Extending MPLS technology in providing quality of service among different autonomous systems using Relay Race transmission approach

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Abstract: - The paper has addressed the serious networking issues including signal strength retention and amplification to larger distance due to negative impact of amplifiers including 5-4-3 rule constraints, impact to internal delay, background noise amplification, limited maximum signal value of amplifier, usage of poor signal generators, lack of repeater support, virtually moving users to bigger distances etc. The research has enhanced the functionalities of MPLS in providing Quality of Service among different autonomous systems with desired signal strength. The research has been carried out in Red Hat Linux environment and using Experimental testbed for evaluation of conceptual, analytical, experimental and methodological details. The paper presents the new approach of Relay Race Transmission in MPLS technology to extend its QoS performance among autonomous systems by the means and methods using Label switched routers instead of signal amplifiers between remote distances. The results are presented with the comparative graphs of default and extended MPLS technology and conclude that extended MPLS technology has an edge over the default MPLS technology in terms of maintaining desired signal strength among autonomous systems and hence providing QoS among ASs.

Key-Words: - QoS, Relay race transmission, 5-4-3 rule, delay, noise, repeater, amplification, autonomous system.

1 Introduction

MPLS is a labeled switched packet transfer technology, providing the performance of packet switching and reliability and consistency of circuit switching. MPLS maintains quality of service within a single autonomous system but does not work well among different autonomous systems due to drop in signal strength transmitted among distance nodes. Although various researches have already been done using repeaters and signal amplifiers to address this issue, but they are having their own limitations including 5-4-3 rule constraints, impact to internal delay, background noise amplification, limited maximum signal value of amplifier, usage of poor signal generators, lack of repeater support, virtually moving users to bigger distances etc. The paper has presented the new approach of Relay Race Transmission in MPLS technology to extend its QoS performance among autonomous systems by the means and methods using Label switched routers instead of signal amplifiers between remote distances. The LSRs can switch, forward and amplify the signals among each other with little complexity because of less switching and forwarding overhead at each label switched router.

1.1 Nature of Problem

Although MPLS works well in providing quality of service within single autonomous system, but the technology drops its value while it comes to provide QoS among different autonomous systems having different kind of repeaters or signal amplifiers for signal amplification among transmitting and receiving stations.

Although a considerable amount of work has been carried out on addressing signal strength issues in MPLS networks using repeaters and signal amplifiers, but it is saddening to note that every solution has its own constraint including 5-4-3 rule constraints, impact to internal delay, background noise amplification, limited maximum signal value of amplifier, usage of poor signal generators, lack of repeater support, virtually moving users to bigger distances etc. and hence results in meta problems (problems within problem) i.e. rectification of one problem may arise to the several other problems. For example, amplification of signal using repeaters/amplifiers may cause severe problems including longer transmission delays, difficulty in filtering the correct signal out of equally amplified background noise; call drops using improper repeater support, poor amplifying device may cause additional noise, Usage of repeater virtually moving user to bigger distance and 5-4-3 Ethernet rule as big constraint in amplifying the signals for large segments.

These issues need to be addressed to support quality of service among autonomous systems and the paper has presented the Relay Race Transmission approach in support of this issue.

Carrying out research on MPLS in a technological manner is what is required today to process MPLS technology in a better way and to derive all its advantages. The use of MPLS technology is showing an upward trend and hence an in-depth study on this technology is warranted. The proposed approach has given the idea to arrange Label switched routers between the end stations at equal distance as like in conventional Relay race. The distance has been calculated on the basis of signal strength retention power of the LSR, the details for which have been given in the next section.

1.2 Past Study

A number of studies have been already done on signal amplification. [1] Proposed Distributed optical amplifiers which are shown to have low noise, but require higher pump power than lumped amplifiers. Three operating modes of an amplifier lightwave system are identified and their relative signal power efficiency and noise performance are described.

[2] Has proposed that Passive linear combining of the amplified and/or translated component signals produces an amplified and/or translated replica of the original signal. [3] Presents a 3-way Doherty amplifier with predistorter (PD) for a repeater application which is implemented using three 60 Watts PEP silicon LDMOSFETs and tested using two-tone and one- and two-carrier down-link WCDMA signals. For the two-carrier downlink WCDMA signal, the amplifier provides -49.1 dBc adjacent-channel-leakage-ratio (ACLR) and 10.3% power-added efficiency (PAE) at an output power 40 dBm which is an improvement of 8.5 dBc in linearity and 2% in efficiency compared to a similar class-AB amplifier. [4] has given the idea that with LD-pumped gain-shifted thulium-doped fiber amplifiers, polarization interleave multiplexing combined with wavelength/polarization demultiplexing for 50-GHz-spaced 40-Gb/s/ch WDM signals, and a transmission line optimization for triple-band systems, the first 10-Tb/s WDM transmission in single fiber using S-, C- and L-bands is demonstrated. [5] Presents the analysis, design, and implementation of a hybrid broad-band distributed amplifier based on four-cascaded single-stage distributed amplifiers (4-CSSDAs) which achieved a measured wide-band performance (0.8-10.8 GHz) with up to 39±2-dB flat gain using discrete packaged active devices. [6] Made a contribution to augment the memory polynomial model to include a sparse delay tap structure that reduces the parameter space required for accurate model identification. [7] Presents that RF power is generated by a wide variety of techniques, implementations, and active devices and

thus linearity can be improved through techniques such as feedback, feedforward, and predistortion
[8] addresses power consumption issues in future high-capacity switching and routing elements and examines different architectures based on both pure packet-switched and pure circuit-switched designs by assuming either all-electronic or all-optical implementation, which can be seen as upper and lower bounds regarding power consumption and shows that implementation in optics is generally more power efficient; especially circuit-switched architectures have a low power consumption. [9] Presents that dual-band receiver employs the Weaver architecture with two tuned radio-frequency stages and a common intermediate-frequency stage which allows operation with 900-MW and 1.8-GHz standards while using only two oscillators. Fabricated in a digital 0.6-μm CMOS technology, the receiver achieves an overall noise figure of 4.7 dB and input third intercept point of -8 dBm at 900 MHz, and 4.9 dB and -6 dBm at 1.8 GHz. The voltage gain is 23 dB with a power dissipation of 75 mW from a 3-V supply. [10] Has investigated the use of MPLS hierarchical architecture for label switched networks for supporting wireless users. The architecture involves requirements at the mobile terminal for initiating or hopping label switched paths at the air interface, and allowing end to end interconnection to the backbone network and proposed a technique to extend RSVP-TE into the WLANs (aka Wi-Fi) domain using MPLS and aspects of the 802.11 QoS standards and techniques. [11] gives an overview of the Long Term Evolution (LTE) of the Universal Mobile Telecommunication System (UMTS), which is being developed by the 3rd Generation Partnership Project (3GPP). LTE constitutes the latest step towards the 4th generation (4G) of radio technologies designed to increase the capacity and speed of mobile communications. [12] Tackle the multilayer IP/MPLS-over-flexgrid optimization problem using an integer linear programming formulation and a greedy randomized adaptive search procedure (GRASP) metaheuristic. Using GRASP, the cost implications that a set of frequency slot widths have on the capital expenditure investments required to deploy such a multilayer network been analyzed. Results show that investments in optical equipment capable of operating under slot widths of 12.5 GHz, or even 25 GHz, are more appropriate, given the expected traffic evolution. [13] Have demonstrated the usefulness of applying Differentiated Services (DiffServ) and MPLS TE in the network to reduce packet drops for drop sensitive applications keeping the network resources utilization optimized and has been concluded the significant reduction in the packet loss after the application of MPLS TE in a DiffServ enabled network IP backbone.

1.3 Research Gaps

- 5-4-3 rule of Ethernet is a big constraint in amplifying the signal for large segments.
- Impact to internal delay.
- Difficulty in filtering the correct signal out from the background noise which will be amplified equally.
- Limiting maximum signal power of the amplifier.
- Usage of repeater virtually moving user to bigger distance.
- Use of a poor device for signal generation, causing noise and products.
- Improper Repeater support.

1.4 Objectives

MPLS & other network technologies are different in many aspects. Several group of research workers have looked at the methods for signal strength amplification in MPLS and other technologies. All these studies have improved our understanding on the effect of amplification of the signal in network technologies. In spite of various amplification solutions, it is clearly felt that all the earlier proposed solutions have their own limitations as discussed in earlier sections and much more work needs to be done in order to amplify the signals in large segments in MPLS and other technologies. The proposed approach of Relay Race transmission is best suited for MPLS technology because of its low overhead in switching and forwarding the packets among label switched routers.

Although various studies have been done in past to identify the solutions for signal amplification, but each one is having its own limitations as discussed in earlier section. The Relay Race transmission approach has been proposed to address these serious issues and to meet the following objectives.

1. Limiting amplification delays and hence reducing transmission delays.

2. Limiting background noise.
3. Increasing signal power to desired level.
4. Avoiding users moving to larger distances.
5. Avoid causing noise signal.
6. Assured call transmission to the operator in wider range of band including EGSM.

2 Problem Formulations

The Research Problem for this study has been mentioned briefly, clearly and sufficiently as below.

2.1 Need and Significance of the paper

The paper presents the new approach of Relay Race transmission using LSRs for amplifying, forwarding and switching the signals in MPLS technology to address severe problems which may occur due to signal amplification with repeaters and amplifiers. The proposed approach has been presented to make MPLS a preferred choice for today's network designers. The research enhances the amplification procedure of signals in MPLS and hence providing quality of service among different autonomous systems with low processing overhead, forwarding overhead and routing overhead.

2.2 Research Problem

MPLS works well in amplifying the signals with repeaters and amplifiers but may arise several other issues which directly affect the quality of service among different autonomous systems. The details of issues those may arise with repeaters and amplifiers are as follows.

2.2.1 5-4-3 rule constraint

The rule implies that there may neither be more than five (5) repeated segments, nor more than four (4) repeaters between any two Ethernet stations; and of the five cable segments, only three (3) may be populated. Although the use of this rule may help in extending the network reach but is having its own constraint which may not be suitable for the applications seeking Quality of Service in wireless networks. The proposed approach may be suitable to rectify this constraint up to maximum level and hence will help in providing the quality of service to the QOS seeking applications.

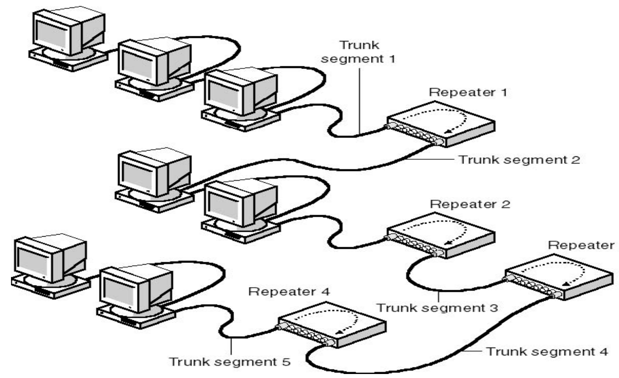

Fig.1: 5-4-3 rule

2.2.2 Impact to internal delay

Each repeater may add transmission delay due to standard delay during signal amplification. The internal delay may be described as follows:
Higher delay => prox. +5us up to standard rep. delay

2.2.3 Difficulty in filtering correct signal

Use of repeaters and signal amplifiers may lead to high difficulty in filtering correct signal out of the background noise that may be amplified equally with the desired signal, the result of which may rise the background and unwanted noise with the desired signal and hence may increase the transmission time and packet loss.

2.2.4. Limiting maximum signal power of the amplifier

The amplifier and repeaters are having their own limitations of maximum signal power and hence may not support the high signal strength beyond their limits. The maximum signal power of the amplifier may be described as follows:

The maximum signal power for picorepeaters is typically from around 5 dBm (3.2 mW)).

2.2.5. Usage of repeater virtually moving user to bigger distance

The use of repeaters may move the users virtually to the longer distances due to repeater delay and delay of RF signal in air. The details of the radio distance are as follows:
Radio distance = real distance + (repeater delay in us) *0.3 km (delay of RF signal in air is 3.3us/km).

2.2.6. Usage of poor signal generators

The use of poor devices for generation and amplification of signals may lead to unwanted noise and other products, which may lead to increase in transmission time and high packet loss.

2.2.7. Improper Repeater support

Repeating only part of the band, such as in cases where the operator is using wider band (e.g., EGSM) or more bands and the repeater does not support EGSM or is only for 900GSM. In the case of improper repeater support, many calls may drop.

3 Problem Solution

The section describes the Experimental testbed and various Research methodologies in detail.

3.1. Experimental Testbed

In this section we describe an experimental test bed with two scenarios with the first one has been showing Relay race transmission approach having physical layout of LSRs among end stations, responsible for routing, forwarding, switching and amplifying the date signal and the latter one has been showing the physical layout of repeaters among nodes placed between end stations.

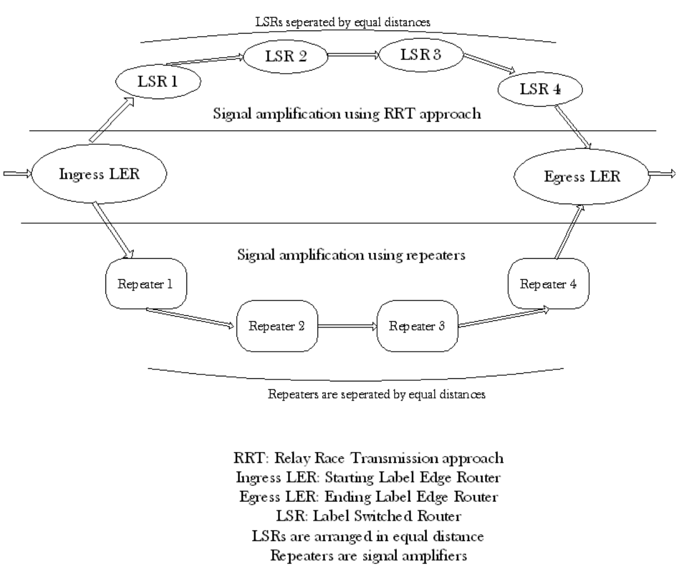

Fig. 2: Experimental testbed

3.1.1 System Requirements

The experiment system is being designed for laboratory so that we can operate in filtered and high visibility environment. Measurements that is critical for performing experiment include

- Use of repeaters for signal amplification.
- Physical layout of LSRs with considerable distance among each other.
- Calculation of data signal and background noise.

The Relay race transmission approach may be fundamental to signal amplification between end stations and provides an edge over the other amplification methods using repeaters, which may lead to severe problems as discussed in earlier section.

3.1.2 Layout

The testbed was chosen to provide the environment to meet the system requirements identified in the above section. Figure 3 shows design of experimental testbed. The testbed has been showing two different scenarios- Signal amplification using repeaters and Signal amplification using our new Relay Race transmission approach.

3.1.3 System architecture

The main goal of the research is to identify the negative impact of the amplifiers including segment length constraint, internal delays, increase in background noise, filtering problem, virtual increase in distance etc. and rectify such problems with a new approach namely Relay Race transmission in which Label switched routers are used instead of amplifiers because of less processing overhead at each LSR.

3.2 Research Methodologies

This section describes the detailed account of processes and methods used in this research.

3.2.1 Limiting transmission delays

Repeater itself generates more than 5 µs delay, which may lead to the higher internal delays and may be described as follows.

Higher delay => approx. +5µs up to standard repeater delay

Hence the internal delay will keep on rising with increase in number of repeaters in transmission way. This cumulative delay will result in loss of packets and hence may disturb the real time applications requiring quality of service.

In the proposed Relay Race Transmission (RRT) approach, label switched routers are placed at equal distance, which amplifies the signal along with switching, routing and forwarding process as soon as signal reaches at them. The mechanism works well with MPLS technology only due to less processing overhead at each LSR. Due to absence of repeaters, the internal repeater delay does not arise and hence may not affect the real time applications and quality of service.

Let us assume number of repeaters and LSRs are 10 in default MPLS & RRT approach based MPLS respectively. The repeater delay is assumed as 6 µs and LSR delay is 1 µs for analysis. The transmission time is assumed to be 10 µs in both cases. The following equation has been used for evaluation of cumulative amplification delay with respect to cumulative increase in number of repeaters and the values of cumulative amplification delay are mentioned in table 1 and table 2.

Higher delay => approx. +5µs up to standard repeater delay
Transmission delay=amplification delay + real transmission time

Table 1: Cumulative T_x delay using repeaters

Cumulative no. of repeaters	Cumulative amplification delay in µs	Transmission delay in µs	Cumulative transmission delay in µs
1	6	16	16
2	12	22	38
3	18	28	66
4	24	34	100
5	30	40	140
6	36	46	186
7	42	52	238
8	48	58	296
9	54	64	360
10	60	70	430

Table 2: Cumulative T_x delay using RRT

Cumulative no. of repeaters	Cumulative amplification delay in µs	Transmission delay in µs	Cumulative transmission delay in µs
1	1	11	11
2	2	12	23
3	3	13	36
4	4	14	50
5	5	15	65
6	6	16	81
7	7	17	98
8	8	18	116
9	9	19	135
10	10	20	155

The comparison of transmission delay with respect to use of repeaters and LSRs for signal amplification has been shown in the next section.

3.2.2 Limiting Background noise

Signal amplification using repeaters may raise the unwanted background noise as it amplifies the unwanted signal equally along with the useful data, hence may disturb the bandwidth which may otherwise be used for transmitting data signal. The misuse of bandwidth by unwanted data signal disturbs the quality of service among autonomous systems. Whereas no such background noise gets increased in the proposed RRT approach as LSRs only switch and forward data signals having appropriate labels and filter and drops the unwanted traffic. This approach hence does not disturb the network bandwidth and assures the quality of service to the network data. The evaluation has been done in terms of bandwidth usage in case of repeaters and RRT approach.

Bandwidth usage= Bandwidth usage of data signal + bandwidth usage of background noise

Let bandwidth usage of real data signal at each repeater and LSR is assumed as 5 Kbits/sec.

Table 3: Bandwidth usage using repeaters

Cumulative no. of repeaters	Cumulative Bandwidth usage of data signal in kbits/second	Cumulative Bandwidth usage of background noise in kbits/second	Total cumulative bandwidth usage in kbits/second
1	5	5	10
2	10	10	20
3	15	15	30
4	20	20	40
5	25	25	50
6	30	30	60
7	35	35	70
8	40	40	80
9	45	45	90
10	50	50	100

Table 4: Bandwidth usage using RRT

Cumulative no. of repeaters	Cumulative Bandwidth usage of data signal in kbits/second	Cumulative Bandwidth usage of background noise in kbits/second	Total cumulative bandwidth usage in kbits/second
1	5	0	5
2	10	0	10
3	15	0	15
4	20	0	20
5	25	0	25
6	30	0	30
7	35	0	35
8	40	0	40
9	45	0	45
10	50	0	50

The performance of RRT approach in limiting the background noise over the use of repeaters has been showing in the comparison graph in the next section.

3.2.3 Increase in signal power

Quality of Service declines in MPLS due to signal power constraint of the repeaters. The repeaters may not support the high signal strength beyond their limits. The maximum signal power for picorepeaters is typically from around 5 dBm (3.2 mW)).This limitation of maximum signal power will not support the desired quality of service among autonomous systems separated by large distances.

The proposed RRT Scheme resolves this issue as label switched routers is installed in place of repeaters. LSR is having no constraint on generating maximum signal power and hence may support real time applications requiring quality of service among autonomous systems. The following equation is showing the relation between signal strength in dBm and power level in mW.

Signal Strength (dBm) = 10 log10 (Power level in mW)

Power level is directly related to the distance from transmitting antenna, more the distance from transmitter, more drops in power level.

Table 5: Transmit power & Signal Strength using repeaters

Power level (Tp) in mW	Signal strength (S) in dBm	Distance travel
3.2 mW	5 dBm	256”
1.56mW	1.9dBm	128"
0.39mW	-4.08dBm	64"
.097mW	-10.1dBm	32"
.024mW	-16.1dBm (5.3	16"
.006mW	- 22.2dBm	8"
.0015mW	-28.2dBm	4"

Table 6: Transmit power & Signal Strength using RRT

Power level	Signal strength	Distance travel
100mW	20dBm	2048"
25mW	13.9dBm	1024"
6.25mW	7.9dBm	512"
3.2 mW	5 dBm	256”
1.56mW	1.9dBm	128"
0.39mW	-4.08dBm	64"
.097mW	-10.1dBm	32"
.024mW	-16.1dBm (5.3	16"
.006mW	- 22.2dBm	8"
.0015mW	-28.2dBm	4"

The performance of RRT approach and use of repeaters in terms of maximum signal strength has been showing in the comparison graph in the next section.

3.2.4 Avoiding users moving to larger distances

The use of repeaters may move the users virtually to the longer distances due to repeater delay and delay of RF signal in air. The details of the radio distance are as follows:

Radio distance = real distance + (repeater delay in µs) *0.3 km (delay of RF signal in air is 3.3 µs /km)

Whereas in proposed RRT approach, neither repeater delay nor delay of RF signal persists due to non-availability of repeaters for signal amplification. LSRs in RRT approach retain radio distance as equal to the actual distance and hence do not move users to larger distances and maintain the desired quality of service among autonomous systems.

Let real distance between the end stations be 500 m i.e. 0.5 km and repeater delay is 6 **µ**s and 1 **µ**s at each repeater and LSR, then the calculated radio distance by using repeaters and LSR are mentioned in following tables.

Table 7: Cumulative radio distance using repeaters

Cumulative no. of repeaters	Cumulative repeater delay in µs	Radio distance in km
1	6	2,3
2	12	4.1
3	18	5.9
4	24	7.7
5	30	9.5
6	36	11.3
7	42	13.1
8	48	14.9
9	54	16.7
10	60	18.5

Table 8: Cumulative radio distance using RRT

Cumulative no. of repeaters	Cumulative repeater delay in µs	Radio distance in km
1	1	0.8
2	2	1.1
3	3	1.4
4	4	1.7
5	5	2.0
6	6	2.3
7	7	2.6
8	8	2.9
9	9	3.2
10	10	3.5

The performance results have been shown in the next section.

3.2.5 Usage of poor signal generators

The use of poor devices for generation and amplification of signals may lead to unwanted noise and other products, which may lead to increase in transmission time and high packet loss, the resultant of which quality of service deteriorates among autonomous systems.

LSRs on the other hand are quality devices generating and amplifying the signals between end stations and neither amplify noise signals, nor generate RF signal delay, repeater delay etc. The use of LSR in RRT approach generates only useful signals, the resultant of which the network bandwidth gets available for useful data transmission only and hence provides desired quality of service.

The performance comparison of poor signal generators and RRT approach has been shown in the next section.

3.2.6 Improper Repeater support

Repeating only part of the band, such as in cases where the operator is using wider band (e.g., EGSM) or more bands and the repeater does not support EGSM or is only for 900GSM. In the case of improper repeater support, many calls may drop.

Since autonomous systems do operate in wider frequency range and hence may require amplification in wider GSM frequency bands including GSM -900, GSM-1800, GSM-1900 and EGSM/EGSM-900, the use of repeaters has their own amplification constraints as discussed in previous paragraph. The RRT approach making use of LSRs for signal amplification does support numerous ranges of bands including P-GSM, EGSM, RGSM, and TGSM and hence may avoid call drops among autonomous systems.

Table 9: Transmission rate w.r.t. band using repeaters

System	Band	Customized band	Uplink (MHz)	Downlink (MHz)	Successful packet transmission rate in %
T-GSM-380	380	380	380.2–389.8	390.2–399.8	0
T-GSM-410	410	410	410.2–419.8	420.2–429.8	0
GSM-450	450	450	450.6–457.6	460.6–467.6	90
GSM-480	480	480	479.0–486.0	489.0–496.0	89
GSM-710	710	710	698.2–716.2	728.2–746.2	85
GSM-750	750	750	747.2–762.2	777.2–792.2	80
T-GSM-810	810	810	806.2–821.2	851.2–866.2	0
GSM-850	850	850	824.2–849.2	869.2–894.2	75
T-GSM-900	900	900	870.4–876.0	915.4–921.0	0
P-GSM-900*	900	920	890.0–915.0	935.0–960.0	70
E-GSM-900*	900	940	880.0–915.0	925.0–960.0	67
R-GSM-900*	900	980	876.0–915.0	921.0–960.0	0
DCS-1800	1800	1800	1,710.2–1,784.8	1,805.2–1,879.8	0
PCS-1900	1900	1900	1,850.2–1,909.8	1,930.2–1,989.8	0

*For P-GSM= T-GSM-900+20, E-GSM= T-GSM-900+40, R-GSM= T-GSM-900+80

Table 10: Transmission rate w.r.t. band with RRT

System	Band	Customized band	Uplink (MHz)	Downlink (MHz)	Successful packet transmission rate in %
T-GSM-380	380	380	380.2–389.8	390.2–399.8	75
T-GSM-410	410	410	410.2–419.8	420.2–429.8	78
GSM-450	450	450	450.6–457.6	460.6–467.6	76
GSM-480	480	480	479.0–486.0	489.0–496.0	77
GSM-710	710	710	698.2–716.2	728.2–746.2	85
GSM-750	750	750	747.2–762.2	777.2–792.2	80
T-GSM-810	810	810	806.2–821.2	851.2–866.2	75
GSM-850	850	850	824.2–849.2	869.2–894.2	76
T-GSM-900	900	900	870.4–876.0	915.4–921.0	80
P-GSM-900*	900	920	890.0–915.0	935.0–960.0	79
E-GSM-900*	900	940	880.0–915.0	925.0–960.0	82
R-GSM-900*	900	980	876.0–915.0	921.0–960.0	70
DCS-1800	1800	1800	1,710.2–1,784.8	1,805.2–1,879.8	72
PCS-1900	1900	1900	1,850.2–1,909.8	1,930.2–1,989.8	74

*For P-GSM= T-GSM-900+20, E-GSM= T-GSM-900+40, R-GSM= T-GSM-900+80

The performance comparison has been shown in the next section.

4 Results and Discussions

The detailed results and discussion of the paper has been discussed in this section.

4.1 Limiting amplification delays

In MPLS, use of repeaters may increase internal delays as discussed in previous section. The proposed RRT approach may reduce the amplification and thus transmission delays. The delay comparison using repeaters and RRT approach in fig.3 and concludes that amplification delays give rise to the high transmission delays in case of using repeaters and hence may effect the quality of service among autonomous systems, whereas amplification delays have no impact on transmission delays in case of using LSRs as signal amplifiers.

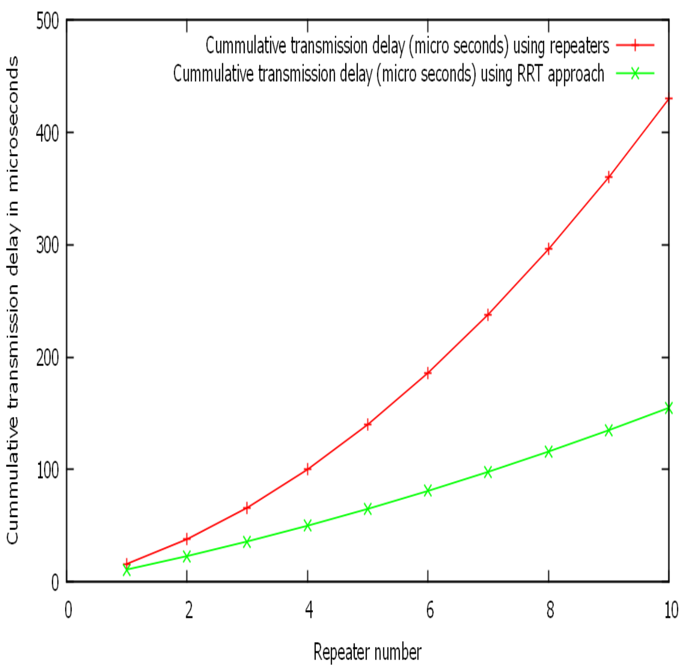

Fig. 3: Comparative analysis of repeaters and RRT approach in terms of transmission delay

4.2 Limiting Background noise and reducing bandwidth usage

The performance comparison of RRT approach in limiting the background noise over the use of repeaters has been showing in fig. 4.

Background noise may lead to the wastage of bandwidth due to the bandwidth usage by unwanted background noise, which gets amplified equally with the useful data signal.

The following graph has been showing the bandwidth usage with repeaters and proposed RRT approach and concludes that high bandwidth is used in case of repeaters as compare to the RRT approach.

The comparison results hereby conclude that the proposed approach helps in providing the desired quality of service to the real time applications by reducing the background noise.

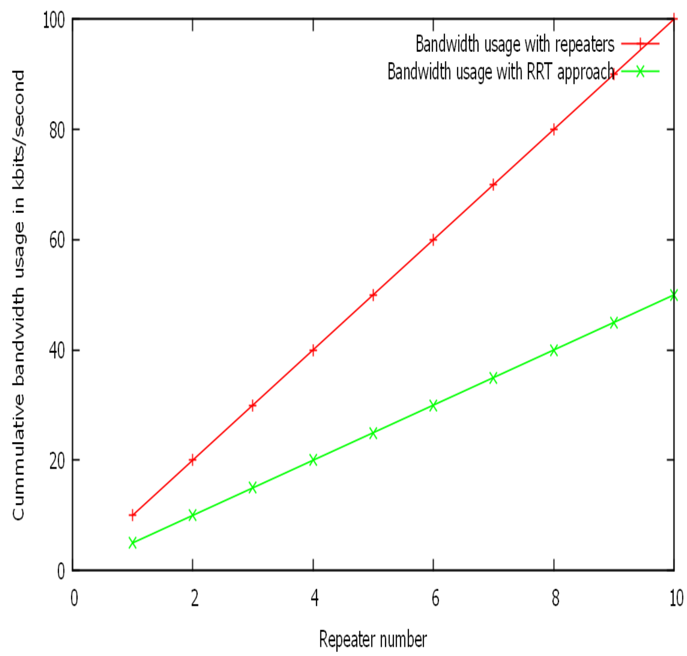

Fig. 4: Comparative analysis of repeaters and RRT approach in terms of bandwidth usage

4.3 Increase in signal power

The performance of RRT approach and use of repeaters in the ratio of power level & signal strength has been shown in following fig. 5.

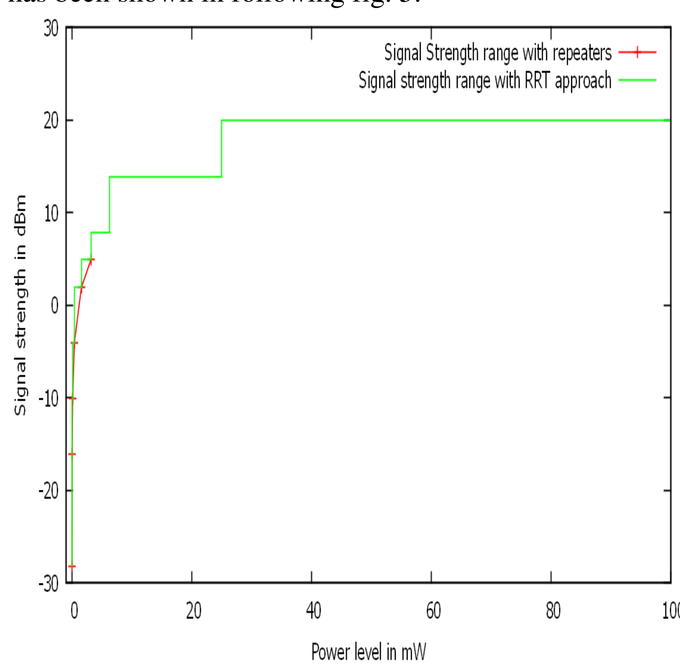

Fig. 5: Comparative analysis of repeaters and RRT approach in terms of signal strength range

The performance of RRT approach and use of repeaters in the ratio signal strength & distance travel has been shown in fig. 6.

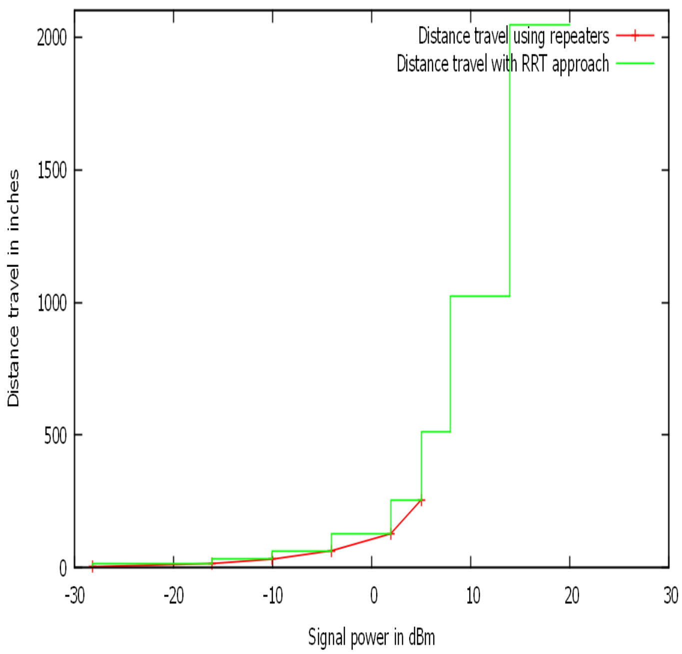

Fig. 6: Comparative analysis of repeaters and RRT approach in terms of distance travel in inches

One the basis of graphs seen in fig. 5 and fig. 6, it has been concluded that signal may travel larger distances using RRT approach as compare to repeaters.

4.4 Avoiding users moving to larger distances

As discussed in earlier section, the use of repeaters may move the users virtually to the longer distances due to repeater delay and delay of RF signal in the air. The radio distance thus becomes much larger than the real distance, which may affect the quality of service among autonomous systems separated through larger distances.

The use of RRT approach may resolve this issue due to absence of repeater delay and RF signal delay in label switched routers being used instead of repeaters.

The performance comparison of usage of repeaters and RRT approach in terms of radio distances has been shown in fig. 7 and it has been concluded that RRT approach does not move the users to the larger distances and hence retain the quality of service among autonomous systems.

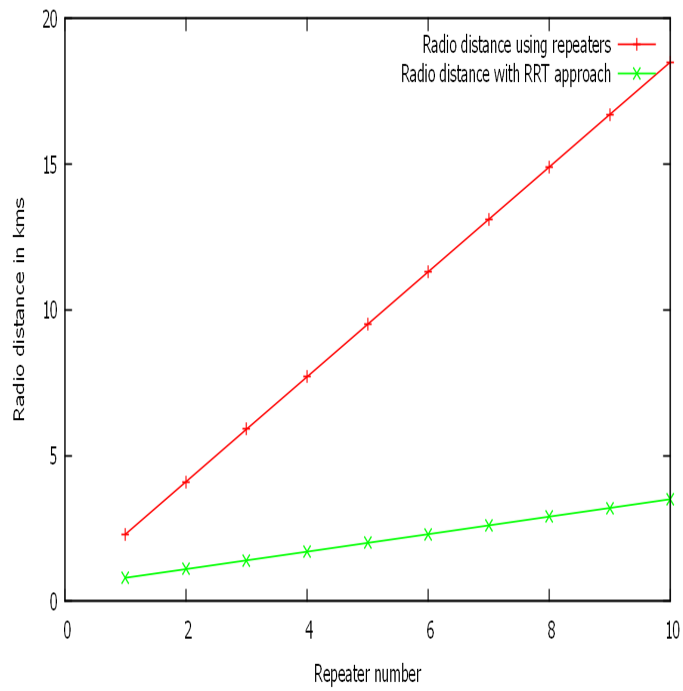

Fig. 7: Comparative analysis of repeaters and RRT approach in terms of radio distances

4.5 Improper Repeater support

The performance comparison of usage of repeaters in terms of successful transmission rate has been presented in the graph seen in fig. 8 and concludes that RRT approach achieves desired QoS.

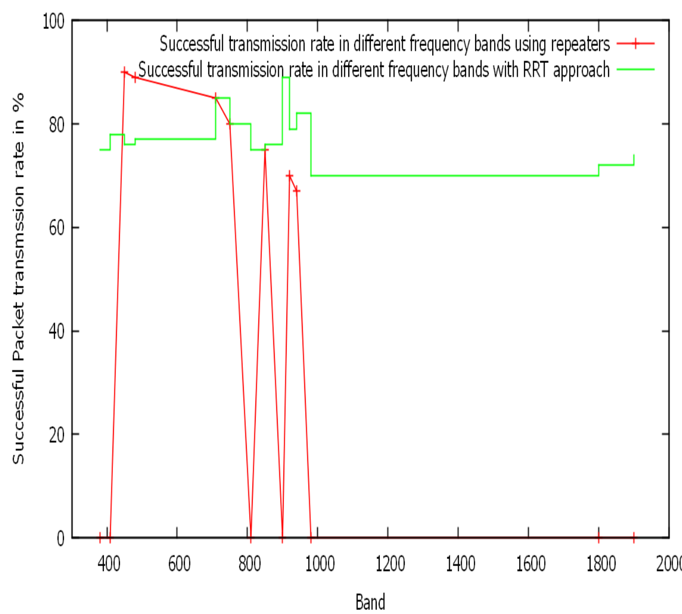

Fig. 8: Comparative analysis of repeaters and RRT approach in terms of radio distances

5 Conclusions and Future Work

The proposed approach has addressed the networking issues including signal strength retention, signal amplification, internal delay, background noise amplification, amplifier constraint, poor signal generation, repeater support issues etc.

The proposed approach makes use of Relay Race Transmission in MPLS technology to extend its QoS performance among autonomous systems by the means and methods using LSRs instead of signal amplifiers between remote distances.

The results presented in the earlier section conclude that extended MPLS technology has an edge over the default MPLS technology in terms of maintaining desired signal strength among autonomous systems and hence providing QoS among ASs.

In future, researchers may identify additional QoS metrics which may further help in providing quality of service in wireless networks.

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Abbreviations

QoS- Quality of Service
AS-Autonomous system
RRT-Relay Race Transmission
LSR- Label Switched Router
MPLS- Multiprotocol Label Switching
LER-Label Edge Router
dBm-Power ratio in decibel
MW-Mega Watt