Correlation-Based Similarity Measure for Multimedia Services With QoS Support

MILAN BJELICA AND ZORAN PETROVIĆ
Communications Department
School of Electrical Engineering, University of Belgrade
Belgrade
SERBIA AND MONTENEGRO

Abstract: - User modelling will extensively be used in future multiservice communication networks. By using its techniques, network operaters and service providers will be able to learn about the user habits and to serve his/her requests more efficiently. In this paper, we describe a correlation-based pseudometric that could be used for creating a model for estimation of the services the user is likely to access in the future.

Key-Words: - User modelling, Multimedia services, Future communication networks, Quality of service

1 Introduction

New multimedia services will pose significant demands not only in front of future communication networks, but service providers as well. In the dynamic multiservice environment, it will be of the greatest importance to offer a user with a set of services that are tailored to meet his/her demands. After the user would access the selected service, quality of service (QoS) mechanisms would be used to maintain the level of quality perceived by him/her at the appropriate level.

As noted in [1], future communication networks will need to create and maintain the profiles of their users, in order to estimate their preferences regarding the presentation of multimedia content. These user profiles are created by using the user modelling theory and, if appropriately made, would enable the estimation or prediction of the services the users would access in the future. The importance of user modelling in mobile networks is emphasized in paper [2]. The modelling would be done by agents that would either reside on the server side, or would be true mobile agents and stay with the user all the time, e. g. on his/her terminal.

In this paper, we address the question of modelling the users of future networks with the intention to create a model for offering them with the services, which are likely to fit their preferences. We shall propose a measure of correspondence between the service and the (estimated) user preferences, which could be used by the provider when deciding which service to offer.

The rest of this paper is organized as follows. In Section 2, we give the overview of related work. Our proposal is presented in Section 3. Section 4 gives some simulation results, and Section 5 concludes the paper.

2 Related Work

The way the humans interact with multimedia content is still not fully explained. This is the reason why there are few works that address the issue of building the service offers.

Ogino in [3] proposed a model that offered the service that would maximize the network provider profit rate. Only network QoS parameters are taken into account and it is not obvious how the higher-level QoS parameters and service attributes influence the service selection.

In our paper [4], we presented a procedure for service selection on the user side that used generalized Euclidean distance. The user chooses the service offer which has the maximal distance from the minimal acceptable quality. However, we do not find this approach too suitable for the future mobile networks. Since the user keeps his/her presentational preferences confidential, the provider would need the large database on that user's previous interactions in order to adequately estimate all parameters in model. Also, Euclidean distance does not seem to represent the attributes of multimedia in the best way.

Extensive work has been done lately in the filed of image retrieval. Doulamis et al. in [5] applied so-called correlation-based relevance feedback to searching over video databases. Pseudometric function is used to determine the level of similarity of database samples to the images that the user has marked as relevant or irrelevant to the current query.

This approach complies with the user model acquisition techniques that are described in [6]. The idea and the results presented in [5] strongly influenced our work in this field.

3 Our Proposal

We shall try to extend the idea presented in [5] to estimating the user preferences and predicting the service he/she is likely to accept. Our goal is to develop a model for offering a service in future multiservice networks which would comply with ITU-T Recommendation G.1000 [7] and framework for QoS negotiation, which we proposed in [8].

Let us start by assuming that through centralized entities such as HLR, service provider has the knowledge on technical parameters of user terminal, **p**. There is no point to offer a user with quality that exceeds **p**. Moreover, we shall assume that provider has the access to data on m services the user has previously accessed. We shall mark these data as $\mathbf{s}_j$, $j = 1, 2, \ldots, m$. We then define the similarity between current service, **s**, and the user preferences as

$$\rho(\mathbf{s}) = \frac{\sum_{i=1}^{n} \alpha_i s_i}{\sqrt{\sum_{i=1}^{n} \alpha_i^2}\sqrt{\sum_{i=1}^{n} s_i^2}}, \quad (1)$$

where α_i, $i = 1, 2, \ldots, n$ are coefficients that take into account user's presentational preferences. Vectors $\boldsymbol{\alpha}$ and $\mathbf{s}$ are of the length n, and their elements α_i and s_i are organized in mutually corresponding way.

Service provider needs to determine the optimal values of coefficients α_i, $i = 1, 2, \ldots, n$. To do that it uses the history data, $\mathbf{s}_j$, $j = 1, 2, \ldots, m$, to maximize the value of function

$$C(\boldsymbol{\alpha}) = \sum_{j=1}^{m} \rho(\mathbf{s}_j) = \sum_{j=1}^{m} \frac{\sum_{i=1}^{n} \alpha_i s_{j,i}}{\sqrt{\sum_{i=1}^{n} \alpha_i^2}\sqrt{\sum_{i=1}^{n} s_{j,i}^2}}. \quad (2)$$

By taking the derivates of (2) regarding to α_k, and setting them equal to zero, we get

$$\sum_{i=1}^{n} \alpha_i \cdot \sum_{j=1}^{m} \frac{s_{j,k}}{\sqrt{\sum_{i=1}^{n} s_{j,i}^2}} = \alpha_k \cdot \sum_{j=1}^{m} \frac{\sum_{i=1}^{n} \alpha_i s_{j,i}}{\sqrt{\sum_{i=1}^{n} s_{j,i}^2}}, \quad (3)$$

$$k = 1, 2, \ldots, n.$$

This gives

$$\alpha_k = \frac{\sum_{i=1}^{n} \alpha_i \cdot \sum_{j=1}^{m} \frac{s_{j,k}}{|\mathbf{s}_j|}}{\sum_{j=1}^{m} \frac{\sum_{i=1}^{n} \alpha_i s_{j,i}}{|\mathbf{s}_j|}}, \quad (4)$$

and also

$$\alpha_l = \frac{\sum_{i=1}^{n} \alpha_i \cdot \sum_{j=1}^{m} \frac{s_{j,l}}{|\mathbf{s}_j|}}{\sum_{j=1}^{m} \frac{\sum_{i=1}^{n} \alpha_i s_{j,i}}{|\mathbf{s}_j|}}, \quad (5)$$

where $|\mathbf{s}_j| = \sqrt{\sum_{i=1}^{n} s_{j,i}^2}$. This brings us to the following recursive relation:

$$\alpha_k = \alpha_l \frac{\sum_{j=1}^{m} \frac{s_{j,k}}{|\mathbf{s}_j|}}{\sum_{j=1}^{m} \frac{s_{j,l}}{|\mathbf{s}_j|}}, \; k \neq l, \quad (6)$$

which enables us to express $n - 1$ coefficients in terms of one, say α_1. To determine α_1, we need an additional assumption, like $|\boldsymbol{\alpha}| = 1$ [5]. Finally, we get

$$\alpha_1 = \frac{1}{\sqrt{\sum_{i=1}^{n} A_i^2}}, \quad (7)$$

where

$$A_i = \frac{\sum_{j=1}^{m} \frac{s_{j,i}}{|\mathbf{s}_j|}}{\sum_{j=1}^{m} \frac{s_{j,1}}{|\mathbf{s}_j|}}. \qquad (8)$$

Knowing the optimal values of α_i, the provider can now check how much its offers correspond with the estimated desires of the observed user.

4 Simulation Results

The expressions (6) and (7) give basis for user modelling. We are now interested in the question of this model's reliability. Unknown coefficients α_i could be determined regardless of the number of observed services that were accessed in the past. Should the user habits express some sort of consistent pattern, then this estimation would be pretty stable, i. e. it should not depend strongly on the history size, m.

To determine whether this applies to our proposal, we ran series of computer simulation tests. Without any loss of generality, we assumed hypothetic audio streaming service, described with three attribute parameters. Maximal quality the terminal could support was set to $\mathbf{p}$ = [44 16 2]. Service history is given in Table 1, while candidate offers are listed in Table 2.

Table 1. Assumed service history.

$\mathbf{s}_1$	[8 8 1]
$\mathbf{s}_2$	[11 8 1]
$\mathbf{s}_3$	[22 8 1]
$\mathbf{s}_4$	[22 8 2]
$\mathbf{s}_5$	[8 12 1]
$\mathbf{s}_6$	[11 8 1]

Table 2. Available service offers.

#1	[16 8 1]
#2	[14 8 2]
#3	[10 16 2]
#4	[8 16 2]

Optimal values of coefficients α_1, α_2 and α_3, as well as the offer ranking for different history sizes, m, are given in Table 3.

It can be seen that the user model converges quickly to the "steady state" solution. It was sufficient to observe three services that were previously accessed to come to the final offer ranking.

Table 3. Simulation results.

m	α_1	α_2	α_3	Order
1	0.7044	0.7044	0.0880	3, 4, 1, 2
2	0.7578	0.6475	0.0809	3, 1, 4, 2
3	0.8302	0.5532	0.0691	1, 3, 2, 4
4	0.8617	0.5020	0.0736	1, 3, 2, 4
5	0.8126	0.5781	0.0739	1, 3, 2, 4
6	0.8116	0.5796	0.0738	1, 3, 2, 4

Simulation was repeated for numerous combinations of input parameters different than those listed above. The results obtained were consistent with the herein presented ones.

4 Conclusion and Future Work

In this paper, we presented a correlation-based pseudometric that could be used for user modelling in future multiservice communication networks. The obtained user model could then be used to estimate the service parameters which would best fit the user needs in the future. Series of simulation tests that we ran showed that our approach does have the potentials to fulfil these expectations.

There are numerous issues that remain open for the future work. The first one would be the offer modelling, i. e. choosing the service parameters that are relevant to the overall end-user experience. It should be aware of different compression schemes that could be applied among the offers that relate to the same service. Next, the original idea presented here could be extended to take into account the evolution of user's presentational patterns. For example, previously accessed services could be assigned with different "weights" that would emphasize their influence on current user habits. Data provided by existing multimedia service providers could significantly help in the model development and could be used in testing its performance under real-world circumstances. Finally, the model could be implemented as a neural network.

References:

[1] Giuseppe Araniti, Pasquale De Meo, Antonio Iera and Domenico Ursino, Adaptively Controlling the QoS of Multimedia Wireless Applications Through 'User Profiling' Techniques, *IEEE Journal on Selected Areas in Communications*, Vol. 21, No. 10, December 2003, pp. 1546-1556.

[2] Alfred Kobsa, Generic User Modeling Systems, *User Modeling and User-Adapted Interaction*, Vol. 11, 2001, pp. 49-63.

[3] Nagao Ogino, Connection Establishment Protocol Based on Mutual Selection by Users and Network Providers, *Proceedings of First International Conference on Information and Computational Economics (ICE)*, 1998.

[4] Milan Bjelica and Zoran Petrovic, QoS Negotiation Procedure for Distributed Multimedia Applications, *Proc. 10th International Conference on Software, Telecommunications & Computer Networks SoftCOM 2002*, pp. 65-69.

[5] Nikolaos D. Doulamis, Anastasios D. Doulamis and Theodora A. Varvarigou, Adaptive Algorithms for Interactive Multimedia, *IEEE Multimedia*, Vol. 10, No. 4, October-December 2003, pp. 38-47.

[6] Wolfgang Pohl, Learning About the User – User Modeling and Machine Learning, in V. Moustakis and J. Herrmann, editors, *Proc. ICML'96 Workshop "Machine Learning Meets Human-Computer Interaction"*, 1996, pp. 29-40.

[7] ITU-T Recommendation G.1000, *Communications Quality of Service: A Framework and Definitions*, Dakar, 2001.

[8] Milan Bjelica, Zoran Petrović, A Framework for QoS Negotiation in Future Mobile Networks, *WSEAS Transactions on Communications*, Vol. 2, Issues 2 and 3, April and July 2003, pp. 199-202.