANIE-FD.

STAGE B - Composing the Logical Diagram of the Algorithm (LSA)

The proposed writing up in the form of a TSFA is appropriate and convenient because it gives the possibility for immediately determining the logical functions of the algorithm (LFA). The LFA's are expressed in the form of:

\[ F = \ldots A_1 Y_{1j} A_j Y_j A_2 \ldots , \]

where \( \phi_{1j} \), \( \phi_j \), etc. are Boole's functions of the logical conditions \( \phi_0 \), \( \phi_1 \), \ldots \( \phi_n \) and \( A_1 \), \( A_j \), \( A_2 \), etc. are the logical operators which are executed in a given phase of a certain regime. The LSA of the regime is put together from the individual LFA's. The overall LSA of the equipment is put together from these individual LSA's. Furthermore, we must as we know perform the corresponding minimization in accordance with known methods [2, 3 and others].

The LSA's introduced by Lyapunov [4] represent an extra-ordinarily convenient mathematical technique for describing the functioning of the varied equipment and systems for processing the information. The description of the operation of the systems, which have been put together from the polyfunctional blocks or include a person as a direct participant in the process development (the cases that are characteristic for the ANIE-OA) is fairly convenient and clear when using the LSA.

For the equipment planned by us we obtained the following minimal forms of the LSA's of the individual regimes:

For Regime I:

\[
\Omega_1 = \begin{bmatrix}
P_1^2 & A_{2A_3} & P_3^3 & A_{6A_9} & P_6^6 & A_{12}\omega \\
2 & A_7 & A_{80} & 4 & 7 & A_{5A_6} & 8 & A_7\omega \\
5 & A_4 & A_{11} & 6 & 7 & A_8 & 8 & A_8\omega \\
\end{bmatrix}
\]

For Regime II:

\[
\Omega_{II} = \begin{bmatrix}
P_1^2 & A_{2A_3} & P_3^3 & A_{12A_9} & P_6^6 & A_{15A_6} & A_{17A_18} & A_{19} \\
2 & 1 & A_{14} & 3 & A_{16} & 4 & 5 & P_1^5 \omega \\
6 & P_1^6 & 1 & A_7 & 3 & A_8 & 4 & P_1^5 \omega \\
- & (A_{2A_3}) & A_{5A_9} & 1 & 5 & A_{19} & 6 & (A_{2A_3}) & \omega \\
\end{bmatrix}
\]

For Regime III:

\[
\Omega_{III} = \begin{bmatrix}
P_1^2 & P_4 & A_{3A_5} & A_{5A_9} & P_6^6 & A_{12A_6} & A_{17A_18} & A_{19} \\
2 & 6 & 3 & 4 & 5 & 6 & A_1 & \omega \\
- & A_{5A_7} & A_{12} & \omega & P_5 & 5 & 6 & A_{17} & \omega \\
\end{bmatrix}
\]

The following designations for the LB's and for the LO's have been used:

a. Logical Conditions:

- P1 - is the equipment "y" switched on?
- P2 - is there at least a signal "x_i"?
- P3 - is the channel "p" blocked?
- P4 - is there a signal "x_1"?
- P5 - is the level of the channel "p" normal?
- P6 - is there a signal for manual blocking?
- P7 - is there a selected channel for the recording?
- P8 - has the signal "e_p" been introduced?
- P9 - has the signal "e_p" been introduced?
- P10 - has the signal "e_p" been introduced?
- P11 - has the signal "e_p" been introduced?
- P12 - is the tape A (or B) in the starting position?
- P13 - does tape A (B) reach the starting position for the second time?
- P14 - is there a fault (disturbance) in BAI?
- P15 - is there a disturbance in the power supply?
- P16 - has the signal "e_p" been introduced?
- P17 - has the signal "e_p" been switched in?

b. Logical Operators:

- A0 - starting position (readiness);
- A1 - switching on the equipment "y";
- A2 - switch on the electric motor;
- A3 - switch on the movement of the tape (A or B);
- A4 - switch on the signal "r_1";
- A5 - switch on the signal "r_2";
- A6 - transmitting of "e_p";
- A7 - blocking of channel "p" in the case of damage;
- A8 - seizure of channel "p" is forbidden!
- A9 - switch off the signal "r_1";
- A10 - switch on the signal "r_3";
- A11 - switch on the signal "r_4";
- A12 - manual unblocking of channel "p";
- A13 - switch on the command "e_p";
- A14 - switch on the signal "r_10";
- A15 - switch on "r_5";
- A16 - switch on the apparatus for the starting position of the tape (EALB) - A or B;
- A17 - switch on the chronometer;
- A18 - working out a signal to zero the chronometer;
- A19 - switch on the signal "r_6";
- A20 - switch on the track for recording;
- A21 - switch off "e_p";
- A22 - switch on "r_7";
- A23 - switch on "r_8";
- A24 - switch on "r_9" (A2);
- A25 - switch on "r_8";
- A26 - introduce "e_p";
- A27 - protective blocking of channel "p";
- A28 - switch off the track for recording;
A29 - switch off the EALB;
A30 - switch off the chronometer;
A31 - switch on "r12";
A32 - switch on "r11";
A33 - switch on "r13";
A34 - automatic switching off of the equipment "y";
A35 - all the channels of the equipment "y" are blocked;
A36 - switch off "r11", "r12" and "r13".

On the basis of LSA (1), (2) and (3) the following minimum form of the LSA of the ANIE-FD was obtained:

$$\Phi_0 = \frac{1}{P_1} \frac{2}{P_2} \frac{2}{P_3} \frac{4}{P_4} \frac{5}{P_6} \frac{A_{36}}{A_{35}} \frac{A_{34}}{A_{33}} \frac{A_{32}}{A_{31}} \frac{A_{30}}{A_{29}}$$

The operation B2 is split up into the following operations B2 → B2' → B2'' to be performed consecutively, i.e. B2 = B2' B2'' .

Fig. 6 shows the basic diagram of the UAE for ATZ of the type A-29 [3]. The UAE is characterized by increased operating reliability, since the need for relays with greater delay has been eliminated here. It is known that with other circuit solutions large delays can be achieved with the help of capacitors having a greater capacitance and lower operating reliability.

3. CONCLUSION

On the basis of a concrete example, ANIE-FD, planned by and experimented with under the guidance of the authors, some basic methodological approaches are considered in the creation of the AIE-OA with the help of the techniques and components of communications technology in the stage of the logical synthesis of its block structure. The construction of the block functional diagram (BFS) of the type shown in Fig. 4 and 5 is proposed as the objective of this stage. This diagram is directly obtained from the minimized form of the overall logical diagram of the algorithm (LSA) of the equipment to be planned.

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