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Investigation of Signalling Flow Transfer Processes based on SCTP Protocol

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Introduction

Real-time information exchange services need to establish communication session. By this reason in PSTN networks used in alarm systems, the main of which is the SS7 (Signalling System Number 7). In the creation of NGN (Next Generation Network) it is necessary to transfer of SS7 information over Internet Protocol (IP) network. This is why SIGTRAN (Signalling Transport Protocol Stack for PSTN signalling over IP) protocol [1] was created, to realize the stream control transmission protocols (SCTP) [2] and adaptation protocols functions. SCTP is responsible for the reliable transfer of signalling information over an IP network and to manage signalling by traffic governance, ensure signalling information. Functions of protocol integration include signalling information from the signalling protocols, using the SCTP services. These protocols are responsible for data segmentation and pocketing, protection of consumers' simulation, transferring information sense changing and other functions.

At analysis of signalling flows, it is necessary to identify the conclusion of the algorithm. As an analytical way to do this difficult, often used for simulation [3–6], which allows the assessment of signal process algorithm. At work, by simulation were determined probabilistic characteristics of SS7 signalling message transmission over an IP network using SCTP protocol delivery, making in mind limited time of transmission and the potential number of repetitions.

Stream Control Transport Protocol

The Stream Control Transmission Protocol is a new IP transport protocol, existing at an equivalent level with Transmission Control Protocol and User Datagram Protocol. Provide transport layer functions to many Internet applications [1].

SCTP is designed to transport PSTN signalling messages over IP networks [1, 2], IPTV (Internet Protocol Television) to deliver information.

SCTP is a supports data exchange between exactly 2 endpoints, although these may be represented by multiple IP addresses with multi-homing. In this figure both endpoints have two interfaces bound to the SCTP association. The two end points are connected through two kind of links: first path at the top and second path at the bottom.

At time when communication session is established one route is selected as the primary and any information transmitted to it. Same route is used to transfer message approvals. In order to reduce delay and to determine when to switch to an alternative route for message approval, timer is used this, according to the recommendation of the IETF RCF2960 allowed up to 500 ms.

Another parameter who controls the transition to an alternative route is re-forwarding number, which determines how many times message will be repeated, if the receiving unit haven‘t got it. Regarding recommendation RCF2960 of SCTP protocol maximum allowed number of retransmission is set to maximum 5 times. Failure to transmit the report of the selected retransmission number is a shift to an alternative route to reduce delays and to avoid. In this case the primary route is marked as inactive, but it sent Heartbeat messages, and only with the approval of the original route can be re-activated.

Multi-streaming allows data from the upper layer application to be multiplexed onto one channel (called association in SCTP) as shown in Fig. 1. Sequencing of data is done within a stream; if a segment belonging to a certain stream is lost, segments following the lost one will be stored in the receiver's stream buffer until the lost segment is retransmitted from the source [3].

Call handling algorithm

SS7 messages arrive at the Signaling Gateway SG1 (Fig. 3) for the transmission of signalling information over IP network (Fig. 2). Later messages are transmitted to the MGC (Media Gateway Controller) through SIGTRAN protocol. Later, depending on how is established connection and network structure, signalling messages can be transmitted back to the same signalling Gateway (SG1) or other network signalling Gateway (SG2). Every received message must be approved, by sending an approval of signal Ack.

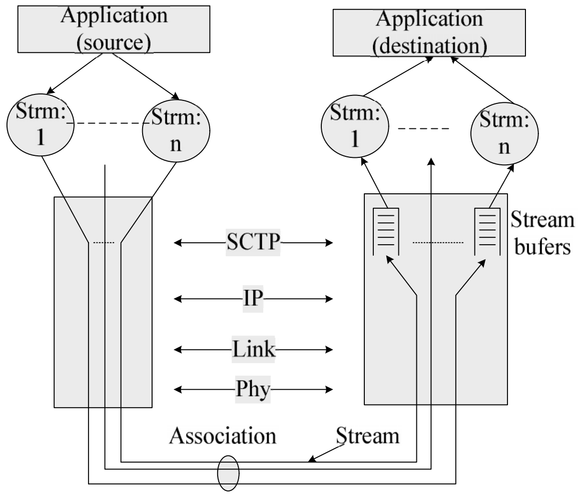

Fig. 1. SCTP association consisting of n streams carrying data from n upper layer applications [3]

Fig. 3 shows the procedure for exchanging signalling information until connection is established and subscriber has been responded. Connection process includes delivery over IP network of three types of signalling message (IAM, ACM, ANM). Total connection time is affected and by time until called subscriber answers. Since this time depends on the user's behaviour, in work it is not appreciated.

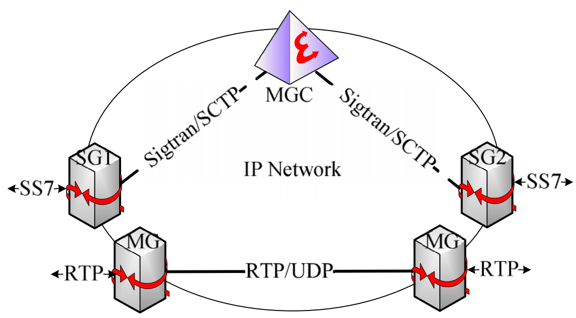

Fig. 2. SCTP position in IP network

According to Fig. 3 shows that the connection between the processes can be identified similar to the procedures associated with the IAM, ACM and ANM messages transmission. To the overall realization of the process algorithm, it can be assessed using a similar algorithm for each transmission. By this assessment we will analyse only the IAM IP network transmission probability characteristics. IAM notification algorithm over IP network shown in Fig. 4.

Phase-type distribution will be used to find an analytical solution to the system [7]. The distribution allows to model one or more inter-related Poisson processes occurring in sequence and is generalisation of Erlang distribution (which requires all phases in the sequence to be identical).

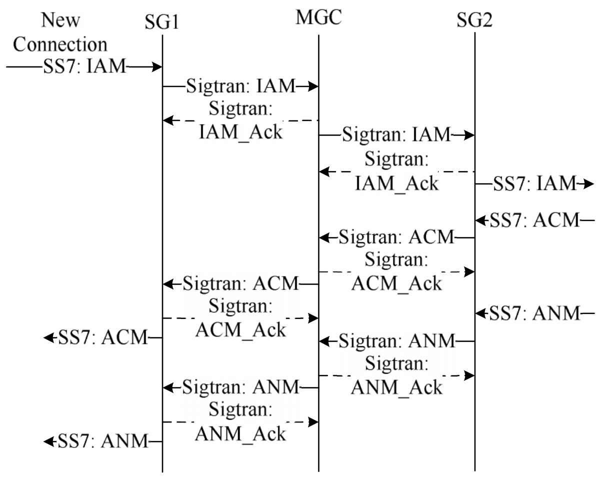

Fig. 3. Signalling message transmission sequence over IP network

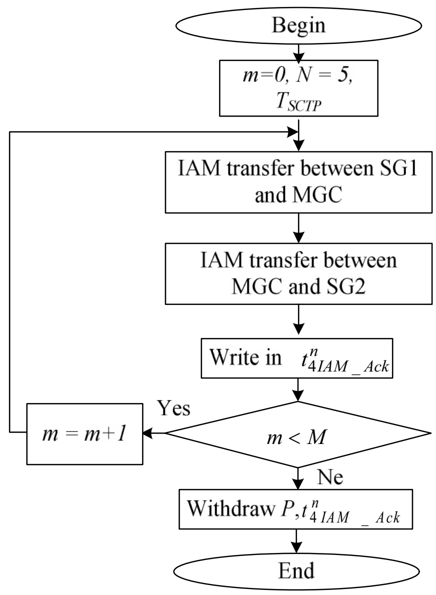

Fig 4. Alarm message transferring over IP network algorithm

Phase-type distribution is defined by initial probability vector

$$\boldsymbol{\alpha} = (p_1, p_2, ..., p_n), \tag{1}$$

where p_i is the probability to start at phase i and by matrix

$$\mathbf{S} = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{2n} & \cdots & r_{nn} \end{pmatrix}, \tag{2}$$

which contains transition rates between corresponding phases. Given these parameters we can calculate distribution function

$$F(x) = 1 - \boldsymbol{\alpha} \exp(\mathbf{S}x)\mathbf{1}, \quad x \geq 0, \tag{3}$$

where $\mathbf{1}$ is a column vector of length n whose elements are all equal to 1. Distribution mean is defined as follows

$$E = -\boldsymbol{\alpha}\mathbf{S}^{-1}\mathbf{1}. \tag{4}$$

As phase-type distribution does not capture all of the specifics of SCTP protocol, we will be using simulation for our further analysis. The number of repetitions n, simulation sample m and SCTP approval waiting time T_{SCTP} are selected for the modeling. IAM signaling message transmission process between the MGC and the SG1 and SG2 and MGC is similar to accordance with algorithm shown in Fig. 5. At simulation IAM signalling message transmission time over IP network is captured. (variable $t^n_{4ACM\_Ack}$) also counted lost messages (variable P). After the simulations collected service times and recorded the number of lost messages are delivered.

In order to make simulation message service time average values τ_{SG1}, τ_{MGC}, τ_{SG2} are determined. Message service time is distributed according to exponential distribution. Message transmission time over IP network, asked the size of τ_{IP}, which distributed according to exponential distribution to. If message transferred be SCTP protocol has been not confirmed within a specified time, the message is repeated within the allowable number of repetitions. Once the prescribed number of reps, the report recorded a loss.

Initial simulation data presented in Table 1.

Table 1. The average message service (transmission) time of the relevant network sites

i	SG1	IP	MGC	IP	MGC	IP	SG2
τ, s	0,02	0,1	0,02	0,1	0,01	0,1	0,02

At time of simulation showed that the signalling gateway service times the average levels of 0.02 s and the average length 0.1 s of the transmission over IP network, using the alarm notification to the replay, over and above the maximum allowable waiting time for approval (0.5 s), do not lose calls transmission of signalling messages IP network. Once approval of the waiting period as of 0.3 s, the number of not served calls is less than 0.5 %.

Phase-type distribution corresponding to our algorithm and the parameters from table 1 has initial probability vector

$$\boldsymbol{\alpha} = (1,0,0,0,0,0,0) \quad (5)$$

and the transition rate matrix

$$\mathbf{S} = \begin{pmatrix} -50 & 50 & 0 & 0 & 0 & 0 & 0 \\ 0 & -10 & 10 & 0 & 0 & 0 & 0 \\ 0 & 0 & -50 & 50 & 0 & 0 & 0 \\ 0 & 0 & 0 & -100 & 100 & 0 & 0 \\ 0 & 0 & 0 & 0 & -10 & 10 & 0 \\ 0 & 0 & 0 & 0 & 0 & -50 & 50 \\ 0 & 0 & 0 & 0 & 0 & 0 & -100 \end{pmatrix}. \quad (6)$$

Using these parameters we arrive at the average message service time of 0,28s which is in line with the results achieved through simulation when there are no failed and resent messages. However, when resent messages are introduced simulation results start to deviate from the phase-type distribution as seen in Fig. 6 and Fig. 7.

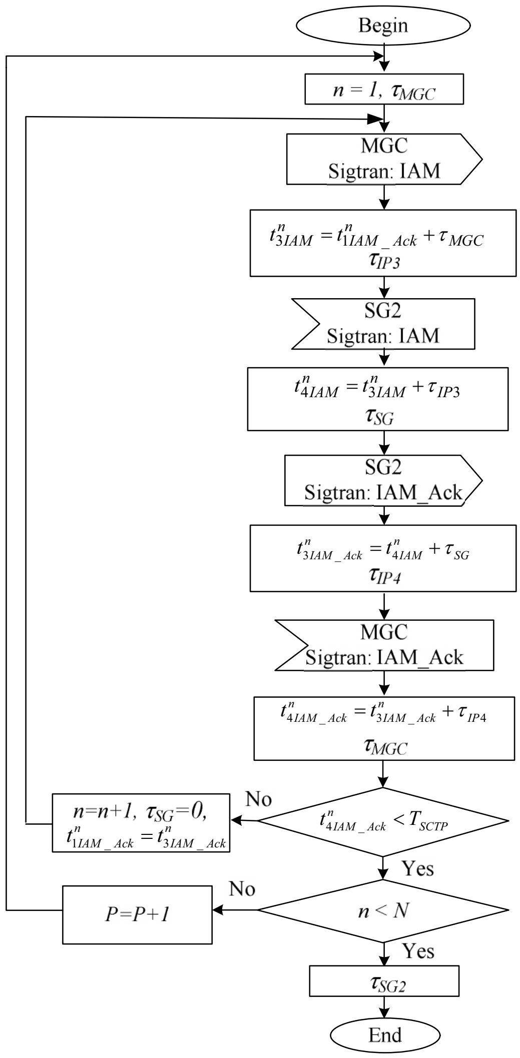

Fig. 5. IAM message transmission between SG1 and MGC over IP network algorithm

Fig. 6 shows the IAM message transmission time distribution over IP network, when there is no re-transmission of messages. Average IAM signalling message transmission time equal to 0.28 s with standard deviation 0.14 s.

Fig. 7 shows the IAM message transmission time distribution over IP network, with repetition time at 0.5 s.

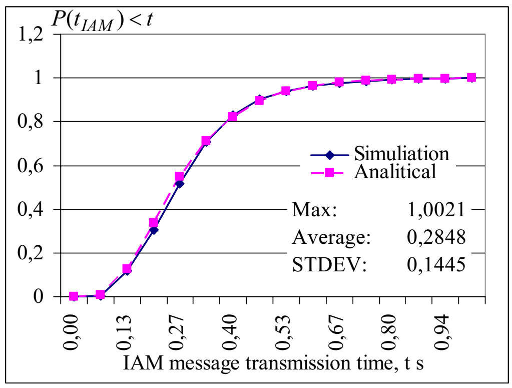

Fig. 6. IAM signalling message transmission over IP network without repetition time theoretical and simulation distributions

Once re-transmitted messages accounted for 7.7%, and twice re-transmitted messages 0.3%. From Fig. 7 we see the simulation result obtained distribution is not exponential distribution, although the individual network nodes have been adopted by the exponential distribution.

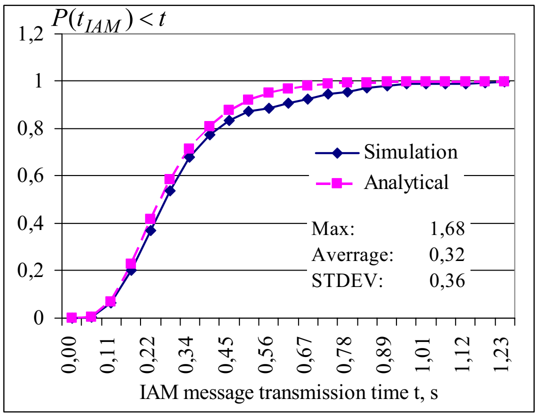

Fig. 7. IAM signalling message transmission time over IP network theoretical and simulation distributions, when $\tau_{SCTP} \leq 0,5$ s

Fig. 8 shows the IAM message transmission time distribution over IP network, with the repetition time at 0.3 s.

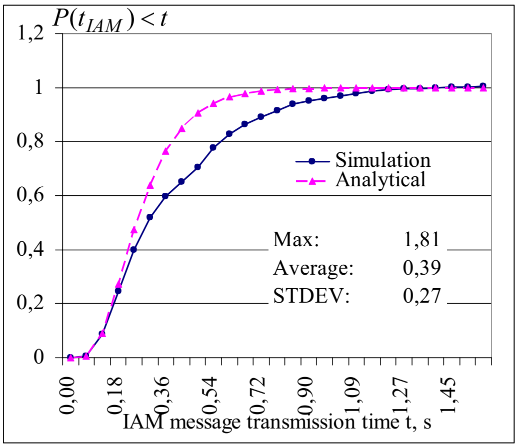

Fig. 8. IAM signalling message transmission time over IP network theoretical and simulation distributions, when $\tau_{SCTP} \leq 0,3$ s

For a sufficiently large number of repetitions, the average transfer time value slightly increased, but decreased standard deviation value.

Conclusions

1. The distribution of signaling message service time is closely approximated by phase-type distribution only if there are no resent messages.
2. Given a finite waiting time for SCTP message mean service time increases due to the need to resend messages. However, stability can be assured in such configuration.
3. These results suggest that when choosing protocol specific parameters in each case, it is necessary to carry out a separate investigation, taking into account the initial data.

References

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To establish reliable signalling information transmission over IP network is used SIGTRAN protocol containing a protocol with the transport flows. This protocol, uses signalling messages over IP network, to determine maximum time and number of repetitions. Reports contain the signalling messages transmission over IP network algorithm, which simulated a notification request over IP network, taking into account differences in SCTP message transmission time. A provisional value of transmission characteristics over IP network is determined. Ill. 8, bibl. 7, tabl. 1 (in English; abstracts in English and Lithuanian).

A. Jarutis. Signalizacijos srautų perdavimo SCTP protokolu tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 2(108). – P. 35–38.

Signalizacijos informacijai patikimai perduoti IP tinklu naudojamas Sigtran protokolas, savo sudėtyje turintis transporto protokolą su valdymais srautais. Šis protokolas, pagrįstas signalizacijos pranešimų perdavimo IP tinklu valdymu, leidžia nustatyti maksimalią perdavimo trukmę ir pakartojimų skaičių. Darbe pateikiamas signalizacijos pranešimų perdavimo IP tinklu algoritmas, pagal kurį modeliuojamas užklausos pranešimo perdavimas IP tinklu, įvertinant skirtingą SCTP pranešimų perdavimo trukmę. Nustatomos laikinės pranešimų perdavimo IP tinklu charakteristikos. Il. 8, bibl. 7, lent. 1 (anglų kalba; santraukos anglų ir lietuvių k.).