it and application at result obtaining. Such approach solves the problem of rapid preparation of agenda (chained list of rules ready for being fulfilled).

And, finally, preliminary detection of logic chains by cellular automaton reduces time for checking out consistency of system of rules when adding new rules into knowledge base. Really, the added rule if it is not includ-

ed into already stored logic chain may be consistently connected both to beginnings of one or several chains and to the end of some chain. Additional checks are not required.

Thus, cellular automaton application as inference machines opens capacity of increasing efficiency of work with bases of knowledge of industrial expert systems.

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STUDYING THE SYSTEM OF PIPE HEADER TELEMECHANICS ON THE BASIS OF COMMUNICATION NETWORK OF GSM STANDARD

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Studying the system of pipe header telemechanics on the basis of communication network of GSM standard has been covered, the results of experiments for two services of GSM have been given. The way of increasing system response speed is suggested and GSM is compared with other services applied at the present in pipe header telemechanics systems.

Different companies all over the world propose solutions on the basis of GSM for tasks of accounting energy resources, navigation, telemetry, logistics, safety etc. [1–3].

Let us enumerate the main services of network of standard GSM: SMS, mode Data call and mode GPRS [4].

SMS (Short Message Service) finds wide application in industrial systems owing to low cost, simplicity in use and convenient service. The disadvantage of this service is limitation in length of massage (not more than 140 bytes). SMS are convenient at small volume of transferred data. For example, electricity meter may be interrogated once in a day.

Mode Data call is identical in its characteristics to general voice mode but in this case not coded voice signal is transferred but user data. Maximal transfer rate (which is constant during the whole communication session) equals to 9600 byte/s.

GPRS is the technology of batch communication (General Package Radio Service) in networks of GSM. The feature of this mode is in the fact that after connection payment is actually transferred information content is paid but not the time of connection.

Let us examine the system of telemechanics of pipe header linear part. It includes several control points (CP) set at pipeline in each 10...15 km and one control station (CS), Fig. 1.
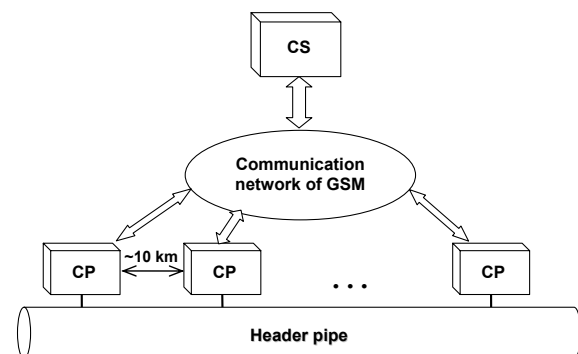

Fig. 1. *Diagram of the system of telemechanics using communication network of GSM standard*

In telemechanic systems (TS) all or some kinds of control information may be transmitted. Transferring information only on values of object parameters the TS is called the system of telemetering system (TM); in remote signaling system (RS) the information on the possible state (usually of two ones) of the controlled object is mainly transferred; in telecontrol system (TS) only control commands are transformed. In combined TS information of two types is transffered, for example, measuring and signaling (TM – TS), control and signaling (TC – TS). In complex TS control information of all types (TC – TS – TM) may be transffered.

Data of TC, TS and TM have the following properties (Table 1).

Table 1. *Properties of data transffered in the system of telemechanics*

Property	TM	TS, TC
Volume	Large	Small
Delivery time	Less critically	More critically
Delivery reliability	Standard requirements	Raised requirements

In the examined system control commands are transferred from CS to CP (TC) and backwards – data required for control (TM and TS). Thus, the examined system is a complex telemechanic system.

Studying the existing developments showed that new complex system of telemechanics on the basis of GSM is should be developed [5].

These are the main properties of the system of telemechanics of header pipe:

a) reliability;
b) validity;
c) speed;
d) efficiency;
e) economy;
f) immunity of transferred information.

To estimate the speed of the system of telemechanics they apply the time of:

- obtaining signals of TM from all CP;
- delivering one signal of TS, TC.

For making preliminary conclusion on possibility of developing the systems of telemechanics of header pipe on the basis of communication of GSM standard the experimental investigation of system layout was carried out.

The layout included communication controller and CP controllers of linear telemecanics of the company «EleSi», Tomsk [6]. GSM modem Siemens TC35i Terminal was connected to each controller.

Investigations were carried out using the service Data call of operator of network of GSM standard «VympelCom» (trade name «Bee Line»).

The research program consisted of three series of experiments carried out in different time. Each series included transferring of remote signaling, telemetring (which were transferred per one communication session with CP) and telecontrol and in this case the time of signal transfer was measured in each experiment. The amount of experience in each series for each signal type was equal to 10.

The sum time for interrogation of one CP amounted to 23 s minimum, maximum – 41 s and at the average – 32 s.

As a result of carrying out the preliminary investigation the conclusion was made that system layout is operable and it is appropriate to develop the system of telemechanics on the basis of communication of GSM standard [7].

The following suggestions on improving system characteristics were stated as well.

1. To study the possibility of reducing time of CP interrogation.
2. To search for ways of reducing time of control command delivery.
3. To provide for protection of information in the system.

The third task was covered in other published works [8, 9], let us dwell at length on first two.

Other services of transferring data given by operator: SMS and GPRS were considered as the alternative to Data call.

Characteristics of services given by «VympelCom» (trade name «Bee Line») in Tomsk were studied as in preliminary investigation. The carried out experiments showed that minimal delivery time of SMS equals to 7 s. Reliability of the service GPRS turned out to be unsatisfactory (due to high frequency of errors and releases of connection) and this service was excluded of examination.

Let us compare indices of speed when using services Data call and SMS.

Let us consider typical system of telemecanics of header pipe consisting of five CP and one CS as an example. Let it be so that it is necessary to obtain TM data with volume of 1 kilobyte and TS data of 10 signals each signal dimension is 1 byte from each CP. It is necessary as well to transfer 10 signals of TC (1 byte) to each CP.

The computed values of speed indices for this task using services Data call and SMS are given in Table 2.

Table 2. *Values of speed indices for services Data call and SMS*

Network service GSM	Time of obtaining signals of TM from all CP, s	Delivery time of one TS,TC signal, s
Data Call	140	27
SMS	280	7

It is seen from the Table that Data Call wins by the first index and SMS, on the contrary, by the second one.

To improve system speed the following solution was suggested: to transfer TM signals by Data call and TS, TC signals by SMS.

Communication of GSM standard is a fundamentally new kind of communication for automation of header pipe. Till this moment the tone frequency channels (TFC) and fiber-optic communication lines (FOCL) became widespread in telemecanics systems of header pipe. In both cases communication channels are dedicated and GSM network, on the contrary, is the public network.

In TFC and FOCL owing to their physical nature connection time (which is the main GSM disadvantage) is almost absent. However, data transfer rate for TFC at industrial use does not exceed 2400 byte/s, as a rule, as the requirements for rates higher than the stated one are not stipulated by standard acts [10]. The comparative diagram of dependence of information transfer time on its amount for TFC and GSM is given in Fig. 2.
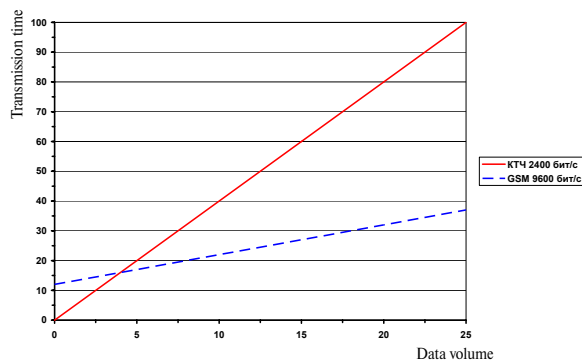
Fig. 2. *TFC and GSM. Comparative diagram of transmission time dependence on data volume*

The diagram shows that at data volume less than 4 Kbyte GSM loses to TFC because of connection time. At volume 4 byte both kinds of communication support similar speed. And at higher volumes it is observed that the higher data volume the greater gain GSM use gives due to 4-fold advantage in transfer rate.

Communication of GSM standard has higher speed and reliability than satellite communication Globalstar used in some cases as a cached circuit. Connection time for Globalstar amounts about to a minute and for GSM it is just 12 sec. Due to the fact that not all satellites are carried into orbit sometimes there is no communication at all during 1...2 h at Globalstar use.

One of the principle advantages of GSM is simplicity and rate of implementation of this kind of communication. In this case sinking of expensive cables and frequency licensing are not required that is typical for radio modifications. It is necessary only to buy GSM stations with antennas, SIM-cards and connect them to the controllers.

GSM communication is also rather cheaper than all other kinds of communication used at the present for automation of header pipes. GSM wins both in equipment cost and operating cost. The comparative Table with approximate annual costs for operation of different kinds of communication for servicing one CP at data volume of TM 3 Kbyte (Table 3) is given below. Computation was made on condition that TM data are transferred each hour.

Table 3. *Comparison of annual costs for operation*

Kind of communication	Cost, th.r./year
Lease of dedicated TFC	20
Globalstar	300
GSM	1,7

A sum of TFC operation was approximately computed for the length of communication section of 10 km. Computation for GSM was made by charge rate «Korporatsiya-1» 1,41 rouble per minute of airtime.

On the basis of the results of studying the telemechanics system characteristics on the basis of GSM and comparison with other kinds of communication the following conclusion may be made. It is reasonable to use GSM communication for header pipe automation in regions where it is impossible or economically inefficient to skin cable communication lines and as a cached communication circuit at very dangerous sections of pipelines as well [11].

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