Users Dimensioning and Traffic Modelling in Rural e-Health Services

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Abstract. The development of e-Health services in rural environments, where broadband networks are usually not accessible, requires a specific analysis of available resources to improve Quality of Service (QoS) management. This work quantifies the maximum number of simultaneous users that fulfill the specific QoS levels in common e-Health services, including both store-and-forward and real-time telemedicine applications. The analysis also proposes variations in the modelling of traffic distributions regarding the number of multiplexed users. The results obtained in this study permit an accurate users dimensioning, which is necessary to optimize the performance and to guarantee the QoS requirements in this kind of services where network resources are limited.

Keywords: e-Health, QoS, rural services, traffic model, user dimensioning.

1 Introduction

The great advance in new technologies in the last years has allowed to increase the quantity and to improve the quality of e-Health services in very varied assistance scenarios (rural environments, tele-assistance, home assistance, etc.) [1]-[3]. Every of these heterogeneous environments includes different Types of Service (ToS) that require specific analyses and precise estimations of the Quality of Service (QoS) level that can offer [4], [5].

In order to achieve that objective, it is crucial to study two aspects: the specific nature of the information to transmit and the exact behaviour of the networks transporting it. Regarding the first aspect, a particular description of traffic models and parameters associated to the service is required. With regard to the second, the network parameters that allow to estimate QoS levels have to be studied to guarantee the feasibility, efficiency and the precise parameter range for the correct behaviour of e-Health services [6]-[8].

In this line, an extended idea is to manage and vary adaptively the transmission of information generated by applications (codecs, transmission rate and compression levels, etc.) to adapt it to network resources (capacity, available bandwidth, performance, etc.). This concept would permit to improve the QoS of e-Health communications to approach their optimum behaviour in every moment [9], [10]. In the last years, this idea has been developed in multimedia scenarios over best-effort networks like Internet, but a detailed analysis in a rural environment, like the one presented in this article, would contribute with quantitative results to optimize QoS and to model the traffic of the sources in the e-Health applications.

Rural scenarios (characterized by the long distances to the hospital) are one of the most representative environments in which new technologies allow to improve health services by bringing closer the hospital and the patient, and benefiting users in a massive way, irrespective of their location. In this context, a study to fix specific models depending on the type of traffic and the volume of information transferred as a function of the available resources are required to correctly develop services and to dimension the maximum number of users to be granted guaranteed QoS in the most adverse situations.

The analysis presented in this article has been carried out thanks to an *ad-hoc* tool [11], [12] designed to characterize, optimize and model traffic and networks from simulations as well as experimental laboratory measurements. Section 2 describes the characteristics of the rural scenario, the use cases and the traffic parameters (from the point of view of the application and the network). Section 3 analyzes the optimum application parameters that fulfill QoS depending on network conditions. These parameters serve as the starting point to Section 4, where the maximum number of system users is obtained. The different traffic models for this environment are presented in Section 5. Finally the results obtained and their translations into adaptive mechanisms to guarantee QoS are discussed in Section 6.

2 Description of the e-Health rural scenario

The features of the rural scenario correspond to a communication between a medical non-specialist (situated in a rural medical centre) and the reference hospital in order to offer tele-consulting with the medical specialist or patient tele-care, see Fig.1. The rural medical centers are situated in a remote place with fixed interconnection technologies (Public Switched Telephone Network, PSTN, or Digital Subscriber Line, DSL). These accesses are often based on narrowband technologies [13], [14]. Thus, for every user connection, the maximum transmission rate to the hospital (*upstream*) $r \leq 64$kb/s is considered in the access point. These different user connections are multiplexed over the remote hospital server, which requires more capacity (C=k·64kb/s, with $k \geq 1$).

In addition, every user connection may include different ToS grouped into two main categories: Store-and-Forward (SF) services and Real-Time (RT) services. SF services are used for applications without time requirements (e.g. medical tests transmission to Electronic Healthcare Record (EHR) database). RT services are used by applications that require minimum thresholds of delay and packet loss (biomedical signals transmission, medical video-conference, etc.). In order to study most of the rural situations, several Use Cases (UC) are proposed, see Fig. 1.

In every UC, it is useful to take into account the study of service performance (according to the occupation factor of network resources, ρ) in order to evaluate the number of simultaneous users (N) that may be multiplexed keeping their individual QoS level.

2.1 Use Cases

Based on the technical description of the rural scenario, several real situations are proposed (UCs, see Fig. 1). The UCs descriptions are the following:

- **UC1**. The most frequent UC consists of remote transmission (to the reference hospital) of medical tests (ECGs, ECHOs, digital images) acquired on the medical centre (SF.Data).
- **UC2**. Including UC1, it adds transmission of clinical/administrative data and remote access to the EHR database (RT.EHR).
- **UC3**. It consists of UC2 adding a RT videoconference with a medical specialist for diagnostic support (RT.Media), which includes audio (RT.Audio) and video (RT.Video) services.
- **UC4**. Including UC3, it is usual to add the RT acquisition and transmission of specific vital signals (pulse, blood pressure) in order to complete patient diagnostic (RT.Bio).

These UCs defined previously include SF and RT services and permit to evaluate and quantify the optimum performance areas depending on N and ρ to guarantee the recommended QoS. The result of this evaluation will also permit to model the traffic parameters that characterize the service to propose new traffic models, and to design optimum algorithms according to the variable conditions of the system. For leading this study, it is necessary to define the main traffic parameters which take part in the scenario, their specific values in the rural context, and the variable QoS to optimize network resources.

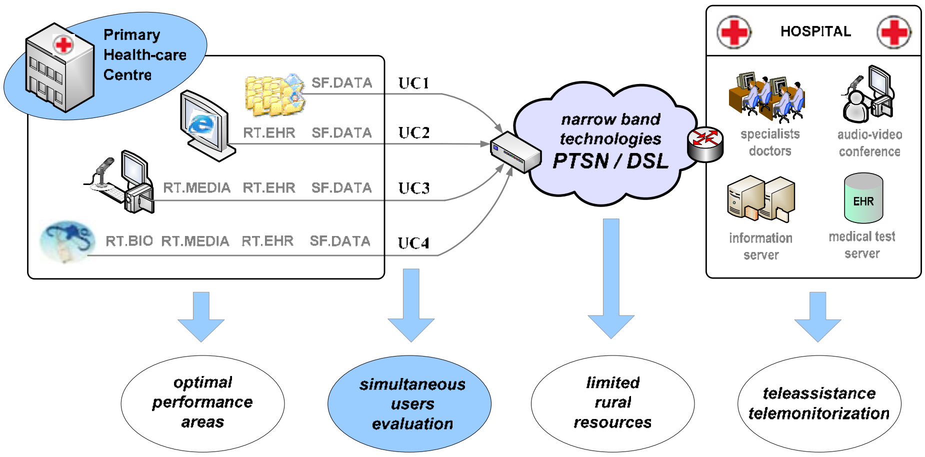


Fig. 1. Evaluation scenario for a rural e-Health service between a Primary Healthcare Centre and a hospital; including transmission of medical tests, patient information, and biomedical signals, EHR updating and audio/video-conference.

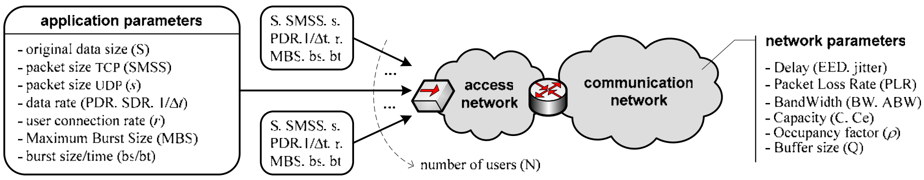


Fig. 2. Application traffic descriptors and network QoS parameters associated to the evaluation of rural e-Health scenarios.

2.2 Traffic descriptors

The QoS definition includes the performance of application as well as network technologies. From both points of view the generic, standard and specific parameters for e-Health services are detailed in the literature [15]-[18], see Fig.2.

A. Application parameters.

- *Data size* (S). Amount of data (in their original format) generated by the traffic generator (source application).
- *Packet size*. The transfer unit size of the Internet Protocol (IP) datagram, using the TCP (SMSS) or UDP (*s*) protocol, depending on the information type (the final packet sizes are calculated adding network and physical layer headers).
- *Data rate*. It may be defined considering several parameters: Peak Data Rate (PDR) that it is the maximum data rate (it is the inverse of the nearest timestamps between two consecutive packets, $1/\Delta t$), and Sustained Data Rate (SDR) that is the transmission data rate measured in a reference time interval ($T = t_{i+n} - t_i$), see (1).
- *Maximum Burst Size* (MBS). It is defined as the maximum number of packets that may be transmitted at PDR guarantying SDR. The burst size (bs), burst time (bt) and Burst Tolerance (BT) are also defined, see (1).

$$\mathrm{MBS} = \left\lfloor 1 + \frac{\mathrm{BT}}{T_s - T} \right\rfloor \quad \text{with} \quad \begin{array}{l} \overline{\mathrm{PDR}} = 1/T \\ \overline{\mathrm{SDR}} = 1/T_s \end{array}, \quad \text{and with} \quad \mathrm{BT} = (\mathrm{MBS}-1)\cdot\left(\tfrac{1}{\mathrm{SDR}} - \tfrac{1}{\mathrm{PDR}}\right) \tag{1}$$

B. Network parameters.

- *End-to-End Delay* (EED) [19]. It is defined as the time since a packet is transmitted until the packet is received at its destination. This is the addition of several delays: accessing, processing, *buffering*, etc. The EDD is completed by other parameters as *jitter* (EED variance between consecutive delays: for RT services, a probability of P[*jitter*>20ms] < 10% must be guaranteed).
- *Packet Loss Rate* (PLR) [20]. It is the number of lost packets with regard to transmitted packets. Thus, the EED-PLR combination is decisive in the QoS study.
- *BandWidth* (BW) and *Available BW* (ABW) [21]. BW represents the capacity (C) for all the communications that share the link and ABW is the capacity not used, which is available for new input connections. Moreover, it is usual to define the effective capacity (C_e) as the real resources for data transmission measured in a reference time interval.
- *Occupation factor* (ρ). It is normally used for link occupation comparisons related to available resources. It is a good indicator of the service efficiency and performance [22], [23]. In a stable system without packet loss, ρ is limited by a maximum value ($\rho_{máx}$). Moreover, the control bits are usually distinguished of the information bits; thus, ρ is usually normalized to its maximum value, see ρ^* in (2).

$$\rho^* = \frac{\rho}{\rho_{máx}} = \frac{C_e}{C_{e_{máx}}} < 1, \quad \text{with} \quad \rho = {}^{C_e}\!/_{C}\,, \; \rho_{máx} = {}^{C_{e_{máx}}}\!/_{C}$$
$$\text{and} \;\; C = r \cdot k \;\; \rightarrow \;\; C_e = r \cdot k_e \;\; \rightarrow \;\; C_{e_{máx}} = r \cdot k_{e_{máx}} \qquad (2)$$

3 Parameters optimization

From the specific characteristics of the rural scenarios and some conclusions obtained in previous works [24], this paper proposes new considerations for the traffic descriptors focused on application parameters: data size (S), packet size (SMSS for TCP, and s for UDP), data rate ($1/\Delta t$), and burst lengths (bs, bt, and MBS). The variation range considered in this study is detailed in Appendix I.

3.1 SF Services.

In order to study the main parameters related to SF services, UC1 (that only includes SF.Data) was analyzed. Thus, the influences of the SF parameters (SMSS, Δt and MBS) were evaluated according to EED and ρ^* thresholds for different congestion levels: low-light (PLR<0.03) and medium-high (PLR<0.10).

Firstly, ρ^* was evaluated for: MBS_i={4, 7, 11 (packets)}, Δt_j={10, 20, 30 (ms)}, and $SMSS_k$={53, 512, 1024, 1500, 2000, 2500 (B)}, and without considering user simultaneousness yet (N=1, $r \leq$ 64kb/s). The results obtained for each (MBS_i , Δt_j) duple, indicated as MBS*i* t*j* in the legend, are shown in Fig. 3. For the most critical situation (PLR<0.10), there is a better behaviour (higher normalized link occupation) in accordance with the decrease of MBS and Δt (in all trends, the best results are obtained with Δt_1=10ms). This yields that, with higher rates, the link utilization is higher and the efficiency improves. This conclusion seems a logic result due to the fact that user rate only depends on the user connection (in the individual access). The discussion about SMSS is not so straightforward because efficiency is high but similar for $SMSS_2$, $SMSS_3$ and $SMSS_4$. These results advise not to discard any SMSS in subsequent evaluations. Moreover, ρ* notably decreases with $SMSS_k$ > 1500B, due to the fragmentation of IP packets.

Secondly, the proposed SF evaluation is completed with the EED analysis. In this case, the selected MBS value influences EED more than the possible Δt values. Again, the lowest MBS values yield the best results (lowest delay, see Fig. 4); this permits to discard MBS_3. Moreover, the best results are obtained with low packet sizes SMSS≤1500B (for an accepted delay variation range in SF services, EED<180s). In this case, there are more significant differences depending on the SMSS value. Therefore, the optimal values that can be selected from this study are: Δt_1=10ms, MBS_1=4 and MBS_2=7, and $SMSS_2$=512B and $SMSS_4$=1500B (the two extreme values that are the most relevant and also the most representative technologically). These values can be considered the default parameters of the system without user multiplexation (N=1), but the next step was to evaluate if this traffic model is valid with N multiplexed users and/or with multiple simultaneous RT services.

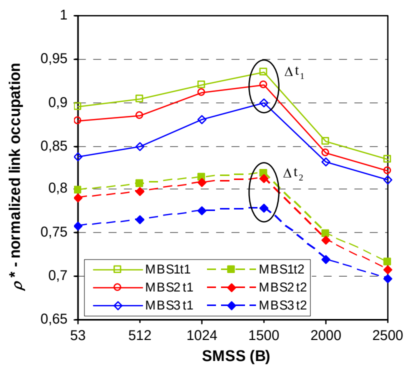


Fig.3 Occupation ρ* depending on SMSS, for the variation range of MBS and Δt parameters.

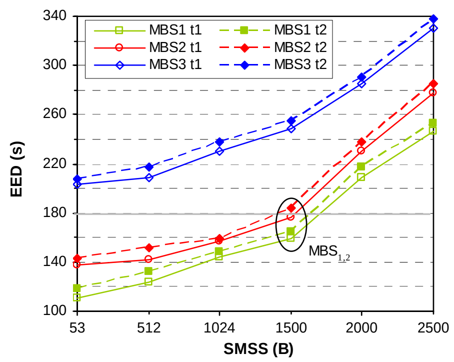


Fig.4 EED depending on SMSS, for the variation range of MBS and Δt parameters.

3.2 RT Services.

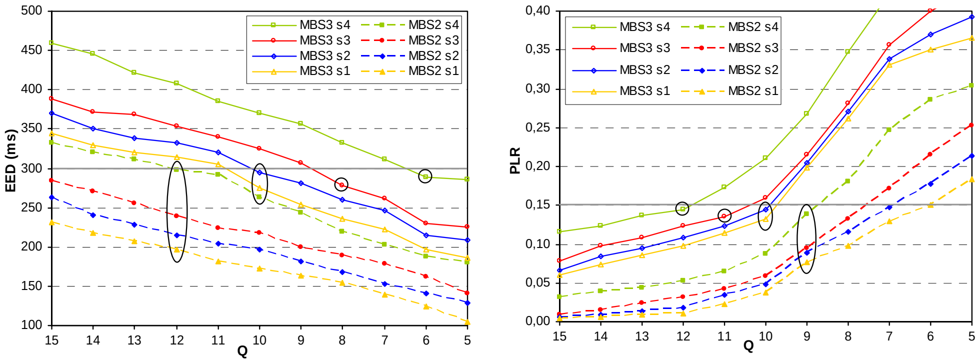
Following with the rural scenario and the previous SF premises, the RT services (UC2, UC3, and UC4) are added to the study in order to evaluate the global influence of RT parameters (s, Δt and MBS) and if they fulfill EED and PLR recommended thresholds.

Firstly, the evaluation of the *buffer* sizes (Q) that guarantee EED and PLR requirements constitutes an interesting analysis to dimension the system. From the experimental and simulated tests, the most relevant results correspond to RT.Media services (distinguishing between RT.Audio and RT.Video) that impose the highest restrictions. Thus, the rural scenario was evaluated with MBS_{Ai}={4, 7 (pps)} and s_{Aj}={100, 240, 300, 400 (B)} for RT.Audio, MBS_{Vi}={5, 10, 15, 30 (*fps*)} and s_{Vj}={1024, 1280, 1500, 4000 (B)} for RT.Video; and an uniform inter-packet time Δt_3=15ms, in both cases. The results obtained for each (MBS_i , s_j) duple are indicated as MBS*i* s*j* in the legend, see Fig. 5 and Fig. 6.

Secondly, and in order to analyze performance limits, the evaluation situations with N=1, 2, and 3 (user connection rate r≤64kb/s) were included; although only the last case (N=3) was critical for the QoS study. Thus, for this last case, Fig. 5 (for RT.Audio) and Fig. 6 (for RT.Video) show the evolution of Q depending on EED and PLR recommended thresholds. In both cases, the trends show that, when *buffer* size increases, EED increases linearly and PLR decreases suddenly. This EED/PLR trade-off conditions the optimal number of simultaneous users and implies the selection of those applications that guarantee QoS:

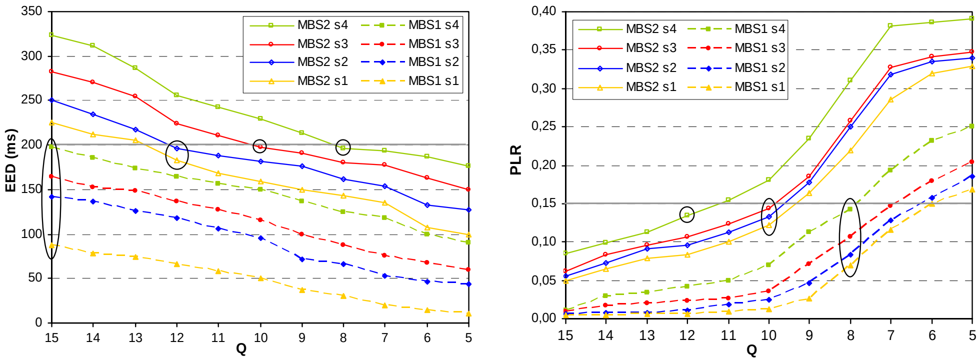
– *RT.Audio service*. For MBS_{A1}=4 and with Q≥8, all the sizes s_{Ai} guarantee QoS. However, for MBS_{A2}=7, only Q=12 (for s_{A1} and s_{A2}) or Q=10 (for s_{A3}) are valid combinations because, for s_{A4}, there is no situation that guarantees QoS.

– *RT.Video service*. For MBS_{V2}=10 (and lower values) and with 12≥Q≥9, all the sizes s_{Vi} guarantee QoS. However, for MBS_{V3}=15, only Q=10 (for s_{V1} and s_{V2}) is a valid combination because, for s_{V3} and s_{V4}, there is no situation that guarantees QoS.



(a) EED (b) PLR

Fig.5 EED and PLR depending on Q, for different MBS and *s* combinations (RT.Audio).



(a) EED (b) PLR

Fig.6 EED and PLR depending on Q, for different MBS and *s* combinations (RT.Video)

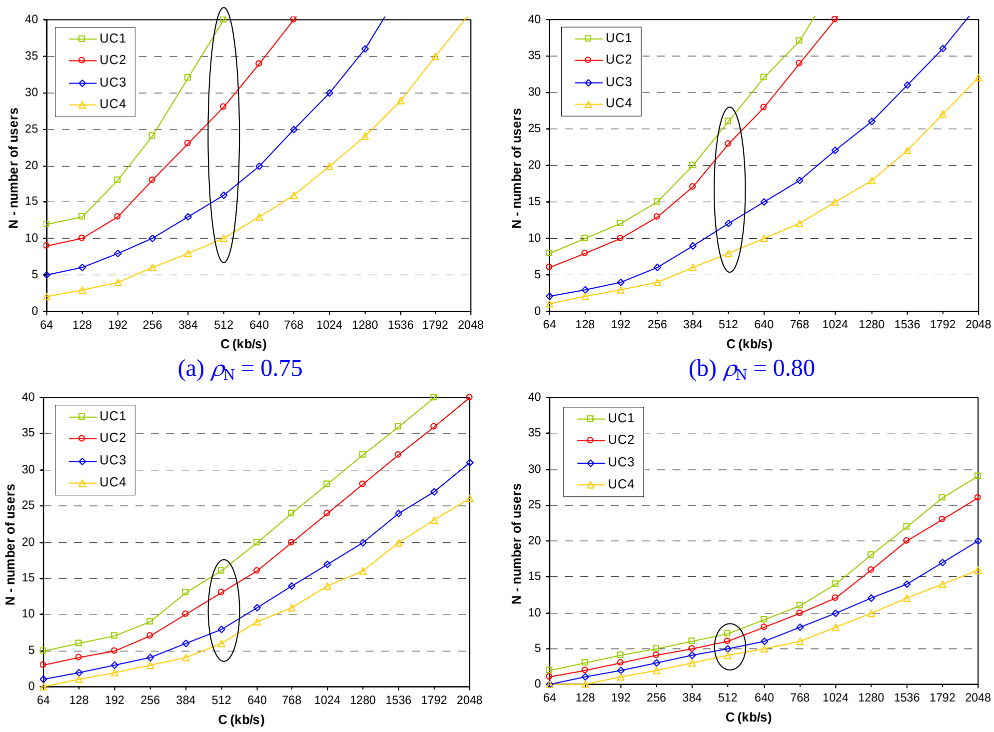
4 Users dimensioning

From the conclusions obtained in the previous section for SF and RT services, this section evaluates the global performance of each ToS according to the multiplexing degree (for different values of link capacity, $C=k \cdot 64$kb/s with $k \geq 1$ and $C \leq 2$Mb/s, and the most restrictive situation, PLR<0.10). The occupation factor (ρ) is a good indicator in order to fairly compare available resources and measure link efficiency. In this case, the graphics do not represent the normalized factor (ρ*) but the relative factor (ρ_N) depending on the number of users (N), see (3), due to the interest of evaluating its quantitative evolution according to the simultaneousness degree.

$$\rho_N = N \cdot \rho = N \frac{C_e}{C} = N \frac{k_e}{k} \quad \text{with} \quad \begin{cases} C_e = k_e \cdot 64\text{kb/s} & (k_e \leq 1) \\ C = k \cdot 64\text{kb/s} & (k > 1) \end{cases} \tag{3}$$

The results obtained for each performance threshold (selected by ρ_N) are presented in Fig. 7. The figures show the evolution of the allowed number of users for each UC according to the available network resources (indicated by the link capacity, C). Regarding the lowest performance, see Fig. 7(a) and Fig. 7(b), the recommended values of N are very high because the network conditions permit a huge number of users. If new ToS are added, N decreases notably because network resources are shared proportionally between each service. If the required performance is higher, see Fig. 7(c) and Fig. 7(d), the variation range of N decreases (as it is shown in the evolution of remarked circled areas), implying a considerably increase of network resources in order to allow accepting new users. In these cases, the quantitative relation between N and C is practically linear with k: for each 64kb/s of link capacity, the system guarantees QoS with a maximum value of k users ($\rho_N > 0.90$).

These results permit to quantify the maximum values of N and, therefore, to dimension the number of simultaneous users that can be allowed in each UC of the rural environments, guaranteeing QoS. Moreover, the curves presented propose diverse recommended performance areas, for a given efficiency threshold and network occupancy level.



(a) $\rho_N = 0.75$ (b) $\rho_N = 0.80$

(c) $\rho_N = 0.85$ (d) $\rho_N = 0.90$

Fig. 7. Recommended performance areas for the variation range of capacity (C) and number of users (N), depending on the useful thresholds and relative link occupancy factor (ρ_N).

5 Traffic modelling

In all this entire study, the results correspond to experimental measurements obtained in the test laboratory evaluated by multiple simulations from traffic models recommended in the literature and detailed in Appendix I. This last section checks the utility of these models for high values of N (as required in the context conditions of the published works), and analyzes their validity for a more limited number of users (as a specific situation of rural scenarios for e-Health services). Thus, the main application parameters, previously characterized, have been considered: MBS and Δt (for SF services); and s, MBS and Δt (for RT services).

Firstly, SF services are usually modelled as Constant Bit Rate (CBR) services with exponential MBS (ON-OFF models); and uniform s and Δt with an exponential mean. The K-S test [25] shows (detailing the values of mean and maximum deviation regarding the theoretical distribution) that, for s and Δt, the mean follows an exponential distribution independently of N, see Table I(b). However, this conclusion in not valid with MBS, which fits better to a log-normal distribution with a small number of simultaneous users (N<15), see Table I(a).

Secondly, and for RT services, RT.Bio follows a uniform CBR model with constant rate, RT.EHR follows a multiple model with three levels (session, page and packet), RT.Audio follows a constant CBR model, and RT.Video is characterized as a Variable Bit Rate (VBR) model with exponential mean. Theoretically, the aggregation of these RT services would imply a complex model characterized by their main parameters: s, following a Pareto distribution; MBS, following an exponential distribution with constant mean; and Δt, following an exponential distribution with exponential mean. The K-S test, for the s parameter, remarks this trend regarding a Pareto distribution; but for MBS and Δt parameters, the K-S test shows that they fit better to a geometric distribution with low values (N<13 and N<14, see Table II(a) and Table II(b), respectively).

In summary, it is remarkable that the SF services can be modelled as CBR (characterized with Δt of exponential mean; and MBS of exponential mean, for high values of N, and log-normal mean, for low values of N). Moreover, the aggregation of RT services follows a multiple model characterized with s (Pareto distribution), and MBS and Δt (exponential distribution, for high values of N, and geometric distribution, for low values of N). Although these differences with the original models are not significant to re-evaluate the entire study proposed, the results obtained are interesting enough to specify more accurate models according to the number of users. These models will permit to optimize the design of new e-Health services allowing the dynamic selection of the application codecs that better fulfill their specific model.

TABLE I. K-S TEST APPLIED TO SF SERVICES

N	LOG mean	LOG max	GEO mean	GEO max	EXP mean	EXP max
4	**0.13**	**0.02**	0.32	0.42	0.17	0.16
6	**0.13**	**0.10**	0.30	0.38	0.18	0.13
8	**0.14**	**0.07**	0.29	0.36	0.18	0.19
10	**0.14**	**0.11**	0.28	0.34	0.16	0.13
12	**0.16**	**0.09**	0.29	0.27	0.17	0.16
13	**0.17**	**0.06**	0.30	0.26	0.17	0.12
14	**0.17**	**0.09**	0.30	0.24	0.17	0.14
15	0.17	0.06	0.27	0.18	**0.17**	**0.10**
16	0.18	0.01	0.28	0.19	**0.16**	**0.01**
18	0.18	0.07	0.30	0.21	**0.16**	**0.11**
20	0.19	0.03	0.26	0.21	**0.15**	**0.04**

(a) MBS

N	LOG mean	LOG max	GEO mean	GEO max	EXP mean	EXP max
4	0.14	0.21	0.23	0.13	**0.05**	**0.07**
6	0.19	0.21	0.23	0.19	**0.07**	**0.05**
8	0.18	0.14	0.24	0.13	**0.11**	**0.07**
10	0.19	0.13	0.22	0.16	**0.13**	**0.08**
12	0.15	0.17	0.24	0.14	**0.11**	**0.08**
13	0.14	0.15	0.21	0.15	**0.10**	**0.10**
14	0.17	0.16	0.22	0.14	**0.11**	**0.09**
15	0.14	0.18	0.24	0.11	**0.10**	**0.07**
16	0.18	0.20	0.23	0.12	**0.09**	**0.07**
18	0.17	0.21	0.21	0.13	**0.08**	**0.09**
20	0.17	0.19	0.23	0.14	**0.07**	**0.08**

(b) Δt

TABLE II. K-S TEST APPLIED TO RT SERVICES

N	LOG mean	LOG max	GEO mean	GEO max	EXP mean	EXP max
4	0.24	0.14	**0.03**	**0.09**	0.18	0.20
6	0.25	0.18	**0.07**	**0.06**	0.19	0.17
8	0.28	0.15	**0.05**	**0.07**	0.17	0.16
10	0.26	0.18	**0.11**	**0.09**	0.16	0.14
12	0.24	0.19	**0.13**	**0.11**	0.15	0.11
13	0.27	0.21	0.16	0.18	**0.14**	**0.08**
14	0.28	0.19	0.18	0.22	**0.14**	**0.07**
15	0.26	0.17	0.19	0.18	**0.13**	**0.09**
16	0.25	0.18	0.18	0.20	**0.14**	**0.10**
18	0.27	0.22	0.20	0.21	**0.13**	**0.12**
20	0.24	0.21	0.22	0.19	**0.15**	**0.11**

(a) MBS

N	LOG mean	LOG max	GEO mean	GEO max	EXP mean	EXP max
4	0.23	0.16	**0.04**	**0.08**	0.20	0.20
6	0.21	0.18	**0.07**	**0.08**	0.18	0.17
8	0.24	0.15	**0.06**	**0.07**	0.16	0.15
10	0.22	0.17	**0.08**	**0.11**	0.17	0.17
12	0.23	0.17	**0.10**	**0.13**	0.17	0.16
13	0.26	0.15	**0.12**	**0.14**	0.16	0.18
14	0.27	0.16	0.15	0.21	**0.13**	**0.11**
15	0.27	0.18	0.16	0.20	**0.13**	**0.09**
16	0.28	0.19	0.18	0.19	**0.14**	**0.08**
18	0.31	0.20	0.20	0.18	**0.15**	**0.10**
20	0.34	0.22	0.24	0.19	**0.16**	**0.11**

(b) Δt

6 Discussion and conclusions

This paper has presented a quantitative analysis of the maximum number of simultaneous users over common e-Health services that can be provided with QoS guarantees in rural scenarios. The results obtained in this study permit to propose several optimum performance areas as a function of available network resources and required thresholds for efficiency and link occupancy. A set of common telemedicine applications (in combinations which define different use cases) has been considered and the influence of their traffic descriptors over the QoS levels has been studied.

Moreover, the probability distribution models associated to the traffic descriptors have been evaluated, showing their validity for high values of N and proposing some modifications when the number of users is limited, such as it may happen in rural scenarios.

In summary, the methodology proposed (in the specific context of rural e-Health services, but valid for other generic multimedia scenarios) can be applied to the optimum design of new services, by adjusting the users multiplexing according to the available network resources in time, and proposing new adaptive QoS mechanisms.

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Appendix I. Variables used in this study

ToS	params	model	Values in this study
SF typeI	S (MB) *r* (b/s)	CBR [*bs* – exponential] CBR [*s*,Δt – unif(expo)]	SMSS={53,512,1500} Δt = {10,20,30} MBS = {4,7,11}
SF typeII	S (MB) *r* (b/s)	OnOff [*bs* – expo] OnOff [*s*,Δt – unif/expo]	SMSS={1024,2k,2k5} Δt = {5,10,15,30} MBS = {1,15,30,60}
audio typeI	*r* (b/s) *s* (b)	OnOff [*bs* – expo/pareto] OnOff [*s* – expo/lognrm]	s_A={100,240,300,400} Δt = {10,15,30} MBS_A = {3,4,5,7}
audio tipoII	*r* (b/s) *s* (b)	CBR [*bs* – expo/ray] On–Off [*s* – expo/unif]	s_A={100,240,480} Δt = {5,10,15,30} MBS_A = {3,4,7}
video typeI	*r* (b/s) PDR, BT	VBR [*bt* – unif/nrm] VBR [*s* – expo/weib]	s_V={800,1024,1500} Δt = {5,10,15,30} MBS_V = {5,10,15,30}
video typeII	*r* (b/s) PDR, BT	VBR [*bt* – expo/gama] VBR [*s* – pareto]	s_V={1024,1280,4000} Δt = {5,10,15,30} MBS_V = {1,15,30,60}
web	Session Page Packet	[Δt expo / *s* logn] [Δt gam / *s* paret] [Δt expo / *s* unif]	*s* ={40,53,512,1500} Δt ={50,75,100,150 } MBS = {20,25,30}
image	*r* (b/s) *h* (b/pix)	CBR/VBR [bs/s – unif/nrm]	*s* ={200,512,1024} *bs* = {1,3,5,10,15}
bio typeI	*r* (b/s) *s* (b)	CBR/VBR [bs/s – unif/unif]	*s* ={512,800,1500} *bt* = {1,6,12,15,30,60}
bio typeII	*r* (b/s) *s* (b)	CBR [bs/s – unif/unif]	*s* ={40,80,100,200,400} *bt* = {10,20,30}

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