

XML scheme gets the telephone numbers and Sipp creates the SIP message for the softswitch. Fig. 1 illustrates the scheme. The SIP message is generated on the basis of data coming from Sipp, i.e. parameters from .csv file, parameters inserted by crisis center's staff and embedded voice record in .wav or .pcap format. Another issue addressed while developing the system was how many messages and subsequent calls are we able to generate at a particular moment. This value depends on computing performance requirements of the server with the system and the softswitch, required bandwidth on the transfer line between the system and the SIP softswitch and finally maximum load of the Sipp application.

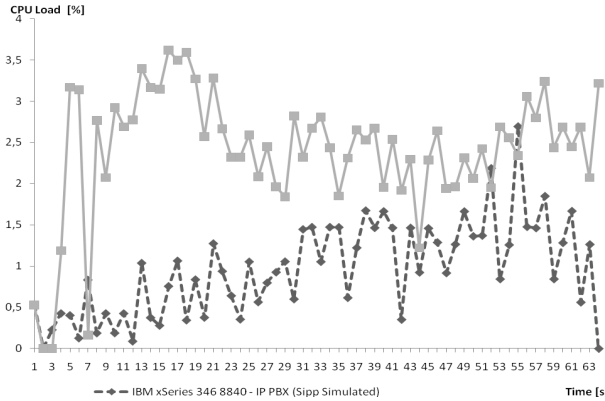


Figure 2. System and IP PBX CPU Load.

The configuration we tested consisted of Dell PowerEdge R510 with our system, the recipient was the IBM server xSeries 346 8840 with the Sipp application in the server mode which simulates the behaviour of a SIP softswitch, including generating calls based on the SIP messages received and playing voice messages to end users. The test itself simulated generation of 500 SIP requests with a 60 second long pre-recorded voice message at a particular moment. The resulting values were obtained using the dstat tool [12]. Fig. 2 shows that the percentage load of CPU of both servers has not exceeded 4%. If we used a real SIP IP softswitch instead of Sipp application in the server mode, the load on CPU would have been higher. On the other hand, we tested using 60 second long pre-recorded voice message. In the real operation, the maximum duration of the voice message will be 30 seconds. It derives from the test that computing performance requirements on hardware do not represent a limiting factor for the maximum amount of calls generated.

In any case, we recommend installing the system and the SIP softswitch separately of two different servers in order to ensure uninterrupted and faultless operation of the whole system. The softswitch's IP address (domain), login name and account password are entered into the system by the staff of the crisis centre.

As regards the required bandwidth on the transfer line between the system and the SIP softswitch, it can also be influenced by the choice of the voice codec applied for the transmission of the voice message. To calculate the real bandwidth BW_M [bps], we used formula (1) where H [b] is the sum of all headers [13]. The parameter C_R [bps] is the codec's transfer speed

(codec rate) and the formula (2) determines the gap between the packets with samples (timing in process of packetizing), where P_S [b] is the payload size [13].

$$BW_M = M \cdot C_R \cdot \left(1 + \frac{H_{RTP} + \sum_{j=1}^3 H_j}{P_S} \right) \quad (1)$$

$$\Delta t = \frac{P_S}{C_R} \quad (2)$$

The last factor which can influence the number of system-generated calls at a particular moment is the maximum load of the Sipp application. While testing, we established that Sipp is the biggest constraint of the whole system. This open-source tool can generate a maximum of 700 SIP requests at a particular moment without a fault. For higher values, the generated INVITE requests contain errors in structure or length. This is why we set the maximum amount of calls generated at a particular moment to 500. In order to be able to distribute even to sets of end users exceeding 500, it was necessary to divide the total amount of requested calls into subsets of 500 requests. We refer to these subsets as groups and set the interval between individual groups to 60 seconds. If we take into account that the maximum length of a pre-recorded voice message is 30 seconds and staff can only set the maximum duration of ringing to 15 seconds, the resulting time is 45 seconds. This means that the call length never exceeds 45 seconds. This indicates that our system can generate 500 calls every 60 seconds. The following chapter describes algorithms used by the system to manage the groups, missed calls and total time necessary for call distribution.

III. METHOD

The previous chapter states that the maximum number of calls which the system can generate at a particular moment is 500. In the text and figures below, this value is referred to as C_{max} . Once the staff member logs in s/he can enter the XML list of end users into the system. The system immediately calculates the total number of calls to be generated C_{req} , number of groups to which the calls will be divided G_n and the estimated time to send all calls T_{snd} [s].

$$G_n \cong \frac{C_{req}}{C_{max}} \quad (3)$$

The number of groups G_n is determined using formula (3), estimated time T_{snd} using formula (4).

$$T_{snd} \cong \left(\frac{C_{req}}{C_{max}} \right) \cdot 60 \quad (4)$$

If, for instance, staff member enters a list with 6800 end users, we will obtain the following values: $C_{req}=6800$, $G_n=14$ and $T_{snd}=816s$.

In case the threat of danger or natural disaster becomes real, staff have exact time models setting the maximum time limits in which all end users should be alerted. This time value is inserted into the system form and is described as the maximum time to send all planned calls T_{max} [s]. Fig. 3 illustrates two situations which can arise after the value is inserted. In the first

case where $T_{snd} \leq T_{max}$, there is time remaining to re-send unanswered calls $Trem$ [s] after all calls have been sent for the first time. In this case, the system generates the value of time remaining $Trem$ and notifies the staff that during this time, the system is to automatically re-initiate calls which have not been answered in the first wave. Where the end user does not answer the call for the second time either, the calls are being re-initiated until $Trem=0$. In the latter case, where $T_{snd} > T_{max}$, the system returns information that the time required to initiate all calls T_{snd} is longer than the maximum time for sending requests set by staff T_{max} and therefore it is not possible to guarantee that all end users will be contacted and requests for unanswered calls re-generated. If staff want to contact all end users, or even set aside time to re-initiate unanswered calls, they need to increase T_{max} so that $T_{max} > T_{snd}$. This is how the staff get an idea of the time plan to generate calls and can thus make further steps to address the situation.

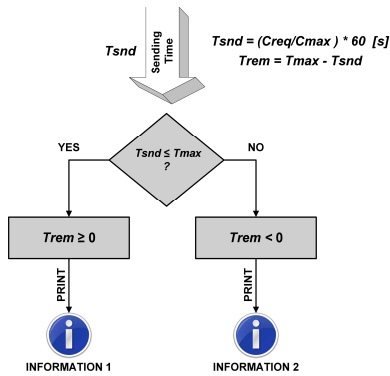


Figure 3. Time diagram

Other values which staff need to enter into the ready-made forms before calls can actually start to be generated is the duration of the ringing at the end user's side, login name and password to the SIP account and of course the location of the pre-recorded voice message.

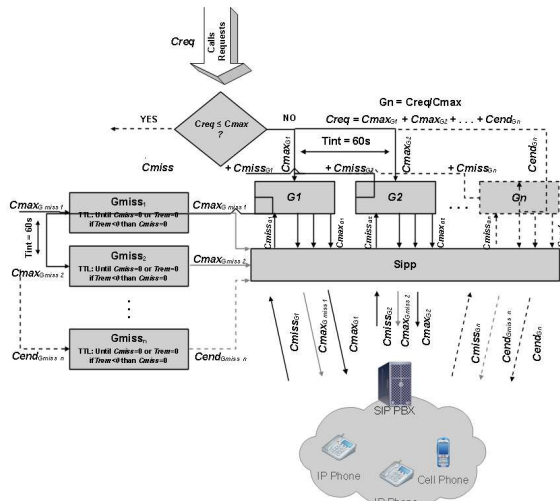


Figure 4. Calls Diagram, $Creq > Cmax$

Once all forms have been filled, the system can start initiating calls according to pre-set parameters. Staff members launch the call generation by pressing the SEND button. At first, the system logs into the IP switchboard and the SIP account created for this purpose and then it starts to generate SIP requests using the Sipp application, Fig. 4. Generating is carried out across individual groups ($G1-Gn$) with 60 seconds interval. Each group contains $Cmax$ call requests, the last group contains the remaining requests ($Cend$). By adding together all $Cmax$ and $Cend$, we obtain a total number of call requests $Creq$ (5). Requests are dispatched to the switchboard in sequence and the switchboard starts to initiate individual calls. At this stage, the end device (cellphone, fixed line, etc.) of the end user starts to ring and keeps ringing for the time defined by staff in the system form. If the end user answers the call within this time span, a voice message containing information about the danger and how to address it is played to him/her. This call is marked as answered ($Cansw$). If the end user fails to answer the call during the defined period of ringing, or the end device is not available, the call is marked as unanswered ($Cmiss$). Once all requests across all groups have been generated, the system adds together all unanswered calls (6). If $Trem > 0$, the system starts to generate SIP requests for call previously unanswered. Where $Cmiss > Cmax$, such calls are again subdivided into individual groups ($Gmiss1 - Gmissn$). The number of these groups can be determined using formula (7). Unanswered calls are re-initiated until $Trem=0$ or until there is no unanswered calls $Cmiss=0$.

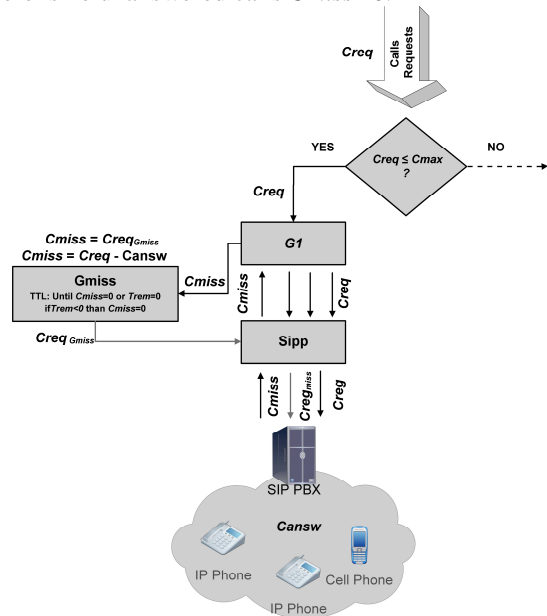


Figure 5. Calls Diagram, $Creq \leq Cmax$

IV. RESULTS

While generating, the system indicates the total number of requests $Creq$, number of groups Gn and $Gmiss$, total number of answered calls $Cansw$, number of

unanswered calls C_{miss} and times T_{snd} and T_{rem} . If an unexpected situation occurs, the whole process can be aborted by pressing the ABORT button.

$$C_{req} = C_{max_{G_1}} + C_{max_{G_2}} + \dots + C_{end_{G_n}} \quad (5)$$

$$G_{miss} \cong \frac{C_{miss}}{C_{max}} \quad (6)$$

$$C_{miss} = \begin{cases} C_{max_{G_{miss1}}} + C_{max_{G_{miss2}}} + \dots + C_{end_{G_{missn}}} \\ C_{miss_{G_1}} + C_{miss_{G_2}} + \dots + C_{miss_{G_n}} \\ C_{req} - C_{answ} \end{cases} \quad (7)$$

Fig. 4 describes the situation where $C_{req} > C_{max}$. Fig. 5 illustrates the situation where $C_{req} \leq C_{max}$ and values of G_n and G_{miss} equal 1. The definition of individual variables is the same as for Fig. 4.

The whole system was designed to distribute pre-recorded voice messages to alert people to danger or natural disaster. Its aim is to provide sufficient information to large population on how to address a particular situation in the shortest time possible in a form which cannot be missed or disregarded. Depending on the content of the pre-recorded message, the system may not only function as a part of the early warning scheme, but it can also function as the basic infrastructure for other areas of human activities. Below we provide an overview of situations in which the system could be used:

- Alert system for population safety during natural disasters (floods, fires, earthquakes, wind storms, snow breaks, dangerous substance leakages), conflicts (attacks, wars, raids, army drills).
- Information system: during traffic congestion, to distribute poll results, to distribute election results, to announce sports competition results, to broadcast news (e.g. for visually impaired).
- Advertising system: to distribute advertisements, to address voters, to announce lottery winners.

Whatever situation the system is applied for, we can always reliably calculate the time necessary to address the target group of end users. We use formula (4) where C_{req} is the total number of end users to be targeted and C_{max} is set to 500. If it was necessary to inform all students at our university (24 058) about a certain event within 1 hour, our system would manage it. The same applies in case a natural disaster should occur – the system is able to advise community population within a certain time span depending on the population size.

The functionality of danger alert communication system was presented at Common Command Centre of Integrated Rescue System of Ostrava City and we started to negotiate conditions for pilot project. The used approach in developed warning system brings new features because the warning is directed to individual people and the managers of crises center get a feedback about accepted calls and can observe not only process of warning but also its efficiency.

V. CONCLUSION

We developed a system which can distribute voice messages in the form of telephone calls using VoIP technology and SIP protocol fast and efficiently. It uses open-source application *Sipp* and any compatible softswitch enabling for registration of an SIP account. The benefit of using voice message to transfer information as opposed to other forms of information systems is that the information can be easily perceived by target audience, thus reducing the probability of it being missed. The system is controlled through a web interface, which makes it accessible from any machine with an Internet browser.

At present, the system is subject to intensive beta testing. We plan to implement several enhancements in the future, such as VoiceXML schemes for creating an interactive media dialog or a more user-friendly installation tool available through the web interface. As the *Sipp* application develops, we expect to increase the maximum amount of generated SIP requests at a particular moment.

ACKNOWLEDGMENT

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