Research Article

Presence Service in IMS

David Petras, Ivan Baronak, and Erik Chromy

*Institute of Telecommunications, Faculty of Electrical Engineering and Information Technology, Slovak University of
Technology in Bratislava, Ilkovičova 3, 812 19 Bratislava, Slovakia*

Correspondence should be addressed to Erik Chromy; chromy@ut.fei.stuba.sk

This paper describes the presence service, which is located in the IP multimedia subsystem. This service allows making many
applications for different groups of people. The paper describes differences between a network without the service and with the
service. The biggest change is an increased number of transmitted messages. The presence uses some part of the IP multimedia
subsystem control layer, which is shown in communication between the user and the server. The paper deals with the number of
generated messages depending on the behaviour of the users. This is described by a mathematical model using discrete Markov
chains.

1. Introduction

Originally, each service or group of services had its own
network for its own use. The idea of the next generation
networks (NGN) comes with the development of technology.
This network would be shared by all services. IP multimedia
subsystem (IMS) is an implementation of NGN [1–7]. IMS
allows interworking between circuit switching and packet
switching networks. IMS has many advantages. New services
do not need to change the structure of the network. Quality
of service is guaranteed through QoS parameters.

The presence service has two roles: to inform the user
about the status of others and to inform others about the user's
status [8]. It is transmitted through session initiation protocol
for instant messaging and presence leveraging extension
(SIMPLE) [9]. This protocol allows the transmission of
messages over the network without changes, when the service
is deployed. Messages are created as XML documents. These
look like PIDF [10] and their extension like RPID [11].

Within the scope of the project "Support of Center of
Excellence for SMART Technologies, Systems, and Services
II" funded by structural funds from the European union, we
have built the most modern IP multimedia subsystem lab at
the Institute of Telecommunications. In this lab we can also
conduct research aimed for services.

IMS consists of three layers: transport, control, and appli-
cation (Figure 1). The transport layer is the lowest. This layer

has two roles. First role is to secure an access of devices from
different types of networks (GPRS, UMTS, IP, PSTN, etc.)
through gateways like Media Gateway (MGW), Signaling
Gateway (SGW). Second role is to transfer messages from
the user to the control layer or from one user to another
user through IP data network. The control layer is the core
of the system. It controls the communication and creates
connections between users. It directs messages through three
call season control function (CSCF) servers. P-CSCF is
an entry point to IMS. I-CSCF provides registration and
interworking between two IMS. S-CSCF is a central point
of direction. It communicates with the application servers.
Home subscriber server (HSS) is a database where user
profiles and data for the service are stored. The Subscriber
location function (SLF) selects the database from several
HSSs. The application layer provides services. There are
three types of servers. SIP application server is used for
applications using the SIP protocol. OSA application server is
independent of the protocol through API between the server
and the control layer. CAMEL application server is used for
applications from legacy network [12].

2. Presence Architecture

Presence architecture is shown in Figure 2. It has three levels:
agents, entities, and a server. The agents collect information
from various sources. The agents are various programmes.
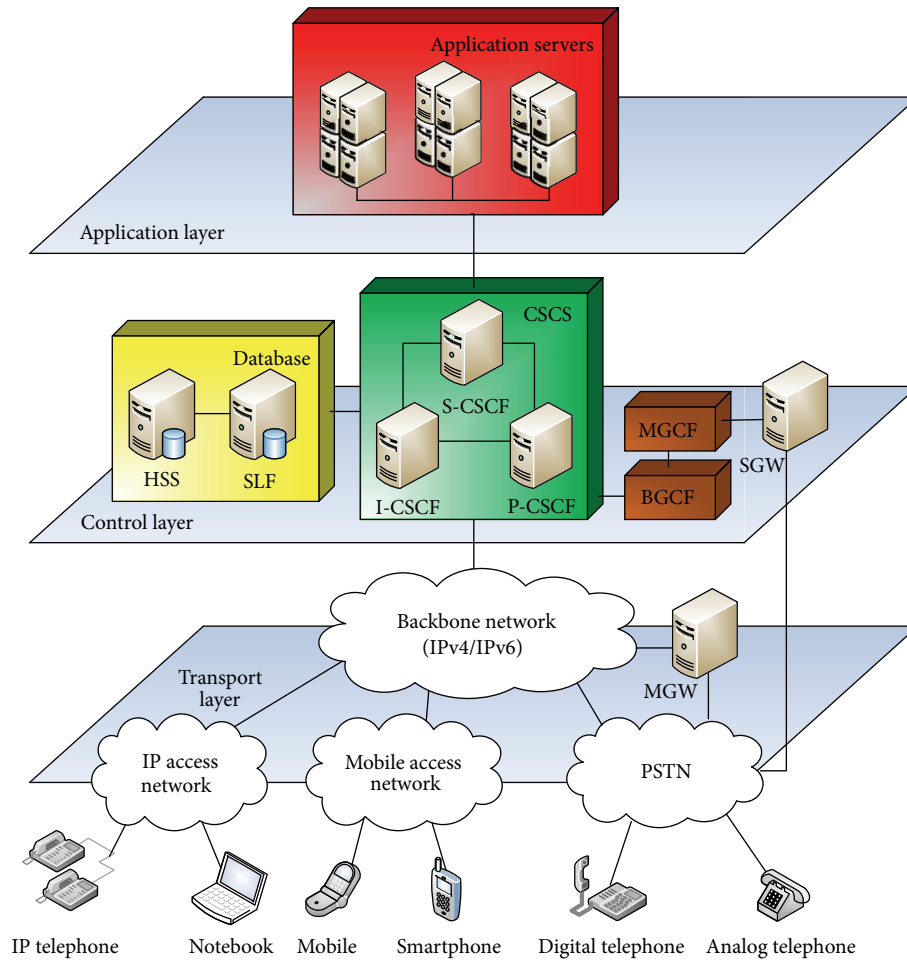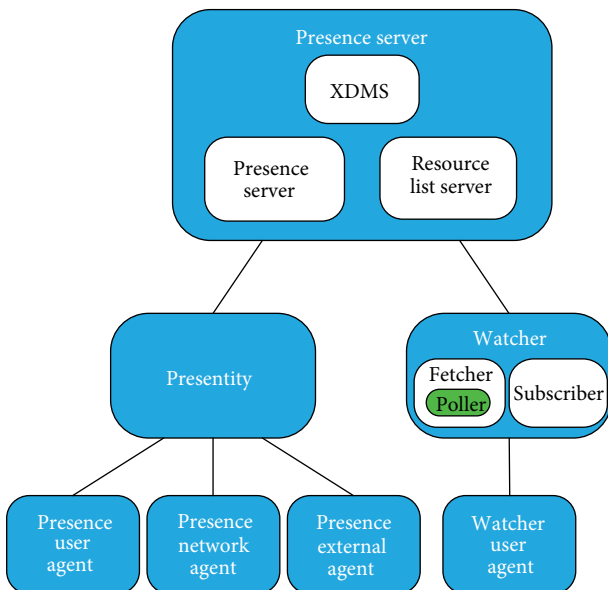
FIGURE 1: Architecture of IMS.

FIGURE 2: Presence architecture.

The presence user agent collects information from user devices. Presence network agent collects information from network elements. Presence external agent collects information from other networks. Watcher presence agent provides information to the watcher.

Entities are characterized by the fact that they can process the SIP messages (UE, S-CSCF, and AS). Entities are divided into two types. Presentity (presence entity) provides information about itself and the watcher observes the status of the others. Watchers are divided into three groups. The fetcher is only interested in the current status. Poller is a special kind of Fetcher, which observes status in certain time intervals. The subscriber also observes the changes in the presence of entities [13]. The server collects and sends information about users, which is stored in XML documents. The presence server receives messages and assigns it to the correct user. The resource list server creates lists of users for watchers and sends their status together. The XML document manager server (XDMS) supports other parts of the presence server. For example, XDMS knows that the watcher is authorized to observe the presence entity. Application server is designed
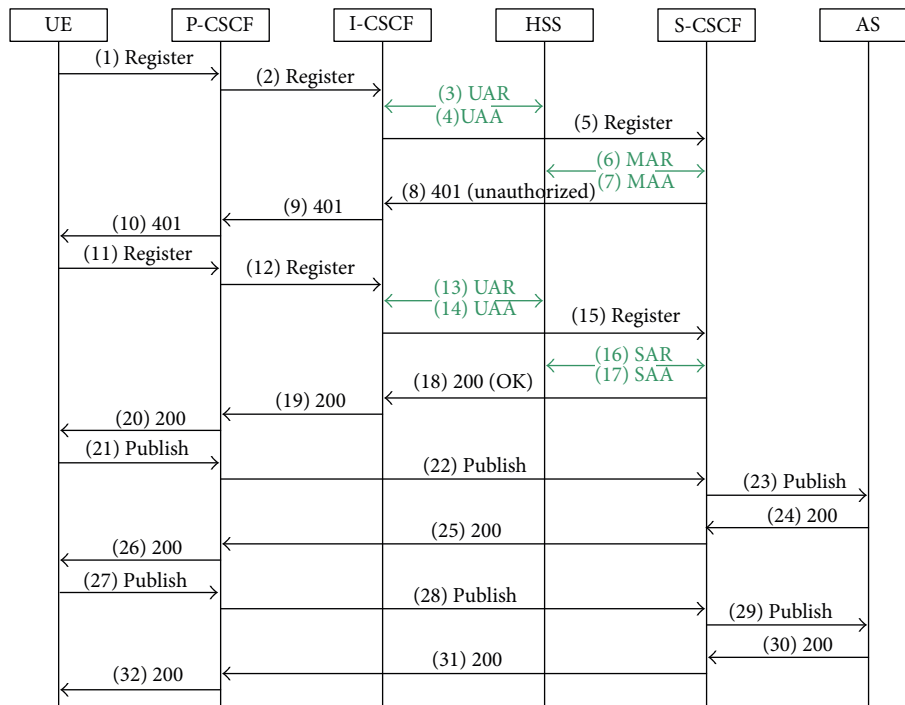
FIGURE 3: Publication status.

so that it could control the number of messages. One of the possibilities is periodic sending of messages. If there are more messages than the server can send, it puts them into a waiting queue. If the waiting queue is full, then the server deletes the messages [14].

2.1. Communication. There are two processes of exchanging messages in the presence service. Process of publishing is shown in Figure 3. This exchange of messages has two parts. The first is registration (messages 1–20) and the second is publication of status (messages 21–32). S-CSCF is assigned to the user during registration. User equipment (UE) is a telephony device, which enters IMS through P-CSCF. P-CSCF through I-CSCF determines where to send the Register request. The information about where to send the message and about the user profile for S-CSCF is stored in the HSS. First, S-CSCF sends a response 401(unauthorized). After receiving answers, UE creates another Register request, after which the user will have successfully registered. A detailed description of the registration is in [15]. In messages 21–23 UE (presentity) sends its whole status in request Publish to the application server (presence server). Messages pass only through P-CSCF and S-CSCF after the registration. S-CSCF knows where the server is according to the initial filter a criteria (iFC). The filter is obtained from the HSS during the registration. Presence server sends confirmation message 200 (OK) as soon as possible, to prevent resending messages. When changing status, UE sends another request Publish, which will go the same way as the first one. The form of the messages is described in [16]. The message itself contains only the change of the status.

The process of subscribing is shown in Figure 4. The figure describes a situation, when the watcher is in another IMS network like presence server. Process of registration is the same as in the previous figure and therefore is not listed. Entry Point is I-CSCF to another IMS network. UE (watcher) creates request Subscribe. The filter is in the request [17]. In the filter, there is information about what the watcher wants to know. UE enters into its IMS network through P-CSCF. It continues to S-CSCF. S-CSCF sends subscribe from the watcher presence network to the presentity presence network. I-CSCF finds S-CSCF and S-CSCF sends request to AS, where there is a list of contacts with status. Upon receiving the request, the application server verifies the user's authority. If it is correct, the application server sends response 200 (OK). AS sends request Notify with the body where it contains the information about the presentity status. Type of watcher is Subscribe in Figure 4. If one of the presentity, which the watcher observes, changes its state, server sends another Notify message without request.

3. Deployment of the Service

Deployment of the presence service means three issues. Application server must be in the application layer. This server receives the information from agents, it stores the information to XML documents, and it sends the information to watcher according to the filter in the request. Agents must be added to the network. User agents are applications on the user's devices. Network agents are applications on network elements in the control layer (S-CSCF and HSS) and on servers in application layer (position server and
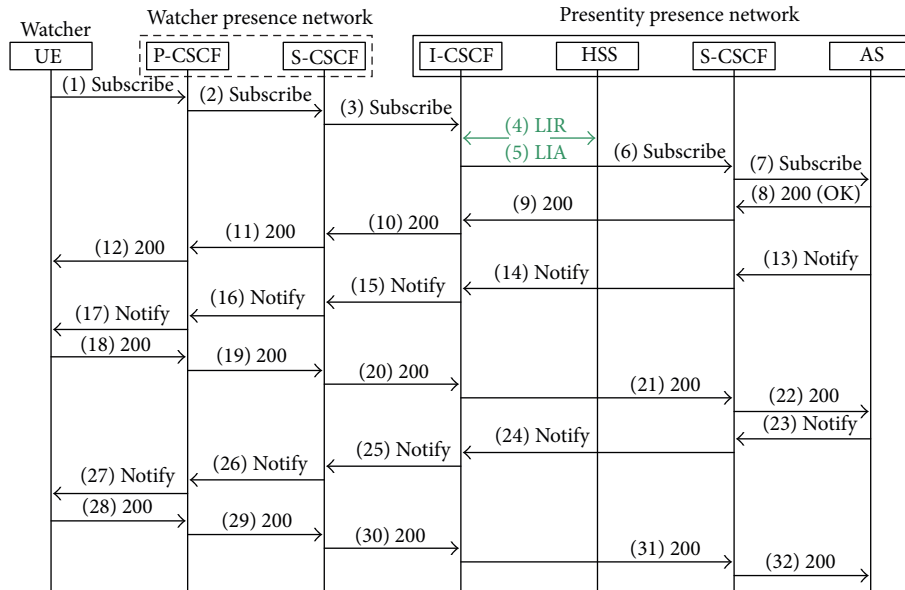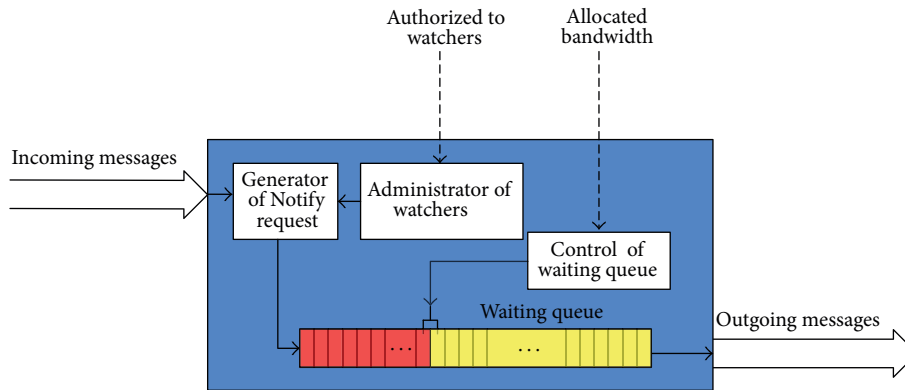
FIGURE 4: Subscribe status.

FIGURE 5: Logical scheme of the presence server.

application server of any other service). External agents collect information from other networks. Another important issue is the increased number of transmitted SIP messages. Fifty percent of transmitted messages are related to this service [18]. That is why it is most important to focus on the number of transmitted messages.

3.1. Messages. Presence service uses three types of SIP requests. publish is sent when presentity logs on (pub_login), logs off (pub_logout), modifies status (pub_modify), and refreshes status (pub_refresh) if it does not change the state. subscribe is sent when presentity starts (sub_initial), ends (sub_terminal), and refreshes (sub_refresh) to subscribe information from presence server. notify is sent by a server; that server notifies status of presentity to watchers (notify). These are eight situations, when someone sends a request [19]. The largest representation has request notify. Number of

notify is given by (1). It is important to create a mechanism to control the number of sent Notify messages [20]. These messages occur after the server receives a message publish; hence it is important to focus on Publish messages:

$$
\begin{aligned}
r\_notify \\
= \text{Watchers} \cdot (r\_pub\_login + r\_pub\_logout \\
+ r\_pub\_modify + r\_pub\_refresh).
\end{aligned} \tag{1}
$$

3.2. Presence Server. In this paper, server creates Notify messages in Figure 5. Incoming messages are Publish requests. Generator of Notify request creates messages to send. Number of messages depends on incoming messages and the number of authorized watchers. Requests Notify are placed in the waiting queue. Messages are sent from the server periodically to avoid network congestion. It is assigned bandwidth for service. The bandwidth divided the waiting
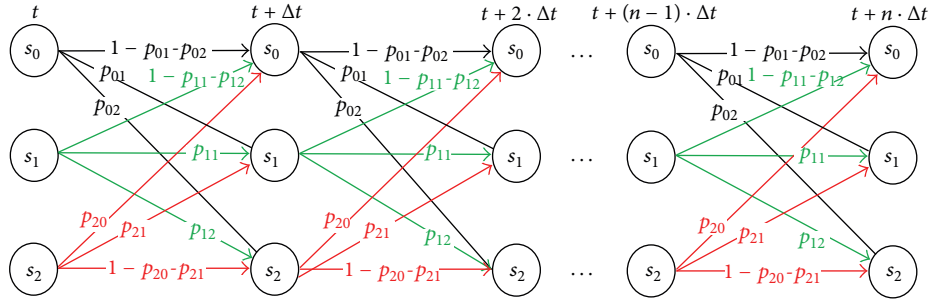
FIGURE 6: Model of making messages.

queue into two parts. Messages in yellow part of waiting queue are sent over time Δt, and messages in the red part of waiting queue must wait for send in next period. If the waiting queue is full and other messages arrive, these massages will be deleted.

4. Model for Creation of Messages

Creation of messages can be described by Markov chain shown in Figure 6. This model describes how many messages are created for time Δt in dependency on the average time the users spend in individual states and their numbers. Users can be in three states. s_0 represents online presentity that has unchanged status from time of its login or last change. s_1 represents online presentity that changed its previous status. s_2 represents offline presentity. Probability of transition from one state to another is given by exponential distribution [21] p_{ij} ($i = 0, 1, 2$; $j = 0, 1, 2$) as follows:

$$p_{ij} = \int_0^{\Delta t} \lambda_{ij} \cdot e^{-\lambda_{ij} x} dx, \tag{2}$$

where λ_{ij} is given by the average time of creation message t_{ij},

$$\lambda_{ij} = \frac{1}{t_{ij}}. \tag{3}$$

The probability, in which the user changes your state is given by the matrix:

$$
\begin{array}{c|c|c|c}
 & s_0 & s_1 & s_2 \\
\hline
s_0 & 1 - p_{01} - p_{02} & p_{01} & p_{02} \\
s_1 & 1 - p_{11} - p_{12} & p_{11} & p_{12} \\
s_2 & p_{20} & p_{21} & 1 - p_{20} - p_{21}
\end{array}
\tag{4}
$$

States means the following:

(i)

$$P(s_0, t \mid s_0, \Delta t) = 1 - p_{01} - p_{02} \tag{5}$$

is the probability in which online presentity does not change your presence status over time Δt.

(ii)

$$P(s_0, t \mid s_1, \Delta t) = p_{01} \tag{6}$$

is the probability in which online presentity changes your presence status over time Δt.

(iii)

$$P(s_0, t \mid s_2, \Delta t) = p_{02} \tag{7}$$

is the probability in which online presentity goes offline over time Δt.

(iv)

$$P(s_1, t \mid s_0, \Delta t) = 1 - p_{11} - p_{12} \tag{8}$$

is the probability in which online presentity does not change your presence status over time Δt.

(v)

$$P(s_1, t \mid s_1, \Delta t) = p_{11} \tag{9}$$

is the probability in which online presentity changes your presence status over time Δt.

(vi)

$$P(s_1, t \mid s_2, \Delta t) = p_{12} \tag{10}$$

is the probability in which online presentity goes offline over time Δt.

(vii)

$$P(s_2, t \mid s_0, \Delta t) = p_{20} \tag{11}$$

is the probability in which offline presentity goes online over time Δt.

(viii)

$$P(s_2, t \mid s_1, \Delta t) = p_{21} \tag{12}$$

is the probability in which offline presentity changes your presence status over time Δt.

(ix)

$$P(s_2, t \mid s_2, \Delta t) = 1 - p_{20} - p_{21} \tag{13}$$

is the Probability in which offline presentity stays offline over time Δt.

States s_0 and s_1 have same probability, because it is a state when presentity is online. Dividing is only for the purpose of illustrating a different message. Offline presentity cannot go to state s_1, because this state is created by the change of the online state. If we change parameters of publish modify and publish refresh, the number of other messages stays the same.

4.1. Meaning of Transition between States. Messages are created when someone goes from one state to another. The number of messages pub_modify is given by (14), the number of pub_login is given by (15), and the number of pub_logout is given by (16). Number of messages pub_refresh is counted differently. Probability of creation of messages is given by (17), where R is the time after which the user sends a message, if not, it changes its state, t_m is the average time of change presence status, and t_{of} is the average time of user log off. The number of messages pub_refresh is given by (18). The number of messages s_pub_x over interval $\langle T_1, T_2 \rangle$ is given by (19), where x is the one has type of messages.

$$\text{pub\_modify}(t)$$
$$= s_0(t) \cdot P(s_0, t \mid s_1, t - \Delta t) \tag{14}$$
$$+ s_1(t) \cdot P(s_1, t \mid s_1, t - \Delta t),$$

$$\text{pub\_login}(t) = s_2(t) \cdot P(s_2, t \mid s_0, t - \Delta t), \tag{15}$$

$$\text{pub\_logout}(t) = s_0(t) \cdot P(s_0, t \mid s_2, t - \Delta t)$$
$$+ s_1(t) \cdot P(s_1, t \mid s_2, t - \Delta t), \tag{16}$$

$$P_{\text{ref}} = \left(1 - \int_0^R \frac{1}{t_m} \cdot e^{(-1/t_m)x} dx \right)$$
$$+ \left(1 - \int_0^R \frac{1}{t_{of}} \cdot e^{(-1/t_{of})x} dx \right), \tag{17}$$

$$\text{pub\_refresh}(t) = s_0(t) \cdot P_{\text{ref}} + s_1(t) \cdot P_{\text{ref}}, \tag{18}$$

$$s\_pub\_x = \int_{T_1}^{T_2} \text{pub\_x}(t)\, dt. \tag{19}$$

The number of notify messages is given by the number of online watchers and the number of Publish messages as follows:

$$\text{notify}(t)$$
$$= \text{watchers}(t) \cdot \big(\text{pub\_refresh}(t) + \text{pub\_modify}(t)$$
$$+ \text{pub\_login}(t) + \text{pub\_logout}(t) \big). \tag{20}$$

5. Using the Model

A network with 550 000 users is given. They are assigned into online users in states s_0 and s_1 and offline users in the state s_2. t_{on} is the average time of the user being in an online state. t_{off} is the average time of the user being in the offline state.
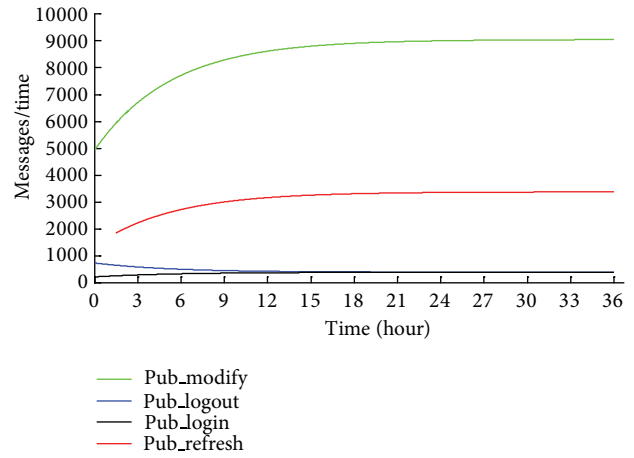

FIGURE 7: Messages in system A.

If t_{on} is more than t_{off}, then the number of online users increases. The number of online users decreases in another case. t_m is the average time of change of user state. Time Δt represents time, when server collects information and subsequently sends them periodically.

System A describes a situation, where the number of online users increases with time. The number of messages created over Δt is shown in Figure 7. The system is characterized by the following:

$$s_0 = 150\,000,$$
$$s_1 = 50\,000,$$
$$s_2 = 350\,000,$$
$$t_{on} = 480 \text{ minutes},$$
$$t_{off} = 240 \text{ minutes},$$
$$t_m = 20 \text{ minutes},$$
$$\Delta t = 0.5 \text{ minutes},$$
$$R = 45 \text{ minutes}.$$

System B describes a situation, where the number of online users decreases over time. The number of messages is shown in Figure 8. The system is characterized by the following:

$$s_0 = 150\,000,$$
$$s_1 = 50\,000,$$
$$s_2 = 350\,000,$$
$$t_{on} = 240 \text{ minutes},$$
$$t_{off} = 480 \text{ minutes},$$
$$t_m = 20 \text{ minutes},$$
$$\Delta t = 5 \text{ minutes},$$
$$R = 45 \text{ minutes}.$$

Figure 9 shows the number of messages pub_modify at different average times of change status t_m. Decrease in t_m would mean adding more applications to the network.
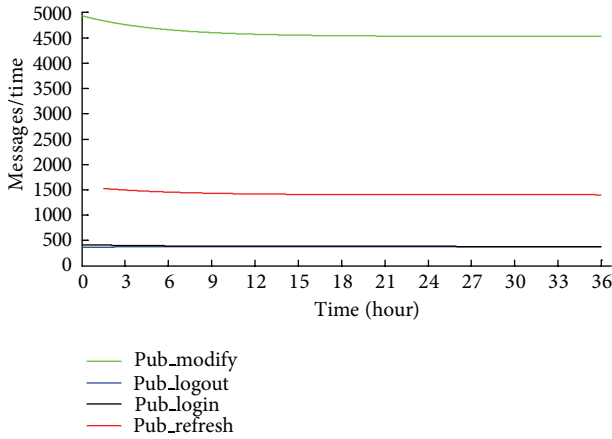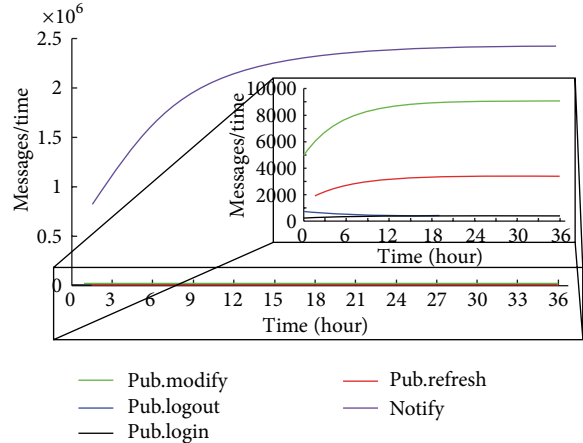
FIGURE 8: Messages in system B.

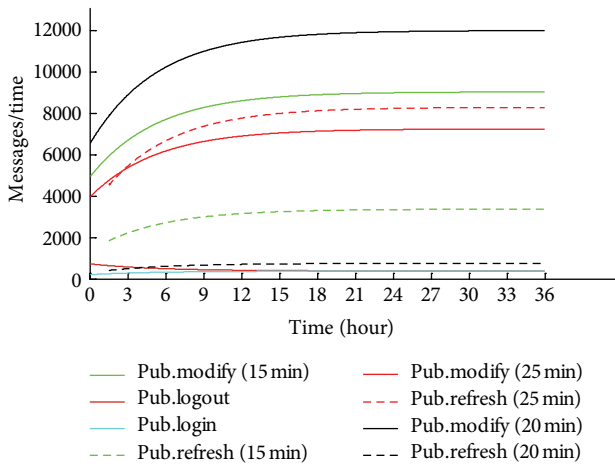FIGURE 10: System A with Notify messages.

FIGURE 9: System A with increasing amount of messages.

If changes are more frequent, the amount of messages is increased.

Figure 10 shows the number of Notify messages, where the number of watchers of one's presentity is increasing with the number of online users. The number of messages is calculated by (19), where the number of watchers is given by (21). k represents the ratio of the amount of users in the telephone list and the amount of all users.

One has

$$\text{watchers}(t) = (s_0 + s_1) * k. \tag{21}$$

For Figure 10, $k = 0.005$.

6. Conclusion

Presence service is one of the key services in IMS. It allows the creation of a huge amount of applications, which can share information. Protection of this information is important. We can find some information about protection in [22, 23]. We have to consider some aspects before its deployment. The service requires creation of agents on the user's devices and some blocks of IMS. Agents collect information and send it to the presence server. The presence server must be at the application layer in which the server processes incoming messages and sends information about the user's state. It is necessary to create a mechanism that controls the number of transmitted messages, because a huge amount of messages can overload the network. We need to determine the number of messages transmitted by the network before designing this mechanism. The model described in this paper can be used for this. This model displays the number of incoming and outgoing messages from the network. Users are in various states at the beginning, and gradually they log out, log in, and change their presence status. The change of the number of transmitted messages is related to this. If we observe this long enough without changing probability, the model will be in a stable state. That means that the same number of users changes their state in every step. We can determine the expected number of messages from the model, and according to this, we can design the size of the waiting queue on the presence server. We can see the ratio of messages if we want to assign different priorities too.
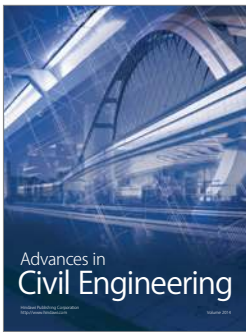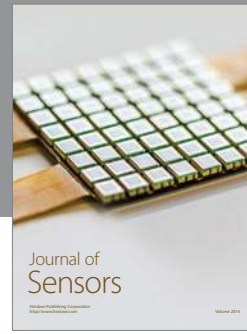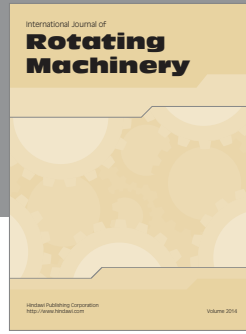
Acknowledgments

References

[1] G. Camarillo and M. Garcia-Martin, *The 3G IP Multimedia Subsystem (IMS): Merging the Internet and the Cellular Worlds*, John Wiley & Sons, New York, NY, USA, 2nd edition, 2006.

[2] A. Al-Hezmi, T. Magedanz, J. J. Pallares, and C. Riede, "Evolving the convergence of telecommunication and TV services over NGN," *International Journal of Digital Multimedia Broadcasting*, vol. 2008, Article ID 843270, 11 pages, 2008.

[3] M. J. Sharma and V. C. M. Leung, "IP multimedia subsystem authentication protocol in LTE-heterogeneous networks," *Human-Centric Computing and Information Sciences*, vol. 2, p. 16, 2012.

[4] Z. S. Khan, M. Sher, and K. Rashid, "Presence based secure instant messaging mechanism for IP multimedia subsystem," in *Computational Science and Its Applications (ICCSA '11)*, vol. 6786 of *Lecture Notes in Computer Science*, pp. 447–457, Springer, 2011.

[5] M. Voznak and J. Rozhon, "Approach to stress tests in SIP environment based on marginal analysis," *Telecommunication Systems*, vol. 52, no. 3, pp. 1583–1593, 2013.

[6] Z. Bečvář, P. MacH, and B. Šimák, "Improvement of handover prediction in mobile WiMAX by using two thresholds," *Computer Networks*, vol. 55, no. 16, pp. 3759–3773, 2011.

[7] P. Zahradník, B. Šimák, M. Vlček, and M. Kopp, "Band-pass filters for direct sampling receivers," in *Proceedings of the 11th International Conference on Networks (ICN '12)*, pp. 44–49, IARIA, Saint Gilles, Reunion Island, 2012.

[8] M. Poikselka, G. Mayer, H. Khartabil, and A. Niemi, *The IMS: IP Multimedia Concepts and Services in the Mobile Domain*, John Wiley & Sons, New York, NY, USA, 2004.

[9] S. Leggio, "SIP for instant messaging and presence leveraging extensions," 2005, http://antoine.fressancourt.free.fr/exjobb/BB_SIP.pdf.

[10] H. Sugano, S. Fujimoto, G. Klyne, A. Bateman, W. Carr, and J. Peterson, "RFC 3863: presence information data format (PIDF)," 2004.

[11] H. Schulzrinne, U. Columbia, V. Gurbani, P. Kyzivat, and J. Rosenberg, "RFC 4480: RPID: rich presence extensions to the presence information data format (PIDF)," 2006.

[12] M. Poikselka, G. Mayer, H. Khartabil, and A. Niemi, *The IMS: IP Multimedia Concepts and Services in the Mobile Domain*, John Wiley & Sons, New York, NY, USA, 2004.

[13] M. Day, J. Rosenberg, and H. Sugano, "RFC 2778: a model for presence and instant messaging," 2000.

[14] M. Wuthnow, M. Stafford, and J. Shih, *IMS: A New Model for Blending Applications*, Taylor & Francis, Boca Raton, Fla, USA, 2010.

[15] G. Camarillo and M. Garcia-Martin, *The 3G IP Multimedia Subsystem (IMS): Merging the Internet and the Cellular Worlds*, John Wiley & Sons, New York, NY, USA, 2nd edition, 2006.

[16] A. Niemi, M. Lonnfors, and E. Leppanen, "RFC, 5264: publication of partial presence information," 2008.

[17] S. Kumar Singh and H. Schulzrinne, "Presence," 2006, /presence_simplified.pdf.

[18] C. Urrutia-Valdés, A. Mukhopadhyay, and M. El-Sayed, "Presence and availability with IMS: applications architecture, traffic analysis, and capacity impacts," *Bell Labs Technical Journal*, vol. 10, no. 4, pp. 101–107, 2006.

[19] C. Chi, R. Hao, D. Wang, and Z. Cao, "IMS presence server: traffic analysis & performance modelling," in *Proceedings of the 16th IEEE International Conference on Network Protocols (ICNP '08)*, pp. 63–72, Orlando, Fla, USA, October 2008.

[20] J. Liao, J. Wang, T. Li, J. Wang, and X. Zhu, "A token-bucket based notification traffic control mechanism for IMS presence service," *Computer Communications*, vol. 34, no. 10, pp. 1243–1257, 2011.

[21] Z. Cao, C. Chi, R. Hao, and Y. Xiao, "User behavior modeling and traffic analysis of IMS presence servers," in *Proceedings of IEEE Global Telecommunications Conference (GLOBECOM '08)*, pp. 2469–2473, New Orleans, La, USA, December 2008.

[22] F. Rezac and M. Voznak, "Penetration tests in next generation networks," in *Mobile Multimedia/Image Processing, Security, and Applications*, vol. 8406 of *Proceedings of SPIE*, Baltimore, Md, USA, 2012.

[23] J. Safarik, M. Voznak, F. Rezac, and L. Macura, "Malicious traffic monitoring and its evaluation in VoIP infrastructure," in *Proceedings of the 35th International Conference on Telecommunications and Signal Processing (TSP '12)*, pp. 259–262, Prague, Czech Republic, 2012.

Journal of
Engineering

The Scientific
World Journal

International Journal of
Rotating
Machinery

Journal of
Sensors

International Journal of
Distributed
Sensor Networks

Advances in
Civil Engineering

Journal of
Control Science
and Engineering

Journal of
Robotics

Journal of
Electrical and Computer
Engineering

Hindawi

Submit your manuscripts at
http://www.hindawi.com

Advances in
OptoElectronics

VLSI Design

International Journal of
Navigation and
Observation

Modelling &
Simulation
in Engineering

International Journal of
Aerospace
Engineering

International Journal of
Chemical Engineering

International Journal of
Antennas and
Propagation

Active and Passive
Electronic Components

Shock and Vibration

Advances in
Acoustics and Vibration