Selection of Appropriate Technologies for Universal Service

Bojan Bakmaz[1], Natasa Gospic[2], Dragan Bogojevic[3], Marijana Davidovic[4]

Abstract – **The project "Universal Service in Serbia-Status, Needs and Proposal of Solutions" aims to develop strategies for Universal Service (US) in Serbia. Carried out in two phases – a preparatory phase and field investigation phase, the Project will address infrastructure, service and investment requirements, based on validated data on demographic and economic characteristics of the territory. One of the expected Project results is proposal of technology which could be applied for specific region. For this reason one of possible methodology in appropriate technology selection is presented in the paper.**

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Keywords – **Universal service, Serbia, Fuzzy logic, critical criteria, UMTS, VSAT, WiMAX, FTTH, DSL.**

I. INTRODUCTION (BACKGROUND AND CONTEXT)

Serbia is in the process of addressing the issue of Universal Service (US) in telecommunications. In terms of organizational responsibilities, the Ministry of Telecommunication and Information Society defines US to be provided by the operators of public fixed telecommunications networks. This is done on the basis of the proposals made by the Regulatory Agency for Telecommunications (RATEL). After definition of US by the Ministry, the role of the RATEL is to designate a telecommunications operator of a public telecommunications network that shall be responsible for the provision of US.

Currently, the scope of US includes the following:

1. Access to a public fixed telephone service, including the service of data transmission using voice telephony which enables quality access to the Internet;
2. Specific measures to ensure equivalent access to the public voice service for disabled users and users with special social needs;
3. Free access to emergency services;
4. Public pay phone service; and
5. Access to telephone operator and directory services.

[1]Bojan Bakmaz is with the Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: b.bakmaz@sf,bg.ac.yu

[2]Natasa M. Gospic is with the Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: n.gospic@sf.bg.ac.yu

[3]Dragan Bogojevic is with the Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: d.bogojevic@sf.bg.ac.yu

[4]Marijana Davidovic is with the Faculty of Transport and Traffic Engineering, Vojvode Stepe 305, 11000 Belgrade, Serbia, E-mail: m.davidovic@sf.bg.ac.yu

It is to be noted that broadband services are not included amongst the obligations. Yet no strategy for information society can ignore broadband access to educational institutions. This issue was addressed in details in [1], [5]. An integral element of the US strategy is the establishment of the Fund for US cost recovery.

In order to answer to these tasks, RATEL creates a Project on Universal Service in Serbia. The main objectives of the project is to develop a detailed overview of the situation of telecom infrastructure and telecom service provisioning in the whole territory of Serbia, organized through regions as administrative units and to recommend appropriate solutions and approaches. The applied Project methodology will include detailed overview of the situation for the locations without telecom services (0% penetration) and locations with low penetration (4 and 10%).

The project is divided into two phases. First phase focuses on definition of the basic data sets (population, age profile, employment, economy etc); existing telecom services; analysis of the universal service levels etc. Within the project specific tariff schemes for users with special social needs will be analyzed in order to determine the amount of subsidies from US fund, along with needs for broadband services,

Researches are based on territorial division of Republic of Serbia as region, municipality and settlements. Republic of Serbia (without Kosovo and Metohija) is divided in 24 region and City of Belgrade, 161 municipalities with 7.498.001 inhabitants, 2.521.190 households and 4.715 settlements (Census 2002). Introducing the telecom statistics data in previously mentioned statistics following databases are created:

- Statistics on the settlements level
- Statistics of the regions where US is critical
- Statistics of municipalities where US is critical

Database related to Statistics on the settlements level contains following data for each settlements:

- Number of inhabitants
- Index of number of inhabitants 2002/1991
- Number of households
- Number of fixed phones
- Teledensity (number of phones per 100 inhabitants in percent)
- Mobile signal coverage
- Internet access

Number of fixed phone was calculated using available data from incumbent operators and Directories (hard and e-format).

Database related to Statistics of the regions where US is critical (contains following data:

- Number of settlements without fixed telephones
- Number of inhabitants without fixed telephones
- Number of settlements where US should be realized
- Number of inhabitants in the settlements where US should be realized
- Number of settlements with telephone penetration less then 4%
- Number of settlements with telephone penetration less then 10%.

Having those data, it was identified: Total number of municipalities with settlements without fixed telephone (number of municipalities and number of settlements) and with penetration of 4% and 10%. In order to check obtained data in the second phase the Questionnaires was created. Field investigation was performed in sampled locations in each region. Minimum number of settlements where elaboration will be performed during second phase will be 150 settlements. This set will be divided in two subsets. First subset is a group of settlements were personal presence of team members in the field is required and second subset are settlements where elaboration will be performed by phone or post.

Analyzing situation in the specific region an appropriate technology for US should be recommended. In principle, this task is performed based on different US examples from different countries and Delphi methods performed by telecom experts. In addition, an attempt to develop new approach based on previous mentioned methods and Fuzzy logic is carried out and presented in this paper.

II. Methodology for Appropriate US Technology Selection

Besides defining the responsibilities for US strategy, its coverage, financing and other regulatory subjects, the methodology of choosing the adequate telecommunication technology is of significant importance. Within the EU directives, ITU studies [3], OECD approach [2] and other available literature on US, the technology neutral approach is treated..

Each of the available technologies has its own performance and economic characteristics, and its advantages and disadvantages for US solutions. For example, cable, fibre, and DSL technologies have significant bandwidth advantages over broadband Wireless Local Loop (WLL), Broadband over Power Line (BPL), and Very Small Aperture Terminal (VSAT). However, cable, DSL (Digital Subscriber Line), and fibre work out best in high populated density areas and may be uneconomic in less density populated areas. A potential scenario in many OECD countries, therefore, is an environment where metropolitan areas have significantly richer capabilities than the rural areas [2]. This may have long-term effects on social and economic opportunities in rural areas and is even more obvious in developing countries.

In deciding which technology is appropriate the following criteria should be considered:

- Density of population,
- Distance to the closest network connection point (CNCP),
- Geographic-topological characteristics of the region, and
- Cost (infrastructure, equipment, operational expenses, etc.)

In addition, it is possible to consider expected traffic per user, aggregated traffic for the whole region, regulatory factors, etc. As many of criteria are linguistic variables the concepts of fuzzy logic, Multi-Attribute Decision Making (MADM), or their combination could be applied.

The authors use fuzzy logic for obtaining analytical solutions of appropriate technology. In this case it is necessary to define input and output variables as well as the set of rules. For the purpose of US following input variables are considered:

- Number of households (NoH) which can be small (S), medium (M), and large (L) (Fig. 1.a);
- Distance from the CNCP: small (S), medium (M), and large (L) (Fig. 1.b);
- Type of region (ToR): plain (P), combined (C), and mountain (M) (Fig. 1.c).

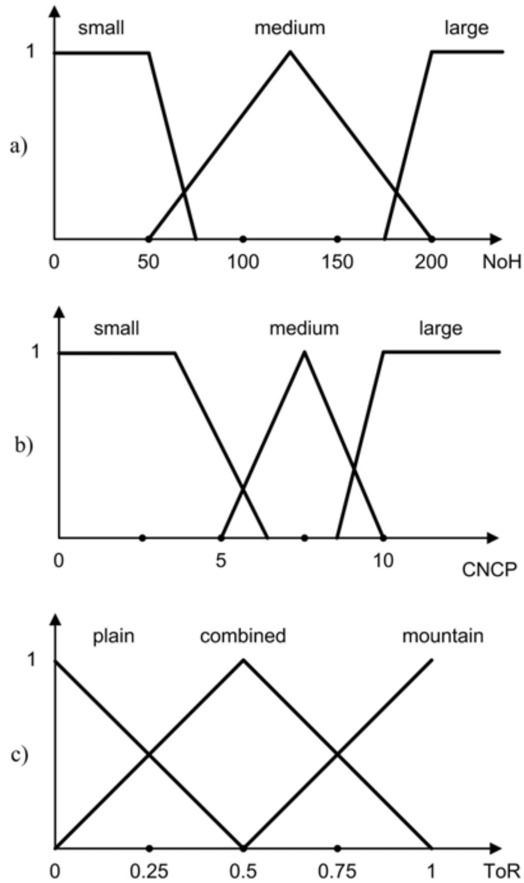

Fig. 1. Input variables: a) number of households, b) distance from the CNCP, c) type of region

In the model, the optimal technology exists as the single output variable [for example cable (FTTH, DSL), UMTS, WiMAX and VSAT]. Model based on fuzzy logic with three inputs and one output variable is shown in Fig. 2.

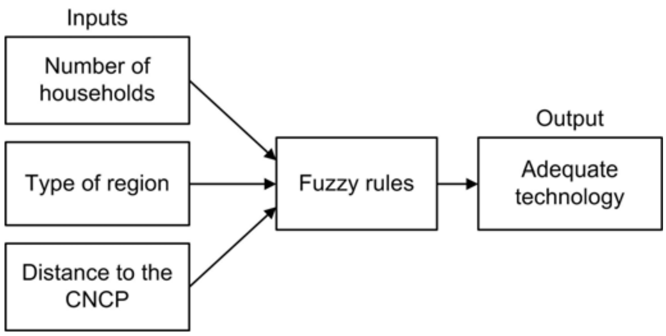

Fig. 2. Fuzzy logic model

The next step in applying Fuzzy logic is definition of the set of rules, in our case 27 rules (3 variables with 3 different labels). The set of rules is shown Table I. The column related to appropriate technology (AT) is defined using Delphi method. Fig 3 shows the obtained results for particular combination of the linguistic variables.

TABLE I
SET OF FUZZY RULES

Rule	NoH	ToR	CNCP	AT
1.	S	P	S	GSM/UMTS
2.	S	P	M	GSM/UMTS
3.	S	P	L	VSAT
4.	S	C	S	GSM/UMTS
5.	S	C	M	WiMAX
6.	S	C	L	VSAT
7.	S	M	S	GSM/UMTS
8.	S	M	M	GSM/UMTS
9.	S	M	L	VSAT
10.	M	P	S	DSL/GSM/UMTS
11.	M	P	M	FTTH/ WiMAX
12.	M	P	L	GSM/UMTS
13.	M	C	S	GSM/UMTS
14.	M	C	M	WiMAX
15.	M	C	L	GSM/UMTS
16.	M	M	S	GSM/UMTS
17.	M	M	M	WiMAX/ GSM
18.	M	M	L	WiMAX
19.	L	P	S	DSL /FTTH
20.	L	P	M	WiMAX
21.	L	P	L	FTTH/ UMTS/ WiMAX
22.	L	C	S	DSL/FTTH
23.	L	C	M	GSM/UMTS
24.	L	C	L	GSM/UMTS
25.	L	M	S	GSM/UMTS
26.	L	M	M	GSM/UMTS
27.	L	M	L	GSM/UMTS

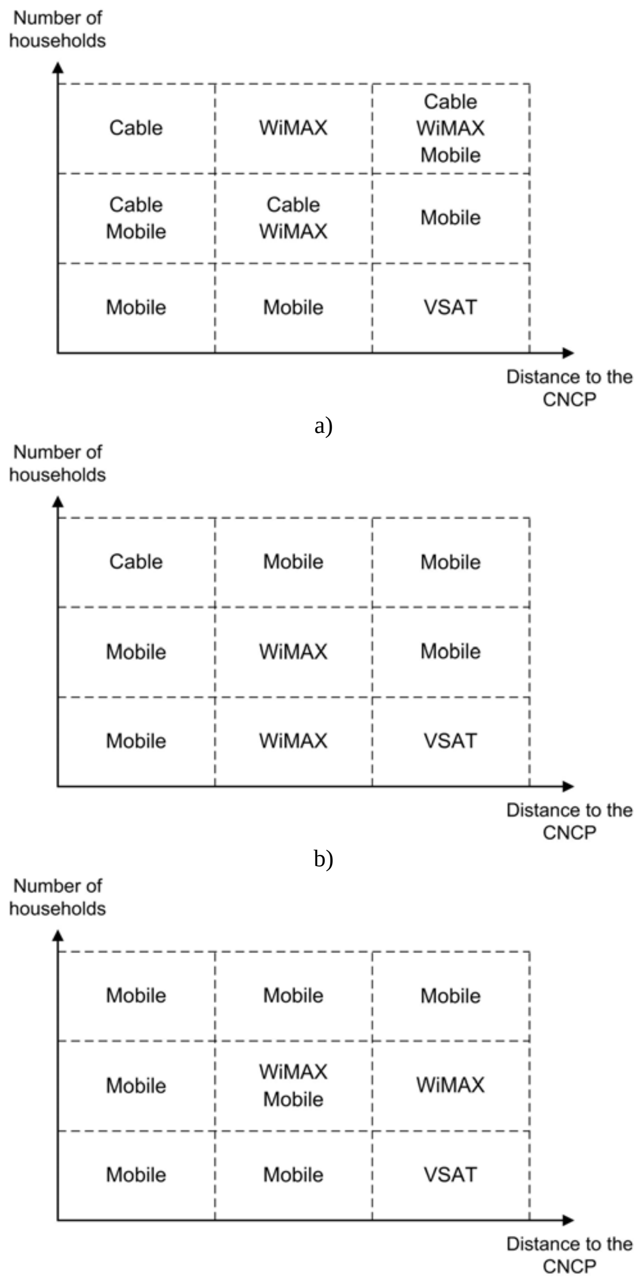

Fig. 3. Graphical interpretation of fuzzy rules:
a) plain region, b) combined region, c) mountain region

III. PRICE FACTOR

The use of fuzzy logic in determining US technology has a disadvantage that price as criteria is not introduced as input variable. If price factor is used drastic enlargement in number of the rules will appear. The enlargement of the number of rules would lead to unacceptable model complexity. The problem with the price factor could be exceeded by introducing it in cases where the output of the fuzzy systems is more than one technology. In that case the most adequate technology will be one with the lowest price per user *C*. In order to compare price differences between different technologies it is proposed that the price of the technology is calculated from the Eq. (1):

$$C = n\,C_{ie}\,/\,u + C_s\,T + C_{te} \qquad (1)$$

where *n* is the number of installation equipment units, *u* the number of users, *Cie* individual price of the installation equipment, *Cs* the service price per user for the one month period, *T* expected operation period in months, and *Cte* individual price for the terminal equipment. This Eq. (1) is checked for several technologies.

IV. CONCLUSION

In the paper one methodology for determining appropriate technologies for US described. Within the EU directives, ITU studies, US examples from different countries and other available literature on US, the technology neutral approach is included. Each of the available technologies has its own advantages and disadvantages for US solutions and the authors propose that the list of potential technologies is selected with Delphi methods performed by telecom experts.

In deciding which technology is appropriate the following criteria should be considered: number of households, distance to the closest network connection point, geographic-topological characteristics of the region and costs. As many of criteria are linguistic variables the concepts of fuzzy logic, MADM, or their combination could be applied.

The price factor is introduced in cases where the output of the fuzzy systems is more than one technology. In that case the most appropriate technology will be one with the lowest price per user, calculated by proposed equation.

In next phase of research described methodology will be applied on US solutions for particular critical municipalities and regions in Serbia.

REFERENCES

[1] Nataša Gospić, Dragan Bogojević, "Izbor politike Univerzalnog servisa: Uskopojasni i/ili širokopojasni servis", *YU INFO 2008*, Kopaonik, Mart 2008.

[2] OECD, "Rethinking Universal Service for a Next Generation Network Environment", *Report of the Working Party on Communication and Information Service Policies*, DST/ICCP/TISP (2005)5/FINAL, April 2006, www.oecd.org

[3] ITU-CTO, Model Universal Service/Access Policies, Regulations and Procedures, Part II, Draft, *ITU/CTO WORKSHOP ON UNIVERSAL ACCESS MODELS*, Gambia, April 2003.

[4] Nataša Gospić, Dragan Bogojević, Slobodan Lazović, Nataša Mitić, "Upravljanje Unverzalnim Servisom", *PosTel 2007*, Zbornik radova, str. 33 – 44, Beograd, Decembar 2007.

[5] Natasa Gospic, Dragan Bogojevic, "Universal Service Wireless Broadband Policy in Serbia", *ITU/BDT Regional Seminar on Broadband Wireless Access (BWA) for CIS, CEE, and Baltic Countries*, Moscow, November 2007.