Data collection system design in SSM networks with unicast feedback – server message definition

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Abstract: The system for mass data collection with cumulative acknowledge is described in this paper. A server message for cumulative acknowledgement is specified. The system is development for single source multicast networks. These networks are characterized by the ability to communicate with concrete network nodes. The groups of nodes are possible to create in these networks. It makes these networks more efficient than the any source multicast networks. The purpose of the first part is to design and describe the system. In the next part are the possible process mechanism discussed. We also introduce an initialization, synchronization and the message transfers. In last part, we discuss a future work.

Key-Words: - SSM and ASM networks, unicast feedback, data collection, RTP, RTCP

1 Introduction

Systems of bulk data acquisition are currently made use of in gathering measured quantities, monitoring and administration of terminal elements. This has to do with the fact that most systems of bulk data acquisition have their centre unit at a great distance from individual communication units. Today the use of the Internet network as the basic communication channel for bulk data acquisition can be seen as the most promising. The main advantages of the Internet are its world-wide deployment and the use of the TCP/IP protocol series. Here the design of a bulk data acquisition system is described that employs the Internet for the transmission of the data acquired. Similar procedures can also be applied in other networks, e.g. GSM. The main elements of the system are the centre unit and the individual acquisition units, which will regularly send the data measured. After receiving a certain amount of data the centre unit will dispatch a cumulative acknowledgement. In the proposed system this acknowledgement is based on multicast transmission. This is also the principle of bulk acknowledgement for the units that form part of the multicast group. The main advantage of this solution consists in the lower burden on the transmission network. The centre unit need not send a separate acknowledgement to each acquisition centre; it will send one acknowledgement to all the units at the same time. The protocol used for bulk data acquisition and cumulative acknowledgement starts from the RTP/ RTCP multimedia protocol and the IPTV transmission.

2 Types of transmission

In IP networks we distinguish two basic methods of directional transmission. The first, older method is the unicast. The other method, currently going through considerable development, is the multicast method.

2.1 Unicast

Unicast is a method for sending information from one source to one target. There is only one source and one target at one instant of time in the unicast system. Today, it is the most frequently used method of communication.

2.2 Multicast

Multicast is a method for sending data which enables sending the same information to more recipients simultaneously and thus avoiding redundant connections. This model can be characterized as multidirectional transmission with the difference that the packet sent is designed for specific recipients only. Currently there are two methods for implementing this principle. Basically multicast became a basic for a mass communication is sensor and ad hoc networks [1], [2] and data acquisition [3].

2.1.1 Any Source Multicast

One method is the “many-to-many” method, or “Any Source Multicast” (ASM) [4]. ASM is a method for creating the distribution tree that allows any communicating point to send a simultaneously receive packets. Each point in this network therefore behaves as a source and simultaneously as a recipient (a client) of transmission.

Routers, which are part of the distribution network, make for each communication path copies of these packets for every receiver on this path. Terminal stations themselves will decide whether they will accept the packet or refuse it. If a new node needs to be included in

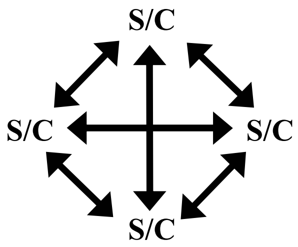

Fig. 1. Multicast process type ASM

the ASM group, all the communicating stations are informed about it. The process is presented in Fig. 1. It is evident that the routes are loaded out of all proportion and therefore this method of implementation is not suitable for large networks; it is only used in small experimental networks.

2.1.2 Single Source Multicast

The other method of implementation is the "one-to-many" method, or "Single Source Multicast" (SSM) [5]. This method starts from the ASM method. SSM can be used only on the assumption that there is only one source of multicast transmission in the given multicast group while the other members of the group are recipients. SSM can thus be exploited for technologies such as IPTV, Internet radio, etc. At the recipients end this method of communication is secured such that the recipient will provide the multicast address for data reception and the unicast address of a specific source of transmission.

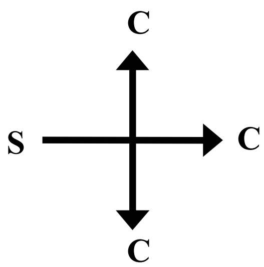

Fig. 2. Multicast process type ASM

All the routers must be appropriately configured for the given transmission. SSM communication is illustrated in Fig. 2. An advantage of SSM consists in that data are sent to specific recipients only and the network is thus not loaded with redundant operation.

3 Incorporation of application layer protocols into multicast

Multicast networks are mostly used for multimedia services, IPTV and Internet radio in particular. To provide multimedia data transmission, these services employ the H.323 protocols specified by ITU-T (International Telecommunication Union, Telecommunication Section) [6] and the SIP (Session Initiation Protocol) specified by IETF (Internet Engineering Task Force) [7]. The RTP and RTCP protocols are employed for the transmission of multimedia data [8].

In the area of bulk data acquisition systems, however, the situation is somewhat different. Today, there is no standardized solution. Admittedly, there are several proprietary protocols such as the DLMS [9] and VDEW [10] protocols used in power engineering. Most of such protocols, however, are designed for only one specific solution or they are in the stage of development. Generally speaking, bulk data acquisition protocols have in the TCP/IP hierarchical model the same standing as protocols for multimedia data transmission. Their position is shown in Fig. 3.

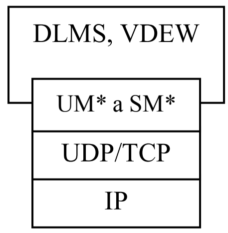

Fig. 3. Protocols for measurement of power engineering data

3.1 RTP/RTCP

In multimedia data transmission the RTP/RTCP protocols are most often used. The RTP (Real-time Transport Protocol) [8] defines the format of packets used for the transmission of audio and video data via the Internet. RTP allows the transmission of any data in real time, such as interactive audio or video. The RTP protocol was originally designed as multicast protocol but it can also be used in a number of unicast applications. For the transmission of multimedia data it employs the UDP (User Datagram Protocol) on the transport layer.

The control protocol, which works in connection with the RTP protocol, is the RTCP protocol. The RTCP extended for SSM networks serves the transmission of the feedback, i.e. informing the source about the state of multimedia data being received [11]. The transmission of RTCP messages is implemented in the form unicast.

The aim does not consist in direct deployment of multimedia protocols in bulk data acquisition systems. In principle, however, these two kinds of transmission are to a certain extent similar and therefore we will make use of only their basic mechanisms or the mechanisms of the RTCP protocol for the deployment in mass data acquisition system with our own implementation of transmission protocols.

Types of RTCP packets:

- Server report (SR) statistics of the number of data transported from the multimedia transmission source to the target.

- Receiver report (RR) reciprocally transported data from the target to the data source.
- Bye packet (BYE) announcement of the termination of terminal point communication.
- Application function (APP) information about individual applications.
- Source description (SDES) information about the source.

3.2 RTCP protocol time sequence
As mentioned above, in an SSM network the RTCP provides the feedback with information on the reception quality of the multimedia application. In the standard RTCP protocol two types of message are assumed. Messages can be sent as often as necessary. Since the RTP protocol takes up most of the data flow for sending multimedia, a minimum bandwidth is reserved for the transmission of RR or SR messages. A total of 5% of the overall network transmission capacity is reserved, 3.75% for the transmission of RR packets, and 1.25% for SR packets. In view of this recommendation the protocol algorithm calculates the interval between RTCP packets and the number of communicating members [12].
Definite periods of time have been fixed for the sending of SR and RR signaling messages. For SR messages, this period has been calculated on the basis of the relation

$$T'_{SR} = \frac{SR}{0{,}25 \cdot BW_{RTCP}} \quad (1)$$

where SR is the average size of RTCP packet in the direction from transmitter to receivers, BW_{RTCP} is the bandwidth reserved for RTCP operation, and n is the number of recipients in the given network.
The period for transmitting RR messages has been determined according to the relation

$$T'_{RR} = \frac{RR}{0{,}75 \cdot BW_{RTCP}} \cdot n \quad (2)$$

where RR is the average size of RTCP packet in the direction from recipients to transmitter, BW_{RTCP} is the bandwidth reserved for RTCP operation, and n is the number of recipients in the given network.
In practical testing it has been established that the RETP/RTCP protocol does not make effective use of the bandwidth allocated. If there are only a few receivers in the network, the time between individual messages is too short and, conversely, the average exploitation of allocated bandwidth is low. These problems led to the resultant period of time between RTCP messages being determined on the basis of relations described by equations 3 and 4. Since the aim is to distribute network operation uniformly in time, every period is multiplied by a random number $r \in (0.5; 1.5)$. This number is determined randomly for every period.

$$T_{SR} = \frac{\max\left(T'_{SR}, T_{\min}\right)}{e^{\frac{3}{2}}} \cdot r\,, \quad (3)$$

$$T_{RR} = \frac{\max\left(T'_{RR}, T_{\min}\right)}{e^{\frac{3}{2}}} \cdot r \quad (4)$$

where T_{min} is the minimum time spacing during which the data are sent.

4 Definition of System
The proposed system of bulk data acquisition is based on a modified RTCP protocol with feedback signaling channel. The proposed system is shown in Fig. 4. This principle was first used in the definition of feedback of RSI packets in the extended RTP/RTCP protocol [8], [11]. This idea became the basis of the design of the system being described. The central point of a multicast measuring group is the telemetric acquisition centre, which provides data acquisition from remote measuring units.

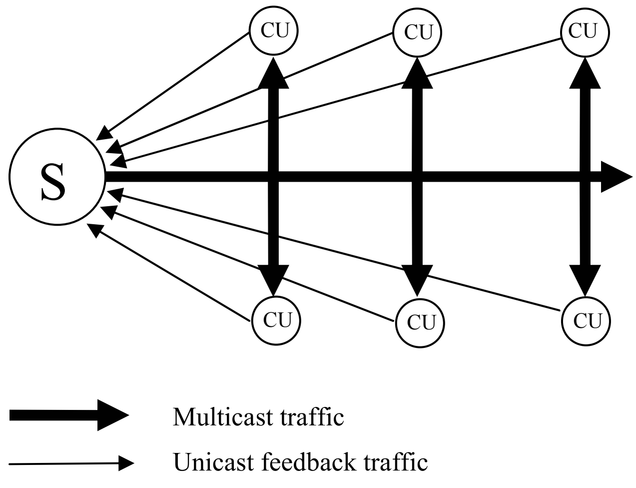

Fig. 4. Definition of bulk data acquisition

From the viewpoint of SSM communication, the acquisition centre plays the role of the generally known source. The measuring units perform the measurement proper of the quantity required and synchronization with current time. From the viewpoint of SSM communication, they are in the position of recipients, who know the specific multicast address for the given transmission, and the physical address of the source. The measuring units will send the measured data in fixed time intervals. The central unit will acknowledge the data received and

provide mutual synchronization of the centre and the units. To prevent excessive loading of the network, the data received will be acknowledged in the form of multicast cumulative confirmations, with the central unit simultaneously confirming/acknowledging several correctly received messages that contain the data measured.
The proposed protocol for the transmission of measured data and subsequent acknowledgement starts from the RTCP protocol. But inherent in the RTCP protocol are several functions that are superfluous for a system of mass data acquisition and therefore they will not be used in the system proposed. For example, the feedback with information about the state of the network is necessary primarily for multimedia services from the viewpoint of ensuring the quality of services. This parameter, however, is not important for the transmission of the data measured. Information regarding delays, fluctuation, etc. will thus not be used for the transmission of the data being measured. By contrast, for the transmission of data in systems of mass data acquisition there are two basic parameters that need to be provided, namely the availability of the target or the source, and delivery acknowledgement.

5 Types of communication message

We have defined the basic types of communication message in the system. By their nature, these messages are divided into:

- messages sent from the communication units to the centre, which always carry the prefix UM (unit message),
- messages sent from the direction of the server of acquisition centre towards communication units. These always carry the prefix SM (server message).

5.1 Unit message

Messages denoted UM serve transmitting in the direction from communication units to a central element. It is obvious from the above definition that the transmission of these messages runs on the unicast principle. Messages are addressed to the physical address of the collection centre. Two types of unit message are distinguished.

5.1.1 Unit Message – Measured Values

Type UM-MV message is designed to send the measured values from communication units to the collection centre. The central unit receives these messages and can subsequently store them in database for further processing. For the received messages containing measured data the central unit generates cumulative acknowledgment.

5.1.2 Unit Message – Synchronization Message

These messages serve to synchronize the communication units with the collection centre. By sending a UM-SY the communication unit initiates the synchronization process and as a response to this message it expects an SM-SY from the central unit. With the M-SY received, the communication unit has been successfully synchronized. There are tree subtypes defined for the UM-SY:

- UM-SY-1 (Init) – message that initiates synchronization; the communication unit sends it to the centre.
- UM-SY-C (Confirm) - message confirming successful synchronization; the communication unit sends it after successfully receiving the UM-SY-1.
- UM-SY-B (Bye) – terminating message by means of which the unit terminates the synchronization process.

5.2 Server Message (SM)

These messages are sent in the direction from the centre to communication units. Two types of Sender Report messages are distinguished. One SM message, of the SM-CA type, serves cumulative acknowledgement. The other SM message is an application packet used for unicast communication between the central server and a specific communication unit.

5.2.1 Server Message – Cumulative Acknowledgement

This type of message is designed primarily for cumulative acknowledgement. A queue of acknowledgement messages is formed for the individual messages received. After a certain period of time or after being filled with a specified number of acknowledgements the queue is sent in the form of multicast. The communication units capture these messages and on the basis of the respective name and timestamp they identify from these messages acknowledgement for the values they sent. In this way the network is made more economical because there is no redundant network operation. At this stage of the development of the system it is assumed that individual cumulative acknowledgements will be properly delivered. The problem of lost acknowledgement will be the subject of further development of the system.
The meaning of individual SM-CA fields is as follows:

- *Version* - protocol version 4 bits for identifying the protocol version.
- *Type* - type of packet. Three basic types are defined: SM-CA, SM-SY and SM-CI.

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 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Version|  subtype  |      TYPE      |         length            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ header
| Number        | group              |     reserved              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                          name_X (ASCII)                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ B1
|                          timestamp                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
|                          name (ASCII)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ B2
|                          timestamp                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+----
|                          name (ASCII)                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ Bn
|                          timestamp                             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+---
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Fig. 5. Format of SM-MV message

- *Subtype* - protocol subtype, the field is used to identify specific data. If the message contains the data measured, the subtype field will be filled with zeros.
- *Length* - the overall size of data being transferred.
- *Number* - the total number of acknowledgements carried by the given message
- Group denotes a specific meter group (electricity meter, gasmeter, water meter, and thermometer). The length of this block is 10 bits, which enables creating 1022 groups in one network. The 0th block and the last block are reserved for special purposes.

The header is followed by blocks for cumulative acknowledgement. These blocks are denoted B_1 to B_n, where n $\in$ (1; k) and

$$k\begin{cases} [k \in N; k \in (0; E_{\max})] \ \forall\ n < E_{\max} \\ k = E_{\max} \ \ \forall n \geq E_{\max} \end{cases} \tag{5}$$

where the coefficient E_{max} gives the maximum number of potential acknowledgements in one SM-PP message without the message being segmented. As an example we give the calculation of E_{max} for the Ethernet technology, where the defined maximum size of data space is 1500 B:

$$E_{\max} = \frac{1}{8}\left(ETH_{\max} - UDP_{header} - IP_{header}\right), \tag{6}$$

$$E_{\max} = \frac{1}{8}\left(1500 - 20 - 8\right) = 183. \tag{7}$$

The maximum number of acknowledgements that can be transported in one SM-CA has been derived from the maximum size of the data block in an Ethernet frame since within the proposed system the Ethernet technology will obviously be one of the most widely used technologies for the actual transfer of messages. The aim has been a maximally effective utilization of network facilities while simultaneously preventing segmentation.
Each block of the acknowledgement is made up of two 32-bit values. The first value is the identification of metering unit (name) and the second is the instant of time (timestamp) to which the given acknowledgement refers, i.e. when the measurement just acknowledged was performed. In this way as many as 183 acknowledgement blocks are filled, which are then sent by multicast to the network. All units that are members of the multicast group will process these packets. If the measuring unit encounters its name with the corresponding timestamp in the message, it means that the acknowledgement is designed for this particular unit. The unit will then reset the timer for testing the availability of the centre. In the opposite case, the unit will discard the packet and wait for the next acknowledgement message.

5.2.2 Server Message – Synchronization Message

These messages will serve to synchronize the centre with a specific communication unit. This synchronization is initialized by the communication unit and therefore the centre need not know at the beginning of communication the physical address of the unit. SM-SY messages are sent as responses to the UM-SY synchronizing initialization. Type SM-SY three defined subtypes:

- SM-SY-I (Init) – initialization message for acknowledging the actually initiated synchronization; it is sent by the centre in the direction to the unit.

- SM-SY-P (Parameters) – message that carries the control parameters necessary for the initial synchronization.
- SM-SY-B (Bye) – termination message; via this message the centre can terminate the synchronization process.

5.2.3 Server Message – Control

These messages serve multicast delivery of control information. Their specific application is derived from the current needs of the centre to inform all nodes simultaneously when a specific event occurs. An example of this type of event can be seen in overheads information of the central unit about the current number of measuring units, re-initialization of synchronization time when it is shifted, announcement of a new physical address, etc. We define four subtypes of SM-CI message:

- SM-CI-T (Time) – control message containing the current time of the collection centre.
- SM-CI-CN (Client Number) – control message containing the current number of communication units in the CN network.
- SM-CI-MT (Measure Time) - control message carrying the time interval t_D, which defines the maximum time for sending the data measured.
- SM-CI-A (Alive) – control message announcing the availability of the centre. This message is always sent every $9 \cdot t_D$.

6 Communication process

6.1 Multicast transmission of control information

To transmit the control information in the system, SM-CI messages are used, which provide information about the control parameters necessary for the communication between the unit and the centre. Individual control messages were described in the preceding chapter. Control messages are sent in the form of multicast, which means that they should be received simultaneously by all the communication units connected to the given multicast group.

6.2 Synchronization

Prior to the transmission itself of the data measure, it is necessary to perform mutual synchronization between the communication unit and the collection centre.

During the synchronization process it is necessary for the two communicating parties to mutually exchange control information required for the communication proper and for the transmission of the data measured. These data include the synchronization time of the centre, the current number of communication units in the network, the interval for sending the data measured, the denotation of the measuring group, and other necessary communication parameters.

Synchronization always begins by the communication unit sending the initialization-of-synchronization message, UM-SY-1. As soon as the centre has noticed an attempt at synchronization, it responds be sending a similar message, denoted SM-SY-I. After the unit has received this acknowledgement of the initialization message, it confirms to the centre the completion of initialization by sending the SM-SY-C message. After the completion of initialization, the centre can send the unit the necessary operation information in the data section of the SM-CM-P message.

The communication unit always responds to this type of message by an acknowledgement message. Once the centre has sent all the operation parameters and received the last acknowledgement message from the unit, it will terminate the synchronization by sending the SM-SY-B message. The unit responds to this message by sending the UM-SY-B message and synchronization is then considered completed.

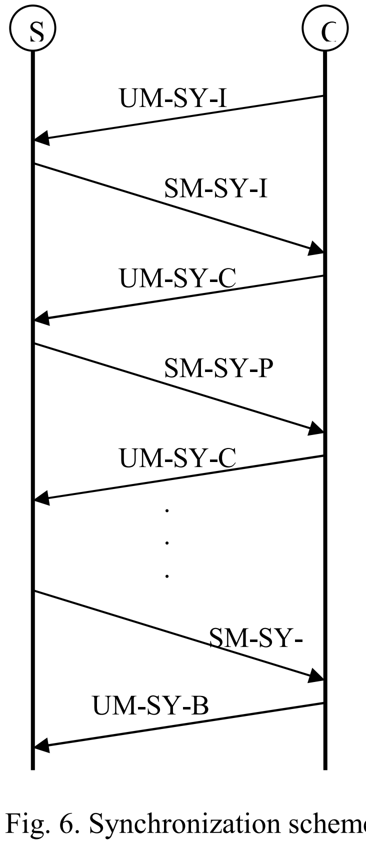

Fig. 6. Synchronization scheme

6.2.1 Synchronized Multiple Access (SMA) method

For the system of bulk data acquisition to work correctly, a principle of synchronizing the communication units with the central has been proposed, which is based on the SMA method. This method solves the problem of multiple access of units to the centre when all the units require simultaneously synchronization with the centre. This can occur, for example, when there was outage in the centre. Four basic rules of communication have been defined for the SMA method:

Initial connection of communication unit
Communication between the communication unit and the centre is initiated by the communication unit sending the UM-SY synchronization message. The unit sends the UM-SY message to the physical address of the centre immediately the communication unit has been put into operation. The unit has the centre address as set by the initial manual configuration. In addition to the physical address of the centre, the communication unit must also know the multicast address of the given transmission. This address may be the same as the physical address of the acquisition centre set in the initial configuration prior to being put into operation. After the acquisition centre has received the UM-SY message, it generates its own SM-SY synchronization message and sends it back to the communication unit. The SM-SY message includes the operation data required by the client station in order to be able to start sending data. In this way the unit is connected to the group as full-fledge member of multicast network. After this initialization process the measurement is fully automatic. It is not expected that thousands of units will want to establish connection during a brief instant of time (with the exception of bulk synchronization in the case of outage in the centre). This initial synchronization should therefore have no pronounced effect on network loading.

Loss of acknowledgement
After initial synchronization, the communication unit draws the data measured and sends the results to the centre. Within a fixed time interval the centre must acknowledge these data in the form of multicast cumulative acknowledgement. If the measuring unit does not receive acknowledgement within the given interval, it means that synchronization has been lost or outage has occurred in the acquisition centre and synchronization must again be carried out. The time interval for which the given unit waits for the acknowledgement of the data sent depends on the nature of data being measured and on the total number of clients in the network. A specific value of this interval is characterized by the relation

$$t_{SYN} = 5 \cdot t_D \tag{8}$$

where t_{SYN} is the time interval for repeated synchronization, and t_D is the time interval defining the maximum period for sending the data measured. Each communication unit receives this interval from the acquisition centre at the beginning of communication and possibly also during communication in the form of control messages.

After the t_D interval the communication unit makes an attempt at synchronization by sending the UM-SY message. To prevent a situation when all units send their initialization messages at the same instant of time, each unit calculates its own value of the time when it will send the UM-SY message. This value is derived from interval t_D on the basis of the relation

$$t_{C_i} = \frac{\frac{4}{5} t_D}{CN} \cdot R\,, \tag{9}$$

where t_D is the time interval defining the maximum period of time for sending the data measured, CN is the current number of units in the network, which is known from the latest completed synchronization. R denotes a random number, which the unit will generate from $k \in <1;CN>$. In case of failure, the unit again calculates the value t_D and the synchronization process is repeated.

Failed repeated synchronization
In case of long-term outage of the acquisition centre the communication units would unceasingly attempt to install synchronization and thus would unnecessarily load the network. A maximum number of repeated transmissions of the UM-SY synchronization message has therefore been set. The number of repetitions is limited to five attempts. When this number of repetitions has been exhausted, the unit interrupts the synchronization process and changes to the standby mode.

Standby mode
A unit that has failed, on the basis of the above procedures, to get synchronized with the centre changes to the standby mode, in which it will wait for type SM-CI-A message. After receiving this message, the unit is informed about the functionality of the acquisition centre and, based on this information; it will make an attempt at synchronization, as described above.

Attending to error states
As mentioned above, the system on the transport layer makes use of the UDP protocol. Thus there may be some risk involved when some of the messages sent do not reach their destination. The main reason for using the UDP protocol is the possibility of using it for applications working in real-time, where emphasis is placed in particular on providing certain delay and a certain measure of loss is no fundamental problem. This fact is important, for example in on-line

measurement of data. Since the technology of network facilities is today sufficiently worked out, the UDP protocol can be used for the synchronization process. The principle of acknowledgement messages in synchronization is important. Both communicating parties possess information about correct synchronization. When an unexpected error occurs in the course of synchronization, the system goes by the rules as defined in the preceding paragraphs.

6.3 Transmission of data measured

After being synchronized, the measuring units will automatically send UM-MV (Receiver Report – Measured Values) messages to the centre. To prevent the centre being flooded with a great number of simultaneously received UM-MV data messages, a method was proposed to spread the sending of data messages over a given interval. Each unit will calculate its moment of sending its own measured data. As soon as the central unit receives a UM-MV message, it saves the currently obtained value in the database for further processing. Subsequently, the acknowledgement procedure is started. The procedure of sending is indicated in Fig. 7.

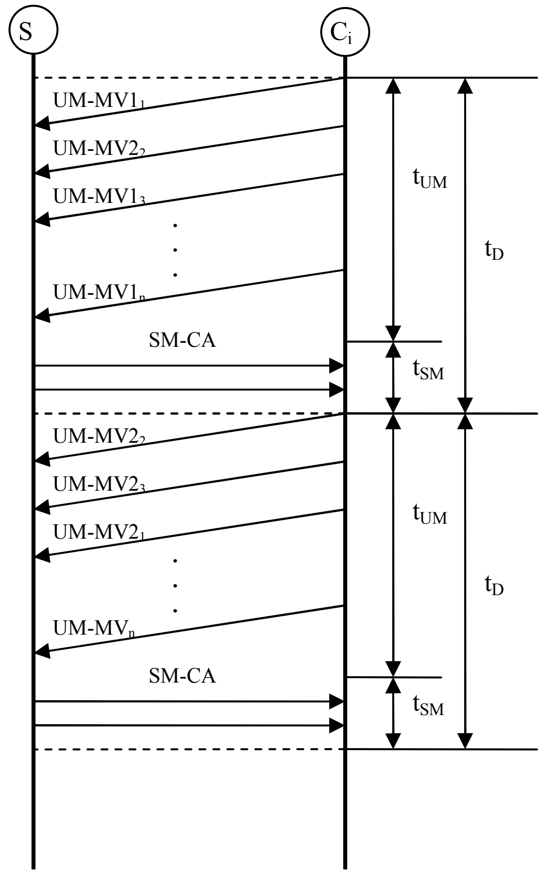

Fig. 7: Principle of cumulative acknowledgement

At time t_{UM}, communication units C_1 to C_N send their messages $UM\text{-}VM_1$ to $UM\text{-}VM_N$, which contain the current measured values. After the time t_{UM} has elapsed, there is another time, t_{SM}, which serves to send the remaining acknowledgements and the calculation of new instants of time for sending the next data messages in the new cycle t_{UM}. This regularity starts from the principle of calculating instants of time in SMA, which are determined accorcing to relation (7).

6.4 Cumulative acknowledgement of data measured

Having sent the data measured, the communication units expect their acknowledgement. Acknowledgement is performed using the SM-CA (Sender Report Cumulative Acknowledgement) messages sent by the collection centre. These messages are sent cumulatively, in the form of multicast, which means that not every data message is acknowledged immediately, the messages are acknowledged cumulatively. The principle of operation is indicated in Fig. 8. The maximum number of acknowledgements that can be transported in one SM-CA message is given by relations (5, 6). The aim is to utilize network facilities with maximum effectiveness and, simultaneously, to prevent segmentation. In one SM-CA message a maximum of E_{max} acknowledgements can thus be transported.

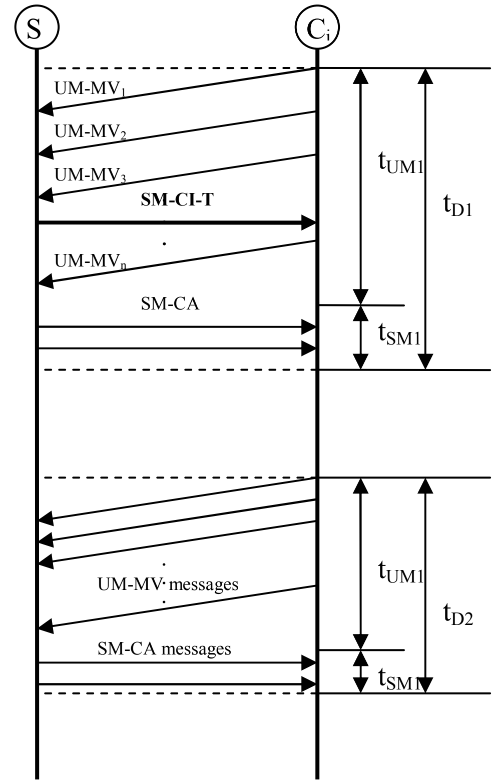

Fig. 8: Mechanism of cumulative acknowledgement with reception of SM-CI-T control message.

The acknowledgement message is sent immediately after it is filled, but at the latest by the end of interval t_D, or else an error of the type of acknowledgement loss might occur.
The time interval t_D defines the maximum time for sending the data measured; it is calculated by the central unit on the basis of the relation

$$t_D = \alpha \cdot t_{\max} \cdot \left(1 - e^{\gamma}\right) \quad (10)$$

where

$$\gamma = -\frac{CN \cdot \beta}{t_{\max}} \quad (11)$$

where α and β are the conversion coefficients dependent on the number of clients, t_{max} is the maximum possible time for sending the data, and CN is the current number of communication units in the network. Specific values of coefficients and are given by the nature of measurement, average size of messages, and the transmission bandwidth defined for the collection centre.
At time t_{UM1}, communication units C_1 to C_N send their messages $UM\text{-}MV_1$ to $UM\text{-}MV_N$, which contain the current measured values. If the number of delivered messages exceeds the limit value E_{max}, the multicast immediately sends the cumulative acknowledgement. After the time t_{UM1} has elapsed, there is another time, t_{SMi}, which serves to send the remaining acknowledgements and the calculation of new instants of time for the next cycle of sending data. If in the course of measurement the centre sends an SM-CI-T message with a new time t_{D2}, the time denotations t_{UM} and t_{SM} are recalculated according to the relations

$$t_{UM} = \frac{4 \cdot t_D}{5} \quad (12)$$

$$t_{SM} = \frac{1 \cdot t_D}{5} \quad (13)$$

7 Conclusion

In the paper the design of a new bulk data acquisition system has been described. The aim has been to design a system that will not depend on just a certain type of medium but will be applicable wherever bulk data acquisition or a kind of long-term monitoring needs to be carried out. The system created draws on the architecture of RTCP protocol for multicast networks with one source of transmission, i.e. the SSM network.
In the next part of the paper the definition of the proposed system is described, together with the new communication protocol, which is based on the RTCP protocol. For the given protocol, individual types of message are defined that are transported both from the acquisition centre and from the communication units. Each message has a certain defined function. The main part of the paper focuses primarily on the description of individual types of message and on the process of communication. After the introductory exchange of synchronization messages and after the adjustment of communication parameters the transmission of measured data runs automatically. The acquisition centre acknowledges these values cumulatively via multicast transmission.
The system of bulk data acquisition described is in the stage of development. In the future it will be necessary to concentrate on the development of parameterization protocols and on implementing the system in some of the available simulation facilities. Then it will be possible to clearly define coefficients for the calculation of individual time intervals and the number of blocks for cumulative acknowledgement.

7 Future work

In the present work the basic design of a system for mass data acquisition with cumulative acknowledgement has been described. It only gives a basic description of the system and there are a number of areas that can be complemented or further developed to the final shape. The system is now designed such that it provides the basic functions for bulk acquisition of required data. The communication protocol has been created on the basis of the RTCP protocol, which uses some similar communication mechanisms. Several message types have been defined, which provide signalling, transmission of control information, transmission of cumulative acknowledgements and, last but not least, the transmission of the measured data themselves.
In the next stage of the design of the system the theoretical design is to be complemented with a detailed mathematical definition of the relations and linkages between individual messages. An analysis will be made as in the case of the RTCP protocol [9]. This will enable specifying the system in greater detail and proposing the protection of the transmission of individual messages. There are reserved bits in the messages for potential protection. It is also necessary to focus on the significance of the group block in the UM-SY communication message and its application for separating individual groups of recipients for cumulative group acknowledgement in a specific system of mass data acquisition. Also, it is necessary to specify in greater detail the calculations of instants of time defined for sending individual messages. These instants should be defined in dependence on the current number of clients in the system, on the division of bandwidth for

measurement and acknowledgement messages, and, in particular, on the nature of measurement. In the case of on-line measurement it is necessary for the measurement messages and their subsequent acknowledgement to take place practically continuously. By contrast, when, for examples, taking readings of power consumption from electricity meters in the private sector it is sufficient to carry out the measurement only the last day of the month.
After completing the theoretical design of the system it will be necessary to realize the simulation stage prior to realizing the system in a real environment. This means implementing the proposed system in a simulation kit and per- forming extensive simulations and testing. The Opnet Modeler [13] or the Network Simulator 2 [14] simulation kit is expected to be used. Final decision will be made on the basis of the properties and supported functions of individual simulation applications that will better correspond to the system designed. The simulation stage is important mainly because it enables establishing potential drawbacks or errors in the system, and also optimizing individual parameters of the system for a specific network environment. Based on practical testing, it will be necessary to determine how to define the t_{max} parameter and subsequent t_D parameters, and how these parameters will be actually dependent on the other parameters of the system, e.g. allocated bandwidth or number of communication units in the network.
The latest stage of system design envisaged in the present is its practical implementation in the real university network environment. The system will thus be deployed in a real environment, where testing similar to that in the simulation will be performed and results of the testing will be evaluated and compared with simulation results. After this we would like to provide a secure transfer for the industry networks like a [15], [16].

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